DEPARTMENT: WATER AFFAIRS
CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

THE CLASSIFICATION OF SIGNIFICANT WATER RESOURCES IN THE OLIFANTS-DOORN WATER MANAGEMENT AREA (WMA 17)

DRAFT INTEGRATED SOCIO-ECONOMIC AND ECOLOGICAL SCENARIO SPECIALIST REPORT

AUGUST 2011

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TABLE OF CONTENT

ACRONYMS

ADE	Aquifer Dependent Ecosystems
BHN	Basic Human Needs
C.A.P.E.	Cape Action Plan for People and the Environment
CD: RDM	Chief Directorate: Resource Directed Measures
CMS	Catchment Management Strategy
CSIR	Council for Scientific and Industrial Research
DEAT	Department of Environment Affairs and Tourism
D: RQS	Directorate: Resource Quality Services
DRIFT	Downstream Response to Imposed Flow Transformations
DSLF	Dry Season Low Flow
DSS	Decision Support System
DWA	Department of Water Affairs (previously DWAF)
EC	Ecological Category
EGSA	Ecosystem Goods, Services and Attributes
EIS	Ecological Importance and Sensitivity
EISC	Ecological Importance and Sensitivity Category
ELU	Existing Lawful Use
ESBC	Ecological Sustainability Base Configuration
EWR	Ecological/Environmental Water Requirements
GIS	Geographic Information System
GRU	Groundwater Response Unit
GW	Groundwater
I&AP	Interested and Affected Parties
IFR	Instream Flow Requirement
ISP	Internal Strategic Perspective
IUA	Integrated Units of Analysis
IWRM	Integrated Water Resource Management
LORWUA	Lower Olifants River Water User Association
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
Masl	metres above sea level
mbgl	metres below ground level
MC	Management Class
MSL	Mean Sea Level
MTIFR	Maintenance Total Instream Flow Requirement
NDSD	National Department of Social Development
NDA	National Department of Agriculture
NGDB	National Groundwater Database

nMAR	Naturalised Mean Annual Runoff
NMMP	National Microbial Monitoring Programme
NWA	National Water Act
PES	Present Ecological Status
PESC	Present Ecological Status Category
RDM	Resource Directed Measures
REC	Recommended Ecological Category
RHP	River Health Programme
RQOs	Resource Quality Objectives
RU	Resource Unit
RWQO	Resource Water Quality Objective
SAM	Social Accounting Matrix
SANBI	South African National Biodiversity Institute
SAWQG	South African Water Quality Guidelines
SW	Surface Water
TDGE	Terrestrial Dependent Groundwater Ecosystems
TDS	Total Dissolved Solids
TWQR	Target Water Quality Range
WMA	Water Management Area
WMS	Water Management System
WRCS	Water Resource Classification System
WSAM	Water Resource Situation Assessment Model
WTW	Water Treatment Works
WWTW	Waste Water Treatment Works

GLOSSARY

Catchment configuration: A set of ecological categories (ECs) within a catchment for each nodal reach representing a significant water resource.

Ecostatus: The totality of the features and characteristics of the river and its riparian areas that bear upon its ability to support an appropriate natural flora and fauna and it capacity to provide a variety of goods and services (Kleynhans *et al.* 2005).

Environmental Water Requirements: An allocation of water with a prescribed distribution in space and time, and of a specific quality, that is deliberately left in a river or released into it, to manage river health and the integrity of ecosystems and communities sustained by river flows.

Habitat Integrity: A measure of the extent or degree to which the integrated composition of physico-chemical and habitat characteristics is maintained on scale that is comparable with the characteristics under natural conditions. Habitat integrity can be used as a surrogate for Ecostatus (Kleynhans *et al.* 2005).

Integrated Unit of Analysis (IUA) class: The desired condition or characteristics of a resource and concomitantly, the degree to which it can be utilised. It may range from minimally to heavily used, depending on societal requirements. The IUA Class is a summary condition recommended for a configuration of water resources within an IUA and between IUAs in a catchment.

Nodes: These are modelling points representative of an upstream reach or area of an aquatic ecosystem (rivers, wetlands, estuaries and groundwater) for which a suite of relationships apply.

Nodal reaches: the upstream reach or area of an aquatic ecosystem as represented by nodes.

Present Ecological State: the current state or condition of a resource in terms of its various biophysical components, i.e. drivers (physico-chemical, geomorphology, and hydrology and biological responses (i.e. fish, riparian vegetation and aquatic invertebrates).

Reserve: The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water of 25 litres per person per day and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No. 36 of 1998).

Significant Water Resources: Water resources that are deemed to be significant from a water resource use perspective, and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in their quality and quantity of water.

1. OVERVIEW

1.1. BACKGROUND

The National Water Act (Act No. 36 of 1998) (NWA) is founded on the principle that National Government has overall responsibility and authority over water resource management for the benefit of the public, without seriously affecting the functioning of the natural environment. In order to achieve this objective, Chapter 3 of the NWA provides for the protection of water resources through a number of measures including the classification of all significant water resources. The Chief Directorate: Resource Directed Measures (CD:RDM) is tasked with the responsibility of ensuring that this chapter of the NWA is properly implemented.

The use of the WRCS to classify water resources is a legal requirement in terms of the National Water Act (NWA, No. 36 of 1998, Chapter 3, Part 1, Section 2(a)). The system provides a set of guidelines and procedures for determining the different classes of water resources, and will be used in a consultative (not consensus seeking) Classification process to classify water resources progressively over a period of time throughout South Africa. The classification process entails a seven step classification process during which the social, economic and environmental implications of different class scenarios and configuration in the catchment are investigated and the consequences communicated to the users and stakeholders in the catchment. The users and stakeholders are then consulted in terms of each of these scenarios in order to recommend a class configuration and scenario to the DWA delegated authority responsible for classification for approval.

The Classification process requires the consideration of all aspects related to the water resources and freshwater biodiversity considerations must be integrated into the resource class scenario planning and it therefore requires consultation with a wide range of stakeholders (not restricted to the classic water users and associated industries). The outcome of the Classification Process provides a Management Class. In order to comply with the class the Resource Quality Objectives and a Reserve requirement for rivers, estuary, wetlands and aquifers needs to be set according to predetermined resource units (Units of Analysis).

A Water Resource Classification System (WRCS) was developed for South Africa and has culminated into Regulations for the Establishment of the Water Resource Classification System, published as Regulation 810 in Government Gazette 33541 dated 17 September 2010. The Department of Water Affairs is now in a process to undertake the Classification Process for some of its priority catchments, of which the Olifants-Doorn WMA was identified as one.

In the development of the WRCS, the Olifants-Doring Catchment was used as a pilot catchment. This resulted in much of the information required for such a classification process being generated for the catchment; however neither the Classification Process nor the consultative process was concluded. In addition, the Environmental Water Requirements for rivers and groundwater in the Sandveld has also been determined.

1.2. OVERVIEW OF THE WRCS

Regulations for the Establishment of the Water Resource Classification System have recently been gazetted for South Africa (Regulation 810, Government Gazette No. 33541, 17 September 2010). The WRCS is required in terms of the National Water Act (NWA, No. 36 of 1998, Chapter 3, Part 1, Section 2(a)) and provides a set of guidelines and procedures for determining the different classes of water resources.

The WRCS is based on the principle of sustainable development and utilisation of water resources which is explicit to the South African Constitution. In line with this, fundamental principles to the NWA are that water-resource management must:

- Meet the water needs for current and future generations;
- Promote the efficient, sustainable and beneficial use of water in the public interest; and
- Protect aquatic and associated ecosystems and their biological integrity.

These fundamental principles are also central to the guideline principles of the WRCS: to balance resource protection and use; ensure sustainability of use; be in national interest and be consistent; be transparent; be implementable; address the interdependency of all resources within the hydrological cycle; be legally defensible and scientifically sound; be at a applicable scale for the management for the resource; be enforceable and auditable; allow for the lowest level of contestation and have the highest level of legitimacy amongst stakeholders; and must make use of existing tools, data and information.

A seven step procedure (Figure 1) was developed for the determination of the Management Class (MC) that is to be recommended for a water resource. To classify South Africa's water resources with the aim of achieving a balance between the protection and use of these resources, the WRCS must be used in a consultative manner. The outcome of the Classification Process is a MC, and to give effect to the class the Reserve and the Resource Quality Objectives (RQOs) for all identified significant water resources (rivers, estuary, wetlands and aquifers) must also be set.

MCs will be:

- Defined for each sub-catchment within the WMA (referred to as the Integrated Units of Analysis [IUAs]);
- Defined in terms of the use that will be made of water resources in an IUA (Table 1); and
- Comprised of a configuration of aquatic ecosystem conditions, resulting in an 'overall condition'.

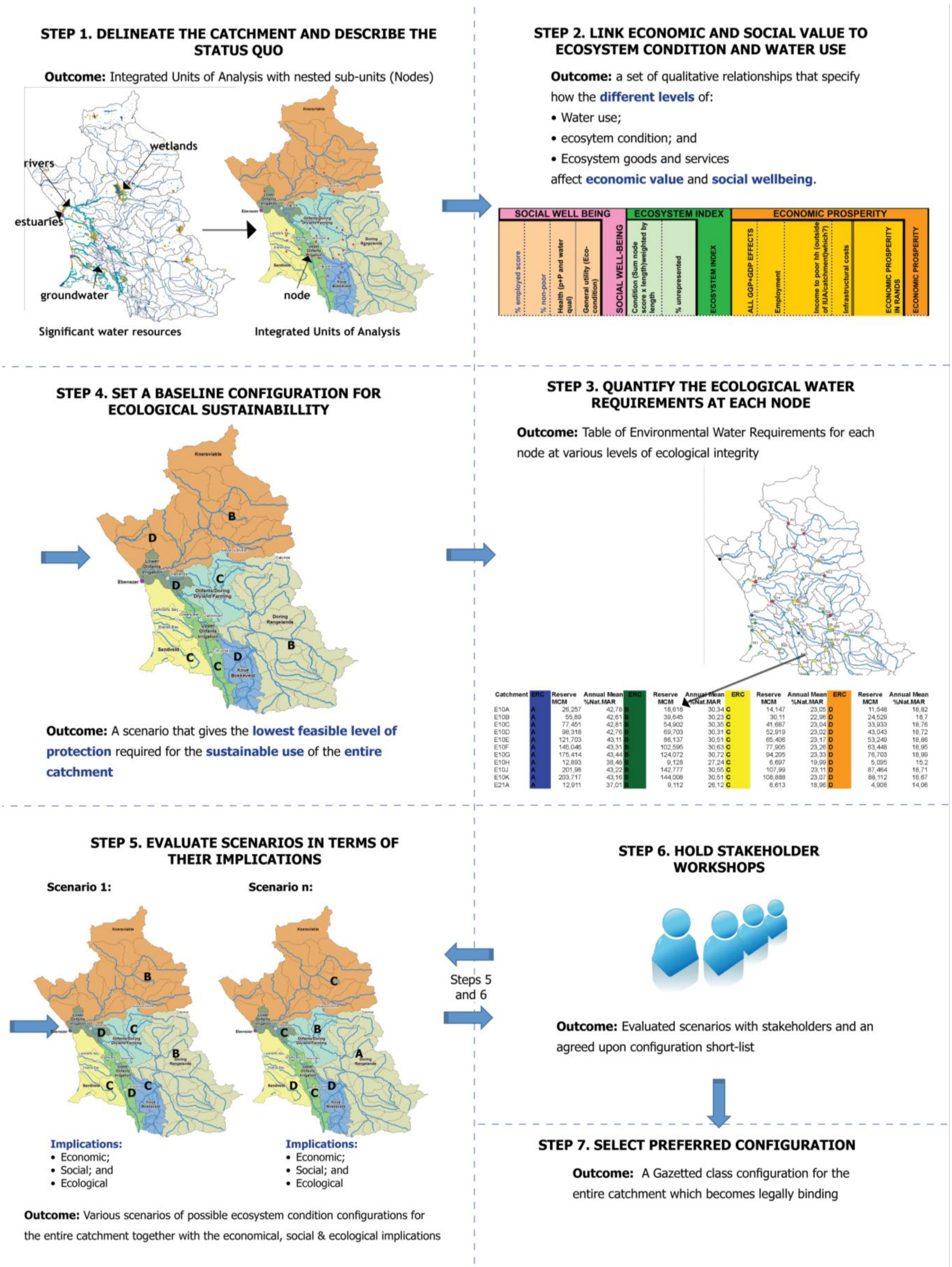


Figure 1.1: A simplified diagram of the seven-step procedure for recommending the Class of a water resource

Table 1.1. Water resource management classes (MC)

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

The WRCS is an integral component of the Integrated Water Resources Management (IWRM) environment and needs to be linked to other processes such as water resource planning and development and the management of its use. There is additional information requirement in the Classification Process that relate to socio-economic issues in the catchment that may not be highlighted in classification system documents.

It is important to understand that the product of a Classification Process is the assignment of a management class to water resources within a catchment, i.e. rivers, wetlands, groundwater and estuary. This outcome may influence the water yield that can be utilised from the resources, and indirectly activities within the catchment, such as land use.

1.3. INTRODUCTION TO THE CATCHMENT

The Olifants/Doorn WMA is located on the west coast of South Africa, extending from about 100 km to 450 km north of Cape Town. The south-western portion mainly falls within the Western Cape Province, and the north-eastern portion falls within the Northern Cape Province. The major river in the WMA is the Olifants River, of which the Doring River (draining the Koue Bokkeveld and Doring area) and the Sout River (draining the Knersvlakte) are the main tributaries. The WMA incorporates the E primary drainage region and components of the F and G drainage regions along the coastal plain, respectively north and south of the Olifants River estuary, covering a total area of 56 446 km^2. The Olifants and Doring Rivers flow strongly during the winter months whilst flows only occur very occasionally in the Sout River. There are also a number of smaller coastal rivers and water courses which flow infrequently.

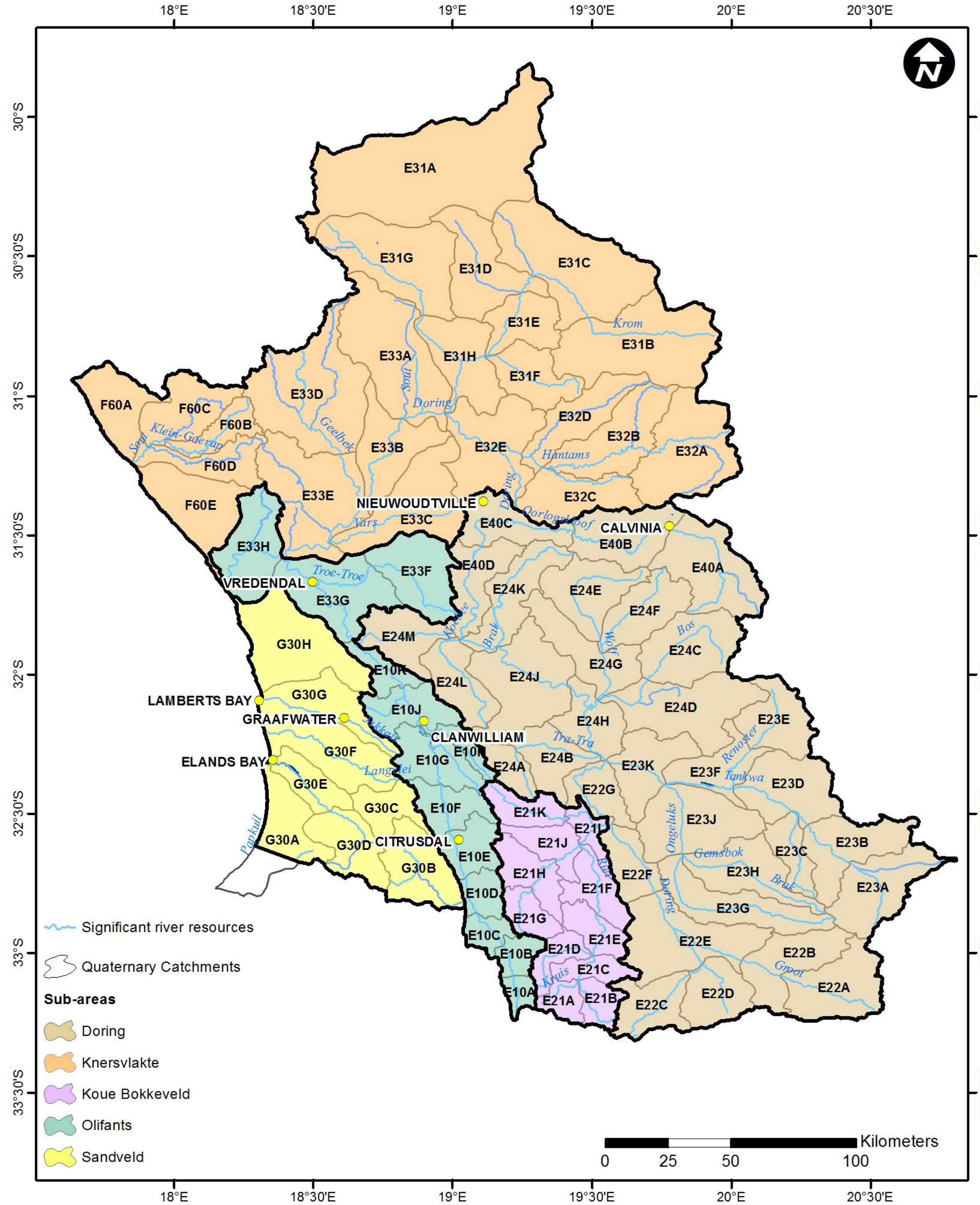


Figure 1.2: The Olifants/Doorn Water Management Area and Sub-areas

The Olifants River is extremely important from a conservation perspective, primarily because of three attributes:

- it contains remnant populations of eight species of endemic fish, the highest number of endemic fish south of the Zambezi River;

- its upper reaches flow through a unique gorge area, which is widely recognised for its aesthetic and recreational appeal; and
- a number of unique and relatively undisturbed tributaries feed it.

Possible historical links with the Orange River also make the river important from a scientific point of view.

The Doring River is particularly important from a conservation point of view. It is inhabited by nine indigenous fish species, seven of which are endemic to the river system. Of these, the mainstream of the Doring River is most important for the larger species. The reaches upstream of the Tankwa River are vital breeding areas for the sawfin (*Barbus serra*), the Clanwilliam yellow fish (*Labeobarbus capensis*), and the Clanwilliam sandfish (*Labeo seeberi*). The latter two are classified as rare Red Data species, while the sawfin is regarded as vulnerable (Skelton, 1987). In addition, the Doring River is the only major river in the region that is not impounded; it flows through several unspoiled gorges; its ecological status is high down the full length of the river and as such it offers a unique wilderness experience to visitors to the area.

The water quality in the Doring River is a unique mixture of two distinct water chemistry systems, the one originating in the Karoo (turbid and saline), and the other in the Cederberg Mountains (clear and fresh). Differences in these systems are largely based on the geological characteristics of their catchments, but are probably also influenced to some degree by land use. In general, water quality in the upper reaches of the two main rivers, the Olifants River and the Doring River, was good but deteriorated in a downstream direction as a result of catchment developments. Surface water is scarce in the Knersvlakte and Tankwa Karoo and it tends to be quite saline.

A combination of habitat degradation and invasion by alien species have significantly contributed towards the decline in endemic fish populations in the Olifants/Doring River Basin, with the Clanwilliam Dam and Bulshoek Barrage having contributed significantly toward this reduction through:

- inundating significant spawning habitat;
- providing barriers to migration;
- providing a haven for alien fish species, which prey on the young of the indigenous species;
- affecting the timing and volume of flows in the downstream river, thereby reducing the quality and suitability of the available habitat for indigenous fish; and
- reducing the frequency and duration of scouring floods resulting in palmiet encroachment into the active channel and reducing available riffle-spawning habitat for the indigenous fish species.

The unique fish community of the Olifants/Doring River system is greatly threatened by these impacts and management measures are urgently required to ensure that further utilisation of the catchment's rivers is sustainable (from Brown *et al*. 2003).

The Olifants Estuary is one of the largest, most diverse estuaries in South Africa. It also has a high functional importance in terms of its role as a nursery area for marine fishes on the West Coast. The estuary has been targeted as a 'Desired Protected Area' by the Resource Directed Measures Directorate in DWAF (DWAF 2004).

In the Sandveld, Verlorenvlei is one of the most important estuarine systems in the Western Cape and one of the largest natural wetlands along southern Africa's west coast. The open water lake is linked to the sea by a narrow, hydraulically inactive estuary channel. Large evaporative losses occur from the lake in summer, however evaporation losses are compensated for by the significant contribution of groundwater to the lake, flowing in from the north-eastern side of the lake. The Verlorenvlei River only feeds the lake during the rainfall months in winter and early summer.

This freshwater coastal lake is classified as a Ramsar site, an important feeding ground for several rare and threatened bird species. It is regarded as one of the ten most important wetlands for wading birds in the south-western Cape and is a particularly important feeding area for the white pelican. Indigenous freshwater fish species occurring in the wetland are the Cape galaxia and the rare Verlorenvlei redfin. Rare and threatened mammals such as the Cape clawless otter, *Aonyx capensis*, have also been recorded.

Climate and rainfall

Climatic conditions vary considerably as a result of the variation in topography. Minimum temperatures in July range from –3ºC to 3ºC and maximum temperatures in January range from 39ºC to 44ºC. The area lies within the winter rainfall region, with the majority of rain occurring between May and September each year. The mean annual precipitation is up to 1 500 mm in the Cederberg Mountains in the south-west, but decreases sharply to about 200 mm to the north, east and west thereof, and to less than 100 mm in the far north of the WMA. Average gross mean annual evaporation (as measured by Symons pan), ranges from 1 500 mm in the south-west to more than 2 200 mm in the dry northern parts. Scenarios of climate-change over the next 50-100 years show this area may potentially receive up to 15% less rain in future.

Topography

The topography of the WMA is of three distinct types, namely rolling hills and sand dunes in the west along the coastal strip, rugged mountains with peaks rising to about 2 000 m above sea level in the southern area, and plains and rocky hills in the north-eastern area that are typical of the Western Karoo. The Olifants River rises in the mountains in the south-east of the WMA and flow north-west. Its deep narrow valley widens and flattens downstream of Clanwilliam until the river flows through a wide floodplain downstream of Klawer. The Doring River is a fan shaped catchment. The main river rises in the south and flows in a northerly direction. It is first joined by the Groot River and then by the Tra-Tra flowing from the west and the Tankwa River from the east, before flowing in a westerly direction to its confluence with the Olifants River just upstream of Klawer.

The north of the WMA is flatter and much of the basin lies between 500 and 900m above sea level. In the east there are significant mountain ranges, the Hantam near Calvinia and the Roggeveld to the south, which rise to about 1 500m above sea level. West of Nieuwoudtville lays the Bokkeveld Mountains escarpment where the plateau elevation of about 700 m drops to about 300 m. The rolling hills and plains of the 30 to 40 km wide strip along the coast from the southern boundary of the WMA to the estuary of the Olifants River are known as the Sandveld. The deep sandy deposits overlaying the bedrock in this area are "primary" aquifers which provide a significant groundwater resource.

Geology

The geology of the area is dominated by sedimentary rocks of the Table Mountain Group (TMG) of the Cape Supergroup, which form the highest (almost north/south trending) mountain ranges. The rocks of the Karoo Supergroup outcrop occur largely in the eastern and northern areas of the catchment of the Doring River and comprise the valley floors of the Olifants River where it overlies the TMG. Sedimentary strata of the Vanrhynsdorp Group occur in the north, with exposures of pre-Cape metamorphic rock in the north-western and north-eastern corners of the area. The coastal plain is variably underlain by the metamorphosed shales of the Malmesbury Formation and the sandstone of the TMG. These are overlain by the more recent semi to unconsolidated sediments of alluvial, wind-blown (Sandveld Group), and marine origin as well as calcrete and ferricrete deposits.

Vegetation

Due to the diverse soil types and variance in rainfall distribution, vegetation is varied and includes at least six veld types and several thousand plant species. Karoo and Karroid Types, False Karoo Types, Temperate and Transitional Forest Types, Scrub Types, and Sclerophyllous Bush Types dominate the Olifants/Doorn WMA.

Population

Approximately 104 000 people live in the area. Almost half of the population live in urban and peri-urban areas. The average population growth rate is about 0.5% per year. However, Vredendal is growing at a rate of about 7% per annum due to migration of people from rural areas.

Economy

The area contributes approximately 0.3% to the gross domestic product of South Africa, with nearly half (R2 billion) contributed by the agricultural sector. Activities in this sector include the production of wine, table grapes, citrus, rooibos tea, fresh fruit, dried fruit, potatoes, wheat, livestock and fisheries. Trade and industry linked to agriculture is the next most important economic sector. Half of the labour force is employed by the agricultural sector, while 8% are unemployed. Nature-based tourism is an important and growing industry in this area, with most of the towns experiencing a growth in this sector. Mining (diamond, gypsum, limestone and marble) occur on a small-scale.

Land-use

Land-use in the Olifants/Doring and Sandveld river catchments consists largely of livestock farming (sheep and goats), with small areas being used for dryland farming. Citrus, grapes, deciduous fruit and potato farming are intensive in the south-west. Urban and rural areas are small. Most of the area is still covered by natural vegetation, although this has been disturbed by over-grazing.

Water-use

Water-use is highest in the Olifants management area, representing over 65% of the total water requirement for the Water Management Area. Close to 20% is used in the Koue Bokkeveld, about 10% in the Sandveld and smaller quantities in the Doring and Knersvlakte management areas.

1.4. THE CLASSIFICATION PROCEDURE

The overall seven-step procedure for recommending a Class of a resource is as laid out in Figure 1. The ecological, hydrological and water quality steps of the classification procedure are highlighted in yellow within the seven steps procedure, while the socio-economic steps are highlighted in green:

Step 1: Delineate units of analysis and describe the status quo; including:

a. Describe present socio-economic status of the catchment.
b. Divide catchment into socio-economic zones.
c. Identify a network of significant resources, describe water resource infrastructure and identify water user allocations. Define a network of significant resources and establish biophysical nodes.
d. Describe communities and their wellbeing.
e. Describe and value the use of water.
f. Describe and value the use of aquatic ecosystems.
g. Define Integrated Units of Analysis (IUAs). *(Together with socio-economic input)*
h. Develop and/or adjust the socio-economic framework and the decision-analysis framework. *(Together with ecological input)*
i. Describe present-day community wellbeing within each IUA.

Step 2: Link value and condition; including:

a. Rationalise the choice of ecosystem values to be considered based on ecological and economic data.
b. Describe the relationships that determine how economic value and social wellbeing are influenced by ecosystem characteristics and the sectoral use of water.
c. Define the scoring system for scenario evaluations.

Step 3: Quantify Ecological Water Requirements (EWRs) and changes in non-water quality Ecosystem Goods, Services and Attributes (EGSAs); including:

a. Identify nodes to which Resource Directed Measures (RDM) data can be extrapolated and extrapolate.
b. Develop rule curves, summary tables and modified time series for nodes for all categories.
c. Quantify the changes in relevant ecosystem components, functions and attributes for each category for each node.

Step 4: Set Ecological Sustainability Base Configuration (ESBC) scenario and establish starter configurations; including:

a. Set ESBC scenario and screen for water quantity, quality and ecological feasibility.
b. Incorporate planning scenarios (future use, equity considerations, existing lawful use, etc.). *(Together with socio-economic input)*
c. Establish RDM catchment configuration scenarios.

Step 5: Evaluate scenarios within the Integrated Water Resource Management (IWRM) process

Steps 5 and 6 form part of the 'Larger Process', where the economic, social and ecological trade-offs will be made. Trade-offs could include the considerations of Existing Lawful Use (ELU) and equity considerations. Emerging from this 'Larger Process' will be the recommended MC which will prescribe the need for RQOs and Reserve, CMS, allocation schedule, modelling system and the monitoring, auditing and compliance strategy to give effect to the class. A number of key questions will need to be addressed in this 'Larger Process'. These include:

- at what level will the trade-offs be negotiated?
- in what institutional setting will they be negotiated?
- what types of scenarios will inform the process of negotiation?; and
- the recommended MC, Reserve, RQOs, CMS and allocation schedule will impact on specific groups of people, so the key question will be who benefits and who pays the social and economic cost?

These key questions should be framed (and assessed) in the context of equity, efficiency and sustainability as required by the NWA, and by the core objectives of the present government which are, amongst others, to '…halve poverty and unemployment by 2014', reduce the regulatory burden on small and medium businesses and eliminate the second economy. Step 5 should therefore contribute to meeting government's objective of '…reduce(ing) inequality and virtually eliminating poverty'. Step 5 should therefore include:

a. Run yield model for ESBC and other catchment configuration scenarios and adjust if necessary. *(Together with socio-economic input);*
b. Assess water quality implications (fitness for use) for all users;
c. Report on ecological condition and aggregate impacts per IUA for each scenario;
d. Value changes in aquatic ecosystems and water yield;
e. Describe macro-economic and social implications of different catchment configuration scenarios;
f. Evaluate overall implications at an IUA-level and a regional-level; and
g. Select a subset of scenarios for stakeholder evaluation.

Step 6: Evaluate scenarios with stakeholders; including:

a. Stakeholders evaluate scenarios and agree on short-list; and
b. DWA recommends IUA classes.

Step 7: Gazette class configuration; including:

a. Populate IWRM summary template and present to Minister or delegated authority;
b. Minister decides on IUA classes, nested category configurations, Reserve(s), allocation schedule(s) and Catchment Management Strategy (CMS);
c. Recommend Resource Quality Objectives (RQOs);
d. Gazetted IUA classes, nested category configurations and RQOs; and
e. Develop plan of action for implementation of recommended scenario.

2. SOCIO-ECONOMIC OVERVIEW

2.1 APPROACH, ASSUMPTIONS AND LIMITATIONS

2.1.1 Approach

In terms of existing data, Volume 3 of the Socio-Economic Guidelines for the 7-Step Classification Procedure provides detailed socio-economic data on the Olifants/Doorn WMA. This report was completed in February 2007 and is largely based on 1996 and 2001 Population Census data. The aim of this report is to provide an up-date of the local baseline socio-economic data for the Olifants/Doorn WMA.

In terms of its administrative setting the Olifants/Doorn WMA falls within two District Municipalities, namely the West Coast District Municipality (WCDM) in the Western Cape Province and the Namakwa District Municipality (NDM) in the Northern Cape Province. The relevant local municipalities within these two district municipalities are the Matzikama, Cederberg, Berg River Local Municipalities and West Coast Management Area in the WCDM, and the Hantam Local Municipality in the NDM. These DM and LM provide the basis for the socio-economic overview of the Olifants/Doorn WMA.

The approach to the study involved:

- Review of demographic data from the 2001 Census Survey;
- Review of relevant planning and policy frameworks for the area, specifically Integrated Development Plans and the West Coast Socio-Economic Profile; and
- Review of existing reports and documentation on the Olifants/Doorn WMA.

2.1.2. Assumptions

Existing data on the Olifants/Doorn WMA

There is a wealth of existing socio-economic data available on the Olifants/Doorn WMA, for example the information contained in the Volume 3 of the Socio-Economic Guidelines for the 7-Step Classification Procedure. The purpose of this report is not to repeat the data contained in this and other reports but to update the current socio-economic data for the study area.

Fit with planning and policy requirements

Legislation and policies reflect societal norms and values. The legislative and policy context therefore plays an important role in identifying and assessing the potential social and economic impacts associated with a proposed development, including the allocation of water. Some of the key policies that guide development in local municipalities have therefore been identified and are summarised in the report. Given the critical role played by water in economic and social development, the development of a water resource classification system for the Olifants/Doorn WMA should be in line with and support key policies that guide development in local municipalities.

2.1.3. Limitations

Demographic data

The demographic data that is available for the study area is largely based on the 2001 Census[1]., While this data does provide useful information on the demographic profile of the affected area, the data are dated and should be treated with care. Where possible reference has been made to the latest demographic data contained in local Integrated Development Plans and other documents.

In addition, the socio-economic data for the study area is linked to the administrative areas, namely the local municipalities and associated wards, and not the quaternary catchment areas.

Access to ward level data

There is no longer any access to Census 2001 data at Ward level via the Municipal Demarcation Board. As such, it was not possible to get ward level data for the local municipalities in Olifants/Doorn WMA. The socio-economic data is therefore described at District and Local Municipal level only.

2.2. OVERVIEW OF THE WEST COAST DISTRICT MUNICIPALITY REGION

The West Coast is a water scarce region that faces water shortages and supply limitations. The West Coast Socio-Economic Profile (2007) notes that in 2004 ~20% of the district's GDPR (Gross Regional Domestic Product) was derived from the agriculture, forestry & fishing sector. The profile points out that the future water shortages faced by the region could act as a significant inhibitor of economic growth.

The majority of the Olifants/Doorn Water Management Area (WMA) falls within the West Coast District Municipality (WCDM), a category C municipality, which is located on the west coast of the Western Cape Province. The district is made up of five local municipalities, namely Matzikama, Cederberg, Bergrivier, Saldanha Bay and Swartland, as well as the four District Management Areas, Bitterfontein, the Cederberg Wilderness Area, West Coast National Park and Hexberg (Figure 2.1). In terms of the Olifants/Doorn WMA, the majority of the area coincides with the Matzikama and Cederberg Local Municipalities, while a small section of the WMA falls within the north western part of the Berg River Local Municipality (LM).

[1] The last comprehensive national census was conducted in 2001. Census 2001 provided demographic and socio-economic data from National to Municipal Ward level. An interim Community Survey (sample based) was undertaken in 2007, but provided information only on provincial and municipal levels. The next comprehensive national census is planned for 2011.

Figure 2.1: West Coast District Municipality

2.2.1. Economic Overview

The WCDM contributed ~ 4 % (R5.6 billion) to the Western Cape's total GDPR (R140.9 billion) in 2004. Of all sectors, only the Agriculture, Forestry & Fishing (17.15% of provincial Gross Regional Domestic Product (GDPR) for the sector) and the Mining (18.5% of provincial GDPR for the sector) sectors contributed more than 15 % to the total Western Cape provincial sector in 2004 (Socio-economic Profile: West Coast District, 2006). However, the West Coast Agriculture, Forestry & Fishing and Mining sectors are fairly small, jointly contributing only 4.7 % to the Western Cape's GDPR. All other sectors in the West Coast contributed less than 5 per cent to the Western Cape total for the respective sectors (Socio-economic Profile: West Coast District, 2006).

In terms of economic growth, the WCDM had an annual average growth rate of 2.4 % (1996 to 2004), which was below the Western Cape's average growth of 2.9 % over the same period (Socio-economic Profile: West Coast District, 2006) (Figure 2.2).

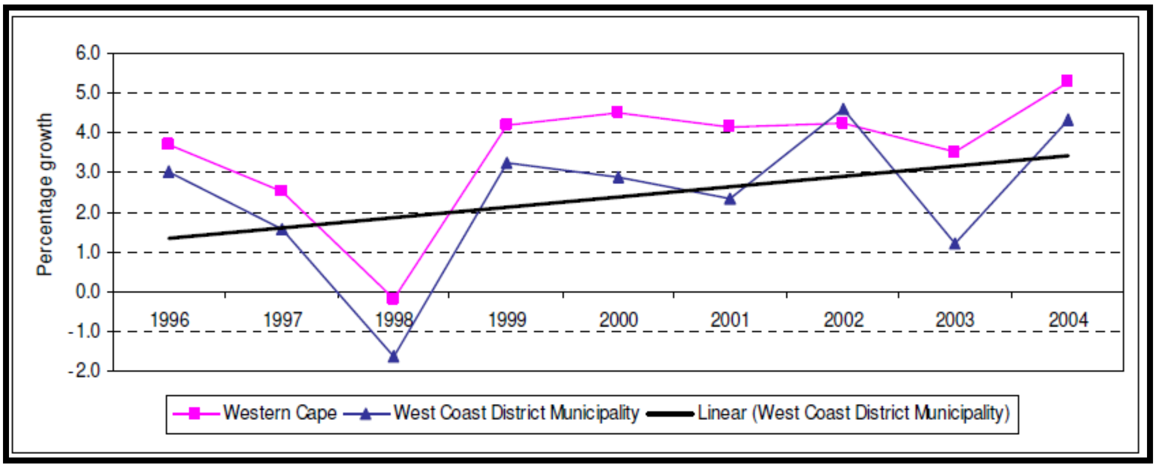


Figure 2.2: GDPR growth trends—West Coast districts and Western Cape, 1996 – 2004 (Source: Socio-economic Profile: West Coast District, 2006)

In terms of economic activity, for the period 1995 and 2004 (Figure 2.3), the biggest change in contribution to GDPR was from the Wholesale & Retail; Catering & Accommodation sector, which increased from 12.7% to 16.1%. The Finance & Business Services sector also increased its share from 12.2% to 13.3%. In terms of contributions per local municipality, Saldanha Bay (33.5%) and Swartland (29.1%) municipalities made the largest contributions to the West Coast District's GDPR in 2004, while the Matzikama, Bergrivier and Cederberg LMs contributed 14.6%, 11.9% and 9.9% respectively (Figure 2.4).

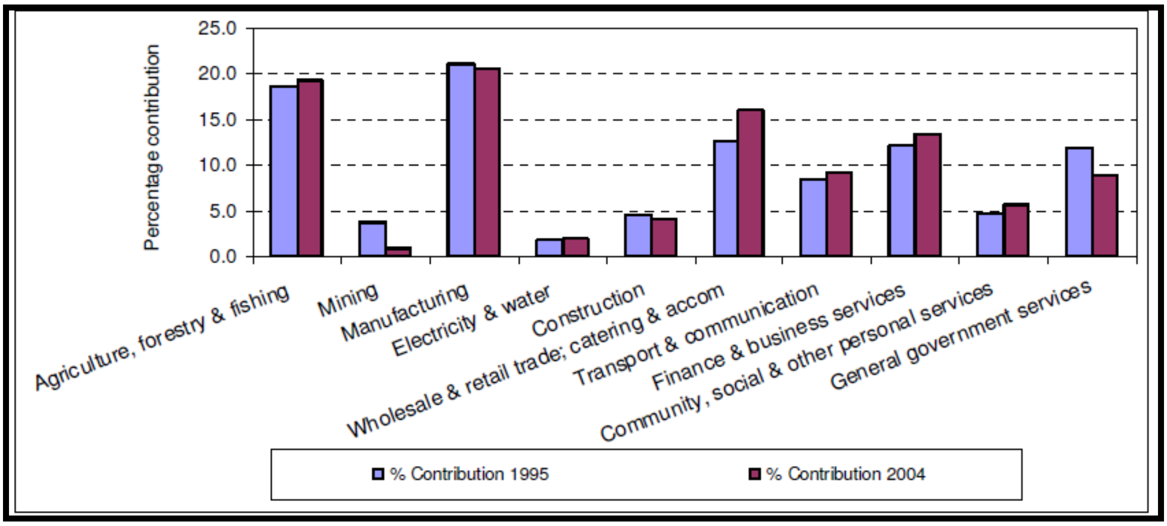


Figure 2.3: West Coast District Municipality - Sectoral contribution to GDPR, 1995 and 2004 (Source: Socio-economic Profile: West Coast District, 2006)

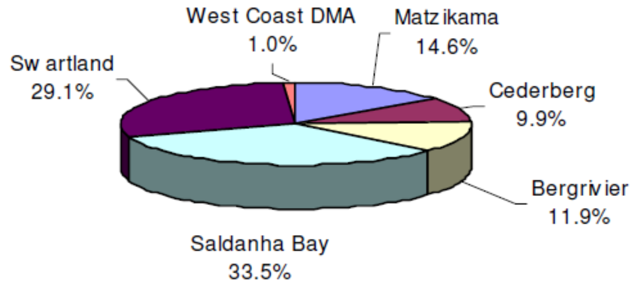


Figure 2.4: Local municipality contribution to District's GDPR, 2004 (Source: Socio-economic Profile: West Coast District, 2006)

The most important economic sectors within the WCDM in 2004 were Manufacturing (20.6%), Agriculture, Forestry & Fishing (19.4%), Wholesale & Retail Trade, and Catering & Accommodation (16.1%) and Finance & Business services (13.3%). The Mining (0.9%) and Construction (4.0%) sectors were relatively small (Socio-economic Profile: West Coast District, 2006). From a growth perspective, the WCDM grew at an average annual rate of 2.4% between 1995 and 2004. The fastest growing sector was Wholesale & Retail Trade; Catering & Accommodation that grew at an average annual rate of 5.1%. This was followed by Community, Social & Other Personal Services (4.1%), Transport & Communication (3.4%) and Finance & Business Services (3.4%) (Socio-economic Profile: West Coast District, 2006) (Table 2.1). Within the Manufacturing sector, the Food, Beverages & Tobacco sub-sector, which is closely linked to the agricultural sector, accounted for 41.7% per cent of the total.

Table 2.1: Sectoral growth, 1995 – 2004

Industry	GDPR 2004 (R million)	Contribution per sector 2004 (Percentage)	Average annual growth 1995-2004 (Percentage)	Average annual growth 2000-2004 (Percentage)	Growth 2003 – 2004 (Percentage)
Agriculture, forestry & fishing	1 093.2	19.4	2.9	2.1	2.5
Mining	53.0	0.9	-12.1	-3.1	1.3
Manufacturing	1 159.8	20.6	2.1	3.3	7.6
Electricity & water	105.9	1.9	2.8	3.4	5.7
Construction	227.4	4.0	0.9	1.9	2.0
Wholesale & retail trade; catering & accommodation	906.2	16.1	5.1	5.2	9.1
Transport & communication	515.3	9.2	3.4	2.7	1.0
Finance & business services	750.3	13.3	3.4	4.8	3.6
Community, social & other personal services	317.5	5.6	4.1	3.6	2.3
General government services	503.0	8.9	-1.0	0.4	0.2
Total	**5 631.6**	**100.0**	**2.4**	**3.1**	**4.3**

Source: Socio-economic Profile: West Coast District, 2006

In terms of sectors within each of the local municipalities, the most important contributors to GDPR within the Matzikama, Cederberg and Berg Rivier LMs were mining in Matzikama (58.7%) and Agriculture, forestry and fishing in both the Cederberg (14.2%) and Berg Rivier (20.5%) (Table 2.2).

Table 2.2: Local municipality sectors' contribution to West Coast District, 2004

Contribution percentage 2004	Saldanha Bay	Swartland	Matzikama	Bergriver	Cederberg	DMA
Agriculture, forestry & fishing	20.6	29.8	13.8	20.5	14.2	1.1
Mining	12.9	10.3	58.7	14.8	0.7	2.6
Manufacturing	47.9	29.4	9.3	7.2	6.0	0.3
Electricity & water	18.9	40.4	29.2	4.9	6.5	0.0
Construction	38.4	30.7	12.8	9.0	7.7	1.5
Wholesale & retail trade; catering & accommodation	30.7	26.7	16.1	11.3	14.2	1.0
Transport & communication	54.5	13.0	14.4	10.2	5.9	2.0
Finance & business services	24.4	44.0	12.8	10.0	8.6	0.2
Community, social & other personal services	36.4	26.0	20.4	3.8	9.9	3.6
General government services	26.3	25.6	18.3	17.6	10.9	1.2
Total	**33.5**	**29.1**	**14.6**	**11.9**	**9.9**	**1.0**

Source: Socio-economic Profile: West Coast District, 2006

The annual average growth rate for the Cederberg LM was 2.9% between 1995 and 2004. The annual growth rates for the Berg Rivier and Matzikama LM over the same period were 0.3% and 1.3% respectively (Table 2.3). The average annual district growth between 1995 and 2004 was 2.4% (Socio-economic Profile: West Coast District, 2006).

Table 2.3: Local municipalities' growth rates, 1995 – 2004

	Average annual growth 1995 – 2004 (Percentage)
Saldanha Bay	2.6
Swartland	3.6
Matzikama	1.3
Berg River	0.3
Cederberg	2.9
DMA	1.3
District	2.4

Source: Socio-economic Profile: West Coast District, 2006

The Manufacturing (40.5%) and Agricultural (10%) sectors were the largest employers (Census 2001). However, the West Coast Socio-Economic Profile notes that these two labour-absorptive sectors only grew moderately in the period 1996 to 2001. The Agriculture sector grew at 2.9% and manufacturing at 2.1% (Socio-economic Profile: West Coast District, 2006).

The total municipal revenue for the West Coast District for the 2006/7 financial year was budgeted at R235,8 million, and is projected to grow at an average annual rate of 0,6 per cent in the medium term. Of significance ~ 97 % of own revenue was generated from the sale of water (Table 2.4) (Socio-economic Profile: West Coast District, 2006).

Table 2.4: Main sources of own revenue, 2005/09 –2008/09

R'000	Budget	Budget	Medium-term estimate		Growth	
	2005/2006	2006/2007	2007/2008	2008/2009	2005/2006-2006/2007	MTREF
Property rates	0.7%	0.6%	0.0%	0.0%	0.0%	-100.0%
Electricity	1.8%	1.7%	1.7%	1.7%	4.8%	6.0%
Water	96.9%	96.8%	97.4%	97.4%	7.9%	7.0%
Sanitation	0.0%	0.0%	0.0%	0.0%		
Refuse removal	0.7%	0.9%	0.9%	0.9%	52.2%	20.0%
Other	0.0%	0.0%	0.0%	0.0%		
Total	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**8.1%**	**6.9%**

Source: Socio-economic Profile: West Coast District, 2006

2.2.2. Demographic Overview

Population

Population projections predict a total population in the West Coast District of 320 929 in 2006. This is up from the 2001 population of 285 323 (CARE, 2005, population projections for all local municipalities in the Western Cape). Between 2001 and 2006 the average annual population growth rate was 2.38 %. The growth rate is projected to decline to 1.95 % between 2006 and 2010, with 346 760 projected for 2010. Most people in the West Coast District (2006) are Coloured (71%), while 17 per cent are White and 12 per cent African (Socio-economic Profile: West Coast District, 2006). The age profile for the WCDM reflects a relatively large proportion of middle-aged inhabitants, particularly in the 30 to 44 year age group, after which the number of people in older age groups decline rapidly. For 2006 the median age in the district is 27, with a dependency ratio[2] of 0.51. The dependency ratio is slowly on the decline and expected to decrease from 0.52 in 2001 to 0.50 in 2010 (Socio-economic Profile: West Coast District, 2006). The local municipalities of Saldanha Bay (25.3%) and Swartland (23.8%) accounted for the largest percentage of the districts total population in 2006. The 2006 population numbers for the Matzikama, Cederberg and Berg Rivier LMs were 58 840 (18%), 45 301 (14%) and 54 568 (17%) respectively (Socio-economic Profile: West Coast District, 2006). The three LM in which the majority of the Olifants/Doorn WMA is located, therefore make up ~ 50% of the total population of the WCDM (Table 2.5).

[2] The dependency ratio is calculated as the number of 0-14 year-olds plus the number of 65-year-olds and older, divided by the number of people in the 15-64-year-old age group. This is to give a rough indication of dependency, but it should be noted that it is not linked to the labour force or income earners (including those of pensionable age who have access to social or private pensions or other income).

Table 2.5: Population projections by municipal area

	District	Matzikama	Cederberg	Bergriver	Saldanha Bay	Swartland	DMA
2001	**285 323**	50 088	39 563	48 076	71 341	72 370	3 884
2006	**320 929**	58 840	45 301	54 568	81 121	76 225	4 873
2010	**346 760**	64 995	49 680	60 292	88 656	77 897	5 239

Source: Centre for Actuarial Research (CARE), 2005

In 2001 the majority of the population (~70%) lived in urban settlements, while the remaining 30% lived in the rural areas. There were substantial differences between local municipalities within the DM. In this regard the majority (51.2%) of the households in the Cederberg LM were rural. The percentages for the Matzikama and Berg Rivier were both 39.3% (Table 2.6).

Table 2.6: Rural and urban households, 2001

	Total number of households	Number of rural households	Rural households (Percentage)	Rural house-holds as percentage of province	Number of urban households	Urban households (Percentage)	Urban households as a percentage of province
West Coast District	**73 444**	22 115	30.1	20.5	51 329	69.9	4.82
Matzikama	**14 090**	5 535	39.3	25.0	8 555	60.7	16.7
Cederberg	**10 366**	5 303	51.2	24.0	5 063	48.8	9.9
Berg River	**11 707**	4 601	39.3	20.8	7 106	60.7	13.8
Saldanha Bay	**18 703**	1 050	5.6	4.8	17 653	94.4	34.4
Swartland	**17 402**	5 018	28.8	22.7	12 384	71.2	24.1
DMA	**1 176**	608	51.7	2.8	568	48.3	1.1

Source: Socio-economic Profile: West Coast District, 2006

Education

Based on the 2001 Census data, approximately 29 % of the population aged 14 and older had less than 7 years of formal education in 2001 and were considered to be illiterate[3]. The figures for the Matzikama, Cederberg and Berg Rivier LMs were 31%, 34% and 30% respectively (Table 2.7). This reflects the high percentage of rural households and the dominant role played by agriculture in these three local municipalities. However, overall the West Coast District does not compare well with other districts in the Western Cape. In the Western Cape ~ 6 % of the total population had no education, while the corresponding figure for the WCDM was ~ 9%. At the higher education levels, 11.2% of the population of the Western Cape had a higher education, while the figure for the WCDM was 6.8 %.

[3] In the South African context, having obtained a primary qualification (i.e. having successfully passed Grade 7) is generally held as the absolute minimum requirement for functional literacy/ numeracy. The National Department of Education's ABET (Adult Basic Education and Training) programme provides education and training up to the equivalent of Grade 9. In this more onerous definition, Grade 9 is required as the minimum qualification for having obtained a basic education (www.abet.co.za).

Table 2.7: Education levels

Education							
	District	Matzikama	Cederberg	Bergriver	Saldanha	Swartland	DMA
Percentage of people older than 14 years illiterate	29	31	34	30	21	31	34
Learner-educator ratio	37	36	36	37	38	37	
Number of schools (High and primary)	133	26	24	24	19	40	

Source: Western Cape Education Department, 2005

Employment

The WCDM had the lowest unemployment rate in the Western Cape in 2001[4]. The provincial average in 2001 was 13.8%. In 2001 the labour force of the West Coast represented roughly 44 % of its total population. The district's working-age population (people between the ages of 15 and 64) was estimated at 212 676, or 66.3 % of its total population in 2006. This is expected to grow at a rate of 2.02 % per annum over the next four years, reaching 240 422 in 2010 (Socio-economic Profile: West Coast District, 2006).

In terms of education levels, 71% of those employed in the WCDM had incomplete secondary education or less. This is reflection of the dominant role played by the agriculture, forestry & fishing in terms of employment. The biggest employer in the West Coast District was the Agriculture, Hunting, Forestry & Fishing sector, employing 43 454 or 40.5 %, followed by Community, Social & Personal Services (12.2% or 13 043 workers), Wholesale & Retail Trade (10.7% or 11 488 workers) and Manufacturing (10.2% or 10 902 workers) (Socio-economic Profile: West Coast District, 2006).

The skills profile of the district is disproportionate across the local municipalities. Saldanha Bay has the largest proportion of highly skilled and skill-employed people (combined total of 68%), while the Cederberg (64.5%) and Berg Rivier (59.3%) LMs have large proportions of low-skilled workers.

Household income

Household income in the West Coast District is concentrated in the middle-to-low income categories. In terms of income, 6.6 % of households have no income, 26.4 % earn between R1 and R800[5] per month and 42.9 % between R801 and R3 200. Therefore, ~ 34% of the households in the WCDM fall below the poverty line. Whites dominate the high-income categories. Female-headed households account for 29.2 % of all households, with 23.3 % of the heads of these households being 60 years or older, which makes the household head eligible for old-age pension (Socio-economic Profile: West Coast District, 2006). Despite having access to social security grants, the female

[4] Census 2001 official definition of *an unemployed person*: "A person between the ages of 15 and 65 with responses as follows: 'No, did not have work'; 'Could not find work'; 'Have taken active steps to find employment'; 'Could start within one week, if offered work'." (www.statssa.gov.za).

[5] R800 per month represents the accepted South African poverty line. Households that earn R800 per month or less are classified as falling below the poverty line.

headed households, specifically those headed by women 60 years and older, represent a significant vulnerable group. Households headed by those aged 15-19 years make up 1.2% of the total number of households.

The average number of grants paid monthly during 2005 in the West Coast District was 2 396. The largest proportions of recipients were those who received child support (39.8%) and old-age (29.3%) and disability grants (24%).

2.3. OVERVIEW OF MATZIKAMA LOCAL MUNICIPAL AREA

The Matzikama LM is a category B municipality located in the northern part of the WCDM and is bordered by the Atlantic Ocean to the west, the Northern Cape Province to the east and other West Coast municipal areas to the north (District Management Area) and south (Cederberg).

The area is characterised by an arid environment, served by a life-giving arterial namely the Olifants River. The river, with its associated canal systems, supports a flourishing agricultural sector that is largely based on viniculture (the cultivation of grapes for wine production). The majority of the farming activities in the region are concentrated along the river. The majority of the population of Matzikama LM are therefore also concentrated along the river. Only the villages of Vanrhynsdorp and the coastal towns of Doringbaai and Strandfontein are not linked to the river. Vredendal is the largest town in the area and it is also centrally located, rendering it the logical economic and administrative centre. Vanrhynsdorp, Klawer and Lutzville can be regarded as secondary towns with established business districts. Ebenhaeser is a small mission town close to the river mouth, while the small settlement of Papendorp is located at the mouth of the Olifants River. The dominant economic activities in the area are:

- *Agriculture (orchards, fruit, vegetables, livestock);*
- *Processing of agricultural products (e.g., viniculture);*
- *Mining (e.g. Namaqua Sands diamonds);*
- *fishing industry; and*
- *Tourism (especially during the flower/floral season).*

2.3.1. Economic Overview

The Matzikama LM's economic activity is spread across a number of sectors led by Agriculture, Forestry & Fishing (18.3%), Wholesale & Retail Trade; Catering & Accommodation (17.7%), and Manufacturing (13.1%), followed by Finance & Business Services (11,7%) and General Government Services (11.2%). Together, these sectors contributed about 72 % of Matzikama's economic output in 2004 (Figure 3.1) (Socio-economic Profile: West Coast District, 2006).

Between 1995 and 2004, the largest proportional increases were in the Community, Social & Personal Services (3.7%), Transport & Communication (3.3%) and Wholesale & Retail; Catering & Accommodation sectors (2.9%). The sectors showing the greatest proportional losses over this period were Mining (9.6%) and Agriculture, Forestry & Fishing (1.7%). The fastest growing sectors in Matzikama were the Community, Social & Personal Services sector (8.6%) and the Transport & Communication sector (6.6%) over the ten-year period 1995 to 2004. These were followed by Wholesale & Retail Trade; Catering & Accommodation (3.3%), Construction (3.2%) and Manufacturing (3%). The average annual growth between 1995 and 2004 was only 1.3 % (Socio-economic Profile: West Coast District, 2006).

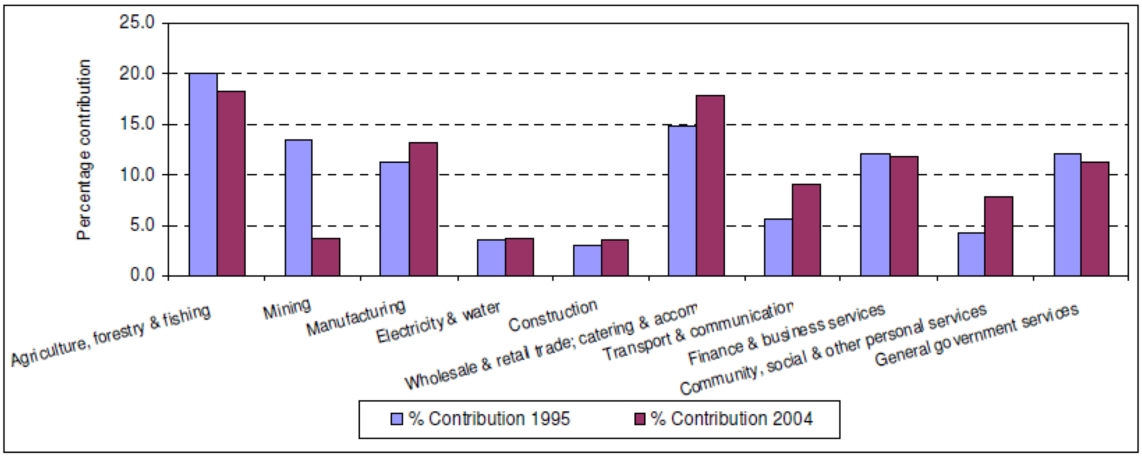


Figure 2.5: Matzikama Municipality - Sectoral contribution to the GDPR, 1995 and 2004

Total municipal revenue for Matzikama Municipality for the 2006/2007 financial year was budgeted at R122.7 million. Own revenue constitutes the largest part of the total (R52.9 million or 43%). Own revenue is derived mainly from electricity (45,4%) and property rates (21.8%) for the 2006/2007 financial year. Other sources of income are water (14.2%), sanitation (11.9%) and refuse removal (6.7%) (Socio-economic Profile: West Coast District, 2006).

Agriculture, forestry and fishing sector

The agriculture, forestry and fishing sector is the largest economic sector in Matzikama and contributed R150.5 million (18.3%) to the Matzikama's GDPR in 2004. The majority of this is linked to intensive farming activities, such as vineyards and tomatoes, concentrated along the Olifants River. On average, the growth in the agricultural sector has been low, with a growth rate of 0.3 % per annum between 1995 and 2004. The average growth rate was negative at -0.6 % between 2000 and 2004, indicating a decline in economic activity. This is cause for concern given the importance of the sector to both the local and the regional economy (Socio-economic Profile: West Coast District, 2006).

Wholesale and retail trade; catering and accommodation

In 2004 this sector was the second largest contributor to economic growth, with a contribution of R146 million (17.7%) to the GDPR. The average annual growth for this sector was 3.3 % over a 9-year period ending in 2004. Growth between 2000 and 2004 was relatively unchanged at 3.2%, although growth picked up on a year-on-year basis at 4.3% for 2003 and 6.9 % for 2004 (Socio-economic Profile: West Coast District, 2006). The growth in the local tourism sector has contributed to this increase.

Manufacturing sector

The manufacturing sector was the third most important sector in 2004 and contributed R107.9 (13.1%) to the Matzikama GDRP. The manufacturing sector in the region is dominated by the food, beverages and tobacco subsector, which accounted for 67.1% of the total for 2004. The concentration in the subsector is closely linked to the strong agricultural activities within the region. Growth in the manufacturing sector as a whole was relatively strong between 1995 and 2004 with 3% average annual growth. The average annual performance between 2000 and 2004 also remained above the 3% mark. However, year-on-year growth in this sector has been fairly erratic, with growth rates of 9.1% in 2004 and negative -4.6 % in 2003 (Socio-economic Profile: West Coast District, 2006).

2.3.2. Demographic Overview

Population

Matzikama's population projection for 2006 was 58 840, which represents 18.3% of the total population of the WCDM. Between 2001 and 2006 the population increased from 50 088 to 58 840. This represented an annual average growth rate of 3.3%. Population growth is expected to slow down to an average annual rate of 2.5 % between 2006 and 2010 (Socio-economic Profile: West Coast District, 2006). The projected population in 2010 is estimated to be 64 995. The municipality's population is predominantly Coloured (74%), while the White population comprises 19% cent and the African population 7% of the total in 2006. In 2001 Matzikama municipality had 14 090 households under its jurisdiction, of which 39.3% were rural. This is significantly higher than the 30.1% figure for the WCDM West Coast District's (Socio-economic Profile: West Coast District, 2006).

The population pyramid of the Matzikama population in 2006 had a broad base, which indicated a large young population with a median age of 28. The 20 to 24-year age group is much smaller, with larger population numbers between 25 and 35 years. This indicates an out-migration in this age group, which could relate to a scarcity of job opportunities or limited access to institutions of higher learning. The dependency ratio in 2006 is 0.50, down from 0.52 in 2001, and is projected to decline even further to 0.49 later in 2006 (Socio-economic Profile: West Coast District, 2006).

The relevant towns in the Matzikama LM include Vredendal, Ebenhaeser, Papendorp, Lutzville and Lutzville Wes, Koekenaap, Klawer and Vanrhynsdorp. With the exception of Vanrhynsdorp all of the towns are located on or in close proximity to the Olifants River. A short description of each town is provided below. The percentage contribution to the total population of the Matzikama LM is illustrated in Figure 3.2.

Vredendal

Vredendal is the largest and most developed town in the area and is also centrally located rendering it the logical economic and administrative centre. The town is located 24 km east of Vanrhynsdorp on the West Coast Tourism Route. The town serves as a major service centre for the agricultural sector, specifically the farming activities that are located along the Olifants River. These services include support, manufacturing and processing services.

Ebenhaeser and Papendorp

The villages are located near the mouth of the Olifants and developed from a mission station founded by the Rynse Church in 1831. The villages have virtually no intrinsic economic base and limited growth potential., Basic infrastructure such as houses, roads (mainly gravel), electricity, sanitation and water are available and the municipality provides support to the emerging farmers from the area. Due to their location near the mount of the Olifants, aquaponics (integration of fresh water aquaculture and hydroponics) and tourism have been identified as potential growth opportunities. However, the education and skills levels, as in most of the other areas in the Matzikama LM, are low and this is likely to hinder future development in these villages.

Lutzville

Lutzville is located ~48 km west of Vanrhynsdorp on the West Coast Tourism Route. The economic activities in the town are largely associated with the Namaqua Sands mine and the large number of irrigation farms in the area. In this regard the majority of workers that work at the Namaqua Sands Heavy Mineral sands mine, which is located to the north of Lutzville, live in the town. The town also hosts and annual agriculture expo and attracts visitors during the spring wild flower season.

Lutzville Wes

Lutzville Wes is located ~18 km west of Vredendal and 2 km south of Lutzville functions as a residential settlement that houses mainly seasonal and, to a lesser extent, permanent farm workers employed on the surrounding farms. Its central location to Vredendal, Lutzville and surrounding farms contributes to its functional role as a low-order rural settlement.

Koekenaap

Koekenaap is located ~ 56km west of Vanrhynsdorp on the West Coast Tourism Route and functions as a low order residential settlement that houses mainly farm workers employed on the large number of surrounding farms. Koekenaap originally developed from the farm Roodeheuwel and the development of the area was linked to the provision of irrigation in 1923. The sharp increase in the population of Koekenaap in recent years is largely linked to the influx of farm workers and their families in search of work. However, besides the farms in the area there are limited employment and economic opportunities within the village of Koekenaap itself.

Klawer

The town is located ~ 22 km south of Vanrhynsdorp on the Cape Namib tourism route and developed from a railway crossing between Cape Town and Bitterfontein. With the reduction in rail transport the agriculture sector and services industry have played an increasingly important role in the town’s economy. Tourism is also a growing activity in the area, with a growing number of tourists participating in agri-tours presented by the Kapel Farm in the area.

Vanrhynsdorp

Vanrhynsdorp is the most southern and oldest town in Namaqualand and was established in 1661. The town is located 300 km north of Cape Town on the intersection to Cape Namibia, Namakwari, and West Coat Karoo tourism routes. The town's economic activities are linked to servicing the agricultural sector and tourism, specifically tourism linked to the spring wild flower season.

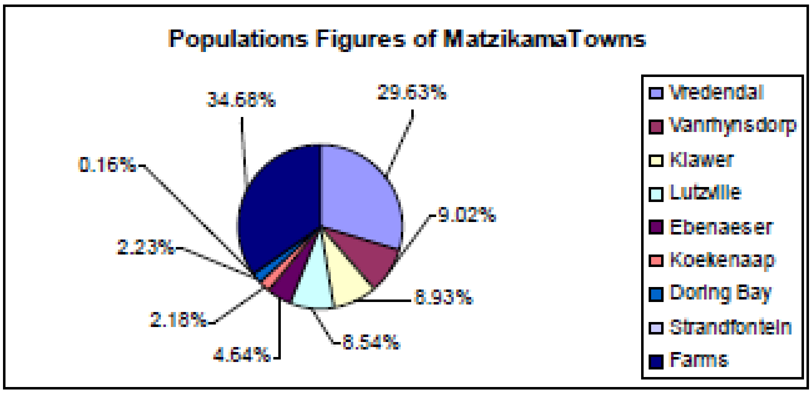


Figure 2.6: Percentage population figures for towns in Matzikama LM

Employment

The unemployment rate in 2001 was 15.8%, higher than the district figure of 13.8%, but is significantly lower than the national average of 33.8%. Between 1996 and 2001 unemployment increased to about 16%.

The Matzikama Municipality's working-age population (people between the ages of 15 and 64) was estimated at 39 305, or 66.8% of its total population in 2006. This is expected to grow at a rate of 2.6% per year over the next four years, reaching 43 587 in 2010. Between 1996 and 2001 labour force participation remained fairly stable at around 68%. During this period the number of people employed increased by 3 765 and unemployed increased by 1 724. Employment increased from 14 940 people in 1996 to 18 705 in 2001 (at 4.6, a year), while the number of the unemployed rose from 1 787 to 3 511 or 14,5 per cent a year over the same period, as the number of work-seekers increased at a significantly faster rate than the local economy's ability to create jobs. Although there was an increase in the number of the employed, the unemployment rate grew from 10.7% to 15.8% during this period. In Matzikama females, Africans, young people and those with lower levels of formal education — especially those with incomplete secondary education — are highly affected by unemployment. Youth unemployment is particularly high, with 70 per cent of the unemployed being between the ages of 15 and 34 (Socio-economic Profile: West Coast District, 2006).

In terms of sectors, the Agriculture, Forestry and Fishing sector accounted for 42.5% of all jobs in the municipality in 2001. However, the figure masks the seasonal nature of job creation in the sector. The Wholesale and Retail Trade and Community, Social and Personal Services sectors followed with roughly 10%. Together these three sectors accounted for 64% of total employment in the Matzikama LM (Socio-economic Profile: West Coast District, 2006).

Household income

Household income is concentrated in the lower middle-income categories, with the bulk of the households sourcing an income of between R4 800 and R76 800 per annum (R400 – R6 400 per month). In proportion to their population size, whites dominate the upper-income categories. Of the total number of households, 5,6 per cent have no income, with an additional 3.96 % only being able to attain an, annual income of less than R4 800 (less than R400 per month). About 30% of households are headed by females, and 7.1% are headed by persons aged between 15-24 years (Socio-economic Profile: West Coast District, 2006). These households represent potentially vulnerable households.

Education and skills

Approximately 31% of the population over 14 years of age had less than 7 years formal education, which qualifies them as being illiterate. When comparing Matzikama to the West Coast district, Matzikama had a slightly smaller proportion of people with higher education levels. About 23.2% of the people had attained a minimum of Grade 12 compared to the district's 25.2%. When correlating education and skills, the poor education attainment levels can also be observed in the proportion of persons in low-skill occupations. In 2001 ~ 56% of Matzikama's employed people could be classified as low-skilled (when skill is grouped by occupation), with the skilled making up 32%. Low-skill occupations represented 12% of employment.

2.3.3. Measure of Well Being

The West Coast Socio-Economic Profile (2006) refers to three indicators of well-being, namely the Human Development Index (HDI), the City Development Index (CDI) and the Provincial Index of Multiple Deprivation (PIMD). The Human Development Index (HDI) is a composite measure that provides information on the human development performance of a region. It is an average of health, education, income and infrastructure indicators. The City Development Index (CDI) is a poverty measurement tool similar to the HDI, but designed to reflect a municipality's investment path.

When compared to the results for the Western Cape, HDI and CDI for Matzikama are similar to those of other local municipalities within the district. When comparing the HDI and CDI of Matzikama to the province, the there is a significant difference in the CDI (Table 3.1). The 10 point difference, 0.81 for the Western Cape compared to 0.71 of the municipality, can largely be attributed to the poor performance in infrastructure (0.70) and waste (0.61) development compared to the Western Cape. These figures highlight infrastructure and waste as development priorities for the municipality (Socio-economic Profile: West Coast District, 2006).

Based on the Provincial Index of Multiple Deprivation (PIMD), the wards of Matzikama are comparatively more deprived than other wards in the Western Cape. All the wards fall within the most deprived wards in the Western Cape. Matzikama also fared poorly on individual ward level on the health deprivation indicator. On the whole Matzikama wards performed poorly with the provincial comparison (Socio-economic Profile: West Coast District, 2006).

Table 2.8: Human and City Development Indices and component scores

	Matzikama Municipality	Western Cape Province
HDI	**0.71**	**0.72**
Health	0.68	0.63
Income	0.77	0.84
Education	0.69	0.68
CDI	**0.71**	**0.81**
Infrastructure	0.70	0.79
Waste	0.61	0.89
Health	0.70	0.68
Education	0.75	0.86
Income	0.77	0.82

Source: Socio-economic Profile: West Coast District, 2006

In terms of housing backlogs, according to Census 2001, Matzikama Municipality had close to 14 465 housing units, of which approximately 90% were brick structures. Informal housing comprised only 10% cent of all housing units. In 2001 the housing backlog for Matzikama was 1 366, but declined to 700 in 2004. Between 1994 and 2004, 2 062 units were built. The current housing backlog is estimated to range between 2 600 and 4 000 units, with Vanrhynsdorp and Vredendal targeted for the construction of 1 500 units.

2.3.4. Key Development Challenges

The Matzikama IDP 2009/2010 and LED strategy identifies a number of potential challenges facing the area. The challenges that have a potential bearing in the WRCS for the Olifants/Doorn WMA include:

- *The lack of skills and training facilities in our communities are contributing largely to poorly developed economies particularly in terms of Black Economic Empowerment;*
- *The lack of project development aid for the local communities and the impact that his has on Black Economic Empowerment. In this regard the IDP notes that the role of the West Coast District Municipality is very limited in supporting the local municipalities in regards to local economic development;*
- *Limited community ownership in local projects;*
- *Lack of leadership, expertise and access to funding in local communities. Successful economic development is a function of well-established industrial bodies such as Emerging Farmers, Women in Construction, Fishing and Aquaculture, Commercials Farmers etc. Due to the lack of leadership, expertise, access to funding etc. it is difficult for existing organisations to prosper and for new organisations to become established;*
- *The need for a land development plan for the Matzikama LM to guide and support economic development. The development of land development plan for all land in the Matzikama municipal area identified as a key priority.*
- *Global warming and climate change;*
- *An increasing influx of people from other provinces and thus a consequential increase in the number of informal settlements (Lutzville, Vredendal and Klawer);*

- *A large housing backlog as proven by the long waiting lists;*
- *Absence of a clear infrastructure development plan; and*
- *Insufficient suitable land for housing and small farmer development*

The risk of global warming, which is likely to impact the Western Cape, poses a threat to the local agricultural and tourism sector. Climate change and its consequences (such as reduced water supply and increases in temperature) have been identified as serious challenges to the local economy. As a result of climate change there is likely to be an increase in the severity and unpredictability of weather patterns. Flooding and storms are predicted which could have a devastating impact on agricultural production.

The impact of climate change is likely to affect species in the internationally recognised biodiversity hotspots, the Fynbos and Succulent Karoo Biomes. The ability to make projections is limited by a high level of uncertainty, since the level of understanding of tolerance is not known. Climate change therefore also poses a threat to the tourism sector. Eco-tourism is one of the fastest growing sectors of the Western Cape economy. Estuaries, which need fresh water for flushing and maintaining salinity profiles will face increased competition for water. This is as a result of human pressures through abusive land use patterns in catchments areas and urban demands. The impacts associated with climate change will therefore be felt across all sectors of the economy.

Floods have been identified as one of the threats associated with climate change in the Western Cape. The IDP indicates that the proposed raising of the wall of Clanwilliam Dam is one way of mitigating the effects of future floods. Preliminary analysis indicates that this will benefit small farmers along the entire length of the river towards Matzikama. The raising of the dam wall also promises to attract more visitors and tourists to the area. Growth in several sectors is thus likely to be stimulated by this development (agriculture, tourism).

In terms of potential initiatives there are a number of initiatives that have a bearing on the WRCS. These include:

- *Development of the coastal area and rivers for tourism and recreation;*
- *Marketing Matzikama - both from the point of view of tourism and investors;*
- *Support of small farmer development programmes; and*
- *Aquaculture development, both marine and freshwater. The development of an Aquaculture strategy is seen as a key priority for implementing aquaculture projects with community involvement in the full value chain of the business;*

2.4. OVERVIEW OF CEDERBERG LOCAL MUNICIPAL AREA

The Cederberg Municipality LM is a Category B municipality located between Matzikama Municipality (north), Berg Rivier Municipality (south), the Atlantic Ocean (west), Cape Winelands District Municipality and the Northern Cape Province (east). The municipality covers an area of 7 339 km² and the main towns include Clanwilliam, Citrusdal, Lamberts Bay, Graafwater, Elands Bay, Wupperthal and Leipoldtville.

The Cederberg municipal area has a very low population density of 5.3 people per km². The urban-rural ratio of households indicates that about 51.2% of the inhabitants of the municipal area do not reside in urban settlements but mainly on farms with a subsequent dispersed settlement pattern. This urban/ rural ratio is unique for the Western Cape in that more people reside in the rural areas within the municipal area as does in urban settlements.

2.4.1. Economic Overview

The GDPR for 2004 was R558.4 million, with Agriculture, Forestry & Fishing (27.7%), followed by Wholesale & Retail trade; Catering & Accommodation (23.0%), Manufacturing (12.4%), and Financial & Business services (11.6%) constituting the main economic sectors (Figure 2.7). These four sectors collectively contributed 74.7% to Cederberg LMs economic output in 2004. The largest proportional increase occurred in the Wholesale & Retail trade sector; Catering & Accommodation (5.2%) and the Financial & Business Services (1.39%) sectors (Socio-economic Profile: West Coast District, 2006).

The fastest growing sectors between 1995 and 2004 were Transport & Communication (6.2%), Wholesale & Retail trade; Catering & Accommodation (5.8%), and Financial & Business services (4.3%). With the exception of Mining, the General Government Services (2.0%) and Electricity & Water (1.2%) sectors declined between 1995 and 2004. In 2004, the annual growth of the Wholesale & Retail trade, Catering & Accommodation sector climbed to 9.9 per cent compared to 9.1 per cent for the district. Similarly, the annual growth in Manufacturing accelerated to 9.2 per cent in the same year (Socio-economic Profile: West Coast District, 2006).

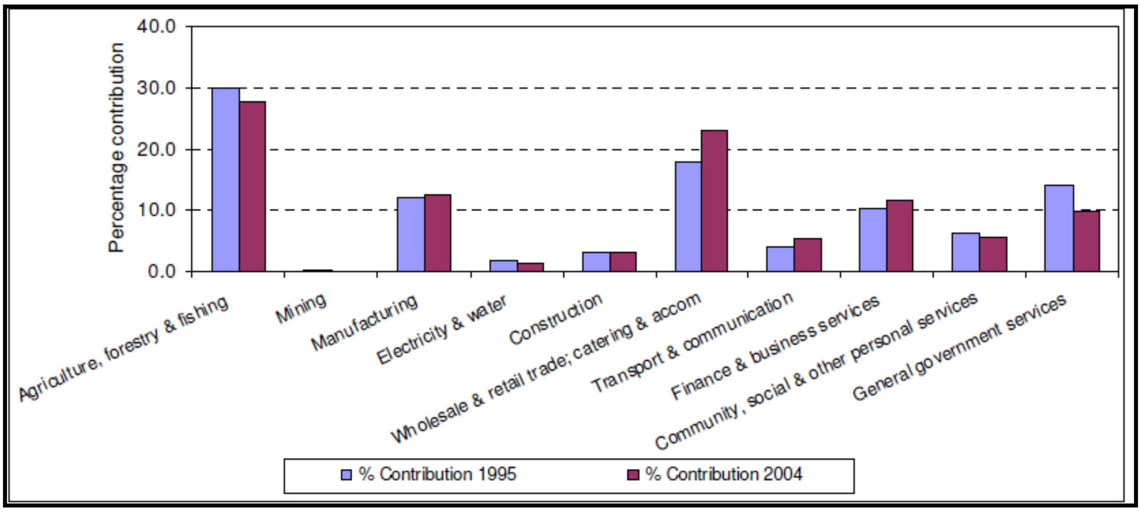
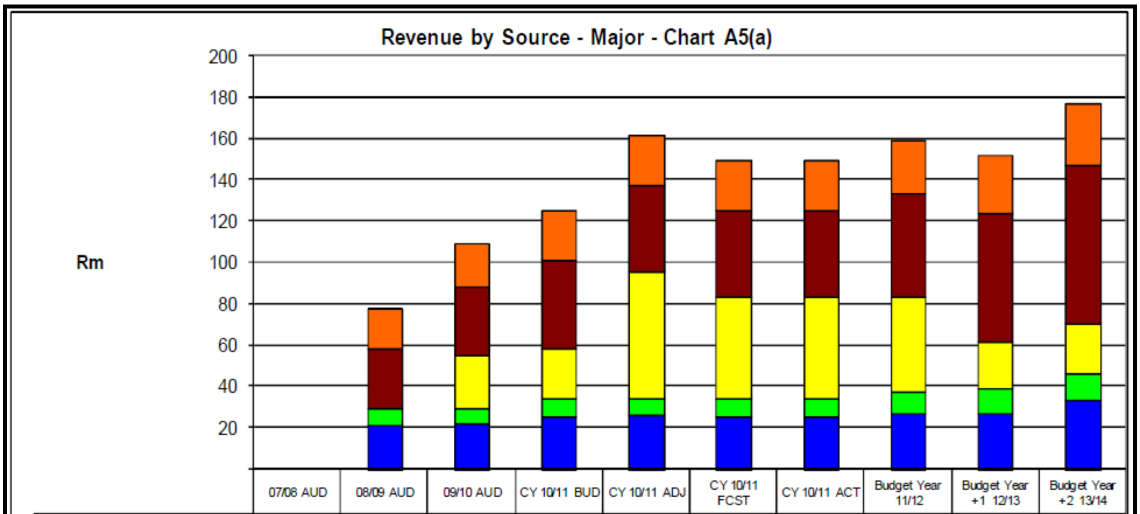


Figure 2.7: Cederberg sectoral contribution to the GDPR, 1995 and 2004 (Source: Socio-economic Profile: West Coast District, 2006)

Own revenue in Cederberg is mainly obtained from electricity and property rates. For the 2006/2007 financial year the proportions were 39.7 % (electricity) and 32.4 % (Property rates). Other sources of income are water (12.8%), sanitation (8.0%) and refuse removal (7.0%) (Socio-economic Profile: West Coast District, 2006).

The Municipal budget for 2011/2012 is R226.4 million. Figure 4.2 illustrates the contribution of water sales to total revenue. On average the revenue generated from the sale of water is in the region of 10% of total revenue.



	07/08 AUD	08/09 AUD	09/10 AUD	CY 10/11 BUD	CY 10/11 ADJ	CY 10/11 FCST	CY 10/11 ACT	Budget Year 11/12	Budget Year +1 12/13	Budget Year +2 13/14
Property rates		20	21	25	25	24	24	26	28	30
Service charges - electricity revenue		29	33	43	41	42	42	50	62	77
Transfers recognised - capital			25	24	62	50	50	46	23	24
Service charges - water revenue		8	7	9	8	8	8	11	12	13
Transfers recognised		21	22	25	26	26	26	27	27	33

Figure 2.8: Revenue sources for Cederberg Local Municipality

Agriculture, forestry and fishing sector

The Agriculture, forestry & Fishing sector is the largest sector in the municipality, contributing 27.7% (R154.8 million) to the total GDPR in the area. The sector includes diversified farming activities such as plantation, citrus, winery, rooibos and fishing activities. Between 1995 and 2004, the sector grew at a relatively slower average annual rate of 2.0%, declining to 1.6% between 2003 and 2004 (Socio-economic Profile: West Coast District, 2006).

Manufacturing sector

The Manufacturing sector was the third largest sector in 2004, and accounted for 12.4% of the total GDPR. The largest subsector within Manufacturing was the Food, Beverages and Tobacco which accounted for 61.2% of total manufacturing in 2004. This highlights the strong links between the manufacturing and agricultural sectors. The extent of concentration is largely driven by agricultural activity that is dominant in the region. Other large subsectors in 2004 were Furniture and Other Manufacturing (13.6%) and Wood and Paper, Publishing and Printing (11.96%). Average annual growth in the Manufacturing sector was 3% per cent between 1995 and 2004. Growth increased slightly between 2000 and 2004 to 3.5% (Socio-economic Profile: West Coast District, 2006).

2.4.2. Demographic Overview

Population

The total population of the LM in 2001 was estimated to be 39 326. Of this total 30 672 (78%) were classified as Coloureds, 5 420 (14%) Whites and 3 204 (8%) Black African (Cederberg IDP, 2011/2012). The total population decreased to 31 944 in 2007 and is predicted to decline to 28 429 in 2010. The information contained in the Cederberg IDP contradicts the information contained in the West Coast District Socio-Economic Profile (2006), which indicates that the population between 2001 and 2006 increased from 39 563 to 45 301, at an average rate of 2.75 % a year. The West Coast Profile report indicates that the local population is expected to grow at a rate of 2.33 % a year between 2006 and 2010, reaching total population of 49 680 by 2010. This total is almost double the figure of 28 429 reflected in the Cederberg IDP (2011/2012). This is an issue of concern as it will impact on water resource requirements.

The IDP notes that between 2001 and 2007, the racial composition of Cederberg Municipality experienced some small but significant changes in the proportional representation of the African and White population groups. In terms of composition, the percentage of Coloureds has essentially remained the same. However, the percentage of Black African's has decreased to ~ 4 %, while the percentage of Whites has increased to ~ 17.5% (Table 2.9).

In terms of rural-urban split, ~ 51% of the households are rural with the remaining 49% being located in the urban settlements. The percentage of rural households is significantly higher than the average for the WCDM, which is ~30%.

Table 2.9: Breakdown of Cederberg Local Municipality population

Population Group	2001	% of Population 2001	2007	% of Population 2007
African	3 204	8.1	1 246	3.9
Coloured	30 672	78	25 076	78.5
Indian or Asian	30	0.1	32	0
White	5 420	13.8	5 590	17.5
Total	39 326	100	31 944	100

Source: Cederberg IDP (2011/2012)

Employment

The unemployment rate in 2001 was 10.2 %. Between 2001 and 2007 the proportion of people wanting to actively participate in the labour market fell from 72.2 to 70.3%; as the number of labour force participants decreased from 18 616 to 14 655. Over the same period, the unemployment rate decreased from 16.7 to 9.2% (Table 2.10).

Table 2.10: Employment data Cederberg Local Municipality

	Total population aged 15-65	Labour fource	LF as a % of PR	Employed	Unemployed	Unemployment rate %
2007	20 844	14 655	70.3	13 309	1 346	9.2
2001	25 790	18 616	72.2	15 503	3 113	16.7

Source: Cederberg IDP (2011/2012)

In 2001 the predominant employer in the Cederberg LM was the Agricultural, Fishing & Forestry sector, which accounted for 57.2% of the total employment. However, the seasonal nature of work in this sector masks the true trend of employment rates and therefore the underlying income trends of communities. Other significant employers were the Community, Social & Personal Services sector (8.7%) and the Wholesale & Retail trade (8.1%) sector (Figure 2.9).

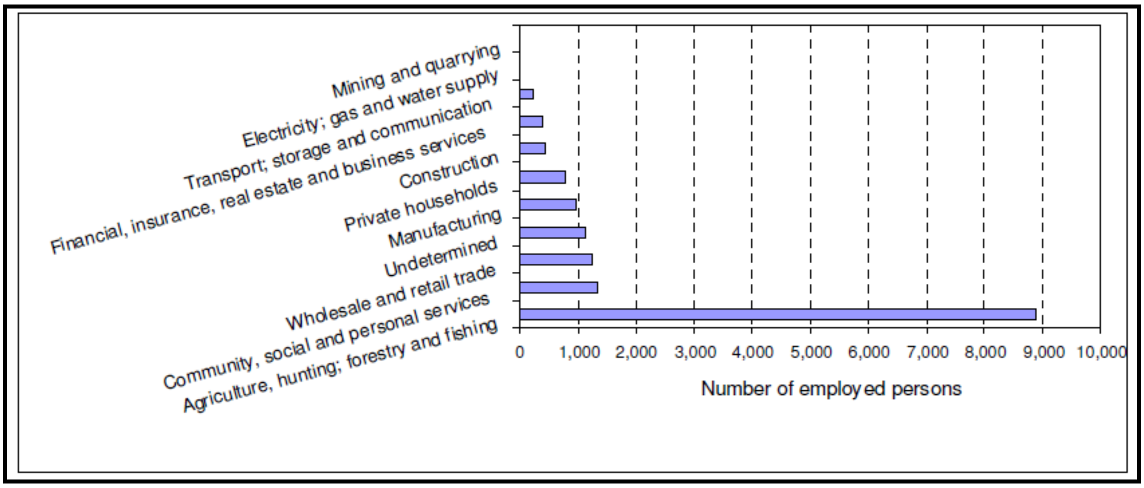


Figure 2.9: Employment by sector, 2001 (Source: Socio-economic Profile: West Coast District, 2006)

The West Coast Socio-Economic Profile (2006) indicates that the Cederberg's working-age population5 (15 and 64 years of age) was estimated at 29 561 or 65.3% of the total population in 2006. This is expected to grow at a rate of 2.5% per year over the next four years, reaching 32 686 in 2010. These figures do however need to treated with caution given the significant discrepancies in projected population numbers between 2006 West Coast Profile and the Cederberg IDP (2011/2012).,

Household income

Household income in Cederberg is concentrated in the lower-middle income groups, with the majority (69.4%) of the households earning a monthly income of between R400 and R3 200. An additional 10.8 % of all households earned less than that – R0 to R400 a month. Female-headed households make up approximately 27% of all households and nearly 7% of all households are headed by young people between the ages of 15 and 24. These households are likely to be more vulnerable, and often have lower incomes (Socio-economic Profile: West Coast District, 2006).

In terms of skills levels, in 2001 ~ 56% of the employed people in the Cederberg LM could be classified as low-skilled, with the skilled making up 26.2% (Socio-economic Profile: West Coast District, 2006).

2.4.3. Measure of Well Being

The West Coast Socio-Economic Profile (2006) refers to three indicators of well-being, namely the Human Development Index (HDI), the City Development Index (CDI) and the Provincial Index of Multiple Deprivation (PIMD). The Human Development Index (HDI) is a composite measure that provides information on the human development performance of a region. It is an average of health, education, income and infrastructure indicators.

The City Development Index (CDI) is a poverty measurement tool similar to the HDI, but designed to reflect a municipality's investment path.

When compared to the results for the Western Cape, the HDI (0.67) and CDI (0.68) index for the Cederberg compared poorly with the provincial indexes of 0.72 and 0.81 respectively. The education and income scores for both the HDI and CDI are particularly low when compared with the province, although the local municipality scored higher on health measures (Table 4.3). The waste (0.52) and infrastructure (0.68) components of the CDI were also below the figures for the provinces, namely 0.89 and 0.79 respectively. According to the Provincial Index of Multiple Deprivation (PIMD) there is some evidence of deprivation as seen in some wards in the Cederberg area. Of all wards in the Cederberg area, 67% fell within the most deprived wards in the Western Cape. Overall, the Cederberg wards performed poorly relative to the provincial levels (Socio-economic Profile: West Coast District, 2006).

Table 2.11: Human and City Development Indices and component scores

	Cederberg Municipality	Western Cape Province
HDI (and components below)	**0.67**	**0.72**
Health	0.67	0.63
Income	0.72	0.84
Education	0.63	0.68
CDI (and components below)	**0.68**	**0.81**
Infrastructure	0.68	0.79
Waste	0.52	0.89
Health	0.69	0.68
Education	0.78	0.86
Income	0.72	0.82

Source: Socio-economic Profile: West Coast District, 2006.

According to Census 2001, the Cederberg LM had an estimated 11 181 housing units of which 93,5 per cent were formal structures, while informal housing comprises only 6,5 per cent of all housing units. The housing backlog in the Cederberg LM was 670 in 2001 and remained unchanged in 2004. Between 1994 and 2004 a total of 940 housing units were built. The municipality has expressed the need for low income housing and for land development for middle-income housing (Socio-economic Profile: West Coast District, 2006).

The IDP (2011/2012) indicates that the total number of households in the Cederberg LM with access to clean potable water increased from ~ 67% in 2001 to 87% in 2007. The only areas where people do not have access to potable water near their dwellings is in the rural areas., In terms of sanitation, the percentage of households that had access to a flush toilet (either connected to a sewage system or a septic tank) increased from ~80% in 2001 to 89% in 2007.

2.4.4. Key Development Challenges

The IDP (2011/2012) identifies a number of project and or challenges facing the Cederberg LM. The following have a bearing on the WRCS.

- *The raising of the Clanwilliam Dam wall;*
- *The creation a climate conducive for economic growth and development;*
- *Addressing of bulk service backlogs in order to unlock the development of medium and low income housing;*
- *Addressing the major socio economic challenges (education, safety and security, HIV/Aids and Health); and*
- *Promoting the interest and well-being of the youth, children, women and disabled persons.*

2.5. OVERVIEW OF BERG RIVIER LOCAL MUNICIPAL AREA

The Berg River LM is bordered in the west by the Atlantic Ocean, in the east by the Groot Winterhoek mountain's with the Berg River defining the southern boundary of the municipality. The Verlorenvlei and the northern section of the Groot Winterhoek mountains define the northern boundary. This is the section of the LM that falls within the Olifants/Doorn WMA. The relevant wards are Ward 5 and 6. The municipal area is approximately 4 407.04 km^2 in size with nine settlements of which three can be classified within the context of Berg River, as major towns namely Piketberg, Porterville and Velddrif. Piketberg serves as the administrative centre of the Berg River Municipality. The smaller settlements include Dwarskersbos, Redelinghuys, Aurora and Eendekuil. The two remaining settlements namely Wittewater and Goedverwacht are Moravian settlements and administered by the Moravian Church as is Genadenberg.

2.5.1. Economic Overview

In 2007 the West Coast district had a Gross Domestic Product (GDP) of R6.8 billion of which the Berg River municipal area contributed R746 933 million representing 11% of the total. This represented the smallest contribution to the WCDM GDP (Socio-economic Profile: West Coast District, 2006)., The municipal area is generally described as a low-growth area within the Western Cape, which over the past two decades has experienced real annual growth in excess of the national average. This subdued growth has been attributed to four key factors:

- *Agriculture, the dominant sector, has been dampened by droughts, lower profitability and rationalization of production techniques;*
- *Fishing has also been dampened due to lower catches and tighter controls;*
- *Being located to the north-west of Cape Town, the area does not fall within the immigration corridor from the Eastern Cape; and*
- *The N 7 transport corridor from Cape Town to Namaqualand and further north (to Namibia and Angola) is only tangential to the municipal area (with Piketberg too close to Cape Town to function as a significant stop for these trucks).*

The most important economic sector in 2004 was the Agriculture, Forestry & Fishing sector which accounted for 33.4% of the GDPR. This was followed by Manufacturing (12.4%), Wholesale & Retail Trade; Catering &

Accommodation (15.2%) and Finance & Business Services (11.2%). General government Services also contributed a considerable proportion (13.2%) (Figure 2.10). Together, these sectors contributed 85.4% of the Berg River LMs economic output in 2004. Between 1995 and 2004, there was a shift in the economic composition of the region. The Wholesale & Retail Trade; Catering & Accommodation (3.78%) and Agriculture, Forestry & Fishing (3.07%) sectors recorded the largest proportional increases. Declining sectors over this period were Manufacturing (by 2.81%) and Mining (by 2.42%) (Socio-economic Profile: West Coast District, 2006).

Total municipal revenue for Bergriver Municipality for the 2006/2007 financial year was R108.7 million. Own revenue constitutes the largest part of the total (R60.1 million or 55.36%). The Municipality's own revenue is mainly from three sources, namely electricity (46.3%), property rates (30,2%) and water (13,1%) for the, 2006/2007 financial year (Socio-economic Profile: West Coast District, 2006).

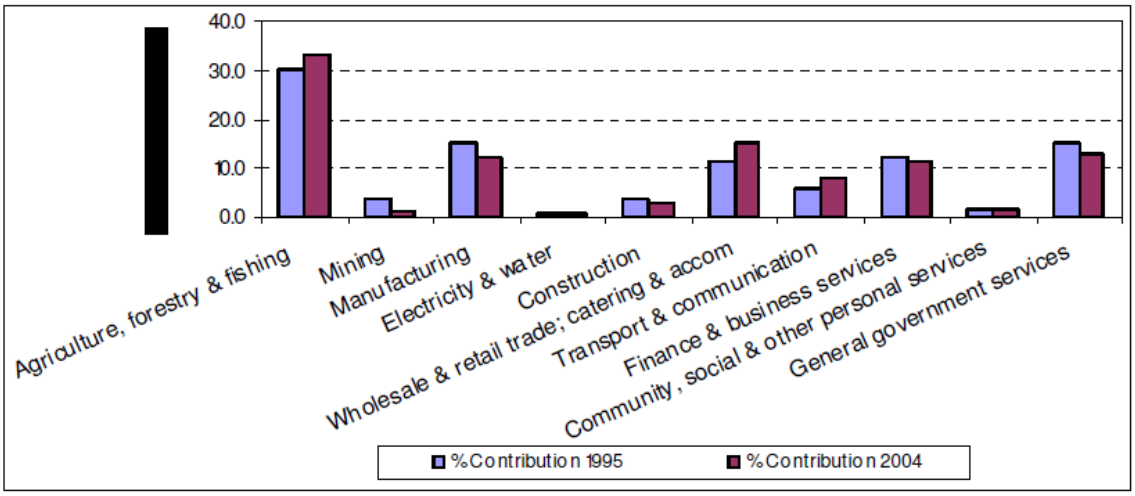


Figure 2.10: Berg River sectoral contribution to the GDPR, 1995 and 2004 (Source: Socio-economic Profile: West Coast District, 2006)

Agriculture, forestry and fishing sector

The Agriculture, Forestry & Fishing sector was the largest economic sector in 2004, with diverse activities including livestock farming (including milk), wheat, potato, fruit, and wine farming, horse breeding, rooibos tea, buchu, flowers (proteas) for export and commercial waterblommetjie sales. The sector grew at 1.4% between 1995 and 2004. Despite the water shortages experienced in the Western Cape, and the general stress in the sector, the sector's importance in Berg River's economy has increased. The sector remains a key economic sector in the region (Socio-economic Profile: West Coast District, 2006).

Wholesale & retail trade; catering and accommodation sector

The Wholesale & Retail Trade; Catering & Accommodation sector was the second largest sector in the Municipality. This sector includes tourist activities. Tourism is strongly linked to the natural environment, and the growth of tourism sector activities would depend on the preservation of the natural environment. Over the last decade this sector has been the fastest growing sector within the Municipality, growing at an average annual rate of 3.6% between 1995 and 2004 (Socio-economic Profile: West Coast District, 2006).

Manufacturing sector

The manufacturing sector contributed 12.4% (or R83 million) to total GDPR. In terms of activities, manufacturing is concentrated in two sub-sectors, namely Foods Beverages & Tobacco (38,1%) and Other Non-metal Mineral Products (28,4%). A large part of the Manufacturing sector (Foods) is directly linked to the size of the agricultural sector. Over the last decade (between 1995 and 2004), the manufacturing sector has declined at an average annual rate of 1.9%. However, in 2004 the sector registered a growth of 4.1% (Socio-economic Profile: West Coast District, 2006).

2.5.2. Demographic Overview

Population

In 2007, the population of Berg River municipality was estimated at 55 999. This accounts for ~17% of the West Coast District's population. Between 2001 and 2006, the population increased at an average annual rate of 2.57% from 48,076 to 54,658. It is however believed that there will be a declining growth rate between 2007 and 2015. Of the total population ~ 61% of the households are urban and the remaining 39% are rural. The majority of the population are Coloured (74%), followed by Whites (19%) and Black Africans (7%).

The population can be classified as youthful, with a median age of 28, just one year above the median age of the District. This profile is reflected in the large child population (between the ages of 0 and 15 years) as well as a large population of those in the 25 to 35 year age group (Socio-economic Profile: West Coast District, 2006). The dependency ratio was 0.52 in 2001 and is expected to drop to 0.51 in 2006. The projected dependence ratio remains at 0.51 in 2010.

Table 2.12: Estimated (urban) population figures for the Berg Rivier municipal area

<table>
<tr><th>Town</th><th>2001</th><th>2005</th><th>2007</th><th>2020</th></tr>
<tr><td colspan="5">Coastal Towns</td></tr>
<tr><td>Velddrif</td><td>7 500</td><td>9 034</td><td>10 700</td><td>18 800</td></tr>
<tr><td>Dwarskersbos
(seasonal)</td><td>500 (500)</td><td>-</td><td>800
(8 000)</td><td>1 600
(16 000)</td></tr>
<tr><td colspan="5">Central Places</td></tr>
<tr><td>Piketberg</td><td>9 600</td><td>9 300</td><td>11 900</td><td>15 800</td></tr>
<tr><td>Porterville</td><td>6 400</td><td>6 500</td><td>7 900</td><td>10 600</td></tr>
<tr><td colspan="5">Isolated Villages</td></tr>
<tr><td>Aurora</td><td>400</td><td rowspan="3">1 250</td><td>420</td><td>470</td></tr>
<tr><td>Redelinghuys</td><td>800</td><td>840</td><td>900</td></tr>
<tr><td>Eendekuil</td><td>600</td><td>1 000</td><td>1 050</td></tr>
</table>

Employment

The unemployment rate 2001 was 7.6%. The Berg Rivier Municipality's working-age population (people between the ages of 15 and 64) was estimated at 36 120, or 66.2% of its total population in 2006. This is expected to grow at a rate of 2.6% a year over the next four years, reaching 39 984 in 2010.

Based on the 2001 Census data, labour force participation declined slightly from 70 per cent to 68.2% between 1996 and 2001. The number of people employed increased to 19 793, while the number of unemployed increased to 1 629 in 2001. The majority of the employed population (75.7%) had not yet completed secondary education. This is reflective of low level of education in the region and the low skills levels. In terms of skill category, 9.1% of the employed are highly skilled, 36.6% skilled and 59.3% are low-skilled. The proportion of low-skilled occupations was the second highest in the District, after Cederberg's 64.5% (Socio-economic Profile: West Coast District, 2006).

In terms of employment, the Agriculture, Forestry & Fishing sector was the major employer, accounting for 53.3% of all jobs in the Municipality. The Community, Social and Personal Services (14.8%), Wholesale & Retail Trade (8.8%) and Manufacturing (7.2%) sectors also made significant contributions to employment (Figure 2.11). The seasonal nature of employment in the agriculture and fishing sector has both social and economic implications for workers owing to fluctuating income. In addition, the weakening global economic situation and changing environmental conditions (long term structural changes) are likely to impact negatively on the agriculture and fishing industries. This bleak economic situation is compounded by the low skills levels resulting in lay-offs in especially the construction and fishing industries (Socio-economic Profile: West Coast District, 2006).

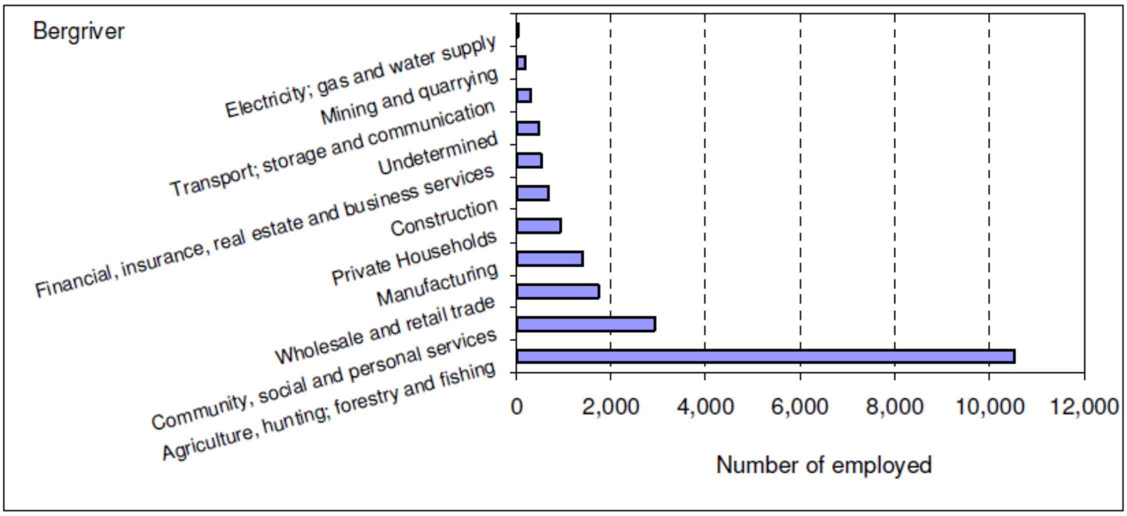


Figure 2.11: Berg Rivier Employment Numbers by Sector, 2001

Income

The majority of households (82.2%) in Berg River have incomes of between R4 801 and R76 800 per annum (R400 to R6 400 per month). The 3.7% of households that have no income is lower than the 6.6% District figure, while 2.7% of all households earn between R1 and R4 800 per annum (less than R400 per month). Approximately 33% of households are headed by females, while 7.3% are headed by persons aged between 15 and 24 (Socio-economic Profile: West Coast District, 2006). This indicates that ~ 40% of all households in the Berg River LM are headed up by potentially vulnerable members of the community, namely women and the elderly.

Education

Approximately 30% of the population over 14 years has had less than 7 years of formal education, just slightly above the District average of 29%. According to Census 2001, about 9.7% per cent of the population in the Berg River LM had no schooling. This is marginally higher than the District average of 9.2%, and almost double the Provincial average of 5.7%. Approximately 23.3% of the individuals in Berg River did not complete primary school education, as compared to 21.7% for the District. The percentage of people with a matric was 18.1% compared to 18.5% for the WCDM. The education levels in the Berg River LM can therefore be regarded as low (Socio-economic Profile: West Coast District, 2006).

2.5.3. Measure of Well Being

The West Coast Socio-Economic Profile (2006) refers to three indicators of well-being, namely the Human Development Index (HDI), the City Development Index (CDI) and the Provincial Index of Multiple Deprivation (PIMD). The Human Development Index (HDI) is a composite measure that provides information on the human development performance of a region. It is an average of health, education, income and infrastructure indicators. The City Development Index (CDI) is a poverty measurement tool similar to the HDI, but designed to reflect a municipality's investment path.

When compared to the results for the Western Cape, both the HDI and CDI do not compare favourably with the Province and the District. The HDI for education was 0.55 compared to the Province's 0.68 (Table 2.13). The CDI components of waste (0.67), education (0.79) and infrastructure (0.74) were particularly low compared to the provincial figures of 0.89, 0.86 and 0.79, respectively (Socio-economic Profile: West Coast District, 2006).

According to the Provincial Index of Multiple Deprivation (PIMD) the majority of wards in the Berg River LM, with the exception of the employment index, were found within the most deprived 50 per cent of wards in the province (Socio-economic Profile: West Coast District, 2006).

Table 2.13: Human and City Development Indices and component scores

	Bergriver Municipality	Western Cape Province
HDI (and components below)	0.66	0.72
Health	0.68	0.63
Income	0.74	0.84
Education	0.55	0.68
CDI (and components below)	0.70	0.81
Infrastructure	0.74	0.79
Waste	0.67	0.89
Health	0.69	0.68
Education	0.79	0.86
Income	0.76	0.82

The housing backlog for Berg Rivier increased to 1 700 in 2004 from 711 in 2001. This issue has been identified by the Berg River Municipality as a priority (Socio-economic Profile: West Coast District, 2006). In 2007 approximately 88% of households had access to piped water inside their homes. This represents a 15% increase from 2001. In terms of sanitation, the percentage of residents using the pit latrine system decreased from 4.5% in 2001 to 0.6% in 2007. Only 1.9% of residents have no toilet facility, indicating an improvement from the 2001 figure of 5.2%. In 2007 only 0.3% of residents used the bucket toilet system as opposed to the 2.6% in 2001. The long-term trend shows that access to sanitation facilities in the municipal area has improved significantly since 2001 (Socio-economic Profile: West Coast District, 2006).

2.6. OVERVIEW OF HANTAM LOCAL MUNICIPAL AREA

The Hantam Local Municipality is located within the Namakwa District Municipality, which in turn is located in the western part of the Northern Cape and covers a geographical area of approximately 126 747.43 km^2[6]. The Namakwa DM consists of 6 local municipalities and is bordered by the Siyanda and Pixley ka Seme Districts of the Northern Cape Province to the North-East and East, respectively, and by the Western Cape Province to the South (the West Coast, Boland and Central Karoo District Municipalities). The Atlantic Ocean is forms the Western boundary, while the Orange River forms the Northern border with Namibia (Centre for Development Support: Arid Areas Report, Volume 1, 2007).

The Local Municipalities within the District include:

- **Hantam:** the Hantam Local Municipality has the second largest population of the District, with around 21 233 people. It includes the towns of Calvinia, Niewoudtsville and Loeriesfontein and covers 27 967.97 km^2.
- **Richtersveld:** in the north, bordering with Namibia along the Orange River, with a total population of 14 612 and an area of 9 607.93 km^2, this municipality is home to Diamond Mines, with Port Nolloth being the largest settlement.
- **Nama Khoi:** includes the towns of Springbok, Okiep, Concordia, Nababeep, Bergsig, Fonteintjie, Carolusberg, Vioolsdrift, Rooiwal, Goodhouse, Matjieskloof, Buffelsrivier, Kleinzee, Bulletrap, Rooiwinkel, Henkries and Komaggas and is the "hub" of the Namakwa District both in terms of economic activity as well as population – with over 54 643 residents. The area covers 15 025.08 km^2;
- **Khai-Ma:** covering around 8 331.94 km^2 and home to approximately 12 571 people, the main towns include Pofadder and Aggeneys.
- **Kamiesberg:** South of Nama Khoi, along the west coast, this area includes Hondeklip Bay, Garies and Kamieskroon as its major settlements. The total population is estimated at over 12 116, the majority of whom

[6] At the time of preparing the report the Namakwa DM and Hantam IDPs could not be accessed from the municipal websites. It was therefore not possible to get more detailed data for both areas. This section will be updated in the final report.

are not economically active. The area is sparsely populated, at about 1 person per square kilometre over the 11 742.47 km^2.

- **Karoo Hoogland:** with a population of just over 10 419, this area is significant for science and technology, with Sutherland being the location of the SALT project. Other towns in this municipal area include Williston and Fraserburg. The majority of the population reside within these four towns. Vast rural and undeveloped areas exist. The total area covers 29 396.73 km^2.

The population density for the Namakwa DM is less than one person per square kilometre. The main sub-districts which it encompasses are those of Namaqualand, and the Hantam to its south-east. The area is rich in mineral deposits and is considered to have substantial tourism potential. The marginal nature of the ecology has attracted considerable interest from environmentalists, and in particular, the Succulent Karoo Environmental Programme (SKEP) (Centre for Development Support: Arid Areas Report, Volume 1, 2007).

2.6.1. Economic Overview

In terms of employment, the most important sectors in the Namakwa DM are the Wholesale and retail trade, repairs hotels and restaurants sector (37%) followed by the Agriculture, Forestry and Fishing sector (17%) and Mining and quarrying (14%). These three sector account for ~ 70% of the employment in the DM (Table 2.14).

Table 2.14: Employment by sectors in Namakwa District

Economic sector	TOTAL
Agriculture; hunting, forestry and fishing	6876
Mining and quarrying	5605
Manufacturing	912
Electricity; gas and water supply	141
Construction	1254
Wholesale and retail trade; repairs, hotels and restaurants	14788
Transport, storage and communication	589
Financial intermediation; insurance; real estate and business services	1178
Community; social and personal services	4427
Private households	2790
Other and not adequately defined	3
Undetermined	1882

Source: Centre for Development Support: Arid Areas Report, Volume 1, 2007.

2.6.2. Demographic Overview

Population

The total population of the DM was 108 087 in 2001. Table 6.2 provides a breakdown of the population for each local municipality within the DM. In 2001 the Hantam LM has a total population of 19 804, which is 18.32% of the total population of the Namakwa DM. More recent figures indicate that the population of the Hantam LM has increased to 21 233 (Centre for Development Support: Arid Areas Report, Volume 1, 2007). The majority of the residents are Coloured (84%), followed by Whites (12%) and Black Africans (4%). Afrikaans is the predominant language in the region with 96% of the population speaking it as a first language.

Table 2.15: Breakdown of population in the Local Municipalities in Namakwa District, 2001

Local Municipality	Population	%
Nama Khoi	44 752	41.39%
Hantam	19 804	18.32%
Khâi-Ma	11 348	10.50%
Kamiesberg	10 743	9.94%
Karoo Hoogland	10 508	9.72%
Richtersveld	10 119	9.36%
Namaqualand	813	0.75%

The population is fairly highly urbanised in all local municipalities (61-83%), except in Kamiesberg (31%) and Nama Khoi (28%). In these municipalities, the development of communal farming is important (Centre for Development Support: Arid Areas Report, Volume 1, 2007) (Table 2.16).

Table 2.16: Urban and rural population, 2001

Local Municipality	Urban population	% urban
Khai-Ma	6 168	69.1
Karoo-Hoogland	8 480	61.1
Hantam	15 316	71.6
Kamiesberg	3 137	31.7
Nama Khoi	15 438	28.8
Richtersveld	9 685	83.7

Source: Centre for Development Support: Arid Areas Report, Volume 1, 2007.

2.7. OVERVIEW OF POLICY DOCUMENTS

One of the key objectives of IDP documents prepared by local municipalities is to ensure alignment between national and provincial priorities, policies and strategies. The key national and provincial policies and strategies include:

- *National Spatial Development Perspective;*
- *National 2014 Vision;*
- *National Key Performance Areas & Local Government Turn Around Strategy;*
- *Western Cape Growth and Development Strategy;*
- *Western Cape Provincial Spatial Development Framework; and*
- *Western Cape Climate Change Strategy and Action Plan.*

2.7.1. National Spatial Development Perspective

The NSDP (2003) puts forward the following national spatial vision:

“South Africa will become a nation in which investment in infrastructure and development programmes support government’s growth and development objectives:

- *By focusing economic growth and employment creation in areas where this is most effective and sustainable;*
- *Supporting restructuring where feasible is to ensure greater competitiveness;*
- *Fostering development on the basis of local potential; and*
- *Ensuring that development institutions are able to provide basic needs throughout the country.”*

The NSDP enables government to answer two critical questions:

- *If government were to prioritise investment and development spending in line with its objectives, where would it invest/spend to achieve sustainable outcomes?*
- *What kinds of spatial forms and arrangements are more conducive to the achievement of our objectives of democratic nation building and social and economic inclusion?*

The NSDP puts forward five normative principles:

- *Rapid economic growth that is sustained and inclusive is a prerequisite for the achievement of other policy objectives, among which poverty alleviation is key;*
- *Government has a constitutional obligation to provide basic services to all citizens wherever they reside;*
- *Beyond the above-mentioned constitutional obligation, government spending on fixed investment should be focused on localities with economic growth and/or economic potential in order to gear up private-sector investment, stimulate sustainable economic activities and create long-term employment opportunities;*

- *Efforts to address past and current social inequalities should focus on people, not places. In localities where there are both high levels of poverty and demonstrated economic potential, this could include fixed capital investment beyond basic services to exploit the potential of those localities. In localities with demonstrated low economic potential, government should, beyond the provision of basic services, concentrate primarily on human development by providing education and training, social transfers such as grants and poverty-relief programmes. People should also be enabled to gravitate - if they choose to - to localities that are more likely to provide sustainable employment and economic opportunities;*
- *In order to overcome the spatial distortions of apartheid, future settlement and economic development opportunities should be channeled into activity corridors and nodes that are adjacent to or that link the main growth centres. Infrastructure investment should primarily support localities that will become major growth nodes.*

2.7.2. VISION 2014

In 2004 Government adopted Vision 2014 as guiding policy. The combination of some of the most important targets and objectives making up Vision 2014 are as follows:

- *Reduce unemployment by half through new jobs, skills development, assistance to small businesses, opportunities for self-employment and sustainable community livelihoods;*
- *Reduce poverty by half through economic development, comprehensive social security, land reform and improved household and community assets;*
- *Provide the skills required by the economy, build capacity and provide resources across society to encourage self-employment with an education system that is geared for productive work, good citizenship and a caring society;*
- *Ensure that all South Africans, including especially the poor and those at risk - children, youth, women, the aged and people with disabilities - are fully able to exercise their constitutional rights and enjoy the full dignity of freedom;*
- *Compassionate government service to the people; national, provincial and local public representatives who are accessible; and citizens who know their rights and insist on fair treatment and efficient service.*
- *Significantly reduce cases of TB, diabetes, malnutrition and maternal deaths, and turn the tide against HIV/Aids, and, working with the rest of Southern Africa, strive to eliminate malaria, and improve services to achieve a better national health profile and reduction of preventable causes of death, including violent crime and road accidents.*
- *Position South Africa strategically as an effective force in global relations, with vibrant and balanced trade and other relations with countries of the South and the North, and in an Africa that is growing, prospering and benefiting all Africans, especially the poor.*

2.7.3. Medium Term Strategic Framework for 2009-2014 (MTSF)

The MTSF base document is meant to guide planning and resource allocation across all the spheres of government. National and provincial departments in particular will need immediately to develop their five-year strategic plans and budget requirements taking into account the medium-term imperatives. Similarly, informed by the MTSF and their 2006 mandates, municipalities are expected to adapt their Integrated Development Plans in line with the national medium-term priorities. Each of the priorities contained in the MTSF should be attended to. Critically, account has to be taken of the strategic focus of the framework as a whole: this relates in particular the understanding that economic growth and development, including the creation of decent work on a large scale and investment in quality education and skills development, are at the centre of the government's approach.

The Medium Term Strategic Framework lists 10 priorities. Of these the following are relevant when considering the development of a WRCS:

- *Speed up economic growth and transform the economy to create decent work and sustainable livelihoods;*
- *Massive programme to build economic and social infrastructure;*
- *Comprehensive rural development strategy linked to land and agrarian reform and food security;*
- *Strengthen the skills and human resource base;*
- *Improve the health profile of society;*
- *intensify the fight against crime and corruption;*
- *Build cohesive, caring and sustainable communities;*
- *Pursue regional development, African advancement and enhanced international co-operation*
- *Sustainable resource management and use; and*
- *Build a developmental state including improvement of public services and strengthening democratic institutions.*

2.7.4. Western Cape Strategic Plan (DRAFT, 2010)

In 2010 the Provincial Government of the Western Cape (PGWC) adopted its own set of 12 Strategic Objectives as part of its Strategic Plan for the Western Cape. The Strategic Objectives largely overlap with the 12 National Outcomes (Section 4.2.1), but are more directly focused on addressing the socio-economic and developmental needs of the Western Cape Province. The Draft Strategic Plan (WCDSP) document is discussed below[7].

The (Draft) Strategic Plan essentially replaces the 2008 Ikapa Growth and Development Strategy as the Province's overarching strategic plan for achieving economic growth, social equity, and broad-based empowerment of its citizens, while maintaining environmental integrity. The Objectives thus embody the key overarching strategic objectives identified by the incumbent Provincial Government for its term in office (i.e. until 2014). With regard to implementation, close co-operation between all three spheres of government is envisaged. However, particular emphasis is placed on provincial and local spheres, and defined concomitant responsibilities.

Strategic Outcomes linked to economic, social and environmental sustainability that are relevant to classification of water resources include:
(1) Increasing opportunities for growth and jobs;
(2) Improving education outcomes;
(4) Increasing wellness, including mental health
(5) Increasing community safety;

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[7] PGWC: Department of the Premier (2010). *Delivering the Open Opportunity Society for All. Western Cape Draft Strategic Plan*.

(7) Mainstreaming sustainability and optimising resource use and efficiency.

The WCDSP couples each of the identified 12 Strategic Outcomes to associated problem statements, objectives, action plans and measurable targets. The discussion below focuses on existing baseline conditions, associated key issues, and proposed intervention strategies associated with those Strategic Objectives specifically of relevance to the classification of water resources.

Provincial socio-economic context

An overview of the current provincial socio-economic and developmental context is provided in an introductory chapter of the WCDSP. The problem statement sections for each of the relevant Outcomes provide additional key information with regard to existing issues specifically in need of priority intervention. As the WCDSP provides a good, fairly up-to-date overview of prevailing provincial socio-economic conditions and developmental challenges, some of the key findings are presented below.

Key demographic findings include the following:

- The province is home to 10% of the national population, but has a GDP share of 14%;
- 32% of the population (~1.67 million people), live in the rural areas of the province;
- The official unemployment rate for the Western Cape was estimated at 23.62% (second quarter 2010). Of the total unemployed, the majority of people were Coloured (272 852) and African (219 777); and
- The Western Cape agricultural sector is highly developed and accounts for almost 21% of South Africa's agricultural production and 45% of the country's agricultural exports. An estimated 23% of the West Coast District Municipality (WCDM) population is employed in the agricultural sector.

Other key socio-economic findings with regard to priority issues facing PGWC in the provision of education, health, community safety and services, include the following:

- The provincial matric pass rate is progressively declining. In 2004 the province achieved an 85% pass rate, but this progressively dropped over the next five years, viz. to 78.6% in 2008. The document notes that this is alarming in view of the fact that a clear casual link between low education levels and poverty obtains. Furthermore, desired economic growth in the province is closely linked to the level of skills and training provided by its population;
- The Western Cape population suffers from a rapidly growing burden of disease. More and more people in the province are getting HIV/AIDS and tuberculosis (TB). In 2008, ~61 000 people tested HIV+ in the Western Cape, and the TB case load was increasing by ~24 500 per year. HIV+ testing prevalence within the age group 15-24 was 15% in 2004. The provincial TB cure rate was 79.4% in 2008;
- Between 2008 and 2010 there were slightly fewer murders and attempted murders in the province. However, the number of cases of people driving while under the influence of alcohol, sexual offences and drug related crimes continued to increase between 2008 and 2010. An increase of almost 9 000 drug-related cases were reported for the 2009/2010 financial year;
- The abuse of substances, especially drugs such as tik (methamphetamine hydrochloride), has reached epidemic proportions in the province. Compared to other provinces, the Western Cape has the second

highest rate of harmful drinking during pregnancy, while the use of tik is highest in the Western Cape. The province does not have nearly sufficient treatment and rehabilitation infrastructure; and

- Current demand for housing far outstrips supply. At current rates of delivery – combined with household growth fuelled in large part by in-migration from other provinces and urbanisation – the number of households with inadequate shelter is likely to nearly double, from between 400 000 and 500 000 (2010) to over 800 000 over the next 30 years.

Key environmental sustainability findings relating to resource use and well-being include the following:

- Climate change constitutes one of the biggest medium-long term challenges facing local communities. Its effect on the province's natural resources, namely land, water, air, soil and biodiversity, as well as ecosystem goods and services, is likely to have a major impact on vulnerable economic sectors such as agriculture and communities (especially the poor communities) within the province;
- In 2004, the main sectoral contributors to the province's carbon footprint, were, Industry (47.3%); Transport (22.3%); Residential (15.5%); and Agriculture (6.1%); Mining and Quarrying was responsible for a relatively small 2.2%;
- In 2004, the Cape West Coast District Municipality (WCDM) generated an estimated 3% of total provincial CO_2 emissions; 14% of the provinces' NO_2 emissions, and 12% of its SO_2 emissions; and
- ~95% of the energy currently used in the province is generated by the burning of non-renewable, greenhouse-effect enhancing fossil fuels (coal and oil). The document notes that this is completely non-sustainable for a number of reasons, including long term resource security (linked, amongst others, to Eskom's capacity and infrastructure), as well as emissions associated with the generation of the electricity.

Action Plans and Targets for 2014

The WCDSP includes action plans and targets aimed at addressing priority intervention areas, linked to the Strategic Objectives.

Proposed socio-economic interventions are underpinned by the Administration's beliefs that "economic growth constitutes the foundation of all successful development; that growth is driven primarily by private sector business operating in a market environment; and that the role of the state is (a) to create and maintain an enabling environment for business and (b) to provide demand-led, private sector-driven support for growth sectors, industries and businesses" (WCDSP; 2010: 8).

Key socio-economic targets which have a potential bearing on well-being include:

- A reduction in HIV prevalence amongst the age group 15-24 (from 15% in 2008) to 8% (by 2015);
- An increase in the TB cure rate (from 79.4% in 2008) to 80% (by 2012/3); and
- An increase in the provision of serviced housing sites from the target of 18 000 (2010) to 31 000 in 2014/15.

2.7.5. Western Cape Provincial Spatial Development Framework

The Western Cape Provincial Spatial Development Framework ("PSDF") was endorsed by Cabinet in June 2009. The PSDF has been approved as a Structure Plan in terms of the Land Use Planning Ordinance (No. 15 of 1985). The PSDF is a long-term planning instrument, which is to be reviewed every five years. The next revision is due in 2014. In as far as could be established, none of the Directives contained in the 2009 PSDF have been amended at present (2011).

The PSDF currently constitutes the fundamental policy instrument with regard to the spatial dimension of all development planning in the Western Cape. The constitutionally defined administrative principles of co-operative governance and hierarchical conformity (in setting policy) mean that all lower order (i.e. district and municipal) spatial development policy documents (e.g. spatial development frameworks, spatial plans, land use determinations) need to conform the essential provisions of the PSDF[8]. One of the key purposes of the PSDF is therefore exactly to guide municipal (district, local and metropolitan) Integrated Development Plans (IDPs) and Spatial Development Frameworks (SDFs), provincial and municipal Spatial Development Plans (SDPs), and other spatial planning documents (e.g. urban edge delineations and zoning schemes).

The PSDF is underpinned by the fundamental assumption that development can only be acceptable and in the public interest if it is environmentally sustainable – that is ecologically justifiable, socially equitable as well as economically viable - and then in a hierarchical relationship, where economic efficiency (prosperity) is underpinned by social equity (human capital), which in turn is underpinned by ecological integrity (ecological capital – or health of ecological systems). The PSDF emphasises that in the South African context, the aspect of social equity is of extreme relevance, as it emphasises the need to redress the wrongs of the past (social justice) as a central component of social sustainability.

A number of key spatial objectives and associated interventions are broadly applicable to decisions affecting the water classification process. These pertain to Objectives 5 and 9 of the PSDF, viz. the "Conservation of the Sense of Place of Important Natural, Cultural and Productive Landscapes" (Objective 5), and the "Minimization of the Consumption of Scarce Resources" (Objective 9). These are each briefly discussed below in relation to their applicability to the PPC proposal.

Objective 5: Conserve the sense of place of important landscapes

The PSDF notes the vital importance of tourism to the Provincial economy. The PSDF therefore stipulates that, with regard to the siting and design of future substantial infrastructural development the relevant provincial guidelines should be followed, and proposals should include provision for environmental, visual and heritage impact assessments.

In this regard, large areas of the Olifants/Doorn WMA have high scenic and heritage value and tourism is an important and growing sector of the economy.

[8] In turn, the PSDF conforms to national spatial and developmental policy (i.e. the 2006 National Spatial Development Perspective) in all essential regards.

Objective 9: Minimize Consumption of Scarce Environmental Resources

The PSDF highlights the province's vulnerability to climate change – i.e. to livelihoods associated with key economic sectors such as agriculture, fisheries and tourism, as well as the continued viability of existing settlement patterns. In this regard the PSDF notes that the West Coast District Municipality (WCDM) is the region in South Africa likely to be most extremely affected by global climate change (PSDF; 2009: 2.4.1.). Vulnerability to climate change is identified as one of six key issues facing the WCDM.

In line with national government's Climate Change Response Strategy, the PSDF makes provisions related to demand management, rationalisation in the use of non-renewable/ scarce resources, as well as the development of replacement renewable resources. Strategies and targets mainly relate to encouraging more efficient settlement patterns, reducing road use and rationalizing (public and private) transport, material recycling and reuse, incrementally shifting energy generation to solar and wind, rationalizing water use, and encouraging the minimized consumption of scarce (irreplaceable) strategic resources such as building materials.

2.7.6. Climate Change Strategy and Action Plan for the Western Cape

The (Western Cape) Climate Change Strategy and Action Plan (Final Draft, December 2008) were commissioned by the Western Cape Department of Environmental Affairs and Development Planning (DEA&DP). The document is aligned with the overarching Western Cape Sustainable Development Strategy, and gives expression to the PGWC's acknowledgement that the Western Cape will inevitably be affected by climate change, and thus needs to timeously intervene by implementing a sound response strategy.

The document consists of two sections. The first section examines climate change and linked socio-economic factors in the Western Cape, and establishes the clear need for a climate change response in the region. The second section outlines the key aspects of the Western Cape's response strategy.

Key findings pertaining to current energy use and greenhouse emissions generation in the Western Cape and the province's extreme vulnerability to climate change include the following:

- South Africa is currently ranked as the 19^{th} greatest emitter of greenhouse gasses (absolute terms) in the world. While the Western Cape's local direct emissions are relatively low, this is largely the result of the province importing most of its electricity (~90%), mainly from Mpumalanga;
- There is little doubt that the Western Cape will experience the effects of human-induced climate change in the near future, possibly as early as 2030. Current predictions indicate that the Western Cape will generally become hotter and drier. Predictions indicate a mean increase in temperature of at least 1 °C by 2050. Higher mean temperatures will have negative consequences for rainfall (frequency, amount) as well as the soil's ability to retain moisture. Periods of drought are anticipated to become more frequent and intense. Drier, hotter conditions will also increase the risk of more frequent, more severe fires;
- Predicted hotter and drier conditions hold significant risks to the Province's key economic sectors and associated livelihoods. Compromised growing conditions and less water available for irrigation will negatively affect the agricultural sector – with massive negative implications for the regional economy, employment as

well as regional food security. Increased sea surface temperatures will likely impact negatively on fish stocks. The tourism sector is likely to suffer from changes in the landscape amenity.

The response strategy and action plan

The document notes that, while in terms of the Kyoto Protocol, South Africa, as a developing nation, does not have to take active steps to mitigate its carbon emissions, valuable export markets in the European Union are already starting to impose carbon emission reduction targets on their suppliers. The Western Cape, whose important agricultural sector is to a large extent export-orientated (wine, fruit, etc.), stands to lose market share on agricultural goods, for example, if no attempt is to be made to achieve at least carbon neutrality (no net emission of carbon for a produced good):

- The Province's response strategy and associated action plan is based on two thrusts, namely adaptation and mitigation;
- Four key outcomes are identified, including reduction of the province's carbon footprint (Outcome 4); and
- Associated strategies include promotion of energy efficiency (including demand management), effective waste management strategies, and cleaner fuel programmes for households and transport.

2.8. EXISTING WATER USE

2.8.1. IDENTIFICATION OF WATER USER SECTORS AND SUB-SECTORS

The Olifants/Doorn WMA Internal Strategic Perspective (ISP) summarised the existing water users and their estimated water use (DWAF, 2005) per sub-area, based on a 1:50 year (98%) level of assurance of supply. This is probably the best estimate of current water usage in the WMA.

The WMA was subdivided into the following sub-areas and quaternary catchments for the purpose of the ISP report (Table 2.1):

- Upper Olifants — E10A - E10G quaternary catchments
- Koue Bokkeveld, — E21A - E21L quaternary catchments
- Doring — E22, E23, E24A-M, E40A-D
- Knersvlakte, — E31A-H, E32, E33A-F, F60
- Lower Olifants — E10H-K, E33F-E33H
- Sandveld — G30A-H

Domestic water users

The main towns in the Lower Olifants (E33) and Upper Olifants (E10) rely on water from the Olifants River Government Water Scheme, which draws water from Clanwilliam Dam and/or the canal system. These are Citrusdal that gets water from the Olifants River and groundwater, Clanwilliam that gets water from Clanwilliam Dam and the Jan Dissels River, and the towns of Vredendal, Vanrhynsdorp, Lutzville, Ebenhaeser and Klawer that abstract water from the irrigation distribution canal.

The primary source of water for towns in the Sandveld (G30), Kromme (E31), Goerap (F60), and Oorlogskloof (E40) is groundwater.

Table 2.17: Water volume requirements (in million m³/a, for the year 2000) at 1:50 year assurance (DWAF, 2005) (Note – this table will be updated once the present demands have been verified)

Sub-area	Irrigation	Urban (1)	Rural (1)	Mining & bulk industry (2)	Forestry (3)	Total local require-ments	Transfers out	Grand Total
Upper Olifants	100	1	1	0	1	**103**	94 (4)	**197**
Koue Bokkeveld	65	0	1	0	0	**66**	0	**66**
Doring	13	1	1	0	0	**15**	0	**15**
Knersvlakte	3	0	1	3	0	**7**	0	**7**
Lower Olifants	140	3	1	0	0	**144**	4 (5)	**148**
Sandveld	35	2	1	0	0	**38**	0	**38**
Total for WMA	**356**	**7**	**6**	**3**	**1**	**373**	**0**	**373**

1) Includes component of the Reserve for basic human needs at 25 l/c/d.
2) Mining and bulk industrial water uses, which are not part of urban systems.
3) Quantities given refer to impact on yield only.
4) Transfers out of the Upper Olifants of 94 million m3/a for downstream irrigation, mainly via the Lower Olifants River canal.
5) Transfers out of the lower Olifants of 4 million m3/a consist of a transfer of 2.5 million m3/a to meet the Namakwa Sands mining requirement, and 0.4 million m3/a to northern Sandveld urban use. The rest is provision for losses.

Agricultural water users

Agricultural activities in this sector include a wide variety of crop types, many of which are high value produce (Provincial Government Western Cape, 2004). The cultivation of wine and table grapes, rooibos tea, citrus, deciduous fruit, wheat, potatoes, flower cultivation and wildflower harvesting, livestock and fisheries contribute to the sector. Wine and dried fruit are important value-added products.

The mean annual precipitation over much of the Olifants/Doorn area is less than 200mm, with the result that except for the wetter southwest, the climate is not suitable for large-scale dryland farming. Only about 4% of the land area in the WMA is used for dryland farming. More than 90% of the land is used as grazing for livestock, predominantly for sheep and goats.

The irrigation agriculture sector is by far the largest water use sector with estimated requirements of about 95% (356 million m^3/a) of the total requirements. The scheduled area under the Olifants River GWS canal system is 11 500 ha with an irrigation quota of 12 400 m^3/ha/a. Although it is estimated that a total area of about 497 km^2 of land is under irrigation, some of this is irrigated only in years when sufficient water is available. It is estimated that an average area of about 400 km^2 of crops grown under irrigation is harvested annually.

In the upper Doring River catchment, an often-found method of abstracting floodwater for private irrigation is the construction of a series of parallel bunds almost at right angles to the river. Floodwater is then diverted onto the lands both to wet the lands and to deposit the rich silt in the water as fertilizer. This method of irrigation is known as "saaidam" irrigation (Department of Water Affairs and Forestry, 1998).

Mining and industrial water users

The only major mine in the area is the Namakwa Sands heavy minerals mine which is situated on the coast in the north-west of the WMA and is supplied with water via an allocation out of the Olifants River canal. There are also several granite quarrying operations in the vicinities of Vredendal and Vanrhynsdorp. Dredging for marine diamonds occurs offshore. Industries in the WMA are small and the majority of them are concerned with the processing and packaging of agricultural products. Approximately only 3 million m^3/a of water is currently required by the mining and industrial sectors., Mining probably has a low water quality requirement (Category 4) and the fruit processing and packaging industries probably have a Category 3 (At least equivalent to domestic water quality requirement) water quality requirement.

Recreation

Tourism is an important and growing component of the WMA economy. Clanwilliam Dam and the Cederberg Wilderness Area support numerous tourism-based businesses. The major towns of the area have experienced a growth in tourism over the past 10 years. Clanwilliam and Bulshoek Dams are extensively used for boating and fishing. All three recreation sub sectors (contact, intermediate contact, and non-contact) are represented in the study area.

2.8.2. Registration of Water use in the Olifants Doorn WMA

Water use registration data supplied by the regional office of the department of Water Affairs in April 2011 was used to summarise water use registration data according to quaternary catchments in which the registrations are listed and according to the type of resource from which the water is used. The use from surface water is divided into the following categories:

- Stream / river,
- Dams,
- Estuaries, and
- Wetlands.

The use from groundwater is divided into the following categories:

- Spring/eye, and
- Groundwater.

Use and interpretation of the water use data

Although some work has been done to validate and verify the registered water use in the Olifants Doorn WMA it has not being completed. In addition to the uncertainty resulting from the lack of a process of validation and verification the following comments can be made which prevents the use of the data in the social and economic modelling:

- In general it would appear that either over registration or under registration has taken place depending on the particular area within the WMA,

- The water use registration is often listed in the area (quaternary catchment) in which it is used and not linked to the point of abstraction of the water which makes the use of the data problematic at a quaternary scale,

- The registration of the water use schemes (Irrigation boards and WUA) is possibly partially duplicated by the registration of individual users within the schemes who have not only registered water use from sources on the individual farming units but also the use from the allocations from the scheme, and

- Crop data is captured in conjunction with the property information but the corresponding hectares that are associated with these crops are unreliable and inconsistent. The typical water use per hectare for the type of crop and/or the area in which the water is applied is inaccurate and inconsistent.

An analysis of the water use registration data (providing the limitations and possible errors in the data sets) provides the following information:

Surface water and groundwater use:

- 72.50% of the water used in the WMA is from surface water and the remaining 27.50% is from groundwater,
- 48.38 % of the surface water use is registered as use from rivers and streams,
- 44.90 % of the surface water use is registered as use from the water supply schemes (old irrigation boards), which includes water from storage dams, and
- 6.13% of the surface water use is registered as use from dams (which is most likely an under registration).

Distribution of registered water use:

The highest registered surface water use is taking place in the Lower Olifants Irrigation area (40.99%), followed by the Upper Olifants (25.94%) and the Koue Bokkeveld area (20.90%). The highest groundwater use is taking place in the Sandveld area (45.67%) followed by the lower Olifants area (23.43%) and the Koue Bokkeveld (12.11%). The combined surface and groundwater use follow a similar pattern as the surface water (30.65% in the Lower Olifants, 25.25% Upper Olifants, 18.48% Koue Bokkeveld and 15.32% in the Sandveld).

Table 2.18: Summary of the registered water use per quaternary catchment from the WARMS system of the Department of Water Affairs (April 2011)

Quaternary number	Surface water						Groundwater			Grand Total
	River / Stream	**Dam**	**Estuary**	**Scheme**	**Wetland**	**Total Surface Water**	**Borehole**	**Spring/Eye**	**Total Ground Water**	
E10A	692 170					692 170	78 520	44 900	123 420	**815 590**
E10B	8 078 740	921 000				8 999 740	8 930 080	2 440 000	11 370 080	**20 369 820**
E10C	201 200	685 550				886 750	1 386 700	176 000	1 562 700	**2 449 450**
E10D										**0**
E10E	1 644 967					1 644 967	1 410 379	532 493	1 942 872	**3 587 839**
E10F	220 000					220 000	156 000		156 000	**376 000**
E10G	28 031 965	67 500		1 792 180		29 891 645	636 900		636 900	**30 528 545**
E10H	3 390 920	960 000		244 000		4 594 920	10 000	109 800	119 800	**4 714 720**
E10J	12 368 297	1 386 120	600 000	17 246 618		31 601 035	9 946 966	80 220	10 027 186	**41 628 221**
E10K	2 426 868			602 680		3 029 548	1 696 740	315 360	2 012 100	**5 041 648**
E21A	8 790 045					8 790 045	2 411 340	114 016	2 525 356	**11 315 401**
E21B	12 247 017	1 612 843				13 859 860	4 686 393	617 103	5 303 496	**19 163 356**
E21C	2 978 600					2 978 600	644 524		644 524	**3 623 124**
E21D	5 869 500	5 045 500				10 915 000	560 126	133 200	693 326	**11 608 326**
E21E	2 617 500	180 000				2 797 500	1 193 000		1 193 000	**3 990 500**
E21F										**0**
E21G	19 497 810	2 356 800			134 400	21 989 010	2 609 560	1 008 500	3 618 060	**25 607 070**
E21H	2 381 050	31 000				2 412 050	278 400	20 000	298 400	**2 710 450**
E21J	1 655 020					1 655 020	14 000	152 560	166 560	**1 821 580**
E21K	317 084					317 084				**317 084**
E21L						0				**0**
E22A	25 000					25 000				**25 000**
E22B						0	181 000		181 000	**181 000**
E22C	221 498	198 000				419 498	801 000		801 000	**1 220 498**
E22D						0				**0**

Quaternary number	Surface water						Groundwater			Grand Total
	River / Stream	Dam	Estuary	Scheme	Wetland	Total Surface water	Borehole	Spring/Eye	Total Ground Water	
E22E	16 000					16 000	20 000		20 000	**36 000**
E22F										**0**
E22G										**0**
E23A										**0**
E23B	1 590 000					1 590 000				**1 590 000**
E23C										**0**
E23D	54 500	80 000				134 500				**134 500**
E23E		42 000				42 000	18 000		18 000	**60 000**
E23F										**0**
E23G										**0**
E23H		52 000				52 000				**52 000**
E23J		32 000				32 000				**32 000**
E23K										**0**
E24A										**0**
E24B	1 785 700	860 000	12 000	624 640		3 282 340	2 821 166	73 800	2 894 966	**6 177 306**
E24C	20 000					20 000				**20 000**
E24D	17 000					17 000				**17 000**
E24E		6 000				6 000				**6 000**
E24F	2 142					2 142				**2 142**
E24G										**0**
E24H	2 440 900					2 440 900	24 000		24 000	**2 464 900**
E24J	4 677 910					4 677 910	197 796		197 796	**4 875 706**
E24K										**0**
E24L	7 113 294					7 113 294	1 874 515		1 874 515	**8 987 809**
E24M		1 040 000				1 040 000	1 637 500	12 500	1 650 000	**2 690 000**
E31A										**0**
E31B										**0**
E31C										**0**

Quaternary number	Surface water						Groundwater			Grand Total
	River / Stream	Dam	Estuary	Scheme	Wetland	Total Surface water	Borehole	Spring/Eye	Total Ground Water	
E31D										**0**
E31E	55 000					55 000				**55 000**
E31F	22 500					22 500	88 732		88 732	**111 232**
E31G										**0**
E31H										**0**
E32A	78 150					78 150	13 500		13 500	**91 650**
E32B	1 050					1 050				**1 050**
E32C	30 000					30 000	12 000		12 000	**42 000**
E32D										**0**
E32E		221 120				221 120	60 720		60 720	**281 840**
E33A	114 560					114 560				**114 560**
E33B	103 200					103 200				**103 200**
E33C	75 000					75 000				**75 000**
E33D										**0**
E33E										**0**
E33F	829 920	74 000				903 920	8 819 132	586 075	9 405 207	**10 309 127**
E33G	6 885 300	72 000		120 695 680		127 652 980	2 943 283	1 032 400	3 975 683	**131 628 663**
E33H	1 233 740					1 233 740	73 596		73 596	**1 307 336**
E40A	56 250	1 875				58 125				**58 125**
E40B	2 507 891	357 455				2 865 346	253 800	23 362	277 162	**3 142 508**
E40C	691 779	150 000				841 779	782 982	47 500	830 482	**1 672 261**
E40D		10 000				10 000	9 000		9 000	**19 000**
F60A										**0**
F60B	30 000					30 000				**30 000**
F60C										**0**
F60D										**0**
F60E										**0**

Quaternary number	Surface water						Groundwater			Grand Total
	River / Stream	Dam	Estuary	Scheme	Wetland	Total Surface water	Borehole	Spring/Eye	Total Ground Water	
G30A	184 400	210 000				394 400	4 420 070		4 420 070	**4 814 470**
G30B	3 510 190	500 836				4 011 026	4 446 952	1 755 234	6 202 186	**10 213 212**
G30C	1 388 622					1 388 622	4 210 624	398 000	4 608 624	**5 997 246**
G30D	1 934 580	885 613				2 820 193	7 047 153	512 970	7 560 123	**10 380 316**
G30E	236 000	939 380			1 096 000	2 271 380	6 771 464	760 000	7 531 464	**9 802 844**
G30F	39 000					39 000	10 681 296	128 400	10 809 696	**10 848 696**
G30G	193 050	310 206				503 256	12 450 217	539 490	12 989 707	**13 492 963**
G30H	548 455					548 455	360 000		360 000	**908 455**
Total	**152 121 334**	**19 288 798**	**612 000**	**141 205 798**	**1 230 400**	**314 458 330**	**107 669 126**	**11 613 883**	**119 283 009**	**433 741 339**

Table 2.19: Summary of water use data per sub-area (from the DWA WARMS system April 2011)

Sub area	Surface water						Groundwater			Grand Total
	River / Stream	DAM	Estuary	Scheme	Wetland	Total Surface Water	Borehole	Spring/Eye	Total Ground Water	
1. Lower Olifants Irrigation	8 119 040	72 000		120 695 680		128 886 720	3 016 879	1 032 400	4 049 279	132 935 999
2 Upper Olifants	57 055 127	4 020 170	600 000	19 885 478		81 560 775	24 252 285	3 698 773	27 951 058	109 511 833
3 Olifants Doring dryland farming	12 482 983	1 200 000				13 682 983	4 501 793	60 000	4 561 793	18 244 776
4 Doring Rangelands	8 736 881	1 629 330	12 000	624 640		11 002 851	4 118 966	97 162	4 216 128	15 218 979
5 Koue Bokkeveld	56 353 626	9 226 143			134 400	65 714 169	12 397 343	2 045 379	14 442 722	80 156 891
6. Knersvlakte	1 339 380	295 120				1 634 500	8 994 084	586 075	9 580 159	11 214 659
7. Sandveld	8 034 297	2 846 035			1 096 000	11 976 332	50 387 776	4 094 094	54 481 870	66 458 202
Total	152 121 334	19 288 798	612 000	141 205 798	1 230 400	**314 458 330**	107 669 126	11 613 883	**119 283 009**	**433 741 339**
Percentages of use from groundwater and surface water	48.38%	6.13%	0.19%	44.90%	0.39%		90.26%	9.74%		
Percentage use						72.50%			27.50%	

Table 2.20: Summary of the use per sub-area and relative distribution between surface and groundwater use

Integrated Unit of Analysis	TOTAL Surface water use	Percentage	TOTAL Ground water use	Percentage	Grand Total	Percentage
1. Lower Olifants Irrigation	128 886 720	40.99%	4 049 279	3.39%	**132 935 999**	30.65%
2 Upper Olifants	81 560 775	25.94%	27 951 058	23.43%	**109 511 833**	25.25%
3 Olifants Doring dryland farming	13 682 983	4.35%	4 561 793	3.82%	**18 244 776**	4.21%
4 Doring Rangelands	11 002 851	3.50%	4 216 128	3.53%	**15 218 979**	3.51%
5 Koue Bokkeveld	65 714 169	20.90%	14 442 722	12.11%	**80 156 891**	18.48%
6. Knersvlakte	1 634 500	0.52%	9 580 159	8.03%	**11 214 659**	2.59%
7. Sandveld	11 976 332	3.81%	54 481 870	45.67%	**66 458 202**	15.32%
Total	**314 458 330**	**100%**	**119 283 009**	**100%**	**433 741 339**	**100%**
Percentage use	**72.50%**		**27.50%**			

2.9. AGRICULTURAL ECONOMIC CONTRIBUTION

A typical farm model representing farms per Integrated Unit of Analysis (IUA) is currently being developed. When one crucial element such as water availability changes, it affects various components of the farming operation differently. The farm model captures the interrelatedness of the components of the farming operation and determines the net financial impact and the effect on employment. As the irrigation water extracted from the Olifants Doorn River system is mainly used for perennial crops or perennial crops in combination with annual crops, the typical farm model structure takes the form of a multi-period budget.

2.9.1. The budget model

The financial performance of the typical farm is influenced by various factors. The factors that directly or indirectly influence prices and quantities of outputs and inputs are the most influential in terms of their effect on profitability. Some factors can, to some extent, be managed or influenced by management. Other exogenous factors are completely beyond the influence of individuals or even groups of producers. These factors are typically determined in the market- and macro environments. They impact on the farm in the form of input prices, product prices, crop yields and the price and availability of inputs like irrigation water. The potential impact of a change in the availability of inputs like irrigation water on the profitability of the typical farm in comparison with the status quo needs to be established. This is being done by the developing whole-farm, multi-period budget models.

To establish the current financial position of each farm, the complexity of the farm needed to be captured. The factors and interrelationships that influence and determine profitability are incorporated in such a way that these factors can be manipulated and can instantly show the financial impact on the entire farm. Whole-farm, multi-period budget models were developed for each Integrated Unit of Analysis (IUA). Budgets allow for the incorporation of large numbers of variables, which allow for accurate reflection of the factors and interrelationships that influence the financial performance of the total farm. The models consist of various sets of data and calculations that are interconnected and are based on standard accounting principles and methods.

Numerous adaptations in terms of farm size, crop rotation system, input costs, interrelationships, investment, replacement of machinery, price levels and own versus borrowed capital can be accommodated in a spread sheet budget model.

The components of the calculation model are shown in Figure 2.12. It illustrates the input component, calculation component and output component of the budget model. Each component consists of various parts.

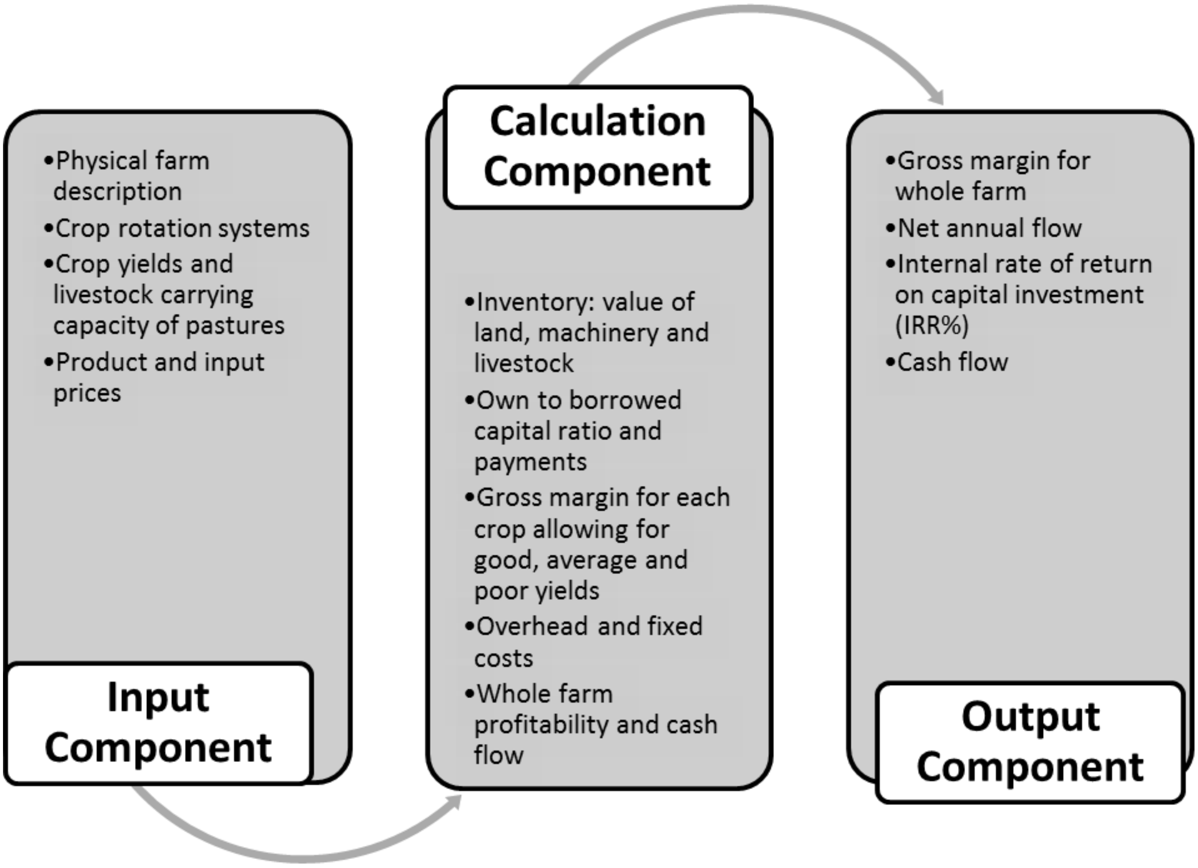

Figure 2.12: A graphic representation of the components of the whole-farm, multi-period budget model

The input component

The input component consists of the description of the physical farm description, land use patterns, crop rotation systems, yield assumptions, input prices and output prices. All of these factors can be adapted, which will immediate impact on the output component.

a) Physical description of the typical farm:

The aim of using a typical farm is to represent a farm with physical parameters to which producers in a particular area can relate. The physical and financial extent of the typical farm for each area was established in three phases. The first phase consisted of an initial description of the farm in physical terms. Producer study-group information, obtained from the local agribusinesses, is used for this exercise, to establish typical farm sizes, land use patterns, machinery and equipment layouts, overhead and fixed cost structures and labour employment.

b) Farm description:

The first important assumption in the typical farm model for each area was the size of the total farm. Within the model, farm size forms the basis that determines numerous other factors. Factors that depend on and change with a change in farm size include cultivated area, land utilisation, mechanisation requirements, investment in fixed improvements, investment in land, number of permanent labourers required, as well as the other fixed costs.

Other physical parameters that influence the financial performance of the typical farm include land ownership, land usability and land utilisation. Total land consists of rented land and own land. Rented land influences the factor cost component of the model. Own land and the assumed own-to-borrowed capital ratio determine the payment required, which impacts on the expected cash flow. All farms include an uncultivated part, which, for example, includes riverbeds, roads, buildings, steep inclinations, sandy soils and rocky fields.

Land utilisation indicates the number of hectares on which each crop is cultivated and depends on the total cultivated area and the crop rotation system. In the model, the crop rotation system can be manipulated to incorporate other crops or other sequences of crops.

c) Financial description of the farm:

The farm's financial description expresses the physical extent of the farm in financial terms. It is presented in the form of an inventory or asset register. It calculates the sum of the investment requirement for all assets. It contains values for all items. Items in the inventory include land, fixed improvements, machinery, equipment and livestock. All these factors are connected and dependent on the farm size, and are automatically adjusted if farm size is altered. The assumptions regarding the relationships between land and moveable items were based on the field capacities of machines and the livestock carrying capacity of pasture. All the assumptions and parameters in the model can also be adjusted.

d) Data on input and output prices:

Lists of prices for all production factors, including machinery and directly allocated inputs like seed, fertilisers, chemicals and fuel, were accommodated in the model. These lists are in the form of data tables, from which items can easily be selected by various spread sheet functions. The budget model is set up to select the prices in the data tables. These tables provide prices and quantities for calculations in the enterprise budgets and inventory, as well as calculations of fixed and overhead costs.

The data tables typically consist of the units in which products are sold, the unit prices, typical or recommended application levels and a calculated value per hectare. Prices can thus be updated, or new products can easily be included. In the budget models, three-year average prices were used throughout. The data tables are incorporated into the model so that prices for alternative products or items can be selected quickly and group discussions are not interrupted in order to look for data elsewhere.

Regarding calculating and incorporating running costs of machinery, two separate sheets were developed, an activity cost sheet and a data sheet. The data sheet includes the complete database of the *Guide to Machinery Costs* (2008, 2009 and 2010). Each item is allocated a code that is used as reference number for 'LOOKUP functions in the spread sheet program. The activity sheet calculates the total running cost for each activity, combining the costs of the implement set, which consists of a tractor and an implement. Any combination of tractor and implement can be selected from the database for which an activity cost per hectare is calculated. The activity is then allocated an activity code. These codes can then be selected in the enterprise budgets to calculate the non-directly allocated costs per hectare for each crop.

The calculation component

The calculation component consists of the various calculations and interconnections that relate and connect the various input parts to generate valid outputs in the form of profitability criteria. Standard and established accounting principles are applied to ensure the validity of the model.

The total investment in mechanisation depends on the number, size and age of machines and equipment. The mechanisation requirement can be calculated. Factors included in the calculation are the area that needs to be cultivated, the time available for the activity, and the capacity of the machine and implement set. This method would however not necessarily present a typical mechanisation layout for each area. The typical mechanisation layout, in terms of sizes, the number and age of machines, and amount and age of equipment were established through consultation with various experts and validated at the group discussions. The most expensive machinery and equipment is required for planting, including preparing the soil and harvesting.

a) Inventory:

The role of the inventory is to calculate the expected capital requirement for the whole farm. The capital requirement is in essence a financial quantification of the sum of all assets required to farm sustainably. Capital items include land, fixed improvements, machinery, equipment and livestock. The investment in land, determined by farm size and the price of land, is the biggest contributor to capital requirements for all areas. Fixed improvements were included with the land price.

The prices for new items were obtained from the *Guide to Machinery Costs* (2008, 2009 and 2010). The number of machines and pieces of equipment for each typical farm was determined by the group of experts. The norm, proposed by the *Guide to Machinery Costs*, for replacing machinery items is 12 years.

b) Gross production value and gross margin:

For each homogeneous area, a separate enterprise budget was compiled for every crop. The price data included in the enterprise budgets were selected from the aforementioned data tables. The model selects the gross margin for the whole-farm budget according to the type of year, which is multiplied by the number of hectares planted under a specific crop. The enterprise budgets include, on a per hectare basis, production value, directly allocated variable costs and non-directly allocated variable costs.

The chosen evaluation criterion for measuring whole-farm profitability is the internal rate of return on capital investment (IRR); therefore, good years, with higher yields and subsequent higher cash-inflow, earlier or later in the evaluation period will influence the IRR. This is caused by the number of periods over which each amount is discounted.

c) Overhead and fixed costs:

Overhead and fixed costs were determined by the information provided by the producer study groups. The overhead and fixed costs for each area were verified during group discussions. The owner's remuneration is included as a fixed cost in the models. Fixed and overhead costs typically include permanent labour, licences, insurance, water scheme levies, fuel and maintenance on general farm vehicles, maintenance on fixed improvements, banking costs, accountant's fees, electricity, communication costs, administration costs and provision for diverse costs.

d) The output component:

The output of the models includes a calculation of whole-farm profitability expressed as an IRR (internal rate of return on capital investment) and a NPV (net present value). The cash flow measures the affordability of the borrowed capital amount in terms of cash flow.

e) Profitability:

The budget models were based on a 20-year calculation period. The main reason for the long period was to capture the nature of the crop rotation systems, some of which run over a 14-year period. Another important reason was to allow for the replacement of machinery and equipment. The 20-year calculation period reflects only a random period in the life of a farm to allow for comparable evaluation. Three-year average prices for all inputs, products as well as land prices were used in the models.

The principal aims of the models are to establish the current financial positions of the typical farms for each homogeneous area and to examine the relative financial impacts of various changes on profitability. All calculations are based on constant prices. The effect of inflation is captured in the use of real interest rates for all cash flows and financial profitability calculations.

By a series of selective-sum formulas, the total area under each crop is calculated. The gross margin for the total farm is the sum of the gross margins for all crops.

The annual fixed and overhead costs remain the same over the calculation period. These costs are typical for each IUA, and were determined with the help of study-group data and verified during the workshops. Capital expenditure is calculated on the information in the inventory or asset register, which is determined by the farm's physical description. Replacement of machinery and equipment is based on the life and age at the beginning of the calculation period and the life of the machines. The salvage value of an item of machinery and equipment is subtracted from the price of the new item.

The capital-flow budget calculates the net flow of funds, which is gross margin, minus overhead and fixed costs, minus capital expenditure. The annual net flow of funds over the 20-year period is used to calculate profitability. The profitability for each typical farm was measured in terms of Net Present Value (NPV) and Internal Rate of

Return on capital investment (IRR). The NPV and IRR are closely related. By definition, the IRR is the rate that when used as an interest rate would return a zero NPV. The NPV measures the present value of future cash flow. The IRR measures the growth that the cash flow generates, as a return on the initial investment. The NPV and IRR are ideal criteria if different projects or options, which start at different times, run over different periods, or have different capital investments, need to be compared to one another. In this instance, the financial implications of various changes to the parameters and assumptions can be established. The impact of different strategies on whole-farm profitability can be measured by the IRR while the size of the initial investment affects the NPV result.

f) Affordability: ratio of own to borrowed finance, and cash flow budget

The affordability of the investment is measured in terms of a cash flow analyses to establish the effect of borrowed capital and interest. The IRR calculation incorporates the size of the required investment and the income generated from that investment. The cash flow budget includes cash items only. The impact of interest payments on the farm's bank balance can be established. As constant prices are used in the models, the three-year average nominal interest rate needed to be converted to a real interest rate. The real interest rate is used in calculating the interest received or paid on the bank balance. The real interest rate is calculated using the following formula:

Real interest rate = {[(1+nominal interest rate) / (1+inflation rate)]-1} %.

The cash flow budget typically calculates the breakeven-year or indicates periods of positive and negative cash flow. Thereby, the affordability of borrowed capital and the replacement of mechanisation items can be established.

Once the scenarios have been scaled down to the most appropriate option the economic models will be applied to calculate the economic benefits or reduction in economic activity and benefits associated with the reduction in water availability and/or an increased in the water availability.

3. SURFACE WATER RESOURCES

A lot of background information exists on the surface waters within the WMA and has been included within the Inception Report for this project (Belcher *et al*, 2011).

Chapter 3 addresses the delineation of surface waters in the WMA and description of their status quo in order to inform the delineation of the Integrated Units of Analysis (IUA) that will be utilised for the classification of surface water resources in the Olifants Doorn WMA.

3.1 NETWORK OF SIGNIFICANT RESOURCES *(STEP 1C)*

Significant water resources are defined as: *Water resources that are deemed to be significant from a water resource use perspective, and/or for which sufficient data exist to enable an evaluation of changes in their ecological condition in response to changes in water quality and quantity*.

The following significant water resources were identified in the WMA:

- 52 mainstream river or major tributaries in each quaternary catchment;
- 36 wetland areas or wetland clusters as identified as Freshwater Ecosystem Protected Areas; and
- 2 estuaries as identified by Turpie (2004).

Table 3.1: List of significant water resources in the Olifants-Doring WMA

Resource name	Sub-area	Quaternary Catchment(s)
	Rivers:	
Bergvallei	Sandveld	G30C
Biedou	Doring	E24J
Bos	Doring	E24F
Brak	Doring	E23H
Brak	Doring	E24K
Brak	Knersvlakte	F60F
Brandewyn	Doring	E24L
Brandkraal	Kouebokkeveld	E21J
Draaikraal	Doring	E24F
Doring	Doring	E22E-G, E24H, E24J, E24K, E24M
Geelbek	Knersvlakte	E33D-E33E
Gemsbok	Doring	E23H
Groot	Kouebokkeveld	E21J
Groot	Doring	E22A, B, E
Hantams	Knersvlakte	E32A-E
Hol	Kouebokkeveld	E33E
Houdenbek	Kouebokkeveld	E21D
Houthoek	Doring	E23C, D
Jakkals	Sandveld	G30G
Jan Dissel	Olifants	E10H
Kamdanie	Knersvlakte	E31F
Klein-Goerap	Knersvlakte	F60B
Klein-Toring	Knersvlakte	E32C
Koebee	Doring	E40D
Kolkies	Doring	E22D
Krom	Knersvlakte	E31B-E, H
Krom Antonies	Sandveld	G30D

Kruis	Kouebokkeveld	E21A
Kruismans	Sandveld	G30B
Langvlei	Sandveld	G30F
Leeu	Kouebokkeveld	E21G, H
Matjies	Kouebokkeveld	E21K
Olifants	Olifants	E10A-K, E33G, H
Ongeluks	Doring	E23G, J
Oorlogskloof	Knersvlakte	E40 A-C
Papkuil	Sandveld	G30A
Renoster	Doring	E23E
Riet	Kouebokkeveld	E21E, F
Rooiwal se Laagte	Knersvlakte	E31G
Rondegat	Olifants	E10G
Sandlaagte	Sandveld	G30H
Seekoeivlei	Olifants	E10J
Sout	Knersvlakte	E33B
Sout	Knersvlakte	F60d
Tankwa	Doring	E23A, B, D, F, K
Tra-Tra	Doring	E24A, B
Troe-Troe	Knersvlakte	E33F
Vars	Knersvlakte	E33C
Verlorevlei	Sandveld	G30D, E
Welgemoed	Kouebokkeveld	E21B
Winkelhaak	Kouebokkeveld	E21C
Wolf	Doring	E24G, C
Wetlands:		
Channelled valley-bottom wetland (36.5) Flat (58.1) Seep (5.1) Valleyhead seep (0.3)	Olifants	E10C
Channelled valley-bottom wetland (93.0) Flat (6.0) Seep (1.0)	Olifants	E10D
Channelled valley-bottom wetland (84.8) Flat (1.4) Seep (12.5) Unchannelled valley-bottom wetland (0.8) Valleyhead seep (0.5)	Olifants	E10E
Channelled valley-bottom wetland (95.8) Flat (0.3) Seep (3.4) Unchannelled valley-bottom wetland (0.5)	Olifants	E10H
Channelled valley-bottom wetland (87.4) Flat (3.4) Seep (8.9) Valleyhead seep (0.3)	Olifants	E10J
Channelled valley-bottom wetland (46.3) Flat (3.2) Floodplain wetland (45.8) Seep (3.9) Unchannelled valley-bottom wetland (0.7) Valleyhead seep (0.1)	Olifants	E10K
Channelled valley-bottom wetland (96.9) Valleyhead seep (3.1)	Kouebokkeveld	E21C
Depression (100.0)	Kouebokkeveld	E21F
Channelled valley-bottom wetland (99.9)	Kouebokkeveld	E21K
Channelled valley-bottom wetland (47.9) Flat (17.5) Unchannelled valley-bottom wetland (34.6)	Doring	E22G
Channelled valley-bottom wetland (84.6) Unchannelled valley-bottom wetland (15.4) Channelled valley-bottom wetland (89.6)	Doring	E23B

Unchannelled valley-bottom wetland (10.4)	Doring	E23B
Channelled valley-bottom wetland (69.1) Unchannelled valley-bottom wetland (30.9)	Doring	E23C
Channelled valley-bottom wetland (54.2) Depression (3.5) Flat (16.0) Unchannelled valley-bottom wetland (20.7) Valleyhead seep (5.7)	Doring	E23D
Channelled valley-bottom wetland (100.0)	Doring	E23F
Channelled valley-bottom wetland (100.0)	Doring	E24A
Channelled valley-bottom wetland (100.0)	Doring	E24B
Flat (26.2) Seep (73.8)	Doring	E24C
Channelled valley-bottom wetland (82.3) Flat (13.0) Unchannelled valley-bottom wetland (4.7)	Doring	E24D
Channelled valley-bottom wetland (13.3) Unchannelled valley-bottom wetland (86.7)	Doring	E24F
Unchannelled valley-bottom wetland (100.0)	Doring	E24G
Channelled valley-bottom wetland (75.9) Depression (24.1)	Doring	E24J
Channelled valley-bottom wetland (100.0)	Doring	E24L
Channelled valley-bottom wetland (6.6) Flat (84.7) Unchannelled valley-bottom wetland (1.9) Valleyhead seep (6.8)	Doring	E24M
Channelled valley-bottom wetland (29.7) Depression (67.2) Flat (0.1) Seep (2.6) Unchannelled valley-bottom wetland (0.2) Valleyhead seep (0.2)	Knersvlakte	E31A
Channelled valley-bottom wetland (5.6) Depression (90.1) Unchannelled valley-bottom wetland (4.2)	Knersvlakte	E31B
Depression (100.0)	Knersvlakte	E31C
Channelled valley-bottom wetland (14.7) Seep (82.9) Unchannelled valley-bottom wetland (2.4)	Knersvlakte	E32A
Channelled valley-bottom wetland (99.9) Valleyhead seep (0.1)	Knersvlakte	E32B
Channelled valley-bottom wetland (93.6) Unchannelled valley-bottom wetland (6.4)	Knersvlakte	E32C
Channelled valley-bottom wetland (0.8) Depression (2.3) Flat (54.4) Seep (42.2) Unchannelled valley-bottom wetland (0.3)	Knersvlakte	E32E
Flat (100.0)	Knersvlakte	E33A
Channelled valley-bottom wetland (39.4) Depression (0.8) Flat (33.8) Unchannelled valley-bottom wetland (26.1)	Knersvlakte	E33B
Channelled valley-bottom wetland (73.2) Depression (0.1) Flat (21.8) Seep (1.0) Unchannelled valley-bottom wetland (0.3) Valleyhead seep (3.7)	Knersvlakte	E33C
Channelled valley-bottom wetland (85.2) Depression (0.3) Flat (12.2)	Knersvlakte	E33E

Floodplain wetland (0.2) Seep (0.1) Unchannelled valley-bottom wetland (0.2) Valleyhead seep (1.8)		
Channelled valley-bottom wetland (12.4) Flat (3.2) Floodplain wetland (81.2) Seep (1.5) Unchannelled valley-bottom wetland (1.0) Valleyhead seep (0.7)	Olifants	E33G
Channelled valley-bottom wetland (74.8) Flat (4.6) Floodplain wetland (15.4) Unchannelled valley-bottom wetland (4.1) Valleyhead seep (0.3_	Olifants	E33H
Valleyhead seep (100.0)	Knersvlakte	E40B
Channelled valley-bottom wetland (33.6) Depression (0.3) Flat (48.5) Seep (11.9) Unchannelled valley-bottom wetland (5.6)	Knersvlakte	E40C
Unchannelled valley-bottom wetland (100.0)	Knersvlakte	F60A
Depression (79.8) Flat (20.2)	Knersvlakte	F60C
Floodplain wetland (100.0)	Knersvlakte	F60D
Flat (65.1) Floodplain wetland (23.9) Valleyhead seep (0.8)	Knersvlakte	F60E
Channelled valley-bottom wetland (15.3) Depression (2.0) Flat (0.3) Floodplain wetland (10.4) Seep (0.7) Unchannelled valley-bottom wetland (24.9) Valleyhead seep (7.7)	Sandveld	G30A
Channelled valley-bottom wetland (73.5) Depression (15.8) Flat (6.0) Seep (3.4) Unchannelled valley-bottom wetland (1.0) Valleyhead seep (0.2)	Sandveld	G30B
Channelled valley-bottom wetland (93.0) Flat (1.8) Seep (5.1)	Sandveld	G30C
Channelled valley-bottom wetland (26.2) Flat (0.6) Floodplain wetland (71.5) Seep (1.8)	Sandveld	G30D
Channelled valley-bottom wetland (0.5) Depression (0.1) Flat (1.0) Floodplain wetland (24.7) Seep (2.3) Unchannelled valley-bottom wetland (0.2)	Sandveld	G30E
Channelled valley-bottom wetland (45.5) Flat (2.5) Seep (0.2) Unchannelled valley-bottom wetland (7.7) Valleyhead seep (0.2)	Sandveld	G30F
Channelled valley-bottom wetland (80.7) Depression (5.1) Seep (10.7) Unchannelled valley-bottom wetland (3.4)	Sandveld	G30G
Channelled valley-bottom wetland (42.9)	Sandveld	G30H

Depression (0.1) Flat (7.1) Floodplain wetland (1.9) Seep (42.3) Unchannelled valley-bottom wetland (5.0) Valleyhead seep (0.6)		
Estuaries:		
Olifants Estuary	Olifants	E33H
Verlorevlei Estuary	Sandveld	G30E

3.2. BIOPHYSICAL AND ALLOCATION NODES (STEP 1D)

RIVER NODES:

Procedure for the establishment of river nodes:

A multi-tiered approach for establishing the location and number of river nodes within the WMA was utilised which gave consideration to a suite of characteristics that dictate the ecological nature of rivers at different scales (Figure 3.1).

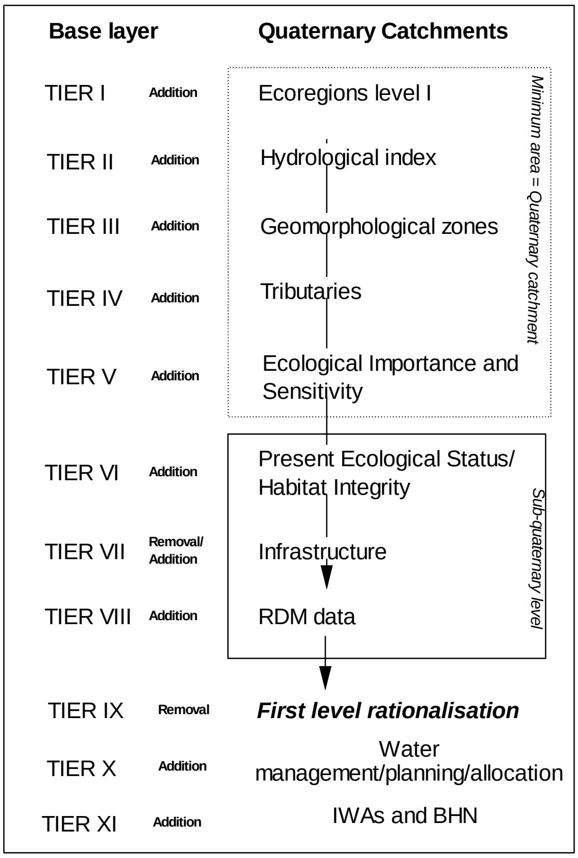

Figure 3.1: Summary of the procedure of river node establishment

Tier I - Ecoregions Level I

Seven level 1 ecoregions occur in the WMA, with the southern Folded Mountains only occurring in a very small portion of the catchment. Thirteen nodes (E10K, E22F, E23K, E24D, E24G, E24M, E31E, E31G, E32E, E40B, G30C, G30D and F60C) were identified that represent the change in ecoregions (node placed at each Ecoregion/quaternary catchment intersection where >75% of the upstream quaternary is comprised of a different Ecoregion from the downstream quaternary).

Table 3.2: Description and distribution of the Level 1 Ecoregions that occur in the Olifants Doring WMA

Name (Ecoregion code)	Drainage area	% area of WMA	Description
Great Karoo (21)	Most of the Doring (E22, 23, 24) and Hantams (E32) catchments, as well as a portion of Oorlogskloof (E40)	32	Characterised by plains with low to moderate relief, although significant areas contain closed hills and mountains with moderate to high relief. Vegetation consists of a diversity of Nama Karoo, Succulent Karoo, Renosterveld and thicket types. The Tankwa and Hantam rivers, both tributaries of the Doring River, are the main rivers in this ecoregion, respectively located in the Doring and Knersvlakte sub-areas.
Nama Karoo (26)	Only the very north eastern portion of the Knersvlakte (E31, E32A&B) and eastern extent of the Doring (E40A&B, E23E)	19	Topography is diverse, but plains with a moderate to high relief and lowlands, hills and mountains with moderate to high relief are dominant. Vegetation consists almost exclusively of Nama Karoo types. This ecoregion is extensive outside the Olifants/Doorn WMA, and rivers with the study area in the Nama Karoo are ephemeral.
Namaqua Highlands (27)	Northern portions of the Knersvlakte (portions of E31, E33 and F60)	4	Closed hills and mountains with moderate to high relief are distinctive in this region. Dominant vegetation types consist of Succulent Karoo types and Renosterveld. This ecoregion is extensive outside the Olifants/Doorn WMA, and rivers within the Namaqua Highlands are ephemeral.
South Western Coastal Belt (24)	Sandveld (G30) excluding the higher lying areas and coastal strip	6	Plains with a moderate to low relief are characteristic of the region, with altitude varying from sea level to 900 m.a.m.s.l. The dominant vegetation type is West Coast Renosterveld, with significant areas of fynbos, succulent Karoo and thicket. This region is located mainly in the Sandveld sub-area, containing the headwaters of the Verlorenvlei, Langvlei and Jakkals rivers.
Western Coastal Belt (25)	Lower Olifants (E33G&H) and western Knersvlakte (E33, F60)	20	Plains with low and moderate relief are typical of this region, with altitude varying from sea level to 700 m.a.m.s.l. Vegetation types consist of succulent Karoo types. The lower Olifants River, and the Doring and Sout rivers traverse this region.
Western Folded Mountains (23)	Kouebokkeveld (E21) and Upper Olifants (E10)	18	Closed hills and mountains with moderate to high relief are distinctive in this area, although tablelands and plains are present. Prominent escarpments occur along the east and north west of the region. Mountain fynbos is the dominant vegetation type. The Olifants River has its source in this region, as does the Groot River, a main tributary of the Doring River.
Southern Folded Mountains (19)	South eastern extreme of the Doring catchment (E22A B&D)	1	The region is characterised by moderate to high relief closed hills and mountains. Vegetation consists largely of Grassy and Mountain Fynbos as well as Little Succulent Karoo in the drier areas. Most of this area is located outside of the WMA and only the very upper reaches of the Doring River occur within the ecoregion.

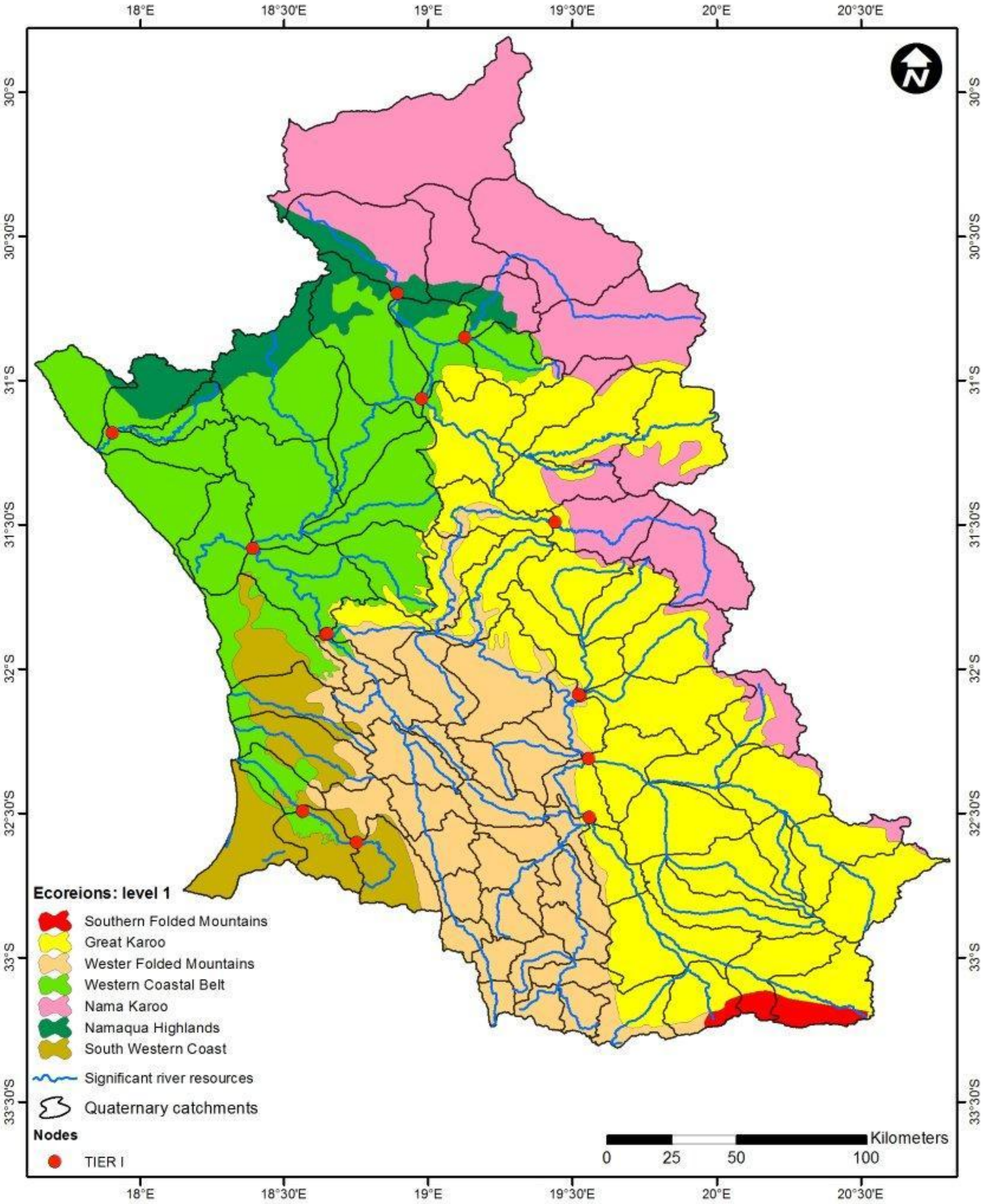

Figure 3.2: Tier I nodes for Level 1 Ecoregions

Tier II – Hydrological Index

The Hydrological Index Classes for the WMA were divided into three classes to represent perennial, seasonal and ephemeral flow regimes.

Table 3.3: Distribution of Hydrological Classes in Olifants Doring WMA

Hydrological Class	% area of WMA	Drainage area
Perennial	15.99%	Upper/Lower Olifants (E10 and E33G&H, Kouebokkeveld (E21), Upper Verlorenvlei (G30B-D)
Seasonal	16.83%	Lower Sandveld (Papkuil, Lower Verlorenvlei and Langvlei (G30 D E)), Lower Doring (E24)
Ephemeral	67.18%	Knersvlakte (E31, E32, E33, F60), eastern portion of the Doring (E22, E23) and northern Sandveld (G30G&H)

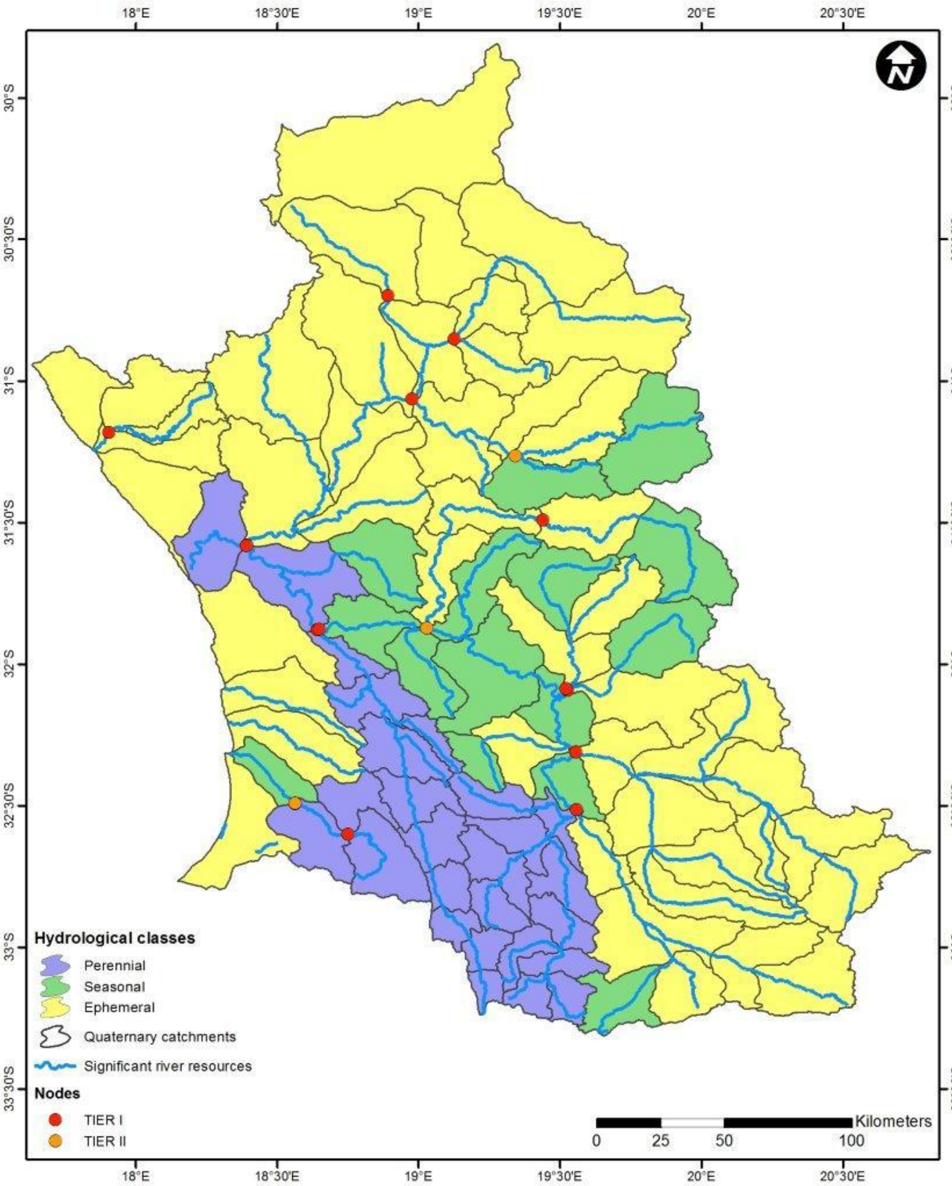

Figure 3.3: Tier II nodes for Hydrological Classes

Seven additional nodes (E24C, E24E, E32A, E32C, E33E, E40A, E40D) over and above the Tier I nodes were added to represent the change in flow regime (change in Hydrological Class) for the rivers in the WMA. Total of nodes after Tier II = 20.

Tier III – Geomorphic zones

Three geomorphic zones were utilised to identify the Tier III nodes:

- Mountain Headwaters, Mountain Streams and Upper Foothill Rivers;
- Lower Foothill Rivers; and
- Lowland Rivers.

There was no Rejuvenated Floodplain River zones present in the WMA.

Nineteen additional nodes (E10C, E10H, E21C, E21D, E21E, E21F, E21G, E21J, E22A, E22D, E23C, E23G, E23H, E24A, E24B, E24L, E33H, G30E, F60D) were inserted at quaternary boundaries where the upstream quaternary was comprised of a different geomorphic zone from the downstream quaternary (>75% of catchment) and upstream of an estuary or lake. Total of nodes after Tier III = 39.

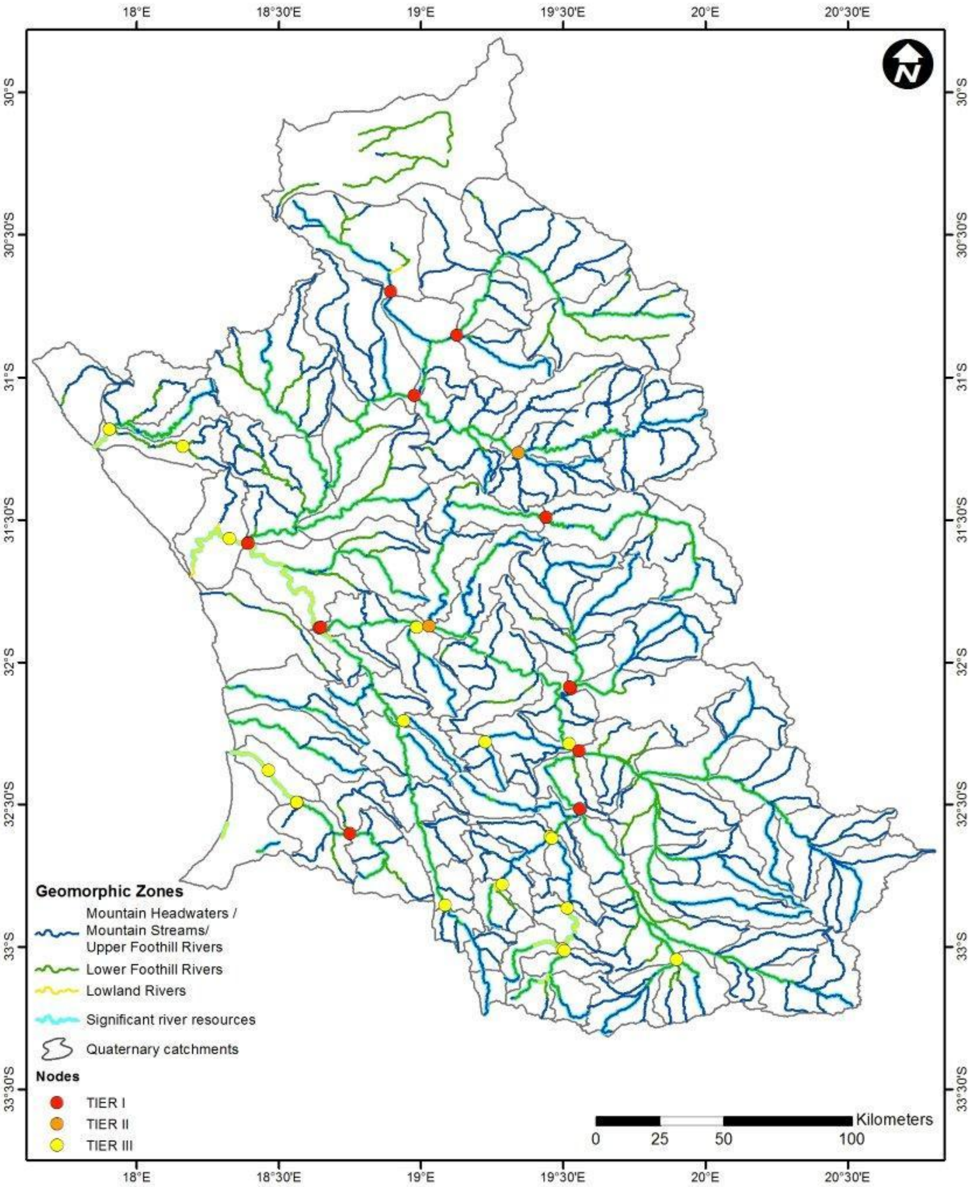

Figure 3.4: Tier IV nodes for geomorphic zones

Tier IV - Tributaries

In this tier, a node was placed at the nearest quaternary intersection on each river (i.e. two nodes - : one for each river upstream of the confluence). Seventeen additional nodes (E21A, E21B, E21L, E22G, E23D, E23F, E23J, E24J, E24K, 3E1F, E31H, E32B, E33B, E33C, E33E, G30B, F60B) were added for this tier. Total of nodes after Tier IV = 56.

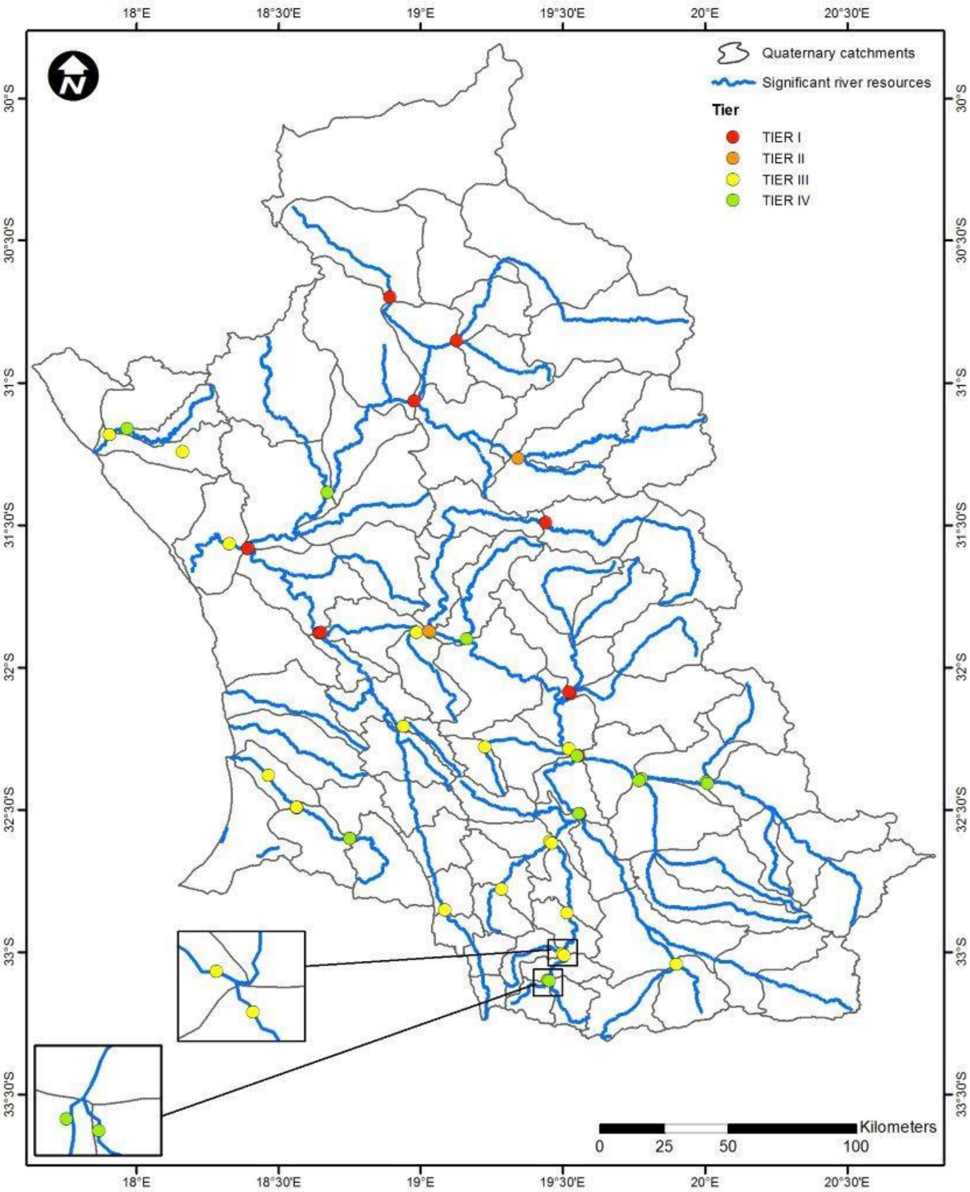

Figure 3.5: Tier IV nodes for the tributaries

Tier V – Ecological Importance and Sensitivity Category (EISC)

Data for the EISC tier was obtained from the desktop estimate of ecological importance and sensitivity which has recently been updated. Nodes were allocated at each quaternary downstream of high or very high EISC reach. Seven additional nodes (E10A, E10B, E24H, E40C, G30A, G30E and G30F) were added for this tier. Total of nodes after Tier V = 63.

Table 3.4: EISC for the Olifants Doorn WMA (Desktop Estimate, 1999)

QUATERNARY	RIVERS	EISC
E10A	Upper Olifants	High
E10B	Upper Olifants	High
E10C	Olifants River	Very High
E10D	Olifants, Visgat, upstream to Bulshoek	Moderate
E10E	Olifants, Visgat, upstream to Bulshoek	Moderate
E10F	Olifants, Visgat, upstream to Bulshoek	Moderate
E10G	Olifants, Visgat, upstream to Bulshoek	Moderate
E10H	Olifants, Visgat, upstream to Bulshoek	Moderate
E10J	Olifants, Visgat, upstream to Bulshoek	Moderate
E10K	Bulshoek to confluence with Doring	Moderate

E21A	Gruis, Groot, Ret	Low
E21B	Gruis, Groot, Ret	Low
E21C	Gruis, Groot, Ret	Low
E21D	Gruis, Groot, Ret	Low
E21E	Groot, Maaitjies, Tra-tra	Low
E21F	Groot, Maaitjies, Tra-tra	Low
E21G	Groot, Maaitjies, Tra-tra	Low
E21H	Groot, Maaitjies, Tra-tra	Low
E21J	Groot, Maaitjies, Tra-tra	Low
E21K	Groot, Maaitjies, Tra-tra	Low
E21L	Groot, Maaitjies, Tra-tra	Low
E22A	upper Doring, Tanqua, Groot	Low
E22B	upper Doring, Tanqua, Groot	Low
E22C	upper Doring, Tanqua, Groot	Low
E22D	upper Doring, Tanqua, Groot	Low
E22E	upper Doring, Tanqua, Groot	Low
E22F	upper Doring, Tanqua, Groot	Low
E22G	Doring, Aspoot	Very High
E23A	upper Doring, Tanqua, Groot	Low
E23B	upper Doring, Tanqua, Groot	Low
E23C	upper Doring, Tanqua, Groot	Low
E23D	upper Doring, Tanqua, Groot	Low
E23E	upper Doring, Tanqua, Groot	Low
E23F	upper Doring, Tanqua, Groot	Low
E23G	upper Doring, Tanqua, Groot	Low
E23H	upper Doring, Tanqua, Groot	Low
E23J	upper Doring, Tanqua, Groot	Low
E23K	upper Doring, Tanqua, Groot	Low
E24A	Groot, Maaitjies, Tra-tra	Low
E24B	Groot, Maaitjies, Tra-tra	Low
E24C	upper Doring, Tanqua, Groot	Low
E24D	upper Doring, Tanqua, Groot	Low
E24E	upper Doring, Tanqua, Groot	Low
E24F	upper Doring, Tanqua, Groot	Low
E24G	upper Doring, Tanqua, Groot	Low
E24H	Doring from Elandsbaai	High
E24J	Doring from Elandsbaai	High
E24K	upper Doring, Tanqua, Groot	Low
E24L	Doring from Elandsbaai	High
E24M	Doring from Elandsbaai	High
E31A	endorheic	Invalid Entries
E31B	Kromme	Moderate
E31C	Kromme	Moderate
E31D	Sout, Handhaaf (Knersvlakte area)	Moderate
E31E	Sout, Handhaaf (Knersvlakte area)	Moderate
E31F	Sout, Handhaaf (Knersvlakte area)	Moderate
E31G	Sout, Handhaaf (Knersvlakte area)	Moderate
E31H	Sout, Handhaaf (Knersvlakte area)	Moderate
E32A	Kromme	Moderate
E32B	Sout, Handhaaf (Knersvlakte area)	Moderate
E32C	Sout, Handhaaf (Knersvlakte area)	Moderate
E32D	Sout, Handhaaf (Knersvlakte area)	Moderate
E32E	Sout, Handhaaf (Knersvlakte area)	Moderate
E33A	Sout, Handhaaf (Knersvlakte area)	Moderate
E33B	Sout, Handhaaf (Knersvlakte area)	Moderate
E33C	Sout, Handhaaf (Knersvlakte area)	Moderate
E33D	Sout, Handhaaf (Knersvlakte area)	Moderate
E33E	Sout, Handhaaf (Knersvlakte area)	Moderate
E33F	Olifants confluence to estuary	Moderate
E33G	Olifants confluence to estuary	Moderate
E33H	Olifants confluence to estuary	Moderate
E40A	Oorlogskloof and upper Oorlogskloof	Moderate
E40B	Oorlogskloof and upper Oorlogskloof	Moderate
E40C	Lower Oorlogskloof, Koebee	High
E40D	Lower Oorlogskloof, Koebee	High
F50A	Groen, Sout, Swartdoring	Moderate

F50B	Groen, Sout, Swartdoring	Moderate
F50C	Groen, Sout, Swartdoring	Moderate
F50D	Groen, Sout, Swartdoring	Moderate
F50E	Groen, Sout, Swartdoring	Moderate
F50F	Groen, Sout, Swartdoring	Moderate
F50G	Groen, Sout, Swartdoring	Moderate
F60A	Groen, Sout, Swartdoring	Moderate
F60B	Groen, Sout, Swartdoring	Moderate
F60C	Groen, Sout, Swartdoring	Moderate
F60D	Groen, Sout, Swartdoring	Moderate
F60E	Groen, Sout, Swartdoring	Moderate
G30A	Graaff Water, Verlorenvlei	High
G30B	Verlorenvlei	Moderate
G30C	Verlorenvlei	Moderate
G30D	Verlorenvlei	Moderate
G30E	Graaff Water, Verlorenvlei	High
G30F	Graaff Water, Verlorenvlei	High
G30G	Jakkals	Low
G30H	Endorheic	Invalid Entries

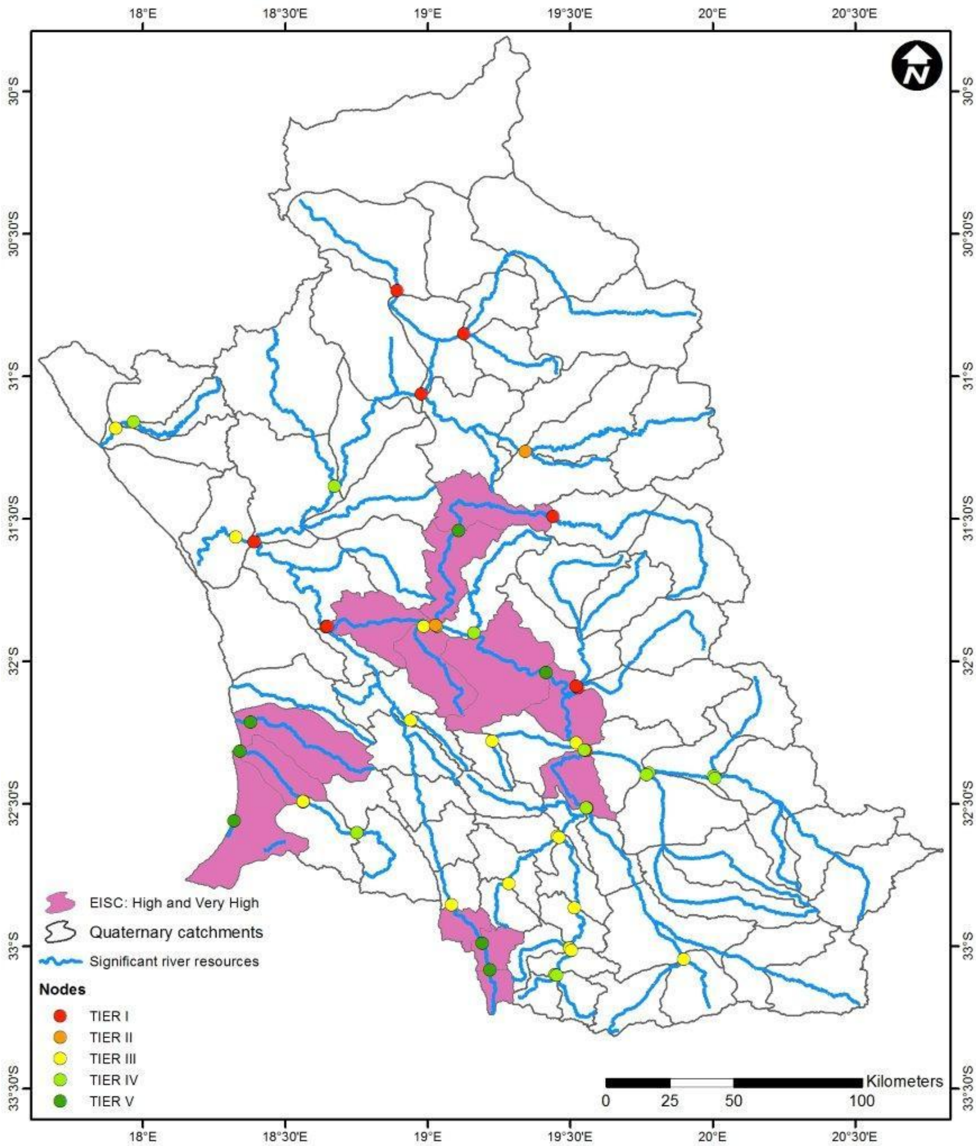

Figure 3.6: Tier II nodes for High and Very High Ecological Importance and Sensitivity

Tier VI – Present Ecological Status (PES) Category

Data for the PES Category tier was obtained from the desktop estimate of present ecological status which has recently been updated. Nodes were allocated at each quaternary downstream of high or very high EISC reach. Three additional nodes (E10D, E10F and E10J) were added for this tier. Total of nodes after Tier VI = 66.

Table 3.5: PESC for the Olifants Doorn WMA

QUAT	PESC (20110 CUM	PES (2011) INC	PESC (1999)
E10A	D	D	CLASS C: MODERATELY MODIFIED
E10B	E	D	CLASS C: MODERATELY MODIFIED
E10C	E	E	CLASS A: UNMODIFIED, NATURAL
E10D	C	D	CLASS D: LARGELY MODIFIED
E10E	C	D	CLASS D: LARGELY MODIFIED
E10F	C	D	CLASS D: LARGELY MODIFIED
E10G	C	C	CLASS D: LARGELY MODIFIED
E10H	C	C	CLASS D: LARGELY MODIFIED
E10J	C	C	CLASS D: LARGELY MODIFIED
E10K	C	C	CLASS D: LARGELY MODIFIED
E21A	B	D	CLASS E - F: NOT AN ACCEPTABLE CLASS
E21B	C	C	CLASS E - F: NOT AN ACCEPTABLE CLASS
E21C	C	C	CLASS E - F: NOT AN ACCEPTABLE CLASS
E21D	E	E	CLASS E - F: NOT AN ACCEPTABLE CLASS
E21E	E	E	CLASS B: LARGELY NATURAL
E21F	E	D	CLASS B: LARGELY NATURAL
E21G	C	C	CLASS B: LARGELY NATURAL
E21H	E	E	CLASS B: LARGELY NATURAL
E21J	E	E	CLASS B: LARGELY NATURAL
E21K	E	E	CLASS B: LARGELY NATURAL
E21L	F	F	CLASS B: LARGELY NATURAL
E22A	E	F	CLASS C: MODERATELY MODIFIED
E22B	F	F	CLASS C: MODERATELY MODIFIED
E22C	E	E	CLASS C: MODERATELY MODIFIED
E22D	E	F	CLASS C: MODERATELY MODIFIED
E22E	E	E	CLASS C: MODERATELY MODIFIED
E22F	E	E	CLASS C: MODERATELY MODIFIED
E22G	E	E	CLASS C: MODERATELY MODIFIED
E23A	F	F	CLASS C: MODERATELY MODIFIED
E23B	E	F	CLASS C: MODERATELY MODIFIED
E23C	F	F	CLASS C: MODERATELY MODIFIED
E23D	F	F	CLASS C: MODERATELY MODIFIED
E23E	E	E	CLASS C: MODERATELY MODIFIED
E23F	E	E	CLASS C: MODERATELY MODIFIED
E23G	E	E	CLASS C: MODERATELY MODIFIED
E23H	F	F	CLASS C: MODERATELY MODIFIED
E23J	E	E	CLASS C: MODERATELY MODIFIED
E23K	E	E	CLASS C: MODERATELY MODIFIED
E24A	E	E	CLASS B: LARGELY NATURAL
E24B	E	E	CLASS B: LARGELY NATURAL

E24C	D	E	CLASS C: MODERATELY MODIFIED
E24D	D	E	CLASS C: MODERATELY MODIFIED
E24E	E	E	CLASS C: MODERATELY MODIFIED
E24F	E	E	CLASS C: MODERATELY MODIFIED
E24G	E	E	CLASS C: MODERATELY MODIFIED
E24H	D/E	E	CLASS C: MODERATELY MODIFIED
E24J	D/E	E	CLASS C: MODERATELY MODIFIED
E24K	E	E	CLASS C: MODERATELY MODIFIED
E24L	E/D	D	CLASS C: MODERATELY MODIFIED
E24M	E	D/E	CLASS C: MODERATELY MODIFIED
E31A	E	E	CLASS E - F: NOT AN ACCEPTABLE CLASS
E31B	E	E	CLASS B: LARGELY NATURAL
E31C	E	E	CLASS B: LARGELY NATURAL
E31D	E	E	CLASS C: MODERATELY MODIFIED
E31E	E	E	CLASS C: MODERATELY MODIFIED
E31F	E	E	CLASS C: MODERATELY MODIFIED
E31G	E	E	CLASS C: MODERATELY MODIFIED
E31H	E	E	CLASS C: MODERATELY MODIFIED
E32A	E	E	CLASS B: LARGELY NATURAL
E32B	E	E	CLASS C: MODERATELY MODIFIED
E32C	E	E	CLASS C: MODERATELY MODIFIED
E32D	E	E	CLASS C: MODERATELY MODIFIED
E32E	E	E	CLASS C: MODERATELY MODIFIED
E33A	E	E	CLASS C: MODERATELY MODIFIED
E33B	E	E	CLASS C: MODERATELY MODIFIED
E33C	C	C	CLASS C: MODERATELY MODIFIED
E33D	E	E	CLASS C: MODERATELY MODIFIED
E33E	D	E	CLASS C: MODERATELY MODIFIED
E33F	C	C	CLASS D: LARGELY MODIFIED
E33G	C	E	CLASS D: LARGELY MODIFIED
E33H	C	E	CLASS D: LARGELY MODIFIED
E40A	C	D/E	CLASS C: MODERATELY MODIFIED
E40B	C	C	CLASS C: MODERATELY MODIFIED
E40C	C	E	CLASS B: LARGELY NATURAL
E40D	E	E	CLASS B: LARGELY NATURAL
F50A			CLASS C: MODERATELY MODIFIED
F50B			CLASS C: MODERATELY MODIFIED
F50C			CLASS C: MODERATELY MODIFIED
F50D			CLASS C: MODERATELY MODIFIED
F50E			CLASS C: MODERATELY MODIFIED
F50F			CLASS C: MODERATELY MODIFIED
F50G			CLASS C: MODERATELY MODIFIED
F60A			CLASS C: MODERATELY MODIFIED
F60B	Still to be updated	Still to be updated	CLASS C: MODERATELY MODIFIED
F60C			CLASS C: MODERATELY MODIFIED
F60D			CLASS C: MODERATELY MODIFIED
F60E			CLASS C: MODERATELY MODIFIED

G30A			CLASS C: MODERATELY MODIFIED
G30B			CLASS C: MODERATELY MODIFIED
G30C			CLASS C: MODERATELY MODIFIED
G30D			CLASS C: MODERATELY MODIFIED
G30E			CLASS C: MODERATELY MODIFIED
G30F			CLASS C: MODERATELY MODIFIED
G30G			CLASS C: MODERATELY MODIFIED
G30H			CLASS E - F: NOT AN ACCEPTABLE CLASS

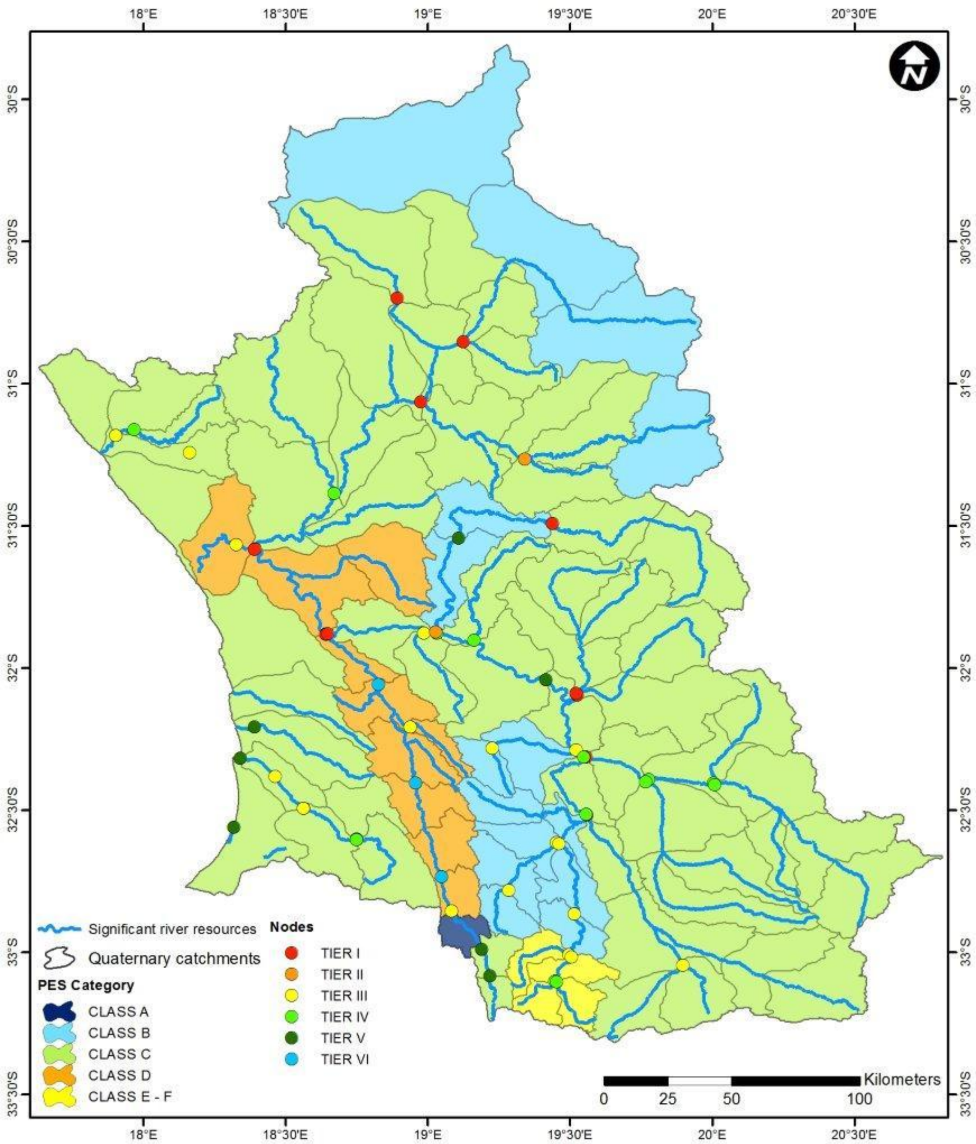

Figure 3.7: Tier II nodes for changes in the present Ecological Status

Tier VII – Water Resource Infrastructure

Nodes were added to the existing suite of nodes:

- at DWAF gauging weirs;
- at the upstream end of major impoundments (Clanwilliam Dam and Bulshoek Barrage);
- on a river immediately upstream of the confluence with an Interbasin Transfer;
- on a river immediately upstream of the influence of a town, mine or other locale likely to have a major impact on water quality; and

- at the quaternary intersection where the area covered by farm dams in the upstream quaternary is >5 times that of the downstream quaternary.

Nodes were removed from the existing suite of nodes if they are inundated by an impoundment. Allocation and/or removal of Tier VII nodes yielded one additional node (E10G). Total nodes after Tier VII = 67.

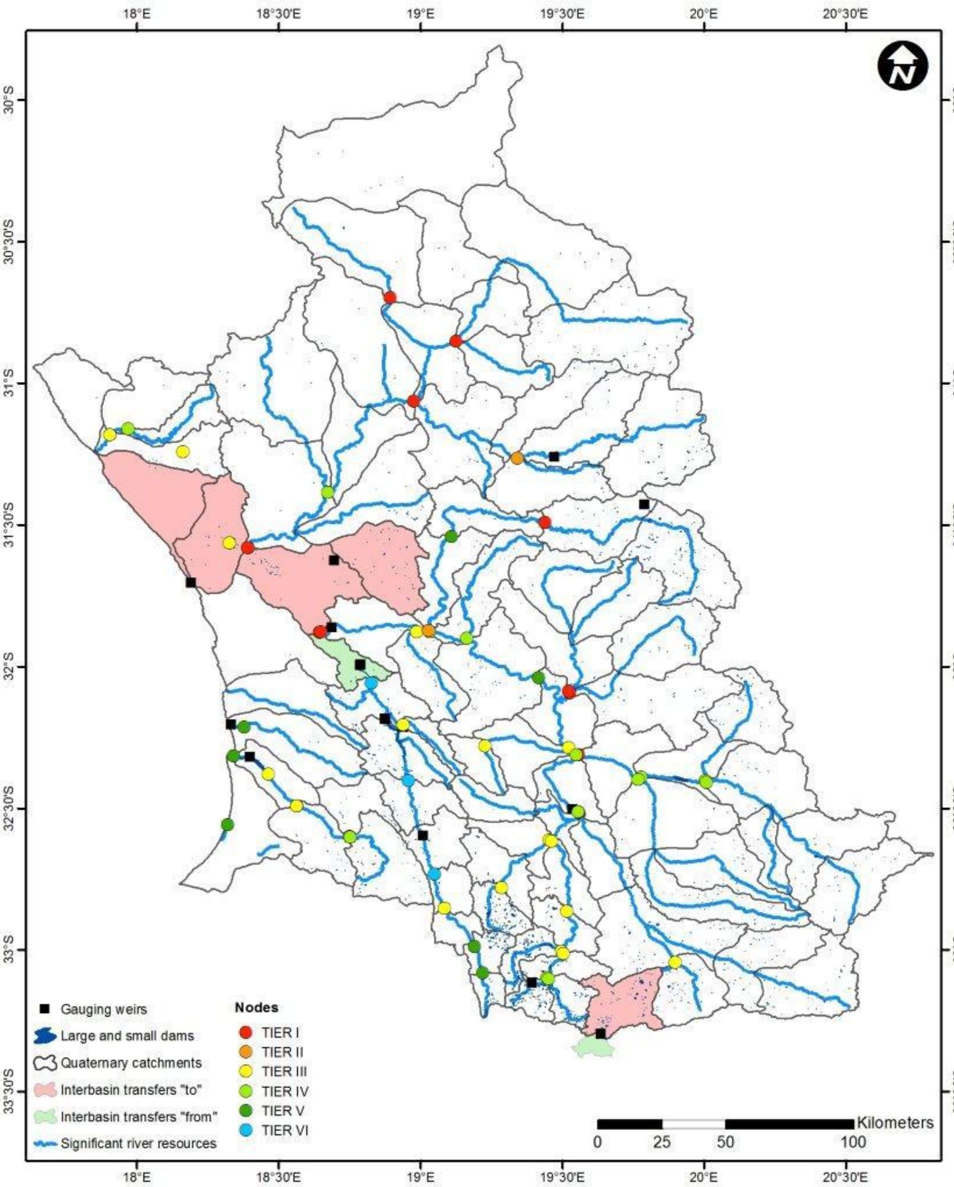

Figure 3.8: Tier VII nodes for Water related infrastructure and interbasin transfers

Tier VIII – RDM data

The Comprehensive Reserve determination was undertaken for the Olifants/Doring catchment (Brown *et al.,* 2004), while an Intermediate level Reserve determination was carried out for the surface waters of the Sandveld (Table). A node was placed at the quaternary intersection downstream of each of the EWR sites., A node was also placed at the exact location of the EWR Site on sub-quaternary tributaries, in this case, the Rondegat River. This resulted in two additional nodes (E10H and G30G). Total nodes after Tier VIII = 79.

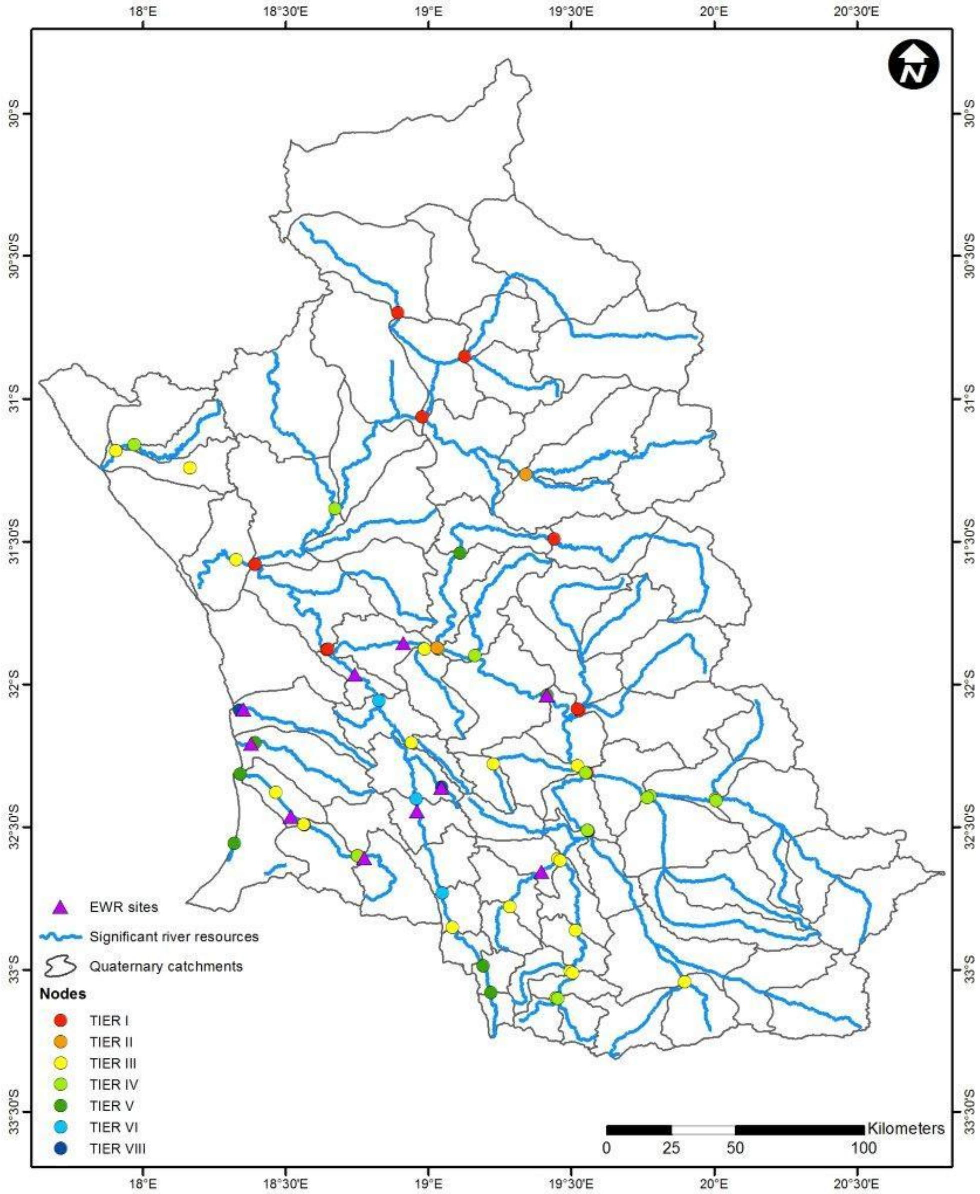

Figure 3.9: Tier VIII nodes for the EWR sites

Table 3.6: EWR river sites in the Olifants Doorn WMA

No.	River	Quaternary catchment5	Description	Latitude	Longitude
1	Olifants	E10F	N7 downstream of the confluence with the Hex River.	32°26.764	18°57.601
2	Olifants	E10K	Downstream of Bulshoek Barrage, just downstream of Cascade Pools.	31°57.974	18°44.463
3	Rondegat	E10F	Upstream of the Algeria staff accommodation, on the road between Algeria and Clanwilliam.	32°21.760	19°02.618
4	Doring	E24J	On the Doring mainstream, immediately upstream of the confluence with the Biedou River.	32°02.410	19°24.896
5	Doring	E24M	At Oudrif.	31°51.446	18°54.754
6	Groot	E21J	Upstream of the bridge at Groot Rivier.	32°39.552	19°23.786
7	Kruismans	G30B	Kruismans River at Duikerfontein	32°36’41”	18°46’28”
8	Verlorenvlei	G30D	Verlorenvlei River at Redelinghuys	32°27’56”	18°31’00”
90	Langvlei	G30F	Langvlei River at Wadrif	32°12’37.8”	18°22’41.7”
10	Jakkals	G30G	Jakkals River at Kookfontein	32°05’21.9”	18°21’08.7”

Tier IX - Rationalisation

In Tier IX the number of nodes is reduced to a manageable level, where nodes are reduced if:

- Minimum river length between nodes less than 10 km.
- Minimum contribution to nMAR = 1% (E22A, E23A, E, G, H and J; E24C, E and F; E31A to H; E32A to D; E33B to D; and E40A).

Fourteen nodes (E22A, E23G, E23H, E24C, E24E, E31F, E31H, E32A, E32B, E33B, E40A, F60B, F60C) were deleted in Tier IX.

Table 3.7: Summary of node selection for Tier I to Tier VIII and nodes selected for rationalisation

TIER NO.	QUATERNARY	NODE	RATIONALISATION TIER (NODES REMOVED)
TIER I	E10K	R13	
TIER I	E22F	R36	
TIER I	E23K	R27	
TIER I	E24D	R21	
TIER I	E24G	R22	
TIER I	E24M	R14	
TIER I	E31E	R2	
TIER I	E31G	R1	
TIER I	E32E	R3	
TIER I	E40B	R12	
TIER I	F60C	R 6	Removed - node<10km apart
TIER I	G30C	R 54	
TIER I	G30D	R 53	
TIER II	E24C		Removed - <1% of nMAR
TIER II	E24E		Removed - <1% of nMAR
TIER II	E32A		Removed - <1% of nMAR
TIER II	E32C	R4	
TIER II	E33E	R8	
TIER II	E40A		Removed - <1% of nMAR
TIER II	E40D	R17	
TIER III	E10C	R42	
TIER III	E10H	R24	
TIER III	E21C	R46	
TIER III	E21D	R45	
TIER III	E21E	R43	
TIER III	E21F	R39	
TIER III	E21G	R41	
TIER III	E21J	R38	
TIER III	E22A	R 18	Removed - <1% of nMAR
TIER III	E22D	R50	
TIER III	E23C	R 35	Removed - node<10km apart
TIER III	E23G		Removed - <1% of nMAR
TIER III	E23H		Removed - <1% of nMAR
TIER III	E24A	R25	
TIER III	E24B	R26	
TIER III	E24L	R15	

TIER III	E33H	R7	
TIER III	F60D	R 58	
TIER III	G30E	R 52	
TIER IV	E21A	R48	
TIER IV	E21B	R49	
TIER IV	E21L	R37	
TIER IV	E22G	R28	
TIER IV	E23D	R32	
TIER IV	E23F	R29	
TIER IV	E23F	R31	
TIER IV	E23J	R30	
TIER IV	E24C		Removed - <1% of nMAR
TIER IV	E24J	R19	
TIER IV	E24K	R16	
TIER IV	E31F		Removed - <1% of nMAR
TIER IV	E31H		Removed - <1% of nMAR
TIER IV	E32B		Removed - <1% of nMAR
TIER IV	E33B		Removed - <1% of nMAR
TIER IV	E33E	R5	
TIER IV	F60B	R 10	Removed - node<10km apart
TIER IV	G30B	R 55	
TIER V	E10A	R 47	
TIER V	E10B	R 44	
TIER V	E24H	R20	
TIER V	E40C	R 11	
TIER V	G30A	R 51	
TIER V	G30E	R 52	
TIER V	G30F	R 56	
TIER VI	E10D	R 40	
TIER VI	E10F	R 33	
TIER VI	E10J	R 23	
TIER VII	E10G	R34	
TIER VIII	E10H	R 24	
TIER VIII	G30G	R 57	

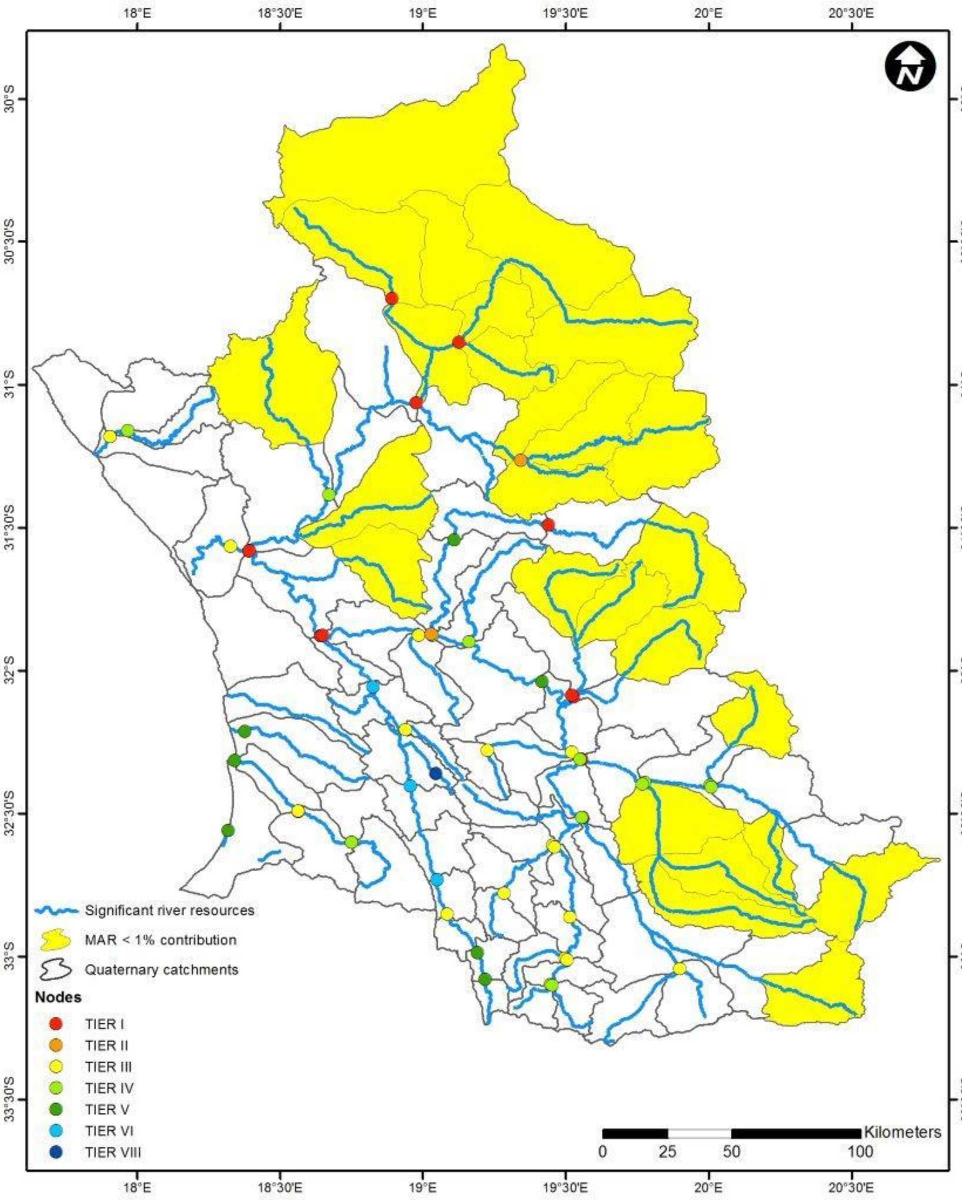

Figure 3.10: Tier IX nodes following the rationalisation of nodes

Final River Nodes

After the rationalisation of nodes, 55 river nodes remain as indicated below in Table 3.8 and presented in Figure 3.11:

Table 3.8: Final River nodes

NODE_CODE	QUATERNARY	NODE_CODE	QUATERNARY	NODE_CODE	QUATERNARY
R1	E31G	R22	E24G	R41	E21G
R2	E31E	R23	E10J	R42	E10C
R3	E32E	R24	E10H	R43	E21E
R4	E32C	R25	E24A	R44	E10B
R5	E33E	R26	E24B	R45	E21D
R7	E33H	R27	E23K	R46	E21C
R8	E33E	R28	E22G	R47	E10A
R9	E33H	R29	E23F	R48	E21A
R11	E40D	R30	E23J	R49	E21B
R12	E40B	R31	E23F	R50	E22D
R13	E10K	R32	E23D	R 51	G30A
R14	E24M	R33	E10G	R 52	G30E
R15	E24L	R34	E10G	R 53	G30D
R16	E24K	R36	E22F	R 54	G30C
R17	E40D	R37	E21L	R 55	G30B
R19	E24J	R38	E21J	R 56	G30F
R20	E24H	R39	E21F	R 57	G30G
R21	E24D	R40	E10E	R 58	F60D

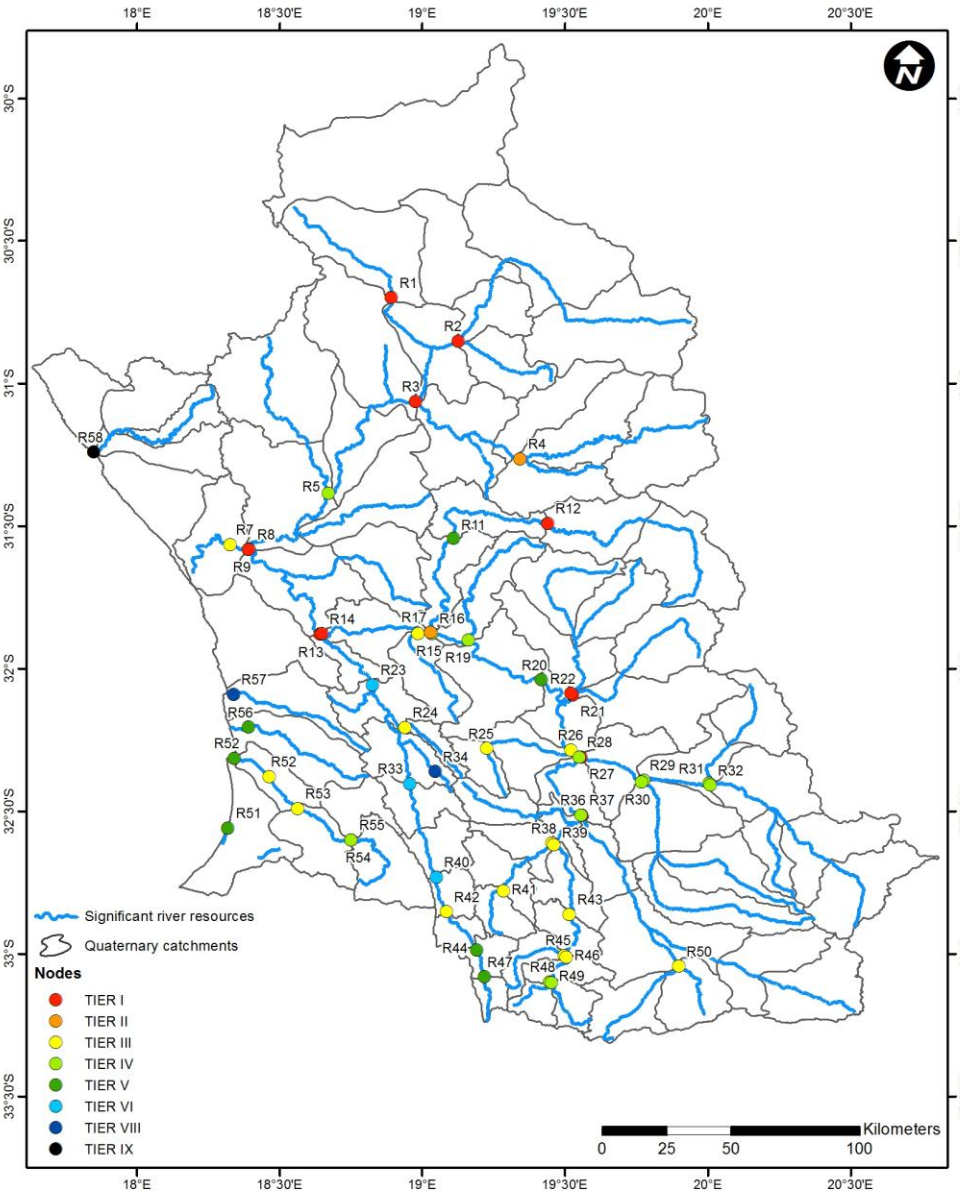

Figure 3.11: Final river nodes for the Olifants Doorn WMA

WETLAND NODES:

A large number of wetlands occur in the Olifants-Doorn WMA and have been identified and described through the fine-scale planning project of C.A.P.E. The various wetland types identified are summarised in the table below:

Table 3.9: Wetland types occurring in the Olifants Doorn WMA

Wetland Type	Occurrence	Characteristics
Arid floodplain wetlands	Occur in the broad valleys of seasonal rivers, with alluvial sandy soils with some clayey depressions (e.g. the lower Sout/Hol River system	Sandstone, granite or shale bedrock is observed within the riverbeds and a salt crust may develop in the riverbed over dry periods. The dominant vegetation type (Namaqualand Rivers) is characterised by a mixture of succulent shrubs and patches of grasses on the riverbeds and banks and a narrow band of trees (*Acacia karoo* or *Tamarix usneoides).*
Alluvial floodplain wetlands	Found in the Olifants River floodplain, Jan Dissels River, and the Verlorenvlei and its major tributaries – Kruismans, Krom Antonies, and Hol rivers	Wide river valleys with braided channels, where periodic inundation of the floodplain sustains wetland habitat. They tend to occur on acid sands, with sandstone and shale bedrock outcroppings. Vegetation is diverse, including a band of perennial trees (often alien) and tall shrubs and swathes of varying width of reeds, sedges and palmiet.
Sandveld floodplain wetlands	Occur along the Langvlei, Verlorenvlei and Jakkals River systems	Seasonal wetlands occur on alkaline to neutral silts and sands, which can be deep in places, and can lie over calcretes and clays. They tend to be saline, and have a high dependence on groundwater. Sandveld floodplains are often wide, sandy systems with braided channels within the wider floodplain. The vegetation type is dominated by small succulent shrubs, such as *Sarcocornia* spp., and rushes, *Juncus kraussii*. Trees, annuals, bulbs and grasses (with the exception of *Cynodon dactylon*) are rare. The botanical diversity is low.
Arid valley bottom wetlands	Occur north of the Sandveld (Klein/Troe-Troe river system, a section of the middle Olifants River, the lower Doring River and a number of small streams in the middle Olifants)	They tend to have a well-defined channel, and are found associated with lower foothill or lowland rivers. Arid valley bottoms are vegetated, usually with reeds and sedges along the water's edge, but often invaded by reeds, *Phragmites australis*, where water is now more permanent as a result of disturbance. The river channels tend to be sandy/silty and unvegetated. Trees (usually alien) occur in the riparian zone. *Acacia karoo* could be expected to naturally occur in valley bottom wetlands.
Sandstone fynbos valley bottom wetlands	Located in the lowlands and higher lying areas, where sandstone fynbos vegetation types occur	They are typically associated with upper and lower foothill river systems, which can be permanent or seasonal, depending on location and aspect. They are fed by hill slope seeps and comprise of a generally well-defined channel with riparian wetland of varying width Floating aquatics can occur in more permanent pools. The underlying soils are derived from sandstones, and are acid. The dominant vegetation is a mix of low to medium height herbaceous species – reeds, restios, grasses, sedges – and scrub shrub-type vegetation – small trees and proteomic and ericoid fynbos species.
Arid seeps	Located along the lower Olifants River (western hill slope and near Ebenhaeser) and its smaller tributaries and are defined by the climate (semi-arid) rather than the underlying geology or soils.	The hill slope are mostly short systems, In the Doring River the seeps are dominated by sedges and grasses, and lie on a mix of acid to alkaline shale- and sandstone-derived soils. Seeps further north tend to be more arid with reeds where there is more permanent water, and riparian trees (*Acacia karoo* and *Prosopis).* Arid seeps are fed primarily by precipitation and upstream surface flow, and are not considered to be particularly important for groundwater recharge.
Sandstone fynbos seeps	Located in the mountain ranges along the Olifants River (Western Cederberg & Kouebokkeveld mountains) and upper reaches of Peddies River (tributary of the Jakkals River) and Lambertshoek River (tributary of the Langvlei).	The seeps are both permanent and non-permanent, depending on location and slope, with those to the north being more arid. The seeps are fairly densely vegetated, and tend to be dominated by restoid (where sands are deeper) and proteoid fynbos and indigenous grasses, but can be invaded by reeds *Phragmites australis* and bulrush *Typha capensis*.
Sand fynbos basin seeps	Occur in the upper Sandlaagte River catchment, the Jakkals River and Verlorenvlei and in the middle to upper Langvlei catchment	The seeps occur on the coastal sand flats at low altitude on acid sands that are deep. The vegetation consists of patches of medium to tall shrubs, separated by dense restiolands. The seeps are generally vegetated, dominated by restios and the rush, *Juncus kraussii*, but can be invaded by the reeds *Phragmites australis* and the bulrush *Typha capensis*, where disturbed. *Sarcocornia natalensis*, which requires seasonal freshwater flooding, can occur in the seeps.
Renosterveld hill slope seeps	Occur within the Renosterveld vegetation types on alkaline shale-derived clays in the upper reaches of tributaries of the Verlorenvlei	They tend to occur on gentle slopes at low altitudes and are dominated by sedges and grasses, but are often impacted and invaded by kikuyu grass, *Typha capensis* and *Phragmites australis*.

Strandveld basin seeps	Occur near the Olifants River mouth, around the upper reaches of the Jakkals River and its tributaries, and north of the Sandlaagte.	They are isolated systems, fed seasonally by precipitation. They tend to occur on neutral to alkaline sands. None of the seeps appear to be important for groundwater recharge. The vegetation type is Cape Inland Salt Pan/Marsh with strandveld surrounding the seep.
Sandstone fynbos depression wetlands	Occur in the upper Jakkals River catchment, inland on gently sloped terrain	The seasonal, shallow (littoral) systems occur in depressions on acid sandstone-derived soils. They are fed by precipitation and are situated in groundwater recharge areas. The depressions are sparsely vegetated and tend to be dominated by restioid and proteoid fynbos and indigenous grasses and sedges, but can be invaded by the reeds *Phragmites australis* and the bulrush, *Typha capensis*.
Sand fynbos depression wetlands	Occur mostly in the west Sandlaagte, Jakkals, Langvlei and Verlorenvlei river catchments	These wetlands are found on acid deep sands, and tend to be fed by groundwater. The majority are isolated, shallow and seasonally inundated. They are mostly muddy or silty depressions which are unvegetated. Where vegetation does occur it is dominated by restios and the rush *Juncus kraussi*.
Strandveld depression wetlands	Situated around the lower Langvlei system, in the Sandlaagte catchment, and a few are scattered around the lower and middle Olifants River	Strandveld depressions tend to be saline and can be vegetated or unvegetated. Those that are vegetated are dominated by grasses (such as *Cynodon dactylon*), *Sarcocornia* spp., and various restios, rushes and sedges.
Arid depression wetlands	Located close to the Sout River in the Knersvlakte, alongside the Moedverloor River (a tributary of the Hol/Sout) and close to the middle Olifants River at its confluence with the Doring River.	All of the arid depressions are fairly saline, ephemeral systems, which are only inundated after good rains in winter. They are silt or mud depressions that are unvegetated, with underlying geology and soils varying from acid to alkaline sands, sandstone- or shale-derived soils.

In addition, the Freshwater Ecosystem Protection Areas (FEPA) were utilised to identify significant wetland areas (Table 3.10). Wetland FEPAs were identified as part of a national FEPA project using ranks that were based on a combination of special features and modelled wetland condition. Special features included expert knowledge on features of conservation importance (e.g. extensive intact peat wetlands, presence of rare plants and animals) as well as available spatial data on the occurrence of threatened frogs and wetland-dependent birds. Wetland condition was modelled using the presence of artificial water bodies as well as by quantifying the amount of natural vegetation in and around the wetland (within 50m, 100m and 500m of the wetland). Based on these factors, wetlands were ranked in terms of their biodiversity importance. Biodiversity targets for wetland ecosystems were met first in high-ranked wetlands, proceeding to lower ranked wetlands only if necessary.

Table 3.10: Freshwater Ecosystem Protection Areas (FEPA) wetland areas within the Olifants Doorn WMA

QUAT No.	Area of Quat (km2)	Total area of FEPA wetlands in quat (km2)	% wetland area to quaternary area	Type of FEPA wetland (%wetland type)	No of wetlands in quaternary	Wetland condition (% of total area of wetlands in category)
E10C	192.5	2.3	1.2	Channelled valley-bottom wetland (36.5) Flat (58.1) Seep (5.1) Valleyhead seep (0.3)	22	AB (84.6) DEF (15.4)
E10D	234.9	12.7	5.4	Channelled valley-bottom wetland (93.0) Flat (6.0) Seep (1.0)	32	AB (16.3) C (0.2) DEF (83.4)
E10E	365.8	21.2	5.8	Channelled valley-bottom wetland (84.8) Flat (1.4) Seep (12.5) Unchannelled valley-bottom wetland (0.8) Valleyhead seep (0.5)	72	AB (9.7) C (1.2) DEF (18.4) Z1 (0.5)
E10H	162.2	5.3	3.3	Channelled valley-bottom wetland (95.8) Flat (0.3) Seep (3.4) Unchannelled valley-bottom wetland (0.5)	27	AB (9) DEF (90)
E10J	468.3	5.2	1.1	Channelled valley-bottom wetland (87.4) Flat (3.4) Seep (8.9) Valleyhead seep (0.3)	11	AB (6) DEF (84) Z1 (10)
E10K	235.3	4.4	1.9	Channelled valley-bottom wetland (46.3) Flat (3.2) Floodplain wetland (45.8) Seep (3.9) Unchannelled valley-bottom wetland (0.7) Valleyhead seep (0.1)	44	AB (50) C (50)
E21C	233.2	1.2	0.5	Channelled valley-bottom wetland (96.9) Valleyhead seep (3.1)	2	AB (100)
E21F	378.6	0.1	0.0	Depression (100.0)	3	AB (100)
E21K	330.3	5.8	1.7	Channelled valley-bottom wetland (99.9)	7	AB (100)
E22G	367.0	1.2	0.3	Channelled valley-bottom wetland (47.9) Flat (17.5) Unchannelled valley-bottom wetland (34.6)	9	AB (100)
E23B	705.3	0.5	0.1	Channelled valley-bottom wetland (84.6) Unchannelled valley-bottom wetland (15.4) Channelled valley-bottom wetland (89.6)	5	AB (100)

QUAT No.	Area of Quat (km2)	Total area of FEPA wetlands in quat (km2)	% wetland area to quaternary area	Type of FEPA wetland (%wetland type)	No of wetlands in quaternary	Wetland condition (% of total area of wetlands in category)
E23C	317.8	0.1	0.0	Channelled valley-bottom wetland (69.1) Unchannelled valley-bottom wetland (30.9)	4	AB (100)
E23D	750.4	5.0	0.7	Channelled valley-bottom wetland (54.2) Depression (3.5) Flat (16.0) Unchannelled valley-bottom wetland (20.7) Valleyhead seep (5.7)	36	AB (100)
E23F	472.8	0.0	0.0	Channelled valley-bottom wetland (100.0)	1	AB (100)
E24A	254.7	0.1	0.1	Channelled valley-bottom wetland (100.0)	4	AB (100)
E24B	467.6	0.0	0.0	Channelled valley-bottom wetland (100.0)	2	AB (100)
E24C	784.0	6.6	0.8	Flat (26.2) Seep (73.8)	69	AB (99) C (1)
E24D	997.5	0.6	0.1	Channelled valley-bottom wetland (82.3) Flat (13.0) Unchannelled valley-bottom wetland (4.7)	17	AB (100)
E24F	582.4	0.0	0.0	Channelled valley-bottom wetland (13.3) Unchannelled valley-bottom wetland (86.7)	2	AB (100)
E24G	632.7	0.0	0.0	Unchannelled valley-bottom wetland (100.0)	2	AB (100)
E24J	1077.8	0.1	0.0	Channelled valley-bottom wetland (75.9) Depression (24.1)	4	AB (100)
E24L	515.8	0.1	0.0	Channelled valley-bottom wetland (100.0)	4	AB (100)
E24M	528.5	0.1	0.0	Channelled valley-bottom wetland (6.6) Flat (84.7) Unchannelled valley-bottom wetland (1.9) Valleyhead seep (6.8)	8	C (100)
E31A	2865.3	8.1	0.3	Channelled valley-bottom wetland (29.7) Depression (67.2) Flat (0.1) Seep (2.6) Unchannelled valley-bottom wetland (0.2) Valleyhead seep (0.2)	34	AB (100)
E31B	1476.5	1.4	0.1	Channelled valley-bottom wetland (5.6) Depression (90.1) Unchannelled valley-bottom wetland (4.2)	19	AB (100)
E31C	1572.2	0.0	0.0	Depression (100.0)	1	AB (100)

QUAT No.	Area of Quat (km2)	Total area of FEPA wetlands in quat (km2)	% wetland area to quaternary area	Type of FEPA wetland (%wetland type)	No of wetlands in quaternary	Wetland condition (% of total area of wetlands in category)
E32A	1117.9	0.8	0.1	Channelled valley-bottom wetland (14.7) Seep (82.9) Unchannelled valley-bottom wetland (2.4)	10	AB (100)
E32B	828.3	0.3	0.0	Channelled valley-bottom wetland (99.9) Valleyhead seep (0.1)	4	AB (100)
E32C	638.1	0.6	0.1	Channelled valley-bottom wetland (93.6) Unchannelled valley-bottom wetland (6.4)	8	AB (75) C (25)
E32E	1001.2	21.6	2.2	Channelled valley-bottom wetland (0.8) Depression (2.3) Flat (54.4) Seep (42.2) Unchannelled valley-bottom wetland (0.3)	187	AB (48) C (47) Z1 (5)
E33A	1354.8	0.0	0.0	Flat (100.0)	1	AB (100)
E33B	701.9	1.2	0.2	Channelled valley-bottom wetland (39.4) Depression (0.8) Flat (33.8) Unchannelled valley-bottom wetland (26.1)	13	AB (100)
E33C	980.1	10.6	1.1	Channelled valley-bottom wetland (73.2) Depression (0.1) Flat (21.8) Seep (1.0) Unchannelled valley-bottom wetland (0.3) Valleyhead seep (3.7)	88	AB (93) C (7)
E33E	1282.3	12.6	1.0	Channelled valley-bottom wetland (85.2) Depression (0.3) Flat (12.2) Floodplain wetland (0.2) Seep (0.1) Unchannelled valley-bottom wetland (0.2) Valleyhead seep (1.8)	98	AB (99.5) C (0.5)
E33G	894.3	17.1	1.9	Channelled valley-bottom wetland (12.4) Flat (3.2) Floodplain wetland (81.2) Seep (1.5) Unchannelled valley-bottom wetland (1.0) Valleyhead seep (0.7)	95	AB (13) C (87)

QUAT No.	Area of Quat (km2)	Total area of FEPA wetlands in quat (km2)	% wetland area to quaternary area	Type of FEPA wetland (%wetland type)	No of wetlands in quaternary	Wetland condition (% of total area of wetlands in category)
E33H	718.5	27.3	3.8	Channelled valley-bottom wetland (74.8) Flat (4.6) Floodplain wetland (15.4) Unchannelled valley-bottom wetland (4.1) Valleyhead seep (0.3_	104	AB (5) C (14) Z1 (6) Z2 (75)
E40B	707.5	0.0	0.0	Valleyhead seep (100.0)	1	AB (100)
E40C	530.0	9.2	1.7	Channelled valley-bottom wetland (33.6) Depression (0.3) Flat (48.5) Seep (11.9) Unchannelled valley-bottom wetland (5.6)	133	AB (43) C (55) Z1 (3)
F60A	570.7	0.0	0.0	Unchannelled valley-bottom wetland (100.0)	2	AB (100)
F60C	621.1	0.0	0.0	Depression (79.8) Flat (20.2)	4	AB (100)
F60D	480.2	0.0	0.0	Floodplain wetland (100.0)	1	AB (100)
F60E	793.5	0.3	0.0	Flat (65.1) Floodplain wetland (23.9) Valleyhead seep (0.8)	10	AB (19) C (16) Z2 (65)
G30A	761.3	31.2	4.1	Channelled valley-bottom wetland (15.3) Depression (2.0) Flat (0.3) Floodplain wetland (10.4) Seep (0.7) Unchannelled valley-bottom wetland (24.9) Valleyhead seep (7.7)	104	AB (35) C (25) Z1 (2) Z2 (38)
G30B	658.4	5.7	0.9	Channelled valley-bottom wetland (73.5) Depression (15.8) Flat (6.0) Seep (3.4) Unchannelled valley-bottom wetland (1.0) Valleyhead seep (0.2)	126	AB (10) C (69) Z1 (20)
G30C	351.2	5.4	1.5	Channelled valley-bottom wetland (93.0) Flat (1.8) Seep (5.1)	18	AB (7) C (93)

QUAT No.	Area of Quat (km2)	Total area of FEPA wetlands in quat (km2)	% wetland area to quaternary area	Type of FEPA wetland (%wetland type)	No of wetlands in quaternary	Wetland condition (% of total area of wetlands in category)
G30D	534.5	4.0	0.8	Channelled valley-bottom wetland (26.2) Flat (0.6) Floodplain wetland (71.5) Seep (1.8)	9	AB (3) C (97)
G30E	352.0	28.0	7.9	Channelled valley-bottom wetland (0.5) Depression (0.1) Flat (1.0) Floodplain wetland (24.7) Seep (2.3) Unchannelled valley-bottom wetland (0.2)	64	AB (3) C (24) Z1 (1) Z2 (71) Z3 (1)
G30F	779.9	11.6	1.5	Channelled valley-bottom wetland (45.5) Flat (2.5) Seep (0.2) Unchannelled valley-bottom wetland (7.7) Valleyhead seep (0.2)	48	AB (5) C (46) Z1 (5) Z2 (44)
G30G	647.2	5.7	0.9	Channelled valley-bottom wetland (80.7) Depression (5.1) Seep (10.7) Unchannelled valley-bottom wetland (3.4)	23	AB (11) C (89)
G30H	1077.3	15.5	1.4	Channelled valley-bottom wetland (42.9) Depression (0.1) Flat (7.1) Floodplain wetland (1.9) Seep (42.3) Unchannelled valley-bottom wetland (5.0) Valleyhead seep (0.6)	90	AB (25) C (60) Z1 (15)

Although wetland condition was a factor in selection of wetland FEPAs, wetlands did not have to be in a good condition (A or B ecological category) to be chosen as a FEPA. Wetland FEPAs currently in an A or B ecological condition should be managed to maintain their good condition. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition.

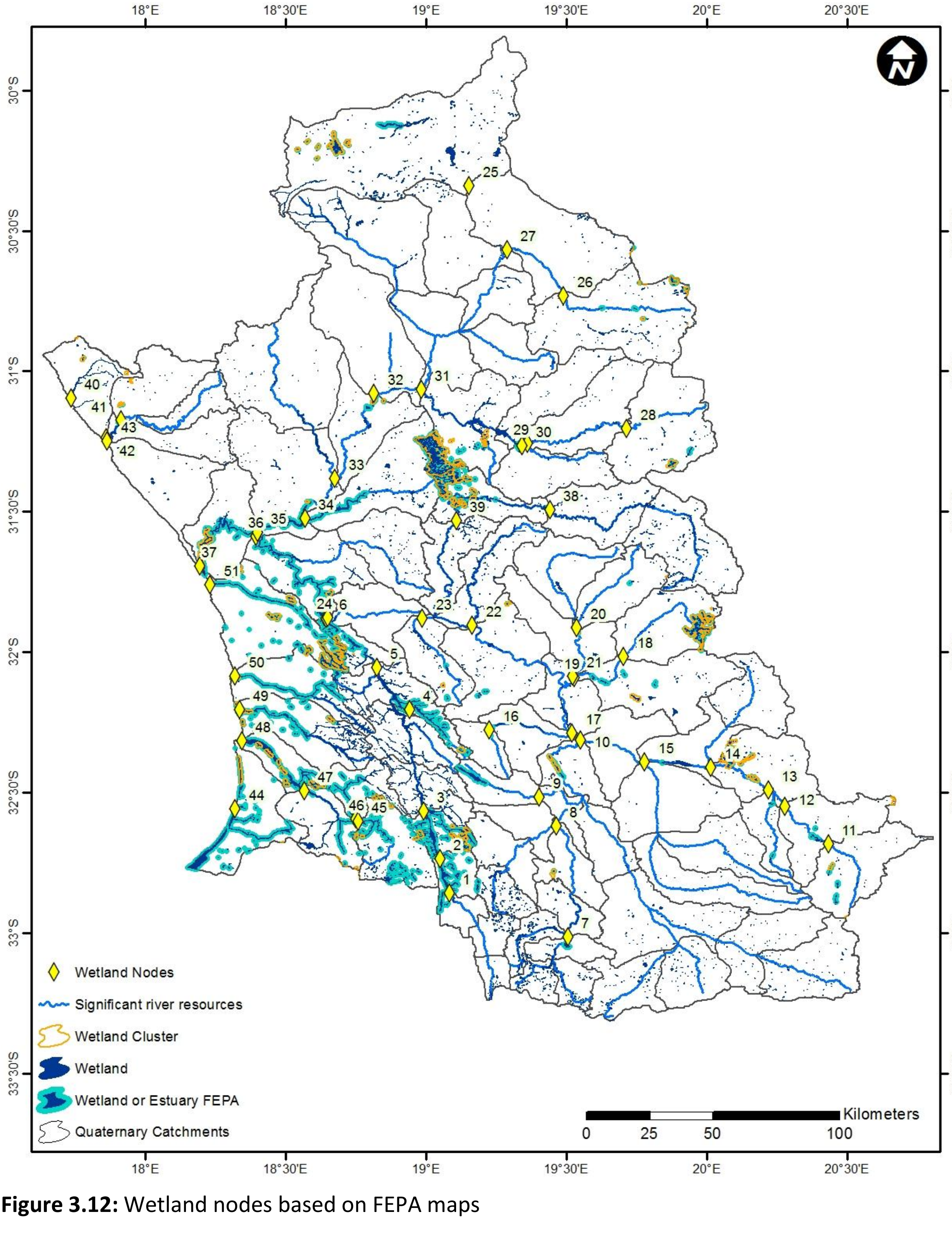

Figure 3.12: Wetland nodes based on FEPA maps

ESTUARY NODES:

In accordance with the WRCS procedure, estuary nodes were placed at the downstream end (at the interface with the sea) for the significant estuaries identified in Section 3.1 of this report. These nodes are intended to provide the relationships that will be used to predict the responses of the upstream estuarine ecosystem to changes in water quality, quantity and timing. Thus two estuary nodes were placed at the mouth of the Olifants River Estuary and the mouth of Verlorevlei (Figure 3.13).

Olifants River Estuary

The Olifants estuary has a total area of 702 ha of typical estuarine habitat plus 797 ha of floodplain saltmarsh, together making up 1 499 ha. The estuary extends from its permanently open mouth (31°42'S; 18°11.34'E) some 36 km upstream to the low water causeway near Lutzville (31º33.8'S; 18º19.78'E). The lateral extent of the estuary is defined by the limit of estuarine vegetation, including floodplain saltmarsh.

Figure 3.13: Google Earth image of the Olifants River Estuary with the river (R7) and estuary nodes (E1)

It is one of the largest of South Africa's estuaries and is considered to be one of the most important estuaries in the country from a conservation perspective. The estuary is also one of the least developed of the large permanently-open estuaries in South Africa which provides a valuable sanctuary for flora and fauna. Birds are an important component of the estuary's biodiversity, where the diversity and numbers of birds are very high, due to the size and diversity of habitats on the estuary and its lack of disturbance. A total of 38 fish species from 30 families have also been recorded in the Olifants River Estuary. These include some highly valuable species such as white steenbras, as well as harders. The estuaries on the west coast are crucial in maintaining the range and stock integrity of estuarine and estuarine dependent species along the entire west coast, and the Olifants estuary is an important nursery area.

Verlorevlei Estuary

Verlorenvlei Estuary (32°24'S 018°26'E) is a relatively small estuary which connects the Verlorenvlei Lake to the sea. The channel is approximately 2.6 km long. It is shallow and hydraulically inactive as a rocky sand-covered bar and some artificial barriers obstruct the mouth, resulting in the system being closed to the sea for much of the time. At the time of its promulgation (1986) as a RAMSAR site, Verlorenvlei was described as a 'fresh oligotrophic lake' with areas of marsh and reedswamp covering a total area of 1 500 ha. The vlei was deemed of importance as a feeding area for the rare white pelican (*Peleanus onocrotalus*).

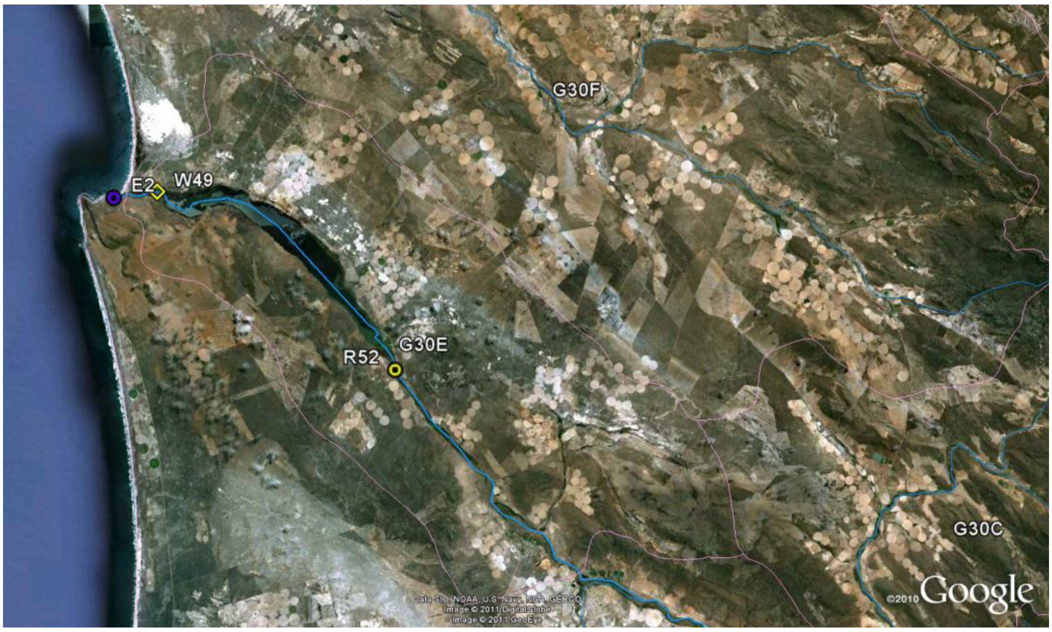

Figure 3.14: Google Earth image of the lower Verlorenvlei system with the river (R7), wetland (W49) and estuary nodes (E1)

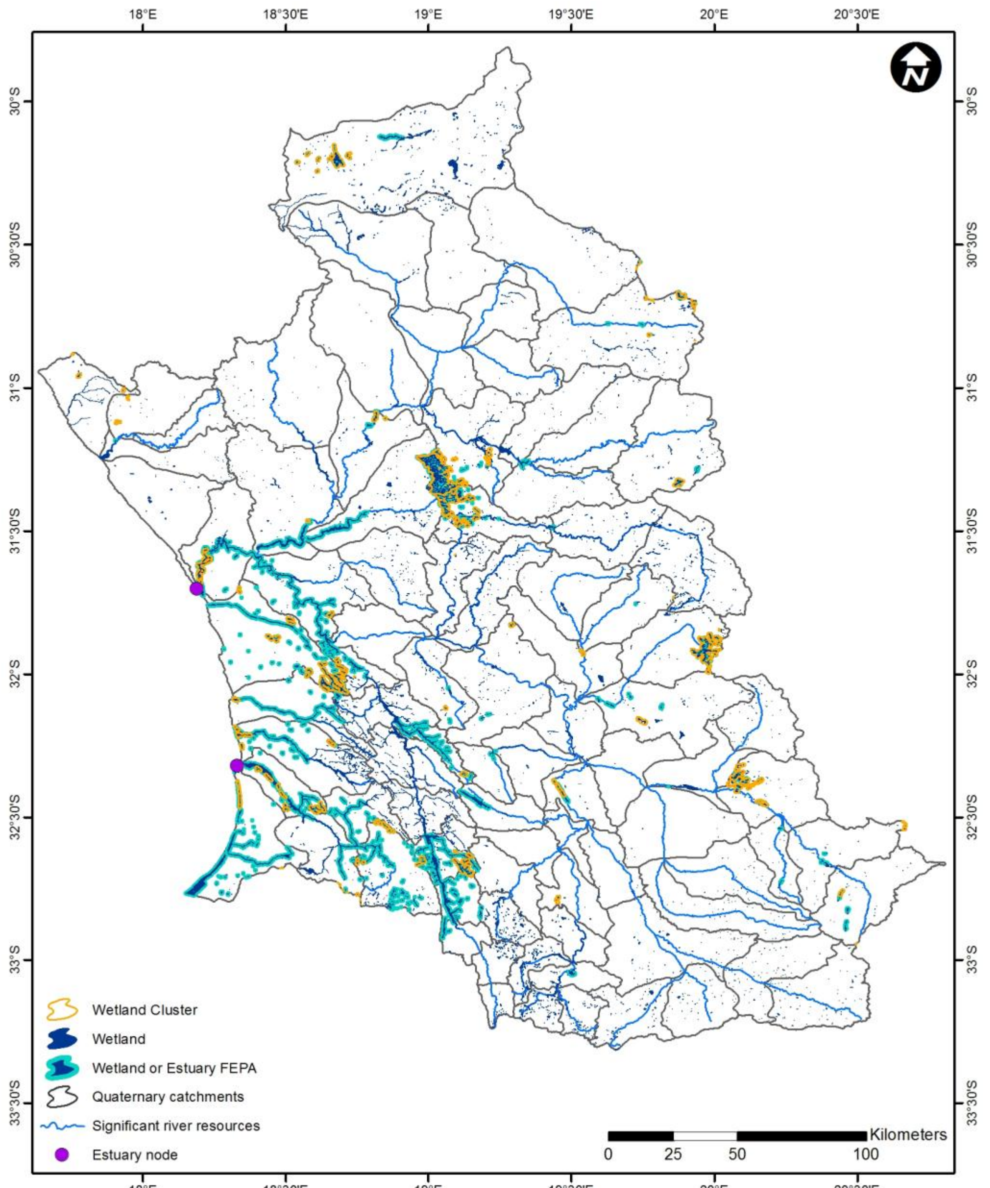

Figure 3.15: Estuary nodes

3.3. HYDROLOGY

3.3.1. Previous Studies

The hydrology for the Olifants Doorn Water Management Area (WMA) was derived for the period 1920-2004 using the available data from the latest studies in the respective catchments of the WMA and extended using patched rainfall data from the WR2005 study and information from previous studies. Table 3.11 provides a summary of the previous studies in the Olifants Doorn WMA.

Table 3.11: Previous studies in the Olifants Doorn WMA

Study	Reference	Upper Olifants	Doring	Lower Olifants
Olifants River System Analysis	DWAF, 1990	Calibration of Hydrology (1920-1988) and system analysis	-	-
	DWAF, 1994		Calibration of Hydrology (1920-1990) using data from 1:50 000 topographical maps	
Olifants/Doring River Basin Study	DWAF, 1998	Extension of Hydrology (1920-1990)	Updated land-use data obtained from DWAF. Calibration of Hydrology (1920-1990)	Extension of Hydrology using WR90 (1920-1990)
Olifants/Doring River Basin Study (Phase II)	DWAF, 2003	P4-1 states that "the hydrological records for the Olifants and Doring River Catchments were extended by 10 years from 1989 to 1999". A report detailing this study could not be obtained and a copy of the files used for the system configuration was obtained from Stephen Mallory. In the Clan-dwn.inc file the streamflows for the years starting in Oct 1998 and Oct 1999 are identical. Consequently, the inflow sequences were omitted in favour of historical sequences generated as part of this study.		
Western Cape Olifants/Doring River Irrigation Study	PGWC, 2001	The draft copy of the main report states that "This yield analysis task was excluded from the WODRIS and done under a separate assignment for the DWAF", Phase II of the Olifants/Doring River Basin Study (see above).		
Olifants Doring Catchment Ecological Water Requirements Study	DWAF 2006 DWAF 2005a	No hydrological analysis – Recommend stream flow requirements at selected sites in the Olifants/Doring including upstream of Clanwilliam Dam, downstream of the Bulshoek Barrage and at the estuary.		
Olifants/Doring Water Management Area : Water Resources Situation Assessment	DWAF, 2002	No hydrological analysis – some synthesis of demands.		
Olifants/Doorn Water Management Area: Internal Strategic Perspective	DWAF 2005b	No hydrological analysis – some synthesis of demands.		
Feasibility Study for the Raising of Clanwilliam Dam in the Western Cape	DWAF 2009	Determine historical inflow sequences for the period 1991 to 2005 to check the severity of the 2003 to 2005 drought.		
Water Resources of South Africa, 2005 Study (WR2005)	WRC, 2009	Calibration of hydrology and update of WR90 for period 1920-2004		

The hydrology in the Upper Olifants catchment was only calibrated during the ORSA, and natural flows generated for the period 1920-1989., It has not been updated since this study. It was extended to 1990 in Phase I of the ORBS, and later extended to 1998 in Phase II. The hydrology for the Feasibility Study for the Raising of Clanwilliam Dam (DWAF, 2009) is the same as that used in the ORBS Phase II (1920-1998). The hydrology derived for the analysis in this project is described in further detail in the sections below.

Upper Olifants catchment

For the Upper Olifants catchment, comprising tertiary catchment E10, representing the catchments upstream of Clanwilliam Dam and Bulshoek dam respectively, the hydrology was calibrated during the Olifants River System Analysis Study (ORSA) (DWAF, 1990) and was used as a point of departure for the extension of monthly hydrology sequences. The hydrology from the ORSA was then taken forward eventually to the Feasibility Study for the Raising of Clanwilliam Dam (DWAF, 2009) and was used in the system model analysis.

The rainfall station groupings and the calibration parameters used to generate naturalised runoffs for the catchments upstream of Clanwilliam Dam from the DWAF (1990) study, were used to extend and update the rainfall and stream flow sequences to the 2004 hydrological year in the WRSM2000. The extended flow sequences were verified by comparing the updated hydrological sequences to those from the ORSA. The comparison of the annual flows for the period 1920-1990 show that the WRSM2000 is adequately replicating the runoff that was previously generated and that the extended sequence can be used with confidence. Figures 3.16 to Figure 3.18 show the annual flow comparisons graphically where the observed flow represents the annual time series from the ORSA.

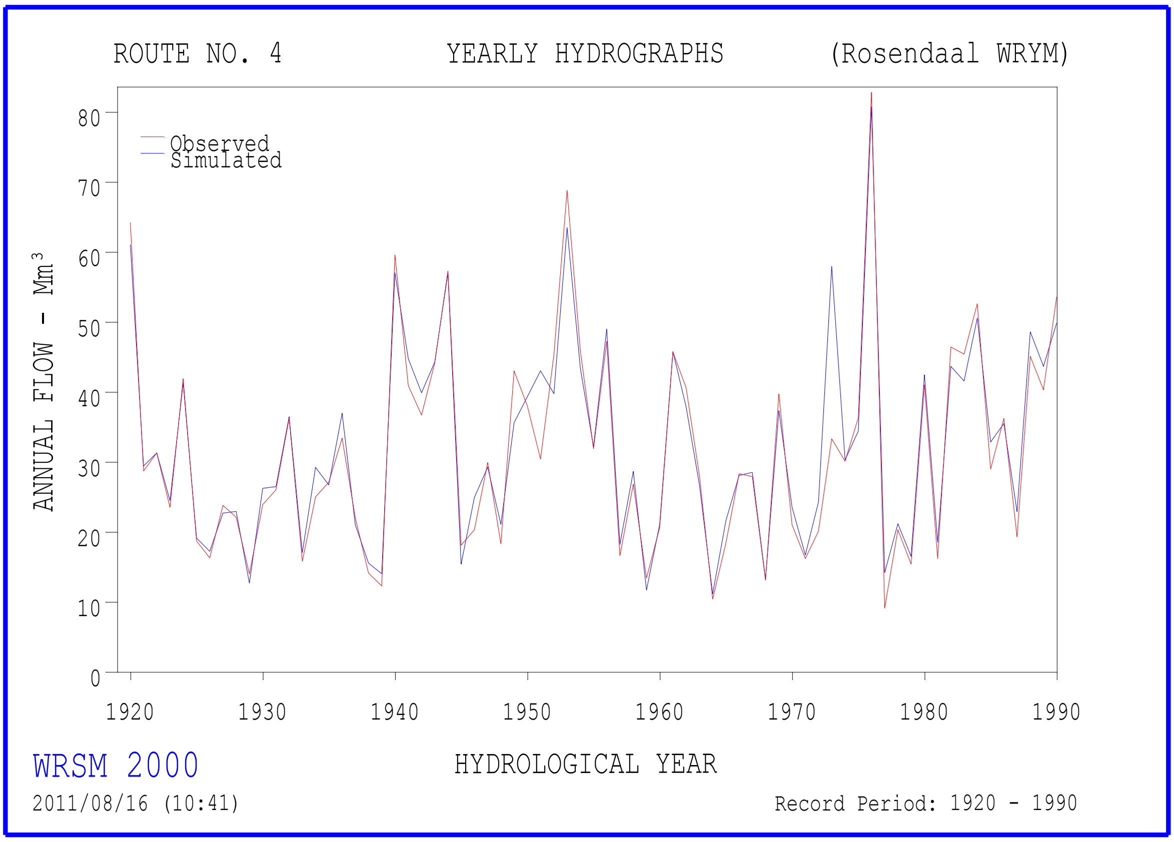

Figure 3.16: Annual flows for sub catchment 1a and 1b – Rosendaal Dam

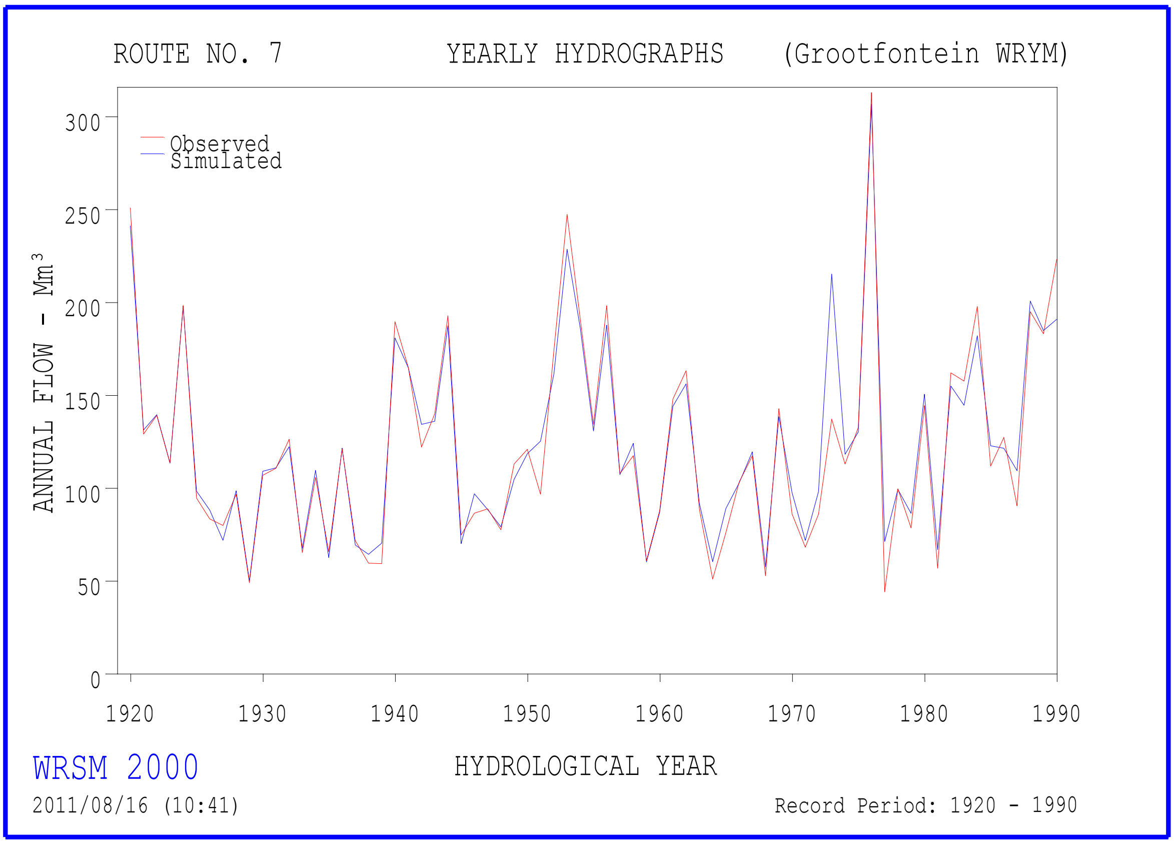

Figure 3.17: Annual flows for subcatchment 2a and 2b – Grootfontein Dam

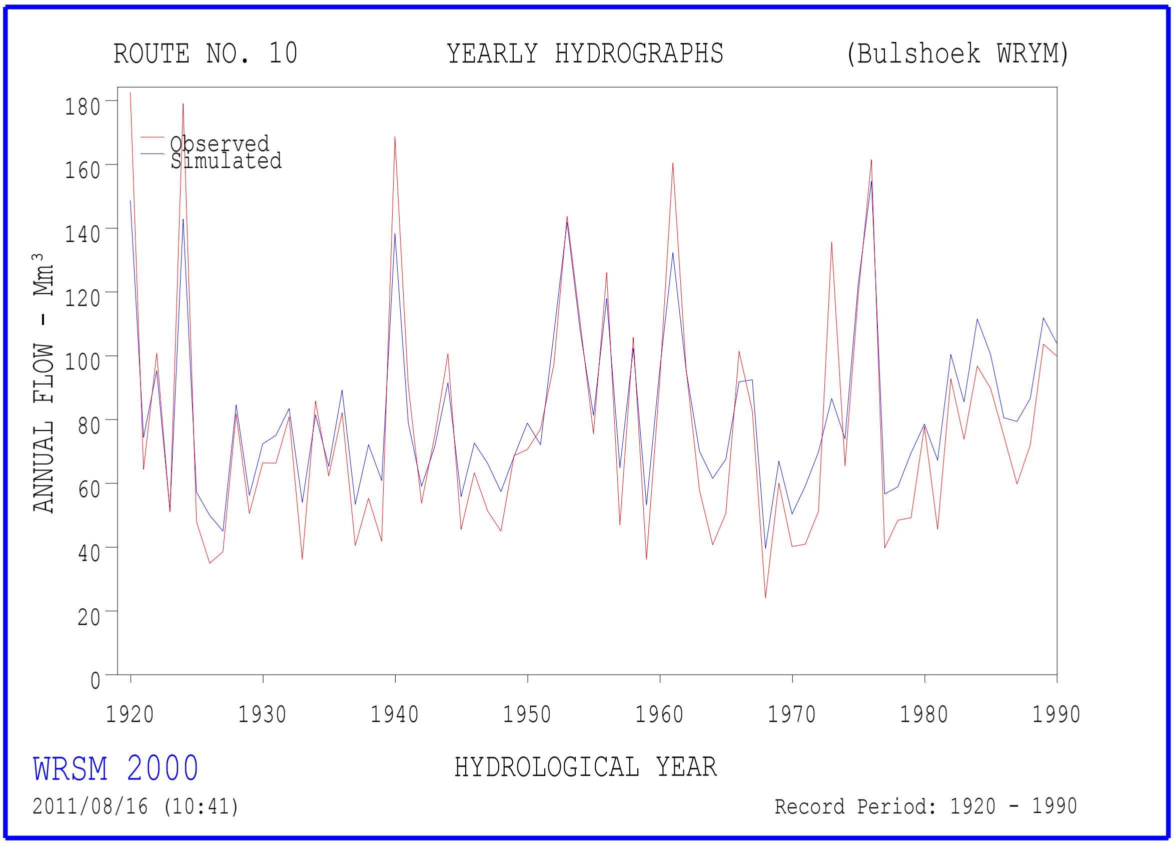

Figure 3.18: Annual flows for subcatchment 4a and 4b – Bulshoek Dam

Following the generation of stream flow sequences for the corresponding catchments in the ORSA, it was necessary to disaggregate the sequences to quaternary catchments – the breakdown of which is presented in Table 3.12. Quaternary catchment E10K was modelled using parameters from WR2005.

Table 3.12: Intersection of quaternary catchments with ORSA catchments based on area and weighted MAP

Catchment (ORSA) (* catchments that cross quaternary boundaries)	**Area**	**MAP**	**Quaternary intersection**	**Area***	**MAP***	**Cumulative area**
1a	35	773	E10A	35	773	35
1b	52	907		52	907	87
2b*	276	784		47	984	134
2a	82	592	E10B	82	592	216
2b*	276	784		120	834	336
2b*	276	784	E10C	109	642	445
3a*	679	466		83	514	528
3a*	679	466	E10D	235	518	763
3a*	679	466	E10E	361	421	1124
3b*	909	404		5	273	1129
3b*	909	404	E10F	386	407	1515
3b*	909	404	E10G	508	407	2023
4a	160	600	E10H	162	400	2185
3b*	909	404	E10J	10	201	2195
4b*	576	336		458	347	2653

Koue Bokkeveld and Doring catchments

In the Olifants/Doring River Basin Study, the Doring catchments were calibrated on two flow gauges in the Doring catchment: E2H002 and E2H003 using the SHELL model., The catchment was divided into four sub-catchments and land use was obtained from DWAF., The calibrated Pitman model was used to generate long term flow sequences for the natural and the present day cases for the period from 1920-1991., The Doring catchment has not been calibrated subsequent to this study and as such, the calibrated Pitman parameters and rainfall station information for the sub-catchments were used in the current study and patched rainfall up to 2005 from the WR2005 study was used to extend the catchment rainfall sequences., Following the verification methodology applied in the Olifants catchment, the flow sequences for the Doring sub-catchments were replicated in the WRSM2000 software using the SHELL configuration and compared to the original sequences from the ORBS (DWAF, 1994)., Comparison of the annual flows at proposed dam sites in that study is presented in Figure 3.19 to Figure 3.24.

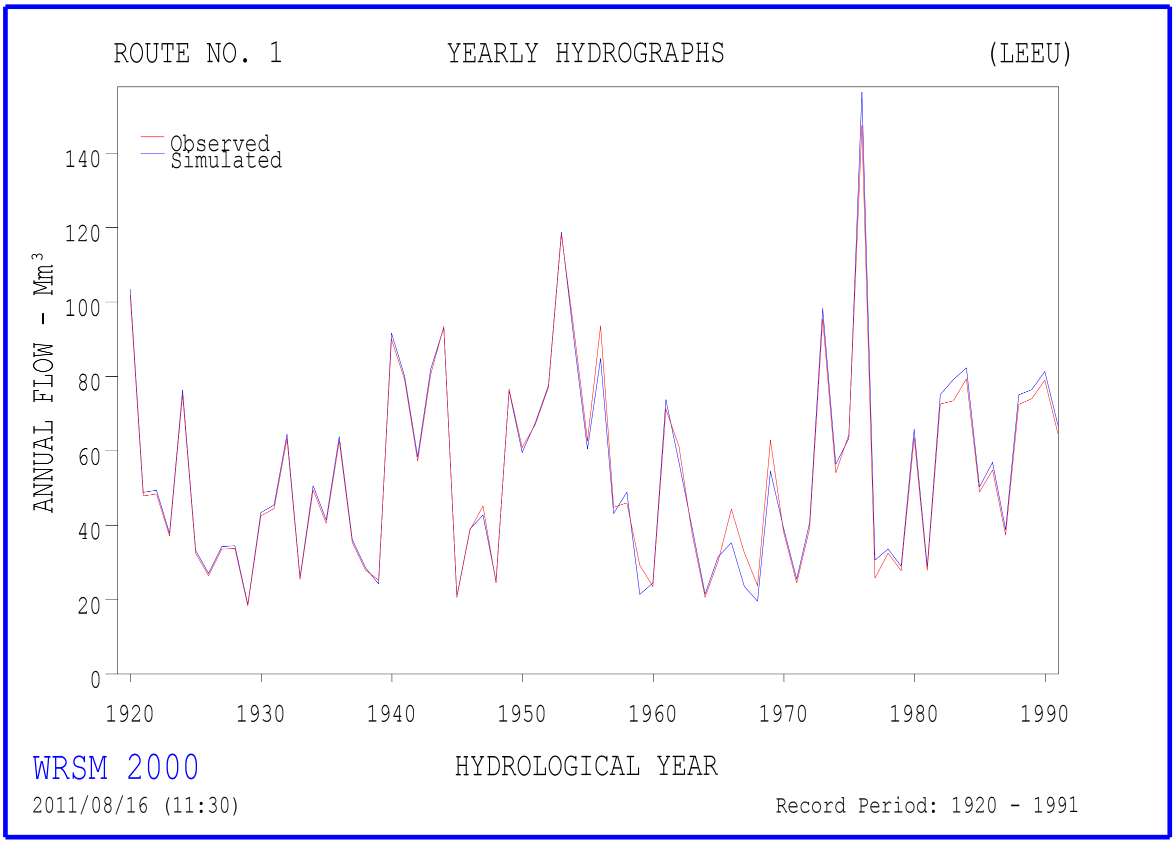

Figure 3.19 Comparison of annual flows for Leeu catchment

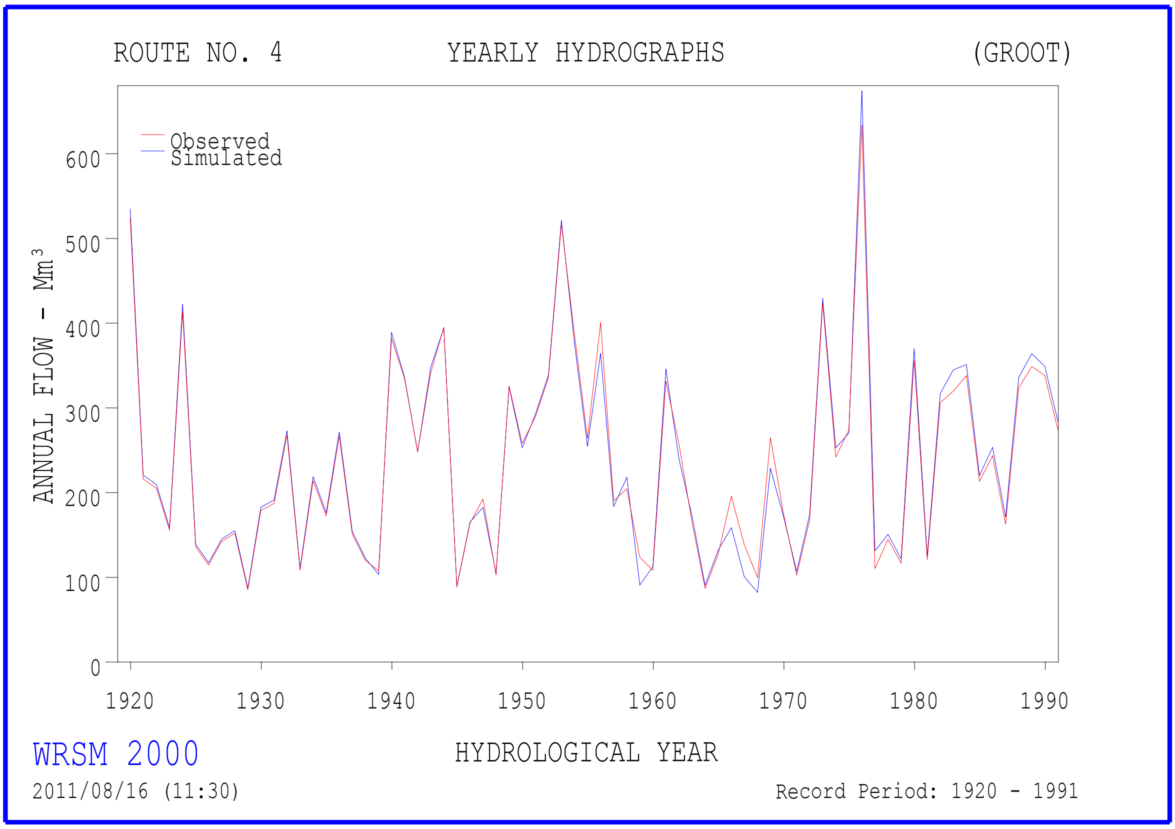

Figure 3.20: Comparison of annual flows for Groot catchment

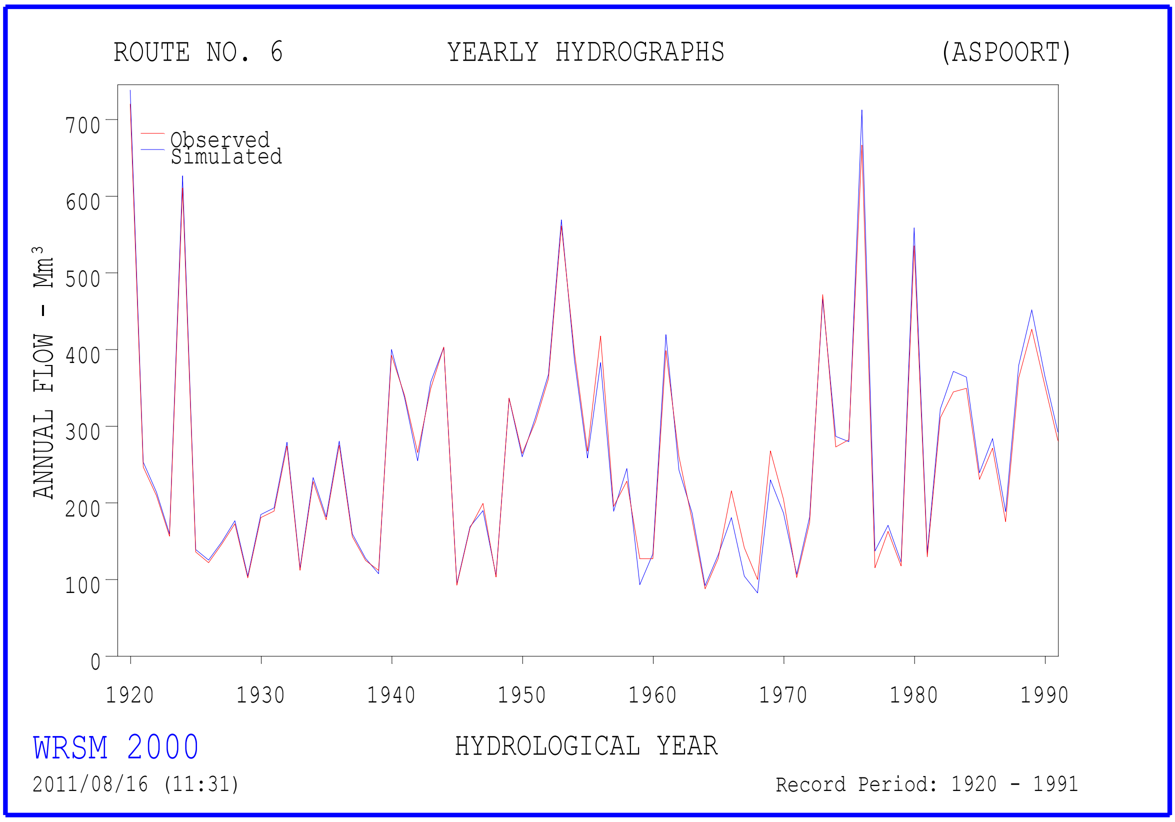

Figure 3.21: Comparison of annual flows for Aspoort Dam catchment

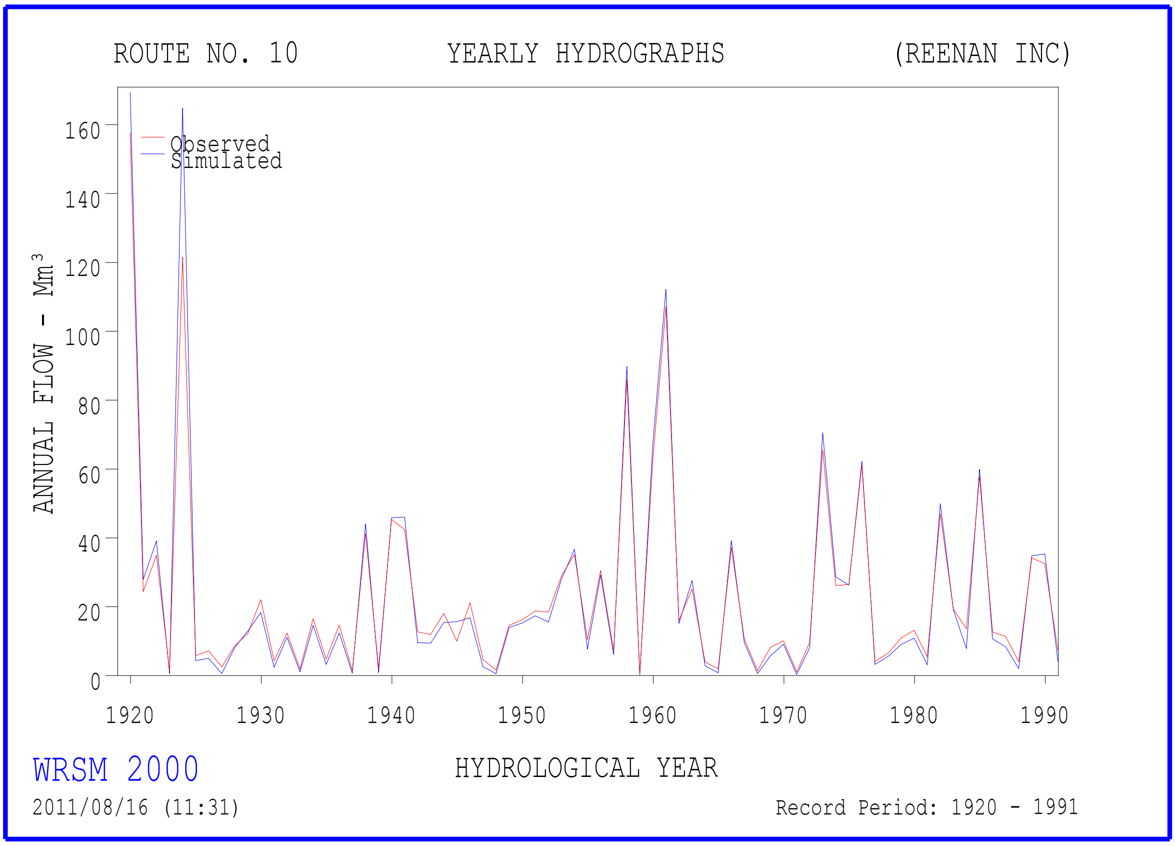

Figure 3.22: Comparison of annual flows for incremental Reenan Dam catchment

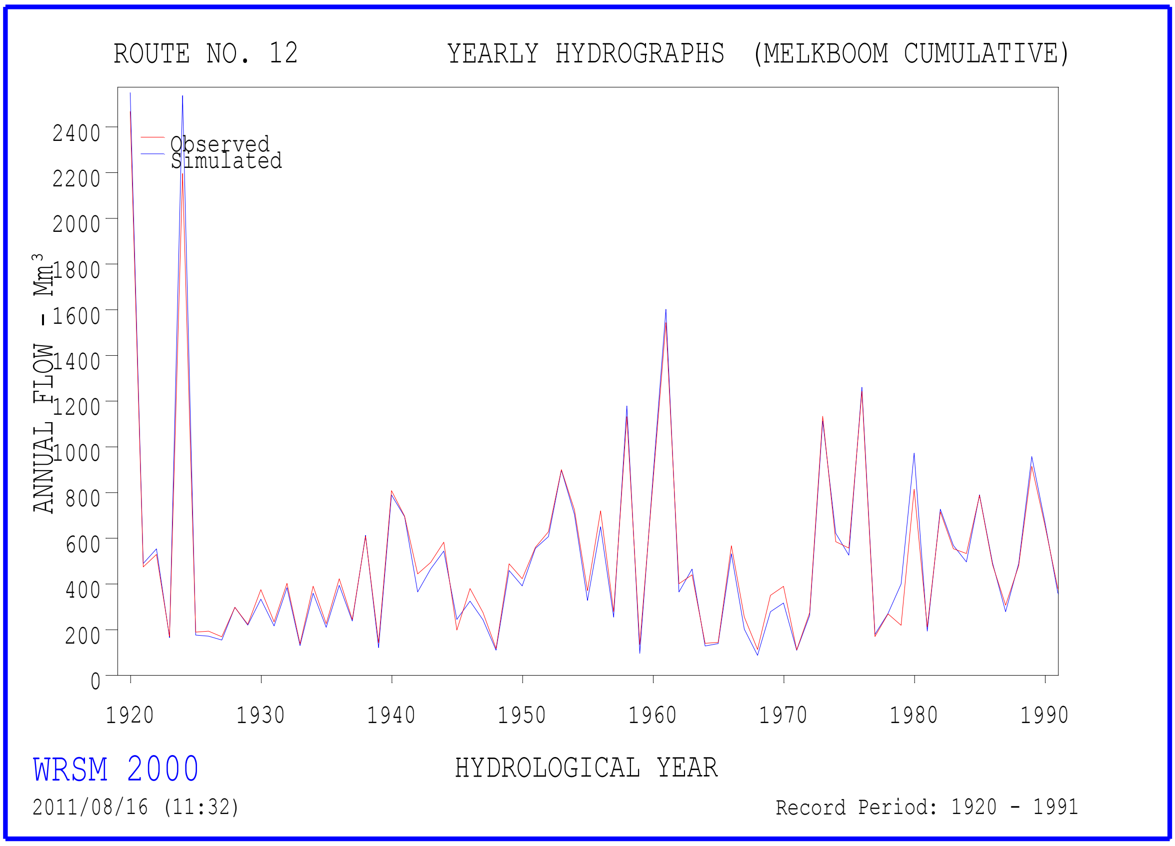

Figure 3.23: Comparison of annual flows for cumulative Melkboom Dam catchment

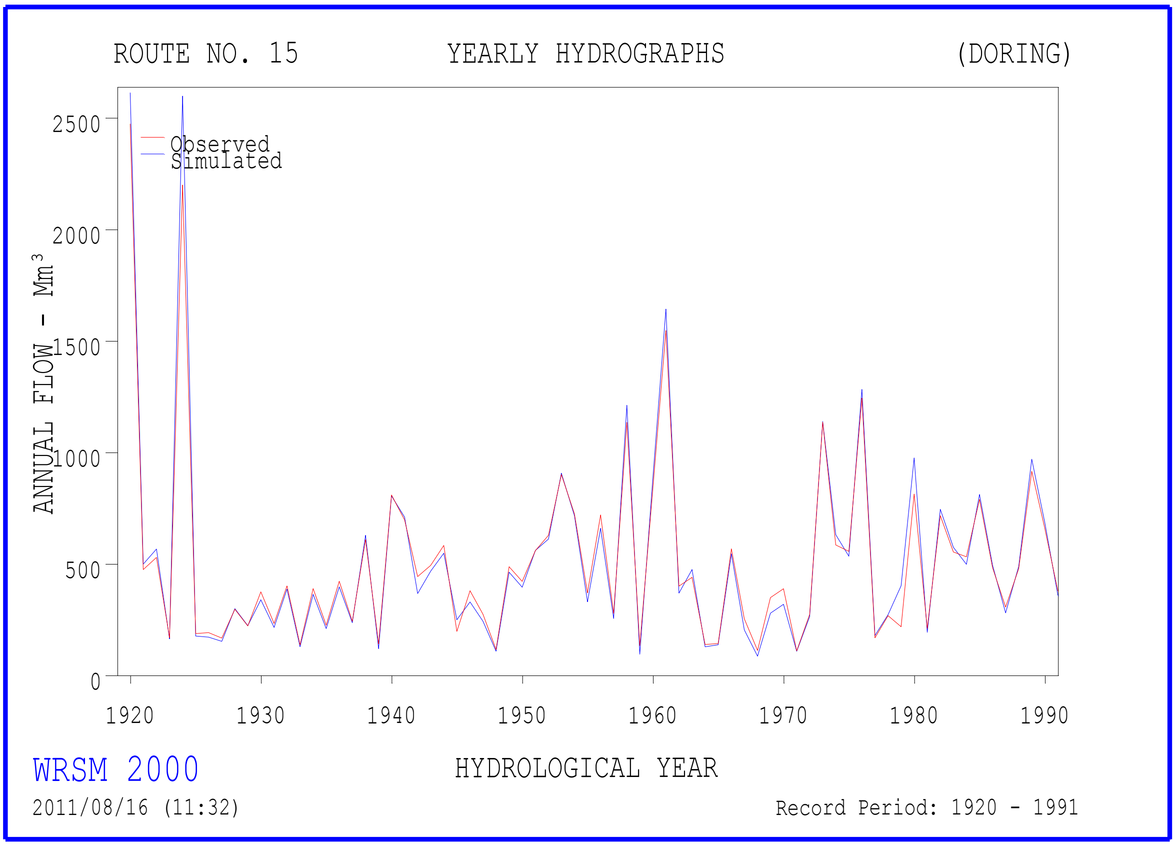

Figure 3.24: Comparison of annual flows for cumulative Doring catchment

Following the generation of stream flow sequences for the corresponding catchments in the ORSA, the parameters for each catchment were transferred to the quaternary catchments that comprise the larger catchments., In order to replicate the cumulative flows in the ORSA, it was necessary to model each quaternary with the same MAP as for the larger catchment because unique quaternary MAPs from the WR2005 resulted in overestimation of catchment runoff once the quaternaries were aggregated to the ORSA catchments. A summary of the ORSA catchment MARs and aggregated quaternary MARs is presented in Table .

Table 3.13: Summary of Doring catchment MARs

ORSA catchment	ORSA 1920-1991 (SHELL)	Aggregated Quaternary MAR 1920-1991 (WR2005 MAP)	Aggregated Quaternary MAR 1920-1991 (Lumped MAP)	% Diff from SHELL (WR2005 MAP)	% Diff from SHELL (Lumped MAP)
D01	224.8	202.1	218.2	-10%	-3%
D02	31.4	50.1	31.7	60%	1%
D03	68.5	82.9	65.5	21%	-4%
D04	189.2	210.3	190.1	11%	0%
Total	**513.8**	**545.3**	**505.4**	**6%**	**-2%**

Knersvlakte, Lower Olifants and Sandveld catchments

Hydrology in the remaining catchments in the WMA, comprising tertiaries E31, E32, E33, F60 and G30 was obtained from the WR2005 study since these catchments have not been previously investigated in further detail.

3.3.2. Updated Hydrology

Natural flows

The updated natural hydrology for each quaternary catchment in the Olifants Doorn WMA is summarised in Table 3.14.

Table 3.14: Natural hydrology for quaternary catchments in the Olifants Doorn WMA

Quaternary catchment	Tertiary	Incremental Natural MAR 1920-2004	Cumulative Natural MAR 1920-2004
E10A	E10	60.5	60.5
E10B	E10	68.5	129.0
E10C	E10	53.4	182.4
E10D	E10	51.4	233.8
E10E	E10	59.7	293.5
E10F	E10	62.1	355.6
E10G	E10	81.7	437.3
E10H	E10	31.1	31.1
E10J	E10	29.8	498.2

Quaternary catchment	Tertiary	Incremental Natural MAR 1920-2004	Cumulative Natural MAR 1920-2004
E10K	E10	7.6	505.7
E21A	E21	39.4	39.4
E21B	E21	1.2	40.7
E21C	E21	1.3	41.9
E21D	E21	50.2	92.2
E21E	E21	1.6	93.8
E21F	E21	2.1	95.9
E21G	E21	55.2	55.2
E21H	E21	83.5	138.7
E21J	E21	1.8	236.3
E21K	E21	1.8	1.8
E21L	E21	1.1	239.2
E22A	E22	4.1	4.1
E22B	E22	3.5	7.7
E22C	E22	2.7	2.7
E22D	E22	2.7	5.4
E22E	E22	5.6	18.7
E22F	E22	2.2	20.9
E22G	E22	6.5	266.6
E23A	E23	8.0	8.0
E23B	E23	7.4	15.4
E23C	E23	3.3	3.3
E23D	E23	7.9	26.6
E23E	E23	5.9	5.9
E23F	E23	5.0	37.5
E23G	E23	7.8	7.8
E23H	E23	6.9	14.8
E23J	E23	9.4	24.2
E23K	E23	6.0	334.3
E24A	E24	4.5	4.5
E24B	E24	8.3	12.8
E24C	E24	13.9	13.9
E24D	E24	17.6	31.5
E24E	E24	11.9	11.9
E24F	E24	10.3	22.1
E24G	E24	11.2	64.8
E24H	E24	8.5	420.4
E24J	E24	19.1	439.5
E24K	E24	11.5	499.1
E24L	E24	9.1	508.2
E24M	E24	9.4	517.6
E31A	E31	0.2	0.2
E31B	E31	1.0	1.0
E31C	E31	1.0	2.0
E31D	E31	0.6	2.6
E31E	E31	0.3	2.9
E31F	E31	0.3	3.2
E31G	E31	0.8	0.8
E31H	E31	0.5	4.5
E32A	E32	4.0	4.0
E32B	E32	3.0	7.0
E32C	E32	2.3	9.3
E32D	E32	2.2	11.5
E32E	E32	3.6	19.7
E33A	E33	0.9	20.6
E33B	E33	0.7	21.3
E33C	E33	1.0	1.0
E33D	E33	1.6	1.6
E33E	E33	1.3	25.2

Quaternary catchment	Tertiary	Incremental Natural MAR 1920-2004	Cumulative Natural MAR 1920-2004
E33F	E33	4.5	4.5
E33G	E33	0.9	1054.0
E33H	E33	0.7	1054.7
E40A	E40	16.6	16.6
E40B	E40	12.5	29.1
E40C	E40	9.4	38.5
E40D	E40	9.6	48.1
F60A	F60	0.2	0.2
F60B	F60	0.2	0.2
F60C	F60	0.4	0.5
F60D	F60	0.3	0.8
F60E	F60	0.1	0.1
G30A	G30	9.8	9.8
G30B	G30	15.3	15.3
G30C	G30	17.5	32.7
G30D	G30	14.1	46.8
G30E	G30	6.8	53.6
G30F	G30	13.3	13.3
G30G	G30	5.3	5.3
G30H	G30	6.8	6.8
TOTAL		**1145.1**	**1145.1**

Present day flows

Present day flows in the Olifants Doorn WMA were derived from the Clanwilliam WRYM configuration for the Upper Olifants, Koue Bokkeveld and Doring catchments and disaggregated to relevant quaternary catchments based on land use areas from WR2005. For the remaining catchments, the present day flows from WR2005 are reported.

Table 3.15: Present day hydrology for quaternary catchments in the Olifants Doorn WMA

Quaternary catchment	Tertiary	Incremental present day demands (million m^3/a)	Incremental Present day Use (million m^3/a)	Incremental Present day flows (million m^3/a)
E10A	E10	7.0	4.4	56.1
E10B	E10	11.3	5.8	62.8
E10C	E10	5.3	3.0	50.4
E10D	E10	13.4	9.8	41.6
E10E	E10	16.7	12.2	47.6
E10F	E10	11.8	8.6	53.5
E10G	E10	21.6	15.8	66.0
E10H	E10	0.0	0.0	31.1
E10J	E10	0.0	0.0	29.8
E10K	E10	0.0	0.0	7.6
E21A	E21	12.7	8.8	30.6
E21B	E21	4.7	3.2	0.0
E21C	E21	3.6	2.5	0.0
E21D	E21	18.0	12.4	37.9
E21E	E21	8.7	6.0	0.0
E21F	E21	4.5	3.1	0.0
E21G	E21	16.6	16.6	38.7
E21H	E21	7.1	4.9	78.6
E21J	E21	5.8	4.0	0.0
E21K	E21	3.8	2.6	0.0
E21L	E21	0.1	0.0	1.1
E22A	E22	1.7	0.5	3.6
E22B	E22	2.9	0.9	2.7

Quaternary catchment	Tertiary	Incremental present day demands (million m^3/a)	Incremental Present day Use (million m^3/a)	Incremental Present day flows (million m^3/a)
E22C	E22	5.3	1.6	1.1
E22D	E22	0.8	0.3	2.5
E22E	E22	1.8	0.6	5.0
E22F	E22	2.2	0.7	1.5
E22G	E22	1.6	0.7	5.8
E23A	E23	0.3	0.2	7.8
E23B	E23	0.5	0.4	7.0
E23C	E23	0.2	0.1	3.2
E23D	E23	0.8	0.6	7.3
E23E	E23	0.9	0.7	5.3
E23F	E23	4.6	3.2	1.8
E23G	E23	0.1	0.1	7.8
E23H	E23	0.1	0.1	6.9
E23J	E23	2.8	2.0	7.4
E23K	E23	6.8	4.8	1.2
E24A	E24	1.0	0.7	3.8
E24B	E24	1.0	0.7	7.6
E24C	E24	2.0	0.7	13.1
E24D	E24	1.7	0.6	17.0
E24E	E24	0.1	0.1	11.8
E24F	E24	0.1	0.0	10.3
E24G	E24	1.2	0.5	10.7
E24H	E24	3.2	1.9	6.7
E24J	E24	1.5	0.6	18.5
E24K	E24	0.1	0.0	11.5
E24L	E24	4.7	1.7	7.4
E24M	E24	3.1	1.5	7.9
E31A	E31	0.0	0.0	0.2
E31B	E31	0.6	0.6	0.4
E31C	E31	0.0	0.0	1.0
E31D	E31	0.1	0.1	0.5
E31E	E31	0.1	0.1	0.3
E31F	E31	0.2	0.2	0.1
E31G	E31	0.0	0.0	0.8
E31H	E31	0.1	0.1	0.4
E32A	E32	0.2	0.2	3.8
E32B	E32	0.1	0.1	2.9
E32C	E32	0.1	0.1	2.2
E32D	E32	0.2	0.2	2.0
E32E	E32	3.1	3.1	0.5
E33A	E33	0.1	0.1	0.8
E33B	E33	0.0	0.0	0.7
E33C	E33	0.0	0.0	1.0
E33D	E33	0.0	0.0	1.6
E33E	E33	0.0	0.0	1.3
E33F	E33	0.0	0.0	4.5
E33G	E33	0.3	0.3	0.6
E33H	E33	0.2	0.2	0.5
E40A	E40	2.2	0.8	15.8
E40B	E40	2.0	0.7	11.8
E40C	E40	5.7	2.1	7.3
E40D	E40	0.5	0.2	9.4
F60A	F60	0.0	0.0	0.2
F60B	F60	0.0	0.0	0.2
F60C	F60	0.0	0.0	0.4
F60D	F60	0.0	0.0	0.3
F60E	F60	0.0	0.0	0.1
G30A	G30	4.8	4.8	5.1

Quaternary catchment	Tertiary	Incremental present day demands (million m^3/a)	Incremental Present day Use (million m^3/a)	Incremental Present day flows (million m^3/a)
G30B	G30	3.1	3.1	12.2
G30C	G30	6.1	6.1	11.4
G30D	G30	5.0	5.0	9.1
G30E	G30	1.1	1.1	5.7
G30F	G30	4.6	4.6	8.7
G30G	G30	2.3	2.3	3.0
G30H	G30	0.8	0.8	6.0
TOTAL		**269.8**	**186.7**	**970.0**

3.4. WATER QUALITY

3.4.1. Overview of water quality in the Olifants-Doorn WMA

Water quality in the upper Olifants River, upstream of Clanwilliam Dam, is suitable for all uses. There is evidence of elevated phosphate concentrations which may be the result of agricultural activities and wastewater return flows in the Citrusdal area. The good quality water is stored in Clanwilliam Dam and Bulshoek Dam from where it is distributed via a system of canals to irrigation farmers in the middle and lower Olifants River valley. In the Olifants River downstream of Clanwilliam Dam and upstream of the Doring River confluence, the water quality remains suitable for agriculture and domestic water supplies although minor impacts of irrigation return flows and treated effluent discharges (elevated phosphate concentrations) are already evident., The Olifants River downstream of the Doring River confluence is progressively impacted by irrigation return flows from the highly cultivated Lower Olifants River irrigation scheme., The result is that water in the lower Olifants River just before the estuary (E1H018) is poor and salinity exceeds the requirement for irrigation use.

Previous studies (Department of Water Affairs and Forestry, 1998) found that there was a difference between unimpacted catchments and the main stem of the Olifants River that was impacted by agricultural activities. Tributaries in the upper Olifants River, like the Jan Dissels River, were largely unimpacted by human development., These rivers showed evidence of seasonal changes in quality., Salinities tended to be higher at the end of the dry summer period while low salinities were observed at the end of winter. However, in the middle and lower Olifants River it was found that there were strong seasonal variations in water quality. High salinities were observed early in winter probably originated from the wash-off of accumulated salts from the irrigated lands by the early rainfall. Lower salinities were observed at the end of winter when most of the salts have been washed off the catchment.

Water quality in the Koue Bokkeveld is ideally suited for all uses (E2H002). A trend of increasing TDS over time was observed in the Leeu River even though the quality is still acceptable. Marked seasonal differences were also found, with higher salt concentrations being observed in summer than in winter (Department of Water Affairs and Forestry, 1998).

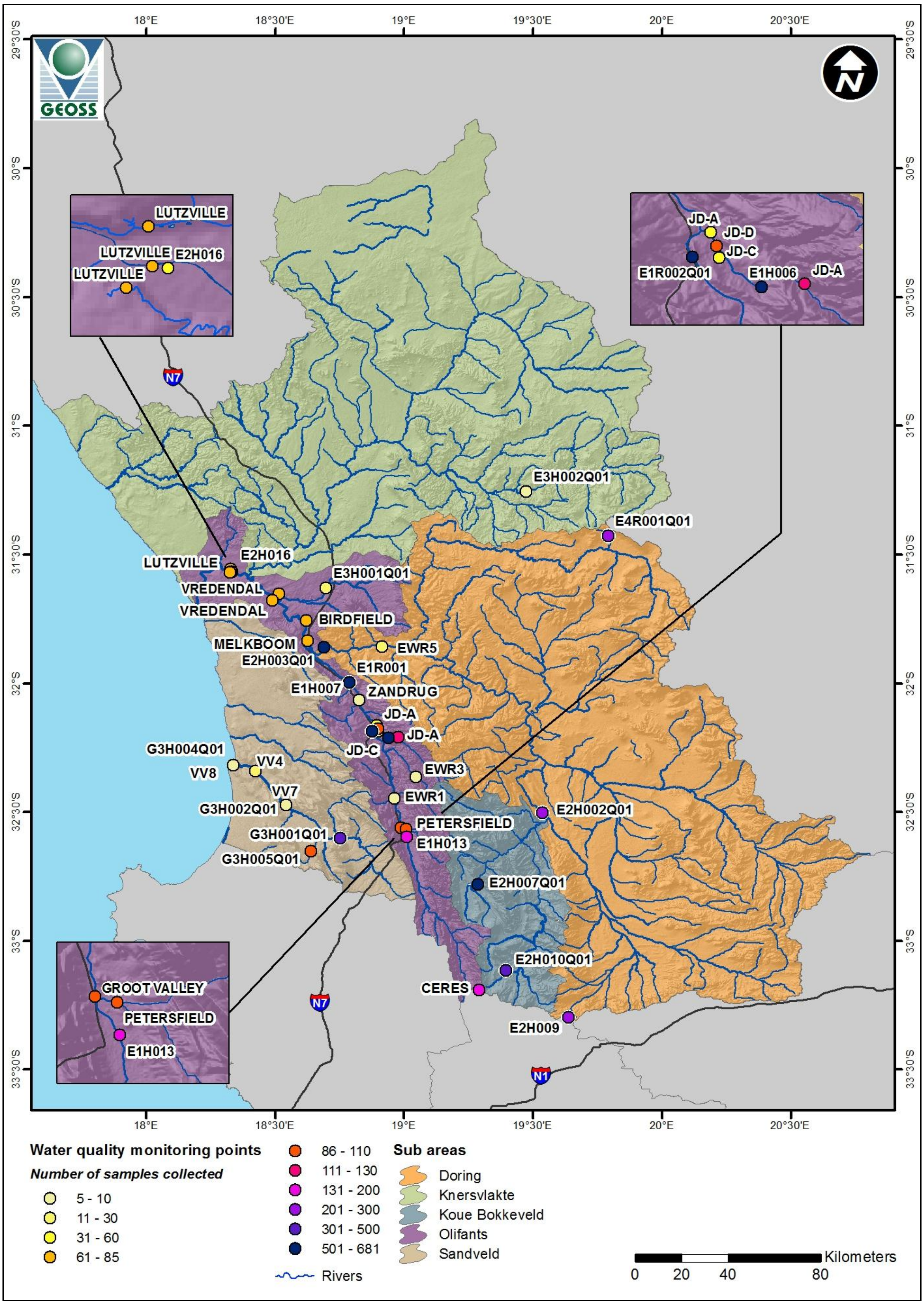

Figure 3.25: Map of the Olifants-Doorn WMA showing the location of water quality monitoring points and an indication of the number of samples collected at each point.

The quality of water in the upper Doring River, when flowing, is suitable for agriculture and domestic water supplies. However, TDS concentrations in the Kruis River are very high and variable and the water quality varied between tolerable to unacceptable (Department of Water Affairs and Forestry, 1998). Water quality in middle Doring River becomes marginal and TDS concentrations increase in a downstream direction. In the lower reaches, the water quality varies between acceptable at the end of winter and tolerable at the end of summer, probably as a result of the predominantly winter rainfall in the catchment. The water quality is still suitable for all uses but it does indicate deterioration. It has been reported that farmers stop irrigating when the water begins tasting salty. Highly saline flows from the Tankwa Karoo tributaries have a sporadic influence on the Doring River.

The water quality status of non-perennial rivers like the Wolf, Koebee and Oorlogskloof, Sout, Krom, and Hantams Rivers are largely unknown. The Knersvlakte is a naturally saline system.

In the Sandveld sub-area water quality is tolerable to completely unacceptable in the Kruis River catchment (upper reaches of the Verlorenvlei River) due to elevated salinities. It improves slightly in a downstream direction but the lack of data precludes any concrete conclusions about water quality in the Verlorenvlei River and in Verlorenvlei itself. The cause of the poor water quality is the result of agricultural activities on the Malmesbury shales, which are high in salts and cover a large part of the Kruis River catchment (Sinclair, 1986).

3.4.2. Identification of Generic Water Quality Requirements

The generic water quality requirements of the two key users sectors, irrigation and domestic water users and their fitness for use categories (Department of Water Affairs and Forestry, 2006), are summarized in **Table** and **Table 3.**

Table 3.16: Generic water quality guidelines for Agricultural Use: Irrigation

WATER QUALITY GUIDELINES FOR AGRICULTURAL USE:, IRRIGATION					
Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
PHYSICAL REQUIREMENTS					
Total Suspended Solids	mg/l	50	75	100	>100
CHEMICAL REQUIREMENTS					
Chloride	mg/l	100	137.5	175	>175
Electrical Conductivity	mS/m	40	90	270	>270
Fluoride	mg/l	2.0	8.5	15.0	>15.0
pH (upper)		8.4	8.4	8.4	>8.4
pH (lower)		6.5	6.5	6.5	<6.5
Sodium Absorption Ratio	mmol/l	2.0	8.5	15.0	>15.0
Sodium	mg/l	70.0	92.5	115.0	>115.0
Aluminium	mg/l	5.0	12.5	20.0	>20.0
Arsenic	mg/l	0.1	1.05	2.0	>2.0
Beryllium	mg/l	0.1	0.3	0.5	>0.5
Boron	mg/l	0.5	0.75	1.0	>1.0
Cadmium	mg/l	0.01	0.03	0.05	>0.05
Chromium VI	mg/l	0.1	0.56	1.0	>1.0

Cobalt	mg/l	0.05	2.75	5.0	>5.0
Copper	mg/l	0.2	2.6	5.0	>5.0
Iron	mg/l	5.0	12.5	20.0	>20.0
Lead	mg/l	0.2	1.1	2.0	>2.0
Lithium	mg/l	2.5	2.5	2.5	>2.5
Manganese	mg/l	0.02	5.1	10.0	>10.0
Molybdenum	mg/l	0.01	0.03	0.05	>0.05
Nickel	mg/l	0.2	1.1	2.0	>2.0
Selenium	mg/l	0.02	0.04	0.05	>0.05
Uranium	mg/l	0.01	0.06	0.1	>0.1
Vanadium	mg/l	0.1	0.56	1.0	>1.0
Zinc	mg/l	1.0	3.0	5.0	>5.0
BIOLOGICAL					
Faecal coliforms	per 100ml	1	500	1000	>1000

Reference: South African Water Quality Guidelines, Volume 4, Agricultural Water Use - Irrigation, (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site-specific conditions.

Table 3.17: Generic water quality guidelines for Domestic Use

WATER QUALITY GUIDELINES FOR DOMESTIC USE					
Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
PHYSICAL REQUIREMENTS					
Hardness	mg $CaCO_3$	200	300	600	>600
Turbidity	NTU	0.1	1	20	>20
CHEMICAL REQUIREMENTS					
Calcium	mg/l	80	150	300	>300
Chloride	mg/l	100	200	600	>600
Chlorine (upper)	mg/l	0.6	0.8	1.0	>1.0
Chlorine (lower)	mg/l	0.3	0.2	0.1	<0.1
Electrical Conductivity	mS/m	70	150	370	>370
Fluoride	mg/l	0.7	1.0	1.5	>1.5
Magnesium	mg/l	70	100	200	>200
Nitrate + Nitrite	mg N/l	6.0	10.0	20.0	>20.0
PH (upper)		9.5	10.0	10.5	>10.5
PH (lower)		5.0	4.5	4.0	<4.0
Potassium	mg/l	25	50	100	>100
Sodium	mg/l	100	200	400	>400
Sulphate	mg/l	200	400	600	>600
Total Dissolved Solids (TDS)	mg/l	450	1000	2400	>2400
Arsenic	mg/l	0.01	0.05	0.2	>0.2
Cadmium	mg/l	0	0.01	0.02	>0.02
Copper	mg/l	1.0	1.3	2.0	>2.0
Iron	mg/l	0.5	1.0	5.0	>5.0
Manganese	mg/l	0.1	0.4	4	>4
Zinc	mg/l	20	20	20	>20
BIOLOGICAL					
Total coliforms	per 100ml	0	10	100	>100
Faecal coliforms	per 100ml	0	1	10	>10

Reference: Quality of Domestic Water Supplies, Volume 1: Assessment Guide. (Water Research Commission, 1998).

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site-specific conditions.

3.4.3. Identification of Site Specific Water Quality Requirements

In the WODRIS report the Provincial Department of Agriculture used a site-specific classification for salinity (**Table**) that is more stringent than the SA Water Quality Guidelines for Irrigation Agriculture to specify the water quality requirements for the Olifants irrigation area and to assess the fitness for use of the water (Provincial Government Western Cape, 2004).,

Table 3.18: Salinity ratings for irrigation in the Olifants River (Provincial Government Western Cape, 2004). The values in brackets represent the generic SAWQG values for irrigation.

Salinity hazard	EC (mS/m)	TDS (mg/l)	Applicability
Low (Ideal*)	10 – 25 *(<40)*	64 – 160 *(<260)*	Can be used on most soils with little likelihood that soil salinity will develop. Some leaching is required but this occurs under normal irrigation practices except in soil of extremely low permeability.
Medium (Acceptable*)	25 – 75 *(40-90)*	160 – 480 *(260-585)*	Can be used for irrigation if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.
High (Tolerable*)	75 – 225 *(90-270)*	480 – 1 440 *(585-1755)*	Not to be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
Very high (Unacceptable*)	≥ 225 *(>270)*	≥ 1 440 *(>1755)*	Not suitable for irrigation water under most conditions.

* - The equivalent water use categories (Ideal, Acceptable, Tolerable, and Unacceptable) were added to the original table.

The Provincial Government Western Cape (2004) values were therefore used to assess the fitness for use for irrigation users for total dissolved salts. Similar site-specific tables were developed for Sodicity, Chloride and Boron (Provincial Government Western Cape, 2004).

Water quality monitoring in the Olifants-Doorn WMA

Water quality data were obtained for the Olifants-Doorn WMA from DWA. There is a number of water quality monitoring points in the WMA. The routine river and reservoir monitoring points are listed in **Table 3.19** and their locations are illustrated in **Figure** .

Table 3.19: Routine river and reservoir chemical water quality monitoring points in the Olifants/Doring WMA where more than 5 samples were collected and an indication of the data record at each monitoring point.

Monitoring Point Name	Location	Type	Catchment	Samples	First Date	Last Date
Cmnt-Ceres-MR800a-Low Water Bridge At Fairfield Farm	Modder River-Drainage Region H10C	Rivers	E10A	131	1995/04/18	2010/11/10
Petersfield 455 @ Road Bridge North Of Citrusdal On Boontjiesrivier	Boontjiesrivier E10E To E10E	Rivers	E10E	105	2008/04/24	2011/05/30
E1H013 Middelpos 553 At Citrusdal On Olifantsrivier	Olifants E10a To E33H	Rivers	E10E	185	1995/07/19	2011/05/30
EWR1 At N7 Heksrivier On Olifants	Olifants E10a To E33h	Rivers	E10F	6	2003/12/01	2004/09/15
Groot Valley 451 D/S Citrusdal And Boontjiesrivier On Olifantsrivier	Olifants E10a To E33h	Rivers	E10F	104	2008/04/24	2011/05/30
EWR3 Steem Rug Upstream Of Forestry Village At Graveyard	Rondegat River-Drainage Region E10g	Rivers	E10G	6	2003/11/29	2004/08/03
E1H011Q01 Clanwilliam Dam On Olifants River: Down Stream Weir	Olifants E10A To E33H	Rivers	E10G	265	1972/06/29	2010/03/30
E1R002R01 Clanwilliam Andriesgrond 204 - Clanwilliam Dam On Olifantsrivier: Near Dam Wall	Clanwilliam Dam	Dam / Barrage	E10G	557	1968/04/03	2010/08/03
Cmnt - Jan Dissels - JD-A - Jan Disselsrivier 270 At Boskloof Bridge On Jan Disselsrivier	Jan Disselsrivier E10H To E10J	Rivers	E10H	111	2007/01/18	2011/05/30
Zandrug Ptn Radyn	Olifantsriver-Adjacent To Radyn Farm	Rivers	E10J	6	2007/09/06	2008/03/06
Cmnt - Jan Dissels - Jd C - Clanwilliam - @ Municipal Abstraction Pumphouse On Furrow From Jan Disse	Left Bank Furrow From Jan Disselsrivier	Canal	E10J	36	2007/01/18	2009/06/18
Cmnt - Jan Dissels - Jd E - Augsburg 197 - @ Road To Nuwevlei Just Past Cemetery On Jan Disselsrivier	Jan Disselsrivier E10h To E10J	Rivers	E10J	37	2007/01/18	2009/06/18
Cmnt- Jan Dissels - Jd-D - Clanwilliam At Road Bridge D/Stream Of Wwtw Outfall On Jan Disselsrivier	Jan Disselsrivier E10h To E10j	Rivers	E10J	109	2004/09/15	2011/05/30
E1H006 - JD-B - Clanwilliam Commonage Warmhoek - @ Gauging Weir On Jan Disselsrivier	Jan Disselsrivier E10h To E10J	Rivers	E10J	507	1978/01/04	2010/08/03
E1H007 Kromme Valley 113 Bulshoek Dam On Left Bank Canal From Bulshoek Dam	Left Bank Canal From Bulshoek Dam	Canal	E10K	232	1972/03/10	2011/05/30
E1r001 Kromme Valley 113 Bulshoek Dam On Olifantsrivier: Near Dam Wall	E1r001 Bulshoek Dam At Kromme Valley	Dam / Barrage	E10K	602	1972/06/29	2010/08/03
E2h010q01 Kruis River At Ebenezer	Kruis River (E2)	Rivers	E21A	345	1982/09/20	2009/11/26
E2h007q01 Leeu River At Leeuw Rivier	Leeu (Dupl Name 5)	Rivers	E21G	524	1977/04/27	2011/01/06
E2h009 Uitkomst Inverdoorn Canal From Valsgatrivier	Inverdoorn Canal At Uitkomst	Canal	E22C	247	1978/02/23	2010/10/26
E2H002q01 At Elands Drift Aspoort On Doringrivier	Doringrivier - Drainage Region E2 E22e To E24m	Rivers	E22G	282	1973/03/02	2009/11/24
G3H001q01 Kruis River At Tweekuilen/Eendekuil	Kruismans	Rivers	E23J	334	1970/05/08	2010/07/15
Ewr5 At Ou Drif On Doringrivier	Doringrivier -	Rivers	E24M	13	2004/03/	2004/08/

Monitoring Point Name	Location	Type	Catchment	Samples	First Date	Last Date
	Drainage Region E2 E22e To E24m				05	13
E2H003Q01 At Melkboom On Doringrivier	Doringrivier - Drainage Region E2 E22e To E24m	Rivers	E24M	681	1972/05/13	2011/01/04
E3H002Q01 Hantams River At Brakke Rivier/Tweefontein	Hantams	Rivers	E32B	7	1990/03/16	1991/10/21
E3H001q01 Troe-Troe River At Farm 256/Troe-Troe	Troe Troe River (E3)	Rivers	E33G	11	1987/07/21	2008/09/02
Vredendal At Buurmanshoogte On Brugkanaal From Olifantsrivier Right Ba	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33G	81	2008/04/24	2011/05/30
Birdfield 306 Klawer At Cornelius Ryk On Brugkanaal From Olifantsrivier	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33G	82	2008/04/24	2011/05/30
Melkboom 384 At Distribution On Brugkanaal From Olifantsrivier Right Bank	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33G	82	2008/04/24	2011/05/30
Vredendal 292 On Left Bank Irrigation Canal From Bulshoek Dam	Left Bank Canal From Bulshoek Dam	Canal	E33G	84	2008/04/24	2011/05/30
E2H016 Olifants River At Lutzville	Olifants E10a To E33h	Rivers	E33H	56	2002/12/11	2011/02/09
Lutzville At Gravel Road On Brugkanaal From Olifantsrivier	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33H	80	2008/04/24	2011/05/30
Lutzville At Low Water Bridge On Olifantsrivier	Olifants E10a To E33h	Rivers	E33H	81	2008/04/24	2011/05/30
Lutzville West On Left Bank Irrigation Canal From Bulshoek Dam	Left Bank Canal From Bulshoek Dam	Canal	E33H	82	2008/04/24	2011/05/30
E4r001Q01 Karee Dam On Karee River: Near Dam Wall	Karee Dam	Dam / Barrage	E40B	210	1977/05/02	2011/02/08
G3h005Q01 Hol River At Wittewater (Papkuilsvlei)	Hol River (G3)	Rivers	G30D	101	1978/05/08	1990/09/12
Verlorevlei Ptn Die Mond Vv8	Verlorevlei	Rivers	G30E	5	2002/09/27	2009/11/20
G3H002Q01 Verlore Vlei At Redelinghuys	Verlorevlei Wetlands (G3)	Wetland	G30E	6	1970/05/08	1972/09/08
G3H004Q01 Verlore Vlei At Elandsbaai	Verlorevlei Wetlands (G3)	Wetland	G30E	7	1970/07/15	1997/04/22
Verlorevlei Ptn Skuinskraal Vv7	Verlorevlei	Rivers	G30E	11	2002/09/27	2010/03/25
Verlorevlei Ptn Grootdrif Vv4	Verlorevlei	Rivers	G30E	13	2002/09/27	2010/06/21

There is a fairly good water quality data record at Clanwilliam Dam (E1R002Q01 & E1H008) and Bulshoek Dam (E1R001 & E1H007) and in the middle and lower parts of the Doring River (E2H002 & E2H003). However, the water quality data records are very poor in the rivers of the Knersvlakte, Oorlogskloof River, the tributaries of the Doring River and the lower Olifants River (PGWC, 2004b).

The National Microbial Monitoring Programme (NMMP) also has a number of river and canal monitoring points in the study area (**Table**). The NMMP sampling points, E1H007 - Kromme Valley 113 Bulshoek Dam On Left Bank Canal From Bulshoek Dam, was selected to represent the Upper Olifants microbial water quality, and Lutzville At Low Water Bridge On Olifantsrivier, was selected to represent the Lower Olifants microbial water quality.

Table 3.20: Routine river and canal microbial chemical water quality monitoring points in the Olifants/Doring WMA.

Monitoring Point Name	Location	Type	Catch ment	Sampl es	first date	Last date
Vredendal 292 On Left Bank Irrigation Canal From Bulshoek Dam	Left Bank Canal From Bulshoek Dam	Canal	E33G	44	2008/04/24	2011/07/13
Vredendal At Buurmanshoogte On Brugkanaal From Olifantsrivier Right Ba	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33G	44	2008/04/24	2011/07/13
Melkboom 384 At Distribution On Brugkanaal From Olifantsrivier Right Bank	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33G	43	2008/04/24	2011/07/13
Lutzville West On Left Bank Irrigation Canal From Bulshoek Dam	Left Bank Canal From Bulshoek Dam	Canal	E33H	43	1999/09/14	2010/11/10
Lutzville At Gravel Road On Brugkanaal From Olifantsrivier	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33H	43	2008/04/24	2011/07/12
Birdfield 306 Klawer At Cornelius Ryk On Brugkanaal From Olifantsrivier	Brugkanaal From Olifantsrivier On Right Bank	Canal	E33G	42	2008/04/24	2011/07/12
E1h007 Kromme Valley 113 Bulshoek Dam On Left Bank Canal From Bulshoek Dam	Left Bank Canal From Bulshoek Dam	Canal	E10K	41	2008/04/24	2011/07/12
Cmnt - Jan Dissels - Jd C - Clanwilliam - @ Municipal Abstraction Pumphouse On Furrow From Jan Dissels	Left Bank Furrow From Jan Disselsrivier	Canal	E10J	9	2008/04/24	2011/07/12
E1h013 Middelpos 553 At Citrusdal On Olifantsrivier	Olifants E10a To E33h	Rivers	E10E	57	2008/04/24	2011/07/12
Groot Valley 451 D/S Citrusdal And Boontjiesrivier On Olifantsrivier	Olifants E10a To E33h	Rivers	E10F	56	2008/04/24	2011/07/12
Petersfield 455 @ Road Bridge North Of Citrusdal On Boontjiesrivier	Boontjiesrivier E10e To E10e	Rivers	E10E	55	2008/04/24	2011/07/12
Lutzville At Low Water Bridge On Olifantsrivier	Olifants E10A To E33h	Rivers	E33H	44	2008/04/24	2011/07/12
Cmnt - Jan Dissels - Jd-A - Jan Disselsrivier 270 At Boskloof Bridge On Jan Disselsrivier	Jan Disselsrivier E10h To E10j	Rivers	E10H	43	2006/07/07	2010/12/03
Cmnt- Jan Dissels - Jd-D - Clanwilliam At Road Bridge D/Stream Of Wwtw Outfall On Jan Disselsrivier	Jan Disselsrivier E10h To E10j	Rivers	E10J	43	2001/11/06	2010/07/21
Cmnt - Jan Dissels - Jd E - Augsburg 197 - @ Road To Nuwevlei Just Past Cemetery On Jan Disselsrivier	Jan Disselsrivier E10h To E10j	Rivers	E10J	9	2008/12/17	2010/11/17
E1h006 - Jd-B - Clanwilliam Commonage Warmhoek - @ Gauging Weir On Jan Disselsrivier	Jan Disselsrivier E10h To E10j	Rivers	E10J	7	2002/12/06	2010/11/10
Cmnt-Ceres-Mr800a-Low Water Bridge At Fairfield Farm	Modder River-Drainage Region H10c	Rivers	E10A	1	2008/10/31	2009/06/18

Present water quality status

The following monitoring points were selected to characterise the water quality status at the outflow to the Sub-areas (**Table**). Data for the period 2000-2010 was used to characterise the present water quality status.

Table 3.21: Monitoring points selected to characterise the water quality at the outflows from the sub-areas**.**

Sub-areas	Outlet No	Quaternary No(s)	Monitoring point	Comment
Doring Rangeland (1)	R 12	E40B	E4R001	Only one sampling point in this IUA, E4R001 – Karee Dam on Karee River. Fair observed data record but no flow data to develop concentration/flow relationship.
Doring Rangeland (2)	R 20	E24H	E4R001	No monitoring points, assumed to be same as E4R001 - Karee Dam on Karee River, low confidence assessment.
Knersvlakte	R 8	E33E	E3H002	There is only one monitoring point in the Knersvlakte with 7 observations, E3H002 - Hantams River At Brakke Rivier/Tweefontein. Low confidence assessment., No
Koue Bokkeveld	R 37	E21L	E2H002	E2H002 – Doring River at Elands Drift/Aspoort. Good data point, sufficient data to develop concentration/flow relationship.
Lower Olifants	R 7	E33H	E2H016	Only one monitoring point, E2H016 - Olifants River at Lutzville. May be marine influence on TDS but estuarine specialist felt it was unlikely and high salinity was due to irrigation return flows upstream of monitoring point.
OD Dryland farming (1)	R 14	E24M	E2H003	Good data record at E2H003 & flow data to develop concentration/flow relationship.
OD Dryland farming (2)	R 26	E24B	E2H002	Water quality in the Tra-Tra was assumed to be the same as those observed at E2H002 close by.
Upper Olifants	R 23	E10J	E1H011	Assumed same as outflow from Clanwilliam Dam. No flow data at Bulshoek Dam to develop a concentration/flow relationship used total outflow from Clanwilliam Dam.
Sandveld			VV4	Water quality monitoring in the Sandveld very poor. Monitoring point in Verlorevlei, Ptn Grootdrif VV4 was assumed to represent water quality in the Sandveld

To assess the fitness for use for the two dominant water uses in the basin, irrigation use and domestic use, a method developed by (Van Veelen, 2002) was used. For each of the monitoring points located at the outflow of an IUA (**Table**), the median, 75th percentile and 95th percentile was calculated for the chemical constituents, for the period 2000-2010. These were then classified using the generic water quality guidelines for irrigation and domestic water use (**Table and Table 3)** and the site-specific guidelines for TDS (**Table 3.18**). Blank spaces in the table indicated that no guidelines were specified for those constituents. The overall status was also determined using Van Veelen’s method.

Doring Rangeland (1 & 2)

Table 3.22: Summary water quality statistics and fitness for use assessment for E4R001Q01 - Karee Dam

E4R001Q01						**Domestic use**				**Irrigation use**			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		81	0.3670	0.4360	0.9560								
Ca.	mg/l	83	16.2970	22.3510	33.2510	🟢	🟢	🟢	🟩				
Cl	mg/l	84	12.2760	15.2380	22.4420	🟢	🟢	🟢	🟩	🟢	🟢	🟢	🟩
DMS	mg/l	74	148.9355	205.7590	297.0930	🟢	🟢	🟢	🟩	🟢	🟠	🟠	🟨
E.C.	mS/m	83	21.5000	27.6000	38.4000	🟢	🟢	🟢	🟩	🟢	🟠	🟠	🟨
F	mg/l	75	0.1580	0.1880	0.2780	🟢	🟢	🟢	🟩	🟢	🟢	🟢	🟩
HARD	mg/l	83	74.4110	102.2970	148.5680								
K	mg/l	83	1.3300	1.7000	2.4220	🟢	🟢	🟢	🟩				
LANGL		74	0.5395	0.7910	1.2520								
Mg	mg/l	83	8.0150	11.2750	17.2800								
NH4	mg/l	82	0.0525	0.0910	0.2070								
NO3+NO2	mg/l	77	0.0550	0.1980	1.0770	🟢	🟢	🟢	🟩				
Na	mg/l	81	10.3720	12.9580	18.7540	🟢	🟢	🟢	🟩	🟢	🟢	🟢	🟩
PO4-P	mg/l	81	0.0260	0.0400	0.0990								
SO4	mg/l	84	8.6975	13.0200	24.0850	🟢	🟢	🟢	🟩				
TAL	mg/l	81	71.8000	92.4040	140.9060								
pH		84	7.8790	8.0900	8.4430	🟢	🟢	🟢	🟩	🟢	🟢	⚫	⬛
Si	mg/l	82	5.5755	6.4640	8.2400								

Key		
	🟩	Ideal
	🟨	Acceptable
	🟥	Tolerable
	⬛	Unacceptable

Water quality in Karee Dam was ideally suited for domestic water supply (Table) and it was, on average, ideal for irrigation water supply although the slightly elevated dissolved salts resulted in the water being categorised as acceptable for irrigation.

Knersvlakte

There was only one sampling point in the Knersvlakte (E3H002 – Hantams River at Brakke River) and only 7 samples were collected from 1990 – 1991. This is insufficient to draw any conclusions about water quality in the Knersvlakte. A once-off survey of quality along the Swart-Doring River in 2009 indicated high salinities along the length of the river surveyed (Rossouw, L., pers comm).

Koue Bokkeveld

Water quality in the Koue Bokkeveld is ideally suited for domestic and irrigation water use (**Table**).

Table 3.23: Summary water quality statistics and fitness for use assessment for E2H002Q01 - Doring River at Elands Drift

E2H002Q01						**Domestic use**				**Irrigation use**			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		81	3.61100	5.39400	8.88900								
Ca.	mg/l	83	3.28000	4.48100	7.89300	●	●	●	■				
Cl	mg/l	84	17.17300	22.05500	32.76100	●	●	●	■	●	●	●	■
DMS	mg/l	73	46.12200	57.22500	89.90300	●	●	●	■	●	●	●	■
E.C.	mS/m	84	8.94000	11.64000	16.60000	●	●	●	■	●	●	●	■
F	mg/l	78	0.10050	0.12500	0.16500	●	●	●	■	●	●	●	■
HARD	mg/l	83	17.24600	22.35800	37.56800								
K	mg/l	82	0.83350	1.20900	2.06400	●	●	●	■				
LANGL		73	2.86600	3.23300	3.78000								
Mg	mg/l	83	2.10600	2.88400	4.57900								
NH4	mg/l	84	0.02000	0.05000	0.07800								
NO3+NO2	mg/l	79	0.05100	0.10300	0.27600	●	●	●	■				
Na	mg/l	80	7.42550	9.70350	15.10900	●	●	●	■	●	●	●	■
PO4-P	mg/l	83	0.01900	0.02700	0.07500								
SO4	mg/l	83	7.16600	9.08600	14.18900	●	●	●	■				
TAL	mg/l	83	8.52800	12.03500	23.16800								
pH		84	7.11000	7.43300	7.85900	●	●	●	■	●	●	●	■
Si	mg/l	84	1.69150	2.25000	2.97300								

Key		
	Green	Ideal
	Yellow	Acceptable
	Red	Tolerable
	Black	Unacceptable

Lower Olifants

Water quality in the Lower Olifants River is very poor as a result of irrigation return flows (Table 3.24). Almost all the constituents are elevated making the water largely unsuitable for domestic water supply and for irrigation water supply. The microbial water quality for E. coli indicate that the water is unacceptable for domestic water supply but acceptable for irrigation water supply.

Table 3.24: Summary water quality statistics and fitness for use assessment for E2H016 - Olifants River at Lutzville

E2H016						**Domestic use**				**Irrigation use**			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		54	6.696	7.825	9.647								
Ca.	mg/l	55	94.369	116.484	136.801	Acceptable	Acceptable	Acceptable	Acceptable				
Cl	mg/l	56	777.327	1085.646	1430.134	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
DMS	mg/l	46	2213.752	2973.601	3443.985	Tolerable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
E.C.	mS/m	56	337.000	437.000	581.000	Tolerable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
F	mg/l	47	0.787	0.986	1.060	Acceptable	Acceptable	Tolerable	Tolerable	Ideal	Ideal	Ideal	Ideal
HARD	mg/l	55	512.028	670.112	791.970								
K	mg/l	55	9.665	12.773	17.938	Ideal	Ideal	Ideal	Ideal				
LANGL		46	1.156	1.281	2.341								
Mg	mg/l	55	68.505	89.032	113.553								
NH4	mg/l	54	0.043	0.063	0.179								
NO3+NO2	mg/l	53	0.094	0.273	0.562	Ideal	Ideal	Ideal	Ideal				
Na	mg/l	53	539.335	708.640	909.009	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Unacceptable
PO4-P	mg/l	53	0.059	0.078	0.191								
SO4	mg/l	56	329.774	446.486	609.959	Acceptable	Tolerable	Unacceptable	Unacceptable				
TAL	mg/l	54	217.876	255.200	289.501								
pH		56	8.196	8.305	8.465	Ideal	Ideal	Ideal	Ideal	Ideal	Ideal	Unacceptable	Unacceptable
Si	mg/l	54	4.470	6.655	8.033								
E.coli	counts /100ml	44	38.000	84.000	272.000	Unacceptable	Unacceptable	Unacceptable	Unacceptable	Acceptable	Acceptable	Acceptable	Acceptable

Key		
	Green	Ideal
	Yellow	Acceptable
	Red	Tolerable
	Black	Unacceptable

Olifants Doring Dryland farming (1)

Water quality in the lower Doring River is on average ideal but there are occasions when high elevated salt concentrations occur, such as during the dry summer months, which changes the fitness for use to acceptable or even tolerable classes (Table 3.25). During those times the water can also become unsuitable for irrigation purposes.

Table 3.25: Summary water quality statistics and fitness for use assessment for E2H003Q01 - Doring River at Melkboom

E2H003Q01						**Domestic use**				**Irrigation use**			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		119	4.1440	5.2730	7.8080								
Ca.	mg/l	120	9.1040	12.7590	38.3240	🟢	🟢	🟢	🟩				
Cl	mg/l	121	52.5740	82.7280	272.0730	🟢	🟢	🔴	🟥	🟢	🟢	⚫	⬛
DMS	mg/l	110	143.0630	207.7180	807.3960	🟢	🟢	🟡	🟨	🟢	🟡	🔴	🟥
E.C.	mS/m	121	27.8000	40.1000	126.6000	🟢	🟢	🟡	🟨	🟡	🟡	🔴	🟥
F	mg/l	111	0.1220	0.1480	0.3230	🟢	🟢	🟢	🟩	🟢	🟢	🟢	
HARD	mg/l	120	50.5620	68.8740	185.1730								
K	mg/l	120	1.9415	2.5270	7.8890	🟢	🟢	🟢	🟩				
LANGL		110	1.6315	2.1270	2.5710								
Mg	mg/l	120	6.4870	9.2910	21.2840								
NH4	mg/l	121	0.0250	0.0570	0.1460								
NO3+NO2	mg/l	119	0.0430	0.1260	0.5120	🟢	🟢	🟢	🟩				
Na	mg/l	120	27.2605	42.4475	191.4310	🟢	🟢	🟡	🟨	🟢	🟢	⚫	⬛
PO4-P	mg/l	121	0.0200	0.0290	0.1000								
SO4	mg/l	121	17.0000	23.4420	96.4770	🟢	🟢	🟢	🟩				
TAL	mg/l	119	21.5630	33.0690	124.9920								
pH		121	7.5800	7.7500	8.1770	🟢	🟢	🟢	🟩	🟢	🟢	🟢	🟩
Si	mg/l	121	1.6430	2.1040	3.3570								

Key	🟩	Ideal
	🟨	Acceptable
	🟥	Tolerable
	⬛	Unacceptable

Olifants Doring Dryland farming (2)

Water quality in the upper Doring River is ideal for domestic water use and for irrigation water use (Table 3.26).

Table 3.26: Summary water quality statistics and fitness for use assessment for E2H002Q01 – Doring River at Elands Drift

E2H002Q01						**Domestic use**				**Irrigation use**			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		81	3.61100	5.39400	8.88900								
Ca.	mg/l	83	3.28000	4.48100	7.89300	●	●	●	■				
Cl	mg/l	84	17.17300	22.05500	32.76100	●	●	●	■	●	●	●	■
DMS	mg/l	73	46.12200	57.22500	89.90300	●	●	●	■	●	●	●	■
E.C.	mS/m	84	8.94000	11.64000	16.60000	●	●	●	■	●	●	●	■
F	mg/l	78	0.10050	0.12500	0.16500	●	●	●	■	●	●	●	■
HARD	mg/l	83	17.24600	22.35800	37.56800								
K	mg/l	82	0.83350	1.20900	2.06400	●	●	●	■				
LANGL		73	2.86600	3.23300	3.78000								
Mg	mg/l	83	2.10600	2.88400	4.57900								
NH4	mg/l	84	0.02000	0.05000	0.07800								
NO3+NO2	mg/l	79	0.05100	0.10300	0.27600	●	●	●	■				
Na	mg/l	80	7.42550	9.70350	15.10900	●	●	●	■	●	●	●	■
PO4-P	mg/l	83	0.01900	0.02700	0.07500								
SO4	mg/l	83	7.16600	9.08600	14.18900	●	●	●	■				
TAL	mg/l	83	8.52800	12.03500	23.16800								
pH		84	7.11000	7.43300	7.85900	●	●	●	■	●	●	●	■
Si	mg/l	84	1.69150	2.25000	2.97300								

Key		
	(green)	Ideal
	(yellow)	Acceptable
	(red)	Tolerable
	(black)	Unacceptable

Upper Olifants

Water quality in the upper Olifants River is ideal for domestic water use and for irrigation water use (Table 3.27). However, the microbial water quality indicates that the water is unsuitable for domestic water supply unless it is disinfected (treated) but it is acceptable for irrigation water supply without treatment.

Table 3.27: Summary water quality statistics and fitness for use assessment for E1H011Q01 - Clanwilliam Dam - Downstream weir

E1H011Q01						Domestic use				Irrigation use			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		140	5.45200	7.73750	10.94350								
Ca.	mg/l	143	2.48900	3.08700	4.64000								
Cl	mg/l	143	19.79900	24.90600	30.81900								
DMS	mg/l	129	48.90500	61.21900	77.19500								
E.C.	mS/m	142	10.30500	13.10000	15.60000								
F	mg/l	129	0.10000	0.11400	0.15700								
HARD	mg/l	143	15.73000	19.11100	24.81400								
K	mg/l	143	0.94000	1.09700	1.78800								
LANGL		129	3.20800	3.54400	4.26900								
Mg	mg/l	143	2.32500	2.74900	3.27900								
NH4	mg/l	140	0.04500	0.07100	0.11300								
NO3+NO2	mg/l	134	0.05500	0.13100	0.25200								
Na	mg/l	139	9.62100	12.24100	15.25000								
PO4-P	mg/l	140	0.01600	0.02400	0.05300								
SO4	mg/l	143	4.76400	6.54500	8.61900								
TAL	mg/l	140	6.58950	9.77950	14.69200								
pH		143	7.00100	7.28700	7.72400								
Si	mg/l	140	2.04850	2.34400	2.73350								
E.coli	counts /100ml	41	5.000	19.000	172.000								

Key		
		Ideal
		Acceptable
		Tolerable
		Unacceptable

Sandveld

The water quality data record in the Sandveld is poor and only a few samples have been collected in Verlorenvlei (Table 3.28). The few samples that have been collected indicated that the quality is mostly unacceptable for domestic water supply and for irrigation due to high salt concentrations.

Table 3.28: Summary water quality statistics and fitness for use assessment for VV4 - Verlorenvlei at Grootdrif

VV4						**Domestic use**				**Irrigation use**			
	Units	No	Median	75%tile	95%tile	50%	75%	95%	Overall	50%	75%	95%	Overall
CORR.		5	8.661	11.415	13.105								
Ca.	mg/l	6	42.874	49.954	127.088	green	green	yellow	yellow				
Cl	mg/l	6	534.724	790.634	2358.895	red	black	black	black	black	black	black	black
DMS	mg/l	4	1331.478	3105.677	4658.115	red	black	black	black	red	black	black	black
E.C.	mS/m	6	244.000	289.000	1163.000	red	red	black	black	black	black	black	black
F	mg/l	4	0.229	0.430	0.602	green	green	green	green	green	green	green	green
HARD	mg/l	6	322.883	434.518	1213.835								
K	mg/l	6	7.422	13.078	32.930	green	green	yellow	yellow				
LANGL		4	0.717	1.068	1.380								
Mg	mg/l	6	54.837	75.838	217.686								
NH4	mg/l	5	0.070	0.128	0.211								
NO3+NO2	mg/l	5	0.040	0.062	0.167	green	green	green	green				
Na	mg/l	6	303.748	417.062	1273.126	red	black	black	black	black	black	black	black
PO4-P	mg/l	5	0.030	0.051	0.176								
SO4	mg/l	6	64.473	93.458	261.904	green	green	yellow	yellow				
TAL	mg/l	5	117.073	157.531	315.681								
pH		6	7.564	8.068	8.322	green	green	green	green	green	green	green	green
Si	mg/l	5	4.153	4.492	5.314								

Key		
	green	Ideal
	yellow	Acceptable
	red	Tolerable
	black	Unacceptable

4. GROUNDWATER

The role of groundwater within the Olifants/Doorn Water Management Area varies. In certain regions groundwater plays an important component of the total water resources budget, whilst in other regions its occurrence is very limited. A lot of background information exists on the geology and hydrogeology of the WMA and has been included within the Inception Report for this project (Belcher *et al*, 2011).

This chapter addresses the actual classification of groundwater resources., A lot of spatial variability exists with regard to groundwater especially as for 78% of the WMA the groundwater occurs within a fractured rock aquifer setting., However this variability is lost to a degree as the unit of analysis for the groundwater classification is per Quaternary Catchment., It is also acknowledged that the groundwater flow is controlled to a large extent by the geological and hydrogeological conditions and not by the surface topography., Quaternary catchments are defined according to topographical variation and features., Nonetheless the analysis has been completed on a Quaternary catchment basis as this facilitates and simplifies the integration of the classification process with the other disciplines.

According to the 7-step classification process, the first 5 steps involve the setting up of the catchment configuration scenarios. This work is the contribution of the groundwater component towards the catchment configuration scenarios. Where necessary the specialists will consult with stakeholders in the WMAs to refine their scenarios. A project team meeting will then be held to integrate the specialist work.

4.1. DELINEATION OF GROUNDWATER UNITS AND DESCRIPTION OF STATUS QUO

The basis used for the groundwater classification was to calculate the groundwater stress index (abstraction/recharge). Table 4.1 lists the groundwater stress index classes and then also the linkage to Present Status Category (FETWater, 2004).

Table 4.1: Groundwater stress index classes

Stress Index (abstraction / recharge)	Description	Present Status Category
< 0.05	Unstressed or low levels of stress	A
0.05 – 0.20		B
0.20 – 0.40	Moderate levels of stress	C
0.40 – 0.65		D
0.65 – 0.95	Stressed	E
> 0.95	Critically stressed	F

The groundwater recharge values were obtained from the Groundwater Resources Assessment Phase II project (DWAF, 2005) per Quaternary Catchment. The groundwater abstraction values were also obtained from the GRAII project work (DWAF, 2005). The groundwater use values as obtained from WARMS were also included, however not used in the calculation of the groundwater stress index.

Once the single PES has been assigned to each resource unit, then the groundwater resource category was determined (Table 4.2).

Table 4.2: Terminology and classes used during the classification process

Category	Present Status Category (PES)	Desired Status Category*	Water Resource Category	Management Class*
A	Unmodified natural	Highly sensitive systems, negligible risk allowed	Natural	Excellent
B	Largely natural	Sensitive systems, small risk allowed	Good	Good
C	Moderately modified	Moderately sensitive systems, moderate risk allowed	Fair	Fair
D	Largely modified	Resilient systems, large risk allowed	Poor	
E	Seriously modified			
F	Critically modified			

* *only considered during public participation and catchment visioning processes*

A summary page has been generated per Quaternary catchment (Appendix A). This Quaternary catchment summary page includes:

- The catchment size;
- The total amount of groundwater recharge occurring annually;
- The volume of groundwater abstracted annually (the sub-division of that groundwater use is also included (i.e. rural use; mining; agriculture – irrigation; agriculture – livestock; industry and aquaculture;
- The groundwater balance (i.e. recharge – abstraction);
- The groundwater stress index;
- The groundwater contribution to river baseflow on an annual basis;
- The Groundwater Reserve volume;
- The aquifer type and yield for the catchment;
- The groundwater quality for the catchment;
- The geological setting of the catchment;
- The present status category (A – F);
- The water resource category;

- The desired water resource category (provisional – needs to be reviewed by stakeholders); and
- The management class (provisional – needs to be reviewed by stakeholders).

Included in the summary page there is a short discussion on:

- the risk to groundwater;
- assumptions and constraints;
- the levels of confidence associated with the classification;
- the implications of using more/less water;
- a brief discussion regarding groundwater “hot spots”; and
- relevant previous work.

The summary of each quaternary catchment is provided in Appendix A and an example for one of the quaternary catchments is shown in Figure 4.1. The data on the summary pages will be further refined during interaction with the other project specialists and during the public consultation process.

A process has been followed whereby the groundwater stress index was calculated for each Quaternary Catchment. The main data used was from the DWAF (2005) work, however if more recent work was completed this was included in the analysis. The agriculture use of groundwater was also assessed using Google Earth to estimate the extent of irrigated areas. In some catchments groundwater abstraction was reported for irrigation, yet there were no evidence of agricultural activity in the catchment. In these situations the classifications were adjusted.

Quaternary Catchment: **E10A**

Present Status Category(A-F):	B	
Desired Water Resource Category (A-F):	B	*(to be finalized)*
Management Class *(Excellent/Good/Fair):*	Good	*(to be finalized)*

Area: 134 km²

Recharge: 17.5895 Mm³/a

Total Use: **3.452 Mm³/a**

Rural:	0.0000	*Mining:*	0.0000
AgIrrig:	3.4440	*Industry:*	0.0000
AgLive:	0.0076	*Aquaculture:*	0.0000

Water Balance: 14.138 Mm³/a

Stress Index: 0.2 *Unstressed or low levels of stress*

GW Contribution to Baseflow: 17.864

Preliminary Rapid Reserve:

GW Reserve completed (Y/N): Y

Aquifer type and yield	***% of Area***
Fractured > 5.0 l/s	21
Fractured 2.0 - 5.0 l/s	79

Groundwater Quality (EC)	***% of Area***
0 - 70 mS/m	100

Geology	***% of Area***	***Hydrological significance***
BOKKEVELD GRP	14.48	Little significance, else regolith aquifer
TABLE MOUNTAIN GRP	85.29	Major fractured rock/secondary aquifer system.

Risk to groundwater:	In central southern portion of catchment intensive agriculture - poss. non-point source contamination risk. Gwater plays an important role is providing baseflow. CSIR studiedthe area intensively using isotopes.
Assumptions and constraints:	Most of the agricultural activity is irrigated from groundwater.
Level of confidence:	low
Implications of using more/less water:	Groundwater monitoring network necessary
Discussion on "hot spots":	In summer groundwaters levels are drawn down significantly, however these recover each winter.
Relevant previous work:	-

Figure 4.1: Example of the groundwater summary page for the quaternary E10A

5. INTEGRATED UNITS OF ANALYSIS

The Olifants Doorn Water Management Area (WMA) has long been divided, from a water resources management point of view, into sub-areas that are based on considerations of land as well as water use. These sub-areas are also relatively homogenous socio-economic zones and represent similar aquatic ecological characteristics.

As the areas have been delimited to quaternary catchment boundaries and are at a sufficiently fine scale to approximate socio-economic zonal boundaries, they have the potential to facilitate the integration of ecological and socio-economic aspects that is required in the classification procedure. These areas have thus formed the basis in the delineation of Integrated Units of Analysis for the Olifants Doorn WMA classification procedure, where some of the original sub-areas (that is the Koue Bokkeveld, Doring Rangelands, Knersvlakte, Olifants and Sandveld) were further divided to further facilitate the classification procedure for the WMA.

The IUA that have been identified through the classification procedure for the WMA consist of the following areas:

1. The **Koue Bokkeveld** area which consists of 11 quaternary catchments (E21A-L) that drains in a northerly direction from the catchment divide between the Olifants Doorn WMA and the Breede WMA). The area can be described as a high altitude irrigation farming area, which is characterised by relatively high winter rainfall and the typical water use is from numerous farm-dams for irrigation purposes.

2. The **Doring Rangelands** which consists of 27 quaternary catchments (E22A-G, E23A-K, E24A-H, E40A-B) that drain the south-eastern and central region of the WMA to the confluence with the Olifants River. It is a relatively mountainous area which is characterised by conservation and livestock farming and a low population density.

3. The **Knersvlakte** which consists of 24 quaternary catchments (E31A-H, E32A-E, E33A-F, F60A-E) and drains the northern region of the WMA This is an arid area characterised by a very low population density and has extensive rangelands as the main land use.

4. The **Upper Olifants** Irrigation area which consists of ten quaternary catchments (E10A-K) and extends from the source of the Olifants River to the Clanwilliam Dam. Here, intensive irrigation farming occurs along the Olifants River valley and the area also contains some of the major urban areas in the WMA.

5. The **Olifants/Doring Dryland** Farming area which consists of seven quaternary catchments (E24J-M, E40C-D, E33F) and includes the lower Doring River and its confluence with the Olifants River. This area is characterised by a relatively high proportion of land under dryland farming, but with livestock still being an important activity.

6. The **Lower Olifants** Irrigation area consists of two quaternary catchments (E33G-H) downstream of the confluence of the Olifants and Doring Rivers to the estuary. It is primarily the irrigation farming area that occurs along the lower Olifants river valley and within the floodplain down to the estuary. The area includes several small urban areas.

7. The **Estuary (Ebenezer)** consists of the communal land area comprising the poor fisher-farming community of Ebenhaeser. This is identified as an important target area in terms of resource-poor irrigation farmers. This area falls within the previous area and is associated with the Olifants Estuary.

8. The **Sandveld** sub-area consists of 8 quaternary catchments (G30A-H) within the coastal strip to the south of the Olifants River mouth. The area is primarily an irrigation farming area where the main water resource is groundwater*.*

Table5.1: Summary of Quaternary Catchments and nodes per IUA

IUA	Quaternary catchments	River Nodes	Wetland Nodes	Estuary nodes
Doring Rangelands	E40B, E40A, E24E, E24F E24G, E24C, E24D, E23E, E24H, E23F, E23K, E23D, E22G, E23J, E23C, E23B, E22F, E23H, E23A, E23G, E22E, E22B, E22A, E22D, E22C, E24B, E24A	R12, R20, R21, R22, R25, R27, R28, R29, R30, R31; R32; R35; R36, R50	W10 – W21, W38,	-
Knersvlakte	E31A, E31C, E31D, E31G, E33A, E31B, E31E, E33D, E31H, E31F, E32D, E33B, E32B, E32A, E32E, E33E, E33C, E32C, F60A, F60B, F60C, F60D, F60E	R1 - R5; R8, R58	W25 – W35, W40 – W43	-
Koue Bokkeveld	E21K, E21L, E21J, E21H, E21F, E21G, E21E, E21D, E21C, E21B, E21A	R37 - R39; R41; R43; R45; R46; R48; R49	W7 - W9	-
Lower Olifants Irrigation	E33H, E33G	R7; R9	W36, W37	-
Olifants/Doring Dryland Farming	E40C, E33F, E40D, E24K, E24M, E24J, E24L	R11; R14; R15; R16; R17; R18; R19; R26	W22 - W24, W39	-
Upper Olifants Irrigation	E10K, E10J, E10G, E10H, E10F, E10E, E10D, E10C, E10B, E10A	R13; R23; R24; R33; R34; R40; R42; R44; R47	W1 - W6	-
Ebenezer	E33H	-	-	E1
Sandveld	G3	R51, R52, R53, R54, R55, R56, R57	W44 – W51	E2

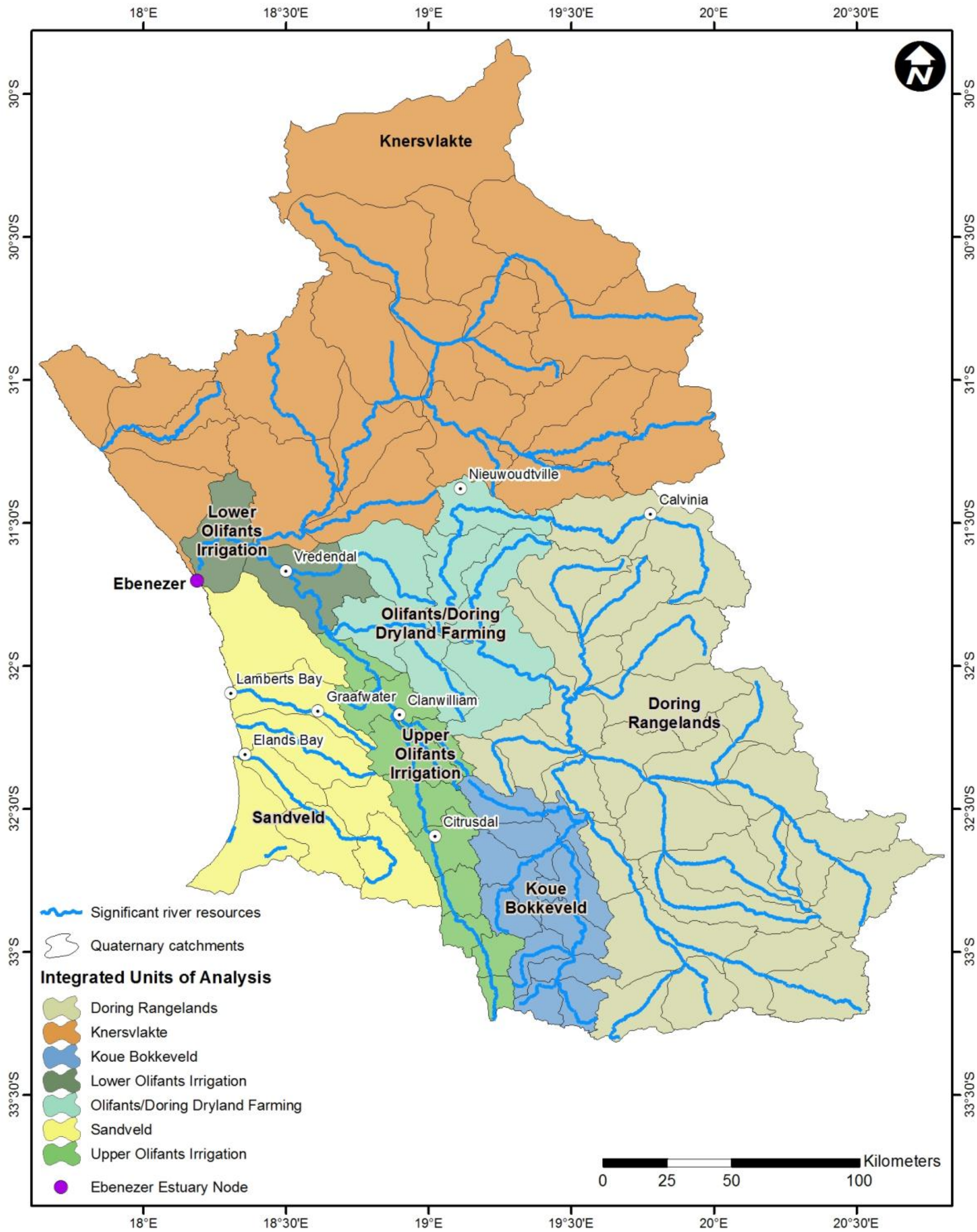

Figure 5.1: Integrated Units of Analysis in the Olifants Doorn WMA

6. ENVIRONMENTAL WATER REQUIREMENTS (EWR) QUANTIFICATION

This section deals with the generation of the flow-ecological condition information at biophysical nodes.

The determination of the EWRs for the river nodes were divided into three groups:

1. Nodes for which a high confidence EWR has already been determined;
2. Nodes for which extrapolation of high confidence EWRs could be undertaken; and
3. Non-extrapolation nodes.

EWRs at each node were generated for the ecological categories of a full-suite of ecological conditions, *that is*:

- Category A/B;
- Category B;
- Category C; and
- Category D.

For nodes that are NOT suitable for extrapolation of data from sites with high-confidence Reserve data, the EWR quantifications were done using the Desktop Model.

6.1. High Confidence EWRs

A number of higher confidence EWRs have been determined in the WMA. These are discussed further below:

Olifants Doring River EWRs:

River nodes R33, R13, R34, R20, R15 and R38 are all in quaternary catchments that have had a Comprehensive Reserve determined for them (Table and 6.1).

Table 6.1: High confidence EWR Sites in the Olifants/Doring River system

EWR Site No.	Quaternary No.	Corresponding River node code	River	Site Name	Latitude	Longitude
1a / 1b	E10F	R33	Olifants	Olifants at Hex River	32°26.764 32°26.680	18°57.601 18°57.504
2	E10K	R13	Olifants	Olifants at Alwynskop	31°57.974	18°44.463
3a / 3b	E10G	R34	Rondegat	Rondegat at Algeria	32°21.760 32°21.739	19°02.618 19°02.593
4a / 4b	E24J	R19	Doring	Doring at Biedou	32°02.410 32°02.416	19°24.896 19°24.783
5	E24M	R14	Doring	Doring at Ou Drif	31°51.446	18°54.754
6a / 6b	E21J	R38	Groot	Groot at Mount Cedar	32°39.552 32°39.377	19°23.786 19°23.982

Table 6.2: Recommended EWRs for the Olifants Doring River system

Site	Portion of the EWR	Recommended Ecostatus	Calculation Notation	$MCMa^{-1}$	%nMAR
EWR SITE 1	MAINTENANCE TOTAL (Volume)	D	DRIFT Annual	185.9	55
			Long-term average	128.57	38.5
EWR SITE 2	MAINTENANCE TOTAL (Volume)	D	DRIFT Annual	194	38
			Long-term average	Not available for this site.	
EWR SITE 3	MAINTENANCE TOTAL (Volume)	B	DRIFT Annual	4.83	63
			Long-term average	4.06	53
EWR SITE 4	MAINTENANCE TOTAL (Volume)	B	DRIFT Annual	277	66
			Long-term average	199	47
EWR SITE 5	MAINTENANCE TOTAL (Volume)	B	DRIFT Annual	310	61
			Long-term average	234.39	46
EWR SITE 6	MAINTENANCE TOTAL (Volume)	B/C	DRIFT Annual	79	57
			Long-term average	63	46

Olifants Estuary EWR:

In the Olifants Estuary Reserve Determination study, seven flow scenarios (natural, present day and five possible future development scenarios) were considered. Three of these were selected to provide for a future B, C and D category for the estuary. These three flow regimes were used to provide the rule-curves for the estuary requirements for different ecological categories.

Table 6.3: Olifants Estuary EWR requirements for a B category (given in 10^6 m^3)

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
99%ile	48.13	32.08	21.5	37.21	24.46	7.77	96.73	194.2	550.92	472.06	230.02	153.7
90%ile	28.9	9.6	7.24	3.64	3.76	3.85	9.62	80.9	151.71	159.08	126.25	65.58
80%ile	16.05	4.3	2.06	1.75	1.68	2.21	4.85	22.01	93.83	104.19	79.44	48.08
70%ile	12.84	2.93	1.68	1.55	1.38	1.81	3.07	11.18	57.99	78.1	66.22	34.22
60%ile	11.49	2.93	1.51	1.51	1.37	1.46	2.88	8.24	42.45	58.26	50.45	25.66
50%ile	10.11	2.93	1.5	1.51	1.34	1.42	2.84	6.19	37.99	51.82	47.54	22.18
40%ile	9.01	2.49	1.5	1.51	1.34	1.42	2.49	3.57	36.22	39.92	44.77	16.34
30%ile	8.32	1.51	1.5	1.51	1.34	1.42	1.76	3.42	24.2	30.79	33.23	14.73
20%ile	6.36	1.43	1.18	1.51	0.91	1.11	1.41	2.05	15.78	21.17	28.07	11.21
10%ile	4.02	0.83	0.58	0.99	0.85	1	1.28	1.15	7.44	9.49	17.41	9.66
1%ile	1.01	0.15	0	0.99	0.34	0	0.04	0.29	0.82	2.07	5.35	4.04

Sandveld Rivers EWRs:

Ecological EWRs have been undertaken for surface waters in the Sandveld at a Rapid Level for components of three river systems:

Langvlei River (G30F):

(i) Instream Flow Requirement (IFR) for the lowest reach (Node R56);
(ii) Environmental Flow Requirement (EFR) for the Wadrif Wetland (Node W49); and
(iii) Environmental Flow Requirement (EFR) for the Wadrif Pan (Node W49).

Jakkals River (G30G):

(i) Instream Flow Requirement (IFR) for the lowest reach (Node R57); and
(ii) Environmental Flow Requirement (EFR) for the Jakkalsvlei Pan (Node W50).

Verlorenvlei River (G30B-E)

(i) Instream Flow Requirement (IFR) for the Kruismans River which represents the upper mainstream, and the Verlorenvlei River at the lowest reach of the mainstream (Nodes R52 and R53); and
(ii) Environmental Flow Requirement (Water Level Specification) for the Verlorenvlei Lake, inclusive of provisional requirements for maintaining acceptable hydrodynamics for maintaining the seasonal connection to the sea (Node E2).

The recommended Reserve specifications are summarised in Table 6.4.

Table 6.4: Surface EWRs for the Sandveld

Surface water component	Location Lat/Long	Node No	Present Ecological State	Ecological Importance & Sensitivity	Recommended Ecological Management Category	Maintain low flow (Mm^3/a)	Drought Low flow (Mm^3/a)	Maintain High flow (Mm^3/a)	Total IFR flow (Mm^3/a)
Langvlei River	-32.21050 18.37825	R56	E/F	C	C	0.520	0.000	1.437	1.957
Wadrif Wetland	-32.21325 18.37721	W49	F	B	C	0.520	0.000	1.437	1.957
Wadrif Pan	-32.20523 18.33834	W49	E	C	C	2.500	1.500	-	5.000
Jakkals River	-32.08942 18.35242	R57	D	C	C	0.089	0.014	0.263	0.352
Jakkalsvlei	-32.08776 18.32152	W50	E	C	C	0.250	-	-	0.500
Verlorenvlei (Duikerfontein)	-32.61139 18.77444	R52	C	B	C	1.683	0.930	2.189	3.872
Verlorenvlei (Redelinghuys)	-32.46556 18.51667	R53	C	B	B	4.537	0.623	8.739	13.276
Verlorenvlei Lake		E2	C	B	B	Water level specification			

Table 6.5: Verlorenvlei Water Level Specification

Component	**Requirement/Motivation**
Frequency and duration of opening	Twice in any single year (autumn, early winter and spring), or alternatively; A single extended period from winter through into spring.
Mouth open conditions	“Semi-closed”, i.e. continuous outflow with minimal seawater intrusion.
Water level (Mouth open)	2.20 m AMSL
Water level (	1.95 m AMSL
Water level (Breaching)	Unknown but less than 2.5 m AMSL

6.2. Extrapolated EWRs

As part of the pilot testing of the classification procedure in the Olifants Doring Catchment, the river nodes in the catchment were tested for their suitability for extrapolation of the high confidence EWRs. River nodes R13, R23, R33, R40, R41 and R48 all share the same Ecoregion, Hydrological Index and Geomorphic zone with EWR 1 and 2, i.e. they all occur within the Western Folded Mountains Ecoregion, they are all perennial and they all occur in Lower Foothill Geomorphic zone. Nodes that shared the same Hydrological Index, Ecoregion and Geomorphic zone (but not necessarily an Altitude Class) with one of the EWR sites were taken forward to a comparison of their fish assemblage characteristics (Table 6.6).

Table 6.6: Extrapolation testing of nodes for Hydrological Index, Ecoregion, Geomorphic zone and Altitude Class

Node	**Hydrological Index**	**Ecoregion**	**Geomorphic Zone**	**Altitude**	**Fish Assemblage / Indicator fish species**	**Nodes for extrapolation**
R36	Ephemeral	Great Karoo	Lower Foothill	200-400		
R32						
R29						
R30						
R27				0-200		
R12				600-800		
R50			Mnt Stream/Upper Foothill	400-600		
R31				200-400		
R22						
R21				0-200		
R2		Nama Karoo	Lower Foothill	400-600		
R1			Mnt Stream/Upper Foothill	600-800		
R 51		South Western Coastal Belt	Lower Foothill	0-200		
R 56			Upper Foothill	0-200		
R 57		Western Coastal Belt	Upper Foothill	Lower Foothill		
R3			Lower Foothill	0-200		
R5						
R8						
R 58						
R11		Western Folded Mountains	Lower Foothill	0-200		
R17						
R4	Seasonal	Great Karoo	Mnt Stream/Upper Foothill	200-400		
R 52		Western Coastal Belt	Lower Foothill	0-200		
R20		Western Folded Mountains	Lower Foothill	0-200	Same	R20
R19					Same	R19
R16					Same	R16
R14					Same	R14
R28				200-400	Same	R28
R44				400-600		
R26			Mnt Stream/Upper Foothill	0-200		
R15						

Node	Hydrological Index	Ecoregion	Geomorphic	Altitude	Fish Assemblage / Indicator fish species	Nodes for extrapolation
R 55	Perennial	South Western Coastal Belt	Mnt Stream/Upper Foothill	0-200		
R 53			Upper Foothill	0-200		
R9		Western Coastal Belt	Lower Foothill	0-200		
R7			Lower River	0-200		
R40		Western Folded Mountains	Lower Foothill	0-200	Same	R40
R33					Same	R33
R23					Same	R23
R13					Same	R13
R44				400-600	Same	R44
R41				600-800	No data	
R48				800-1000	No data	
R42			Mnt Stream/Upper Foothill	0-200	Same / Different	R42
R34					Same	R34
R 54					Same / Different	
R24				200-400	Same	R24
R37					Same / Different	
R25				400-600	Same / Different	
R38					Same	R38
R39					Same	R39
R47				600-800	Different	
R49				800-1000	No data	
R46					No data	
R43			Rejuvenated Floodplain	800-1000		
R45						

None of the EWR sites in the Sandveld were considered for extrapolation purposes as they were undertaken at a Rapid level.

6.3. Non-extrapolated EWRs

Based on the updated hydrology (section 3.3), the Desktop Reserve Model was utilised to generate the remainder of the EWRs. EWR tables, rule curves and modified time series were generated using the Desktop Model for each of the quaternaries and for each of the ecological categories (A/B, B, C and D). A list of the EWRs determined and the level of determination are provided in Table 6.7. A summary of the EWR results is provided in Table 6.8.

Table 6.7: Summary of level of EWR determinations

Node	Quat	Regional type	Determination Method	Node	Quat	Regional type	Determination Method
R1	E31G	W Karoo	Desktop assessment	R 31	E23J	W Karoo	Desktop assessment
R2	E31E	W Karoo	Desktop assessment	R32	E23D	W Karoo	Desktop assessment
R3	E33E	W Karoo	Desktop assessment	**R33**	E10F	W Cape (wet)	EWR 1
R4	E32C	W Karoo	Desktop assessment	**R34**	E10G	W Cape (wet)	EWR 3
R5	E33B	W Karoo	Desktop assessment	R36	E22F	W Karoo	Desktop assessment
R7	E33H	W Cape (wet)	Desktop assessment	R37	E21L	W Cape (dry)	Desktop assessment
R8	E32E	W Karoo	Desktop assessment	**R38**	E21J	W Cape (wet)	EWR 6
R9	E33G	W Karoo	Desktop assessment	R39	E21F	W Cape (wet)	Extrapolated from EWR 3&6
R11	E40C	W Karoo	Desktop assessment	R40	E10D	W Cape (wet)	Extrapolated from EWR 1&2
R12	E40A	W Karoo	Desktop assessment	R41	E21G	W Cape (dry)	Desktop assessment
R13	E10K	W Cape (wet)	EWR 2	R42	E10C	W Cape (wet)	Extrapolated from EWR 3&6
R14	E24M	W Karoo	Extrapolated from EWR 4&5	R43	E21E	W Cape (dry)	Desktop assessment
R15	E24L	W Cape (dry)	EWR 5	R44	E10B	W Cape (wet)	Extrapolated from EWR 3&6
R16	E24K	W Karoo	Extrapolated from EWR 4&5	R45	E21D	W Cape (dry)	Desktop assessment
R17	E40D	W Karoo	Desktop assessment	R46	E21C	W Cape (dry)	Desktop assessment
R19	E24J	W Karoo	EWR 4	R47	E10A	W Cape (wet)	Desktop assessment
R20	E24H	W Karoo	Extrapolated from EWR 4&5	R48	E21A	W Cape (dry)	Desktop assessment
R21	E24D	W Karoo	Desktop assessment	R49	E21B	W Cape (dry)	Desktop assessment
R22	E24G	W Karoo	Desktop assessment	R50	E22D	W Karoo	Desktop assessment
R23	E10J	W Cape (wet)	Extrapolated from EWR 1&2	R 51	G30A	W Karoo	Desktop assessment
R24	E10H	W Cape (wet)	Extrapolated from EWR 3&6	R 52	G30E	W Cape (dry)	Rapid assessment
R25	E24A	W Karoo	Desktop assessment	R 53	G30D	W Cape (dry)	Rapid assessment
R26	E24B	W Karoo	Desktop assessment	R 54	G30C	W Cape (dry)	Rapid assessment
R27	E23K	W Karoo	Desktop assessment	R 55	G30B	W Cape (dry)	Rapid assessment
R28	E22G	W Karoo	Extrapolated from EWR 4&5	R 56	G30F	W Karoo	Rapid assessment
R 29	E23F	W Karoo	Desktop assessment	R 57	G30G	W Karoo	Rapid assessment
R30	E23J	W Karoo	Desktop assessment	R 58	F60D	W Karoo	Desktop assessment

Table 6.8: Summary of Environmental Flow Requirements for WMA

Node	Quat No	Regional type	Incremental									Cumulative								
			MAR	A/B		B		C		D		MAR	A/B		B		C		D	
				EWR	%	EWR	%	EWR	%	EWR	%		EWR	%	EWR	%	EWR	%	EWR	%
R47	E10A	W Cape (wet)	60.475	21.903	36.22	17.931	29.65	12.064	19.94	7.834	12.95	Incremental catchment								
R44	E10B	W Cape (wet)	68.528	25.925	37.83	21.183	30.91	14.2	20.72	9.309	13.58	129.003	48.789	37.82	39.888	30.92	26.781	20.76	17.465	13.54
R42	E10C	W Cape (wet)	53.402	20.276	37.97	16.586	31.06	11.14	20.86	7.268	13.61	182.405	69.073	37.87	56.375	30.91	37.854	20.75	24.77	13.58
R40	E10D	W Cape (wet)	51.363	19.415	37.80	15.896	30.95	10.684	20.80	6.985	13.60	233.767	88.437	37.83	72.327	30.94	48.621	20.8	31.623	13.53
	E10E	W Cape (wet)	59.7	19.508	38.68	19.508	38.68	13.001	21.79	8.483	14.21	293.467	111.493	37.99	91.201	31.08	61.248	20.87	39.961	13.62
R33	E10F	W Cape (wet)	62.09	23.652	38.09	19.316	31.11	12.907	20.79	8.401	13.53	355.557	135.545	38.12	110.684	31.13	74.392	20.92	48.429	13.62
R34	E10G	W Cape (wet)	81.716	31.142	38.11	25.513	31.22	17.074	20.89	11.142	13.64	437.273	166.857	38.16	136.466	31.21	91.512	20.93	59.869	13.69
R24	E10H	W Cape (wet)	31.063	11.422	36.77	9.33	30.04	6.284	20.23	4.097	13.19	Incremental catchment								
R23	E10J	W Cape (wet)	29.817	11.41	38.27	9.324	31.27	6.252	20.97	4.067	13.64	498.153	190.522	38.25	155.777	31.27	104.295	20.94	68.393	13.73
R13	E10K	W Cape (wet)	7.562	2.887	38.18	2.362	31.24	1.586	20.97	1.031	13.64	505.716	193.093	38.18	157.772	31.2	105.956	20.95	68.976	13.64
R48	E21A	W Cape (dry)	39.425	14.253	36.15	11.668	29.50	7.848	19.91	5.096	12.93	Incremental catchment								
R49	E21B	W Cape (dry)	1.23	0.398	32.36	0.324	26.33	0.217	17.61	0.138	11.21	Incremental catchment								
R46	E21C	W Cape (dry)	1.284	0.416	32.36	0.338	26.33	0.226	17.61	0.144	11.21	41.939	14.861	35.43	12.155	28.98	8.168	19.48	5.285	12.6
R45	E21D	W Cape (dry)	50.217	18.154	36.15	14.861	29.59	9.996	19.91	6.49	12.92	Incremental catchment								
R43	E21E	W Cape (dry)	1.616	0.523	32.36	0.426	26.33	0.284	17.61	0.181	11.21	93.772	33.385	35.6	27.314	29.13	18.359	19.59	11.89	12.68
R39	E21F	W Cape (wet)	2.091	0.739	35.37	0.618	29.54	0.406	19.41	0.264	12.62	95.862	33.924	35.39	28.32	29.54	18.642	19.45	12.059	12.58
R41	E21G	W Cape (dry)	55.22	19.967	36.16	16.346	29.60	10.994	19.91	7.139	12.93	Incremental catchment								
	E21H	W Cape (dry)	83.495	30.175	36.14	24.702	29.59	16.615	19.90	10.788	12.92	138.715	50.142	36.15	41.048	29.59	27.61	19.9	17.926	12.92
R38	E21J	W Cape (wet)	1.747	0.66	37.76	0.541	30.93	0.364	20.81	0.238	13.61	236.325	89.155	37.73	73.103	30.93	49.046	20.75	31.989	13.54
	E21K	W Cape (dry)	1.819	0.589	32.36	0.479	26.33	0.32	17.61	0.204	11.21	Incremental catchment								
R37	E21L	W Cape (dry)	1.076	0.348	32.35	0.283	26.33	0.189	17.60	0.121	11.21	239.22	85.128	35.59	69.645	29.11	46.812	19.57	30.314	12.67
	E22A	W Karoo	4.138	1.321	31.93	1.075	25.98	0.719	17.37	0.457	11.04	Incremental catchment								
	E22B	W Karoo	3.522	1.124	31.93	0.915	25.98	0.612	17.37	0.389	11.05	7.66	2.446	31.93	1.99	25.98	1.33	17.37	0.846	11.05
	E22C	W Karoo	2.704	0.863	31.93	0.702	25.98	0.47	17.37	0.299	11.04	Incremental catchment								
R50	E22D	W Karoo	2.736	0.874	31.92	0.711	25.97	0.475	17.37	0.302	11.04	2.736	0.874	31.92	0.711	25.97	0.475	17.37	0.302	11.04
	E22E	W Karoo	18.688	5.966	31.93	4.854	25.98	0.971	17.37	2.064	11.05	18.688	5.966	31.93	4.854	25.98	3.246	17.37	2.064	11.05
R36	E22F	W Karoo	2.206	0.704	31.92	0.573	25.97	0.383	17.37	0.244	11.04	20.894	6.671	31.93	5.427	25.98	3.629	17.37	2.308	11.05
R28	E22G	W Karoo	6.493	2.242	34.53	1.693	26.07	1.227	18.90	0.791	12.18	266.606	91.89	34.47	69.632	26.12	50.403	18.91	32.464	12.18

Node	Quat No	Regional type	Incremental									Cumulative								
			MAR	A/B		B		C		D		MAR	A/B		B		C		D	
				EWR	%	EWR	%	EWR	%	EWR	%		EWR	%	EWR	%	EWR	%	EWR	%
	E23A	W Karoo	8.001	2.594	32.42	2.111	26.38	1.412	17.64	0.899	11.24	Incremental catchment								
	E23B	W Karoo	7.402	2.4	32.42	1.953	26.38	1.306	17.64	0.832	11.24	15.403	4.994	32.42	4.064	26.38	2.717	17.64	1.731	11.24
	E23C	W Karoo	3.339	1.082	32.42	0.881	26.38	0.589	17.64	0.375	11.24	Incremental catchment								
R32	E23D	W Karoo	7.875	2.553	32.42	2.078	26.38	1.389	17.64	0.885	11.24	26.617	8.63	32.42	7.023	26.38	4.695	17.64	2.991	11.24
	E23E	W Karoo	5.922	1.92	32.42	1.562	26.38	1.045	17.64	0.666	11.24	Incremental catchment								
R29/31	E23F	W Karoo	4.964	1.61	32.42	1.31	26.38	0.876	17.64	0.558	11.24	37.503	12.16	32.42	9.895	26.38	6.616	17.64	4.215	11.24
	E23G	W Karoo	7.844	2.53	32.42	2.069	26.38	1.384	17.64	0.881	11.24	Incremental catchment								
	E23H	W Karoo	6.93	2.247	32.42	1.828	26.38	1.223	17.64	0.779	11.24	Incremental catchment								
R30	E23J	W Karoo	9.396	3.046	32.42	2.479	26.38	1.658	17.64	1.056	11.24	24.17	7.837	32.42	6.377	26.38	4.264	17.64	2.716	11.24
R27	E23K	W Karoo	6.006	1.947	32.42	1.584	26.38	1.059	17.64	0.675	11.24	334.286	113.133	33.84	92.254	27.6	61.812	18.49	39.666	11.87
R25	E24A	W Karoo	4.523	1.471	32.53	1.197	26.47	0.801	17.70	0.51	11.28	Incremental catchment								
R26	E24B	W Karoo	8.281	2.694	32.54	2193	26.48	1.466	17.71	0.935	11.29	12.803	4.166	32.54	3.39	26.48	2.267	17.71	1.445	11.29
	E24C	W Karoo	13.855	4.509	32.55	3.67	26.49	2.454	17.71	1.564	11.29	Incremental catchment								
R21	E24D	W Karoo	17.62	5.735	32.55	4.667	26.49	3.121	17.71	1.989	11.29	31.475	10.244	35.55	8.337	26.49	5.576	17.71	3.554	11.29
	E24E	W Karoo	11.855	3.858	32.54	3.14	26.48	2.099	17.71	1.338	11.29	Incremental catchment								
	E24F	W Karoo	10.285	3.348	32.55	2.724	26.49	1.822	17.71	1.161	11.29	22.14	7.205	32.54	5.864	26.49	3.921	17.71	2.499	11.29
R22	E24G	W Karoo	11.186	3.64	32.54	2.962	26.48	1.981	17.71	1.263	11.30	64.801	21.09	32.55	17.164	26.49	11.477	17.71	7.315	11.29
R20	E24H	W Karoo	8.534	2.939	34.43	2.405	28.18	1.613	18.90	1.04	12.18	420.425	145.009	34.49	118.359	28.15	79.287	18.86	51.048	12.14
R19	E24J	W Karoo	19.05	6.562	34.44	5.35	28.09	3.583	18.81	2.322	12.19	439.475	151.095	34.38	123.243	28.04	82.852	18.85	53.34	12.14
R16	E24K	W Karoo	11.521	3.957	34.34	3.236	28.09	2.167	18.81	1.393	12.09	499.1	171.455	34.35	139.843	28.02	94.006	18.84	60.513	12.12
R15	E24L	W Cape (dry)	9.127	3.02	33.09	2.46	26.95	1.646	18.03	1.052	11.53	508.227	176.478	34.72	144.163	28.37	96.754	19.04	62.376	12.27
R14	E24M	W Karoo	9.35	3.117	33.34	2.644	28.28	1.861	19.91	1.149	12.28	517.577	179.315	34.65	146.538	28.31	103.155	19.93	63.252	12.22
	E31A	W Karoo	0.223	0.071	31.74	0.058	25.82	0.038	17.27	0.024	10.98	Incremental catchment								
	E31B	W Karoo	9.789	0.308	31.53	0.251	25.66	0.168	17.17	0.107	10.91	Incremental catchment								
	E31C	W Karoo	1.034	0.326	31.53	0.265	25.66	0.178	17.17	0.113	10.91	2.012	0.634	31.53	0.516	25.66	0.345	17.17	0.22	10.91
	E31D	W Karoo	0.544	0.172	31.52	0.14	25.65	0.093	17.17	0.059	10.91	2.556	0.806	31.53	0.656	25.66	0.439	17.17	0.279	10.91
R2	E31E	W Karoo	0.324	0.102	31.47	0.083	25.62	0.056	17.14	0.035	10.90	2.88	0.908	31.53	0.739	25.66	0.494	17.17	0.314	10.91
	E31F	W Karoo	0.324	0.102	31.47	0.083	25.62	0.056	17.14	0.035	10.90	Incremental catchment								

Node	Quat No	Regional type	Incremental									Cumulative									
			MAR	A/B		B		C		D		MAR	A/B		B		C		D	
				EWR	%	EWR	%	EWR	EWR	%	EWR		EWR	%	EWR	%	EWR	%	EWR	%
R1	E31G	W Karoo	0.814	0.257	31.52	0.209	25.65	0.14	17.16	0.089	10.91	Incremental catchment									
	E31H	W Karoo	0.488	0.154	31.50	0.125	25.63	0.084	17.15	0.053	10.90	4.506	1.42	31.52	1.156	25.65	0.773	17.17	0.492	10.91
	E32A	W Karoo	4.033	1.3	32.24	1.058	26.23	0.707	17.54	0.45	11.16	Incremental catchment									
	E32B	W Karoo	2.985	0.963	32.24	0.783	26.23	0.524	17.54	0.333	11.16	7.018	2.263	32.24	1.841	26.23	1.231	17.54	0.784	11.16
R4	E32C	W Karoo	2.302	0.741	32.20	0.603	26.20	0.403	17.52	0.257	11.15	9.32	3.004	32.23	2.444	26.23	1.634	17.53	1.04	11.16
	E32D	W Karoo	2.225	0.716	32.21	0.583	26.20	0.39	17.52	0.248	11.15	11.544	3.72	32.23	3.027	26.22	2.024	17.53	1.288	11.16
R8	E32E	W Karoo	3.604	1.162	32.23	0.945	26.23	0.632	17.53	0.402	11.16	11.544	3.72	32.23	3.027	26.22	2.024	17.53	1.288	11.16
	E33A	W Karoo	0.324	0.102	31.47	0.083	25.62	0.056	17.14	0.35	10.90	20.579	6.584	31.99	5.357	26.03	3.582	17.4	2.278	11.07
R5	E33B	W Karoo	0.694	0.218	31.47	0.178	25.61	0.119	17.14	0.076	10.89	21.273	6.805	31.99	5.536	26.03	3.702	17.4	2.354	11.07
	E33C	W Karoo	1.009	0.315	31.23	0.257	24.43	0.172	17.04	0.109	10.84	Incremental catchment									
	E33D	W Karoo	1.59	0.499	31.36	0.406	25.53	0.272	17.09	0.173	10.86	Incremental catchment									
R3	E33E	W Karoo	1.326	0.416	31.35	0.338	25.52	0.227	17.09	0.144	10.86	21.273	6.805	31.99	5.536	26.03	3.702	17.4	2.354	11.07
	E33F	W Karoo	4.53	1.466	32.37	1.193	26.34	0.798	17.61	0.508	11.22									
R9	E33G	W Karoo	0.948	0.296	31.24	2.41	25.44	0.162	17.04	0.103	10.84	25.197	8.054	31.96	6.553	26.01	4.381	17.39	2.786	11.06
R7	E33H	W Cape (wet)	0.757	0.243	32.05	0.197	26.07	0.132	17.43	0.084	11.09	1053.968	363.208	34.46	296.547	28.14	198.931	18.87	128.079	12.16
R12	E40A	W Karoo	16.631	5.413	32.55	4.405	26.49	2.946	17.71	1.878	11.29	Incremental catchment									
	E40B	W Karoo	12.494	4.066	32.54	3.309	26.48	2.213	17.71	1.41	11.29	29.125	9.479	32.55	7.714	26.49	5.158	17.71	3.288	11.29
R11	E40C	W Karoo	9.365	3.048	32.54	2.48	26.48	1.659	17.71	1.057	11.29	38.491	12.527	32.54	10.195	26.49	6.817	17.71	4.345	11.29
R17	E40D	W Karoo	9.163	3.128	32.54	2.546	26.48	1.702	17.71	1.085	11.29	48.104	15.655	32.54	12.741	26.49	8.519	17.71	5.43	11.29
	F60A	W Karoo	0.201	0.065	32.36	0.053	26.33	0.035	17.61	0.023	11.21	Incremental catchment									
	F60B	W Karoo	0.174	0.056	32.41	0.046	26.37	0.031	17.63	0.02	11.23	Incremental catchment									
	F60C	W Karoo	0.344	0.114	33.20	0.093	27.05	0.062	18.10	0.04	11.57	Incremental catchment									
R 58	F60D	W Karoo	0.28	0.093	33.38	0.076	27.19	0.051	18.20	0.033	11.65	0.799	0.265	33.23	0.216	27.07	0.145	18.12	0.093	11.59
	F60E	W Karoo	0.055	0.017	31.15	0.014	25.38	0.009	17.01	0.006	10.86	Incremental catchment									
R 51	G30A	W Karoo	9.837	3.496	35.54	2.86	29.07	1.922	19.54	1.244	12.65	Incremental catchment									
R 55	G30B	W Cape (dry)	15.248	5.654	37.08	4.629	30.36	3.113	20.42	2.028	13.30	Incremental catchment									
R 54	G30C	W Cape (dry)	17.495	6.081	38.88	5.554	31.75	3.72	21.26	2.429	13.88	Incremental catchment									
R 53	G30D	W Cape (dry)	14.098	5.112	36.26	4.185	29.69	2.815	19.97	1.829	12.97	46.842	17.649	37.68	14.443	30.83	9.706	20.72	6.33	13.51

Node	Quat No	Regional type	Incremental									Cumulative								
			MAR	A/B		B		C		D		MAR	A/B		B		C		D	
				EWR	%	EWR	%	EWR	EWR	%	EWR		EWR	%	EWR	%	EWR	%	EWR	%
R 52	G30E	W Cape (dry)	6.791	2.446	36.02	2.002	29.49	1.347	19.83	0.874	12.87	53.633	20.133	37.54	16.479	30.72	11.077	20.65	7.222	13.47
R 56	G30F	W Karoo	13.256	4.652	35.09	3.802	28.68	2.553	19.26	1.649	12.44	Incremental catchment								
R 57	G30G	W Karoo	5.33	1.862	34.93	1.521	28.54	1.021	19.16	0.659	12.37	Incremental catchment								
R 58	G30H	W Karoo	6.845	2.452	35.82	2.006	29.31	1.349	19.71	0.875	12.78	Incremental catchment								

7. WATER RESOURCE CLASSIFICATION SCENARIOS

There may be numerous possible ecological category configurations for a particular catchment, ranging from the catchment ecological sustainability baseline configuration (ESBC) which would permit maximum use scenario to a minimum use scenario, that is, the catchment is maintained in near-pristine (A/B-category) condition throughout. To facilitate the decision making process, four representative catchment configuration scenarios have been selected and the resulting balance generated for evaluation. These are:

- Scenario 1 - Ecological Sustainability Baseline Configuration ESBC (which would permit maximum use) scenario;
- Scenario 2 - Present Ecological State (PES) scenario;
- Scenario 3 - RDM scenario (approved ecological Reserve); and
- Scenario 4 - Conservation targets and Recommended Ecological Category (1999) Scenario.

The four selected scenarios are discussed in greater detail in the following sections.

7.1. EWR balance spread sheet for consideration of scenarios

A hydrological model was not available for use in considering the various scenarios for the Olifants Doorn WMA. However as part of the pilot testing of the classification procedure in the Olifants Doring catchment, an EWR balance excel spread sheet was used which allows for a consideration of the compliance with the EWRs for each quaternary within the catchment (Figure 7.1). The spread sheet thus allows for consideration of both the incremental and cumulative EWR for each ecological category (A/B, B, C and D) throughout the catchment. The spread sheet was updated with the newly generated EWR values (based on the updated hydrology) for the four ecological categories and expanded to include the G30 and F60 catchments.

7.2. Catchment Configuration Scenarios

7.2.1. Scenario 1 - Ecological Sustainability Baseline Configuration (which would permit maximum use) scenario

The ESBC scenario is defined in the classification guidelines documents as the "*lowest theoretical level of protection required for the sustainable use of the entire catchment"*. In order to initiate the setting up of the balance a **starter configuration** is generated in which all the ecological categories is adjusted to a D category for both the cumulative and incremental catchment areas (Figure 7.1). It is not intended to provide a viable catchment configuration scenario but should rather be used to start the process on the lowest level (category D). The outcome of all catchment at a D category is represented in Figure 7.1. It is clear that is not feasible or possible to set all the ecological categories at D as this will result in a configuration in which the water required for the EWR (ecological Reserve) will not be achieved in the downstream catchments. Implying therefore that the water supplied by an ecological category D category in the upper catchment is not sufficient to comply with a D requirement in the lower parts of the catchments. Figure 7.1 indicates that in almost all of the catchments there is a deficit in complying with the EWR for maintaining the desired downstream ecological condition.

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol	Categ controls
48	E21A		0			B		5.096		5.096	5.096	0.000	1	
49	E21B		0			C		0.138		0.138	0.138	0.000	1	
46	E21C		2	49,48		C		0.144	0.18	5.198	5.285	-0.087	1	1
45	E21D		0			E/F		6.490		6.490	6.490	0.000	1	
43	E21E		2	46,45		E/F		0.181	0.40	11.469	11.890	-0.421	1	1
39	E21F		1	43		E/F		0.264	0.71	11.023	12.059	-1.036	1	1
41	E21G		0			C		7.139		7.139	7.139	0.000	1	
38	E21H	E21J	1	41		E/F		11.026	0.15	18.015	31.989	-13.974	1	1
37	E21K	E21L	2	38,39		E/F		0.325	0.60	28.763	30.314	-1.551	1	1
50	E22C	E22D	0			E/F		0.601		0.601	0.302	0.299	1	
36	E22A	E22B E22E E22F	1	50		E/F		3.154	1.77	1.985	2.308	-0.323	1	1
28	E22G		2	37,36		E/F		0.791	1.26	30.279	32.464	-2.185	1	1
32	E23A	E23B E23C E23D	0			E/F		2.991		2.991	2.991	0.000	1	
31	E23E		0			E/F		0.666		0.666	0.666	0.000	1	
29	E23F		2	32,31		E/F		0.558	0.56	3.655	4.215	-0.560	1	1
30	E23G	E23H E23J	1	29		E/F		2.716		6.371	2.716	3.655	1	
27	E23K		2	28,30		E/F		0.675	0.84	36.485	39.666	-3.181	1	1
25	E24A		0			E/F		0.510		0.510	0.510	0.000	1	
26	E24B		1	25		E/F		0.935	0.49	0.955	1.445	-0.490	1	1
21	E24C	E24D	0			D		3.553		3.553	3.554	-0.001	1	
22	E24E	E24F E24G	0			E/F		3.762		3.762	7.315	-3.553	1	
20	E24H		4	27,26,21,		D		1.040	2.00	43.795	51.048	-7.253	1	1
19	E24J		1	20		D		2.322	1.61	44.507	53.340	-8.833	1	1
16	E24K		1	19		E/F		1.393		45.900	60.513	-14.613	1	
12	E40A	E40B	0			C		3.288		3.288	1.878	1.410	1	
11	E40C		1	12		C		1.057	1.38	2.965	4.345	-1.380	1	1
17	E40D		1	11		E/F		1.085	1.33	2.720	5.430	-2.710	1	1
15	E24L		2	16,17		D		1.052	2.01	47.662	62.376	-14.714	1	
14	E24M		1	15		E/F		1.149	1.77	47.041	63.252	-16.211	1	1
47	E10A		0			D		7.834		7.834	7.834	0.000	1	
44	E10B		1	47		E/F		9.309	0.11	17.033	17.465	-0.432	1	1
42	E10C		1	44		E/F		7.268	0.21	24.091	24.770	-0.679	1	1
40	E10D		1	42		C		6.985	0.28	30.796	31.623	-0.827	1	1
33	E10E	E10F	1	40		C		16.884	0.77	46.910	48.429	-1.519	1	1
24	E10H		0			C		4.097		4.097	4.097	0.000	1	
23	E10G	E10J	2	33,24		C		15.209	2.16	64.056	68.393	-4.337	1	1
13	E10K		1	23		C		1.031	0.73	64.357	68.976	-4.619	1	1
4	E32A	E32B E32C	0			E/F		1.040		1.040	1.040	0.000	1	
2	E31B	E31C E31D E31E	0			E/F		0.314		0.314	0.314	0.000	1	
1	E31G		0			E/F		0.089		0.089	0.089	0.000	1	
3	E31F	E31H E32E	3	4,2,1		E/F		0.490	0.20	1.733	2.354	-0.621	1	1
5	E33A	E33B	1	3		E/F		0.426	0.05	2.109	2.354	-0.245	1	1
8	E33C	E33D E33E	1	5		C		0.426	0.10	2.435	1.288	1.147	1	1
9	E33F	E33G	2	14,13		C		0.611	1.30	110.709	2.786	107.923	1	1
7	E33H		2	8,9		C		0.084	0.34	112.888	128.079	-15.191	1	1
Est	E33H		1	7		C		0.084		112.972	128.079	-15.107	1	1

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol	Categ controls
	F60A		0			C		0.023		0.023	0.023	0.000	1	
	F60B		0			C		0.020		0.020	0.020	0.000	1	
	F60C	F60B	0			C		0.040	0.07	-0.010	0.040	-0.050	1	1
58	F60D	F60C	0			C		0.033	0.20	-0.167	0.093	-0.260	1	1
	F60E		0			C		0.006		0.006	0.006	0.000	1	
51	G30A		0			C		1.244		1.244	1.244	0.000	1	
55	G30B		0			C		2.028		2.028	2.028	0.000	1	
54	G30C		0			C		2.429		2.429	2.429	0.000	1	
53	G30D	G30B G30C	2	54,55		C		1.829	0.55	5.736	6.330	-0.594	1	1
52	G30E	G30D	1	53		C		0.874	0.74	5.870	7.222	-1.352	1	1
56	G30F		0			C		1.649		1.649	1.649	0.000	1	
57	G30G		0			C		0.659		0.659	0.659	0.000	1	
	G30H		0			C		0.875		0.875	0.875	0.000	1	

Figure 7.1: **Starter configuration** with all the ecological categories selected as a D category

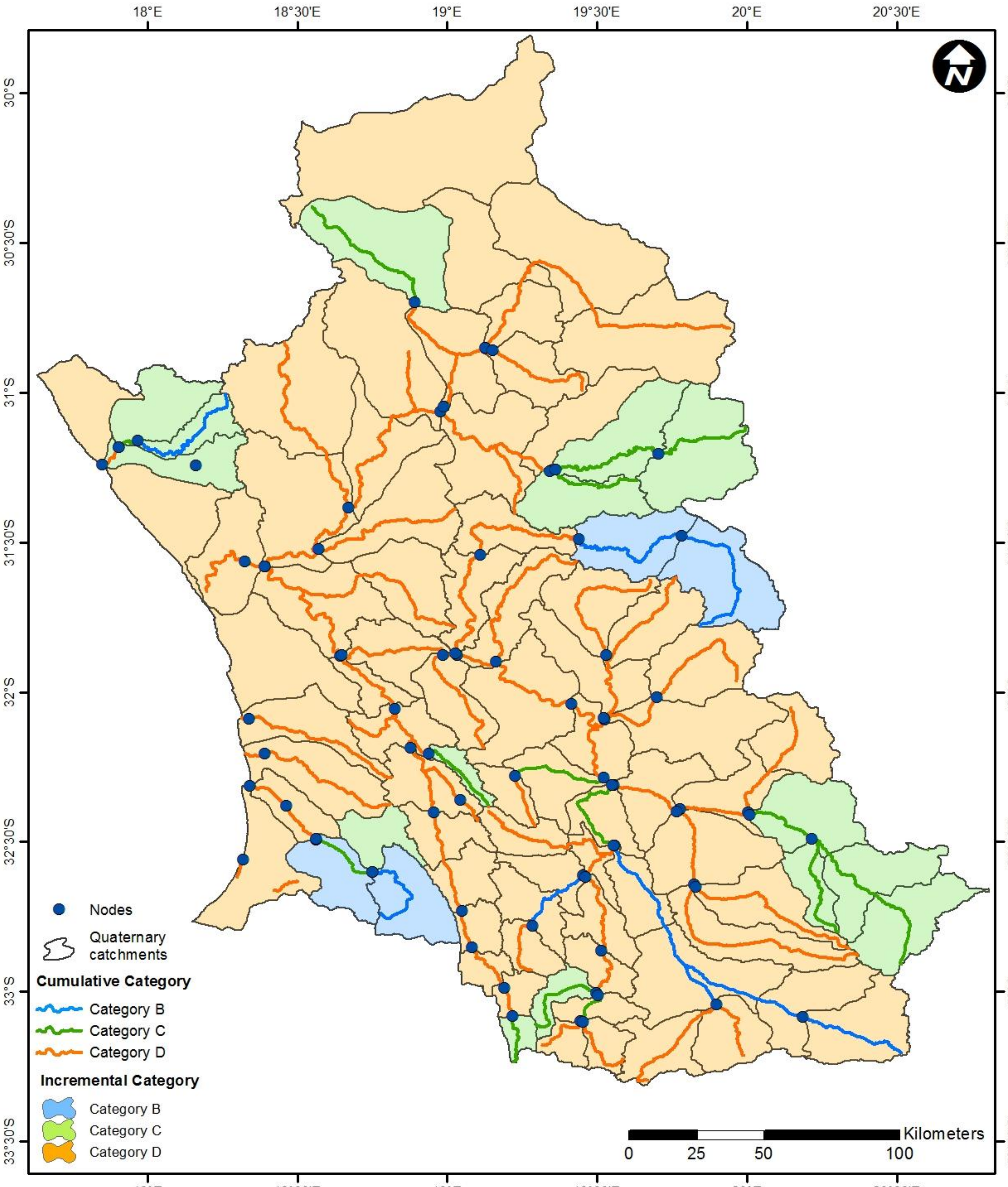

Figure 7.2.1: Scenario 1 - Ecological Sustainability Baseline Configuration (ESBC) indicating the selected cumulative and incremental ecological categories

Node	Quaternary Single	Multiple	Directly linked nodes		Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
48	E21A		0			B		5.096		5.096	5.096	0.000	1	
49	E21B		0			C		0.138		0.138	0.138	0.000	1	
46	E21C		2	49,48		C		0.226	0.18	5.280	5.285	-0.005	1	2
45	E21D		0			E/F		9.996		9.996	9.996	0.000	2	
43	E21E		2	46,45		E/F		0.181	0.40	15.057	11.890	3.167	1	1
39	E21F		1	43		E/F		0.264	0.71	14.611	12.059	2.552	1	1
41	E21G		0			C		7.139		7.139	7.139	0.000	1	
38	E21H	E21J	1	41		E/F		25.243	0.15	32.232	31.989	0.243	1	3
37	E21K	E21L	2	38,39		E/F		0.325	0.60	46.568	30.314	16.254	1	1
50	E22C	E22D	0			E/F		0.601		0.601	0.302	0.299	1	
36	E22A	E22B E22E E22F	1	50		E/F		7.417	1.77	6.248	2.308	3.940	1	3
28	E22G		2	37,36		E/F		1.227	1.26	52.783	32.464	20.319	1	2
32	E23A	E23B E23C E23D	0			E/F		4.696		4.696	4.695	0.001	2	
31	E23E		0			E/F		0.666		0.666	0.666	0.000	1	
29	E23F		2	32,31		E/F		0.558	0.56	5.360	4.215	1.145	1	1
30	E23G	E23H E23J	1	29		E/F		2.716		8.076	2.716	5.360	1	
27	E23K		2	28,30		E/F		0.675	0.84	60.694	39.666	21.028	1	1
25	E24A		0			E/F		0.510		0.510	0.510	0.000	1	
26	E24B		1	25		E/F		1.466	0.49	1.486	1.445	0.041	1	2
21	E24C	E24D	0			D		3.553		3.553	3.554	-0.001	1	
22	E24E	E24F E24G	0			E/F		3.762		3.762	7.315	-3.553	1	
20	E24H		4	27,26,21,22		D		1.040	2.00	68.535	51.048	17.487	1	1
19	E24J		1	20		D		2.322	1.61	69.247	53.340	15.907	1	1
16	E24K		1	19		E/F		1.393		70.640	60.513	10.127	1	
12	E40A	E40B	0			C		7.714		7.714	4.405	3.309	3	
11	E40C		1	12		C		1.057	1.38	7.391	4.345	3.046	1	1
17	E40D		1	11		E/F		1.085	1.33	7.146	5.430	1.716	1	1
15	E24L		2	16,17		D		1.052	2.01	76.828	62.376	14.452	1	
14	E24M		1	15		E/F		1.149	1.77	76.207	63.252	12.955	1	1
47	E10A		0			D		12.064		12.064	12.061	0.003	2	
44	E10B		1	47		E/F		9.309	0.11	21.263	17.465	3.798	1	1
42	E10C		1	44		E/F		7.268	0.21	28.321	24.770	3.551	1	1
40	E10D		1	42		C		6.985	0.28	35.026	31.623	3.403	1	1
33	E10E	E10F	1	40		C		16.884	0.77	51.140	48.429	2.711	1	1
24	E10H		0			C		6.284		6.284	6.284	0.000	2	
23	E10G	E10J	2	33,24		C		15.209	2.16	70.473	68.393	2.080	1	1
13	E10K		1	23		C		1.031	0.73	70.774	68.976	1.798	1	1
4	E32A	E32B E32C	0			E/F		1.634		1.634	1.634	0.000	2	
2	E31B	E31C E31D E31E	0			E/F		0.314		0.314	0.314	0.000	1	
1	E31G		0			E/F		0.140		0.140	0.140	0.000	2	
3	E31F	E31H E32E	3	4,2,1		E/F		0.490	0.20	2.378	2.354	0.024	1	1
5	E33A	E33B	1	3		E/F		0.426	0.05	2.754	2.354	0.400	1	1
8	E33C	E33D E33E	1	5		C		0.426	0.10	3.080	1.288	1.792	1	1
9	E33F	E33G	2	14,13		C		0.611	1.30	146.292	2.786	143.506	1	1
7	E33H		2	8,9		C		0.084	0.34	149.116	128.079	21.037	1	1
Est	E33H		1	7		C		0.084		149.200	128.079	21.121	1	1

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	CumulativeFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
	F60A		0			C		0.023		0.023	0.023	0.000	1	
58	F60D	F60C F60B	0			C		0.263	0.20	0.063	0.093	-0.030	1	4
	F60E		0			C		0.006		0.006	0.006	0.000	1	
51	G30A		0			C		1.244		1.244	1.244	0.000	1	
55	G30B		0			C		2.028		2.028	2.028	0.000	1	
54	G30C		0			C		2.429		2.429	2.429	0.000	1	
53	G30D	G30B G30C	2	54,55		C		6.286	0.55	10.193	6.330	3.863	1	1
52	G30E	G30D	1	53		C		2.703	0.74	12.156	7.222	4.934	1	1
56	G30F		0			C		1.649		1.649	1.649	0.000	1	
57	G30G		0			C		0.659		0.659	0.659	0.000	1	
	G30H		0			C		0.875		0.875	0.875	0.000	1	

Figure 7.2.2: Scenario 1 - Ecological Sustainability Baseline Configuration (ESBC)

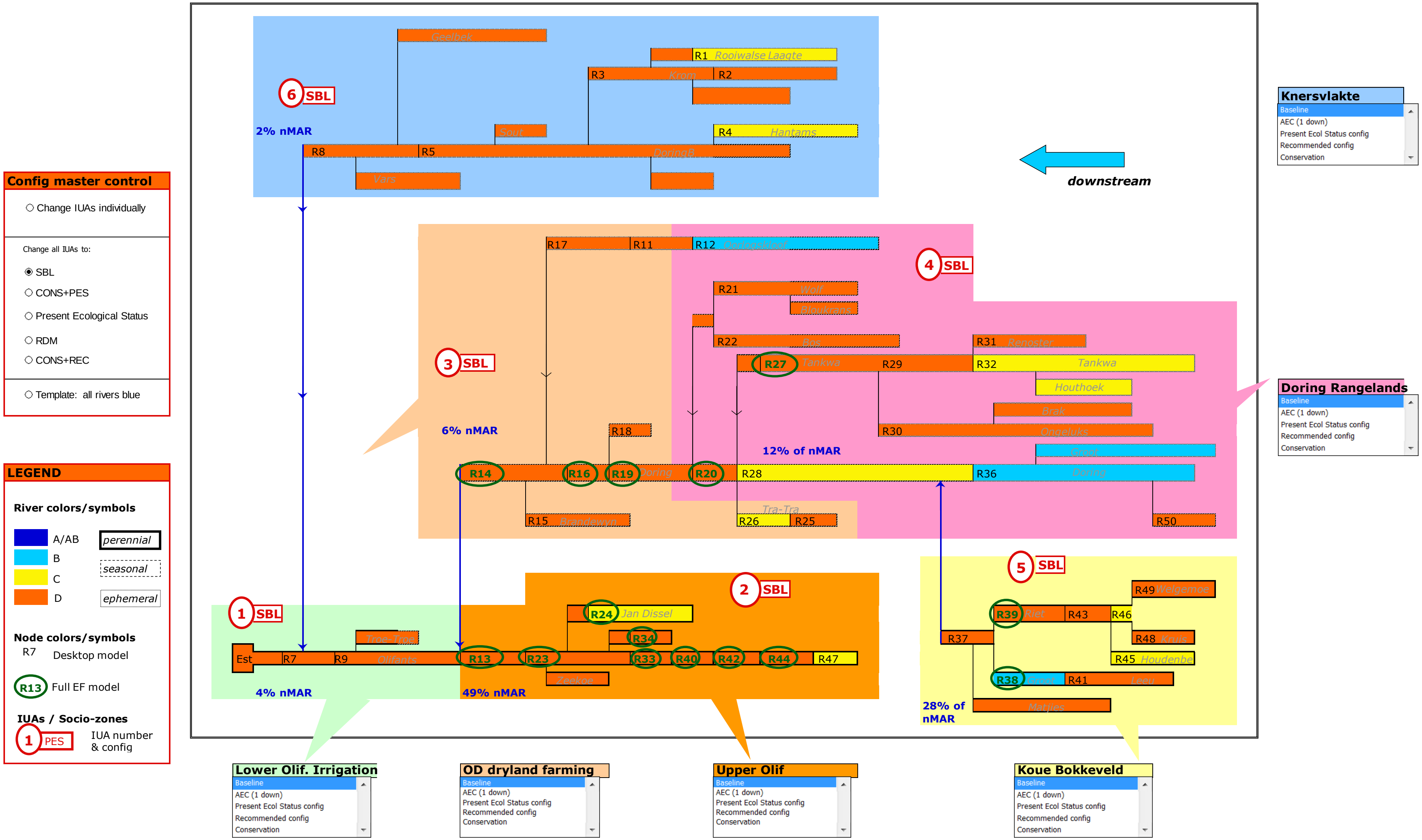

Figure 7.2.3: Scenario 1 - Ecological Sustainability Baseline Configuration

From the starter configuration the establishment of the ESBC scenario is achieved by moving sequentially upstream/downstream using the D category as the starting point at each node and adjusting the ecological category until sufficient water is supplied throughout the catchment to satisfy the required flow for the categories downstream (Figure 7.2.2). This requires starting at the downstream end of a catchment, and working upstream according to the river nodes, while considering the water quantity, quality and ecosystem condition and functions required to support this base configuration.

Figure 7.2.1, 7.2.2 and 7.2.3 provides a configuration of resource categories that ensures that the downstream EWRs are met throughout the catchment. This configuration of resource categories can therefore be seen as the lowest volume of EWRs that would be required to achieve a sustainable level of ecosystem functioning (D category – the lowest sustainable ecosystem category). The configuration does not address any freshwater biodiversity conservation aspects.

Table 7.1. Summary of water resource categories for the ESBC

Ecological sustainability baseline configuration								
Quaternary	**Incremental Category**	**Cumulative Category**	**Quaternary**	**Incremental Category**	**Cumulative Category**	**Quaternary**	**Incremental Category**	**Cumulative Category**
E10A	C	C	E23C	C	C	E32C	C	C
E10B	D	D	E23D	C	C	E32D	D	D
E10C	D	D	E23E	D	D	E32E	D	D
E10D	D	D	E23F	D	D	E33A	D	D
E10E	D	D	E23G	D	D	E33B	D	D
E10F	D	D	E23H	D	D	E33C	D	D
E10G	D	D	E23J	D	D	E33D	D	D
E10H	C	C	E23K	D	D	E33E	D	D
E10J	D	D	E24A	D	D	E33F	D	D
E10K	D	D	E24B	C	D	E33G	D	D
E21A	D	D	E24C	D	D	E33H	D	D
E21B	D	D	E24D	D	D	E40A	B	B
E21C	C	D	E24E	D	D	E40B	B	B
E21D	C	C	E24F	D	D	E40C	D	D
E21E	D	D	E24G	D	D	E40D	D	D
E21F	D	D	E24H	D	D	F60A	D	D
E21G	D	D	E24J	D	D	F60B	B	C
E21H	B	D	E24K	D	D	F60C	C	C
E21J	B	D	E24L	D	D	F60D	D	C
E21K	D	D	E24M	D	D	F60E	D	D
E21L	D	D	E31A	D	D	G30A	D	D
E22A	B	D	E31B	D	D	G30B	B	B
E22B	B	D	E31C	D	D	G30C	C	C
E22C	D	D	E31D	D	D	G30D	C	B
E22D	D	D	E31E	D	D	G30E	D	D
E22E	B	D	E31F	D	D	G30F	D	D
E22F	B	D	E31G	C	C	G30G	D	D
E22G	C	D	E31H	D	D	G30H	D	D
E23A	C	C	E32A	C	C			
E23B	C	C	E32B	C	C			

7.2.2. Present Ecological State (PES) scenario

For this scenario, the present ecological status (PES as recently updated in 2011), was used to generate the PES scenario. Where the updated PES is not yet available, the 1999 PES data was utilised. Figure 7.3.2 indicates that there are a large number of quaternaries where there is a deficit in achieving the EWR flows further downstream. This deficit is created by the insufficient supply from the upstream catchments. It should however be borne in mind that the spread sheet provides merely an indication of the ecological flow requirement balance in terms of the EWRs and does not take into account other non-flow related impacts on the PES. In many cases the condition of the streams in the WMA have a reduced ecological integrity as a result of habitat disturbances (bulldozing of the river bed and banks) and not as a result of a lack of flow. The flow category could therefore be much higher presently and there should be no need to adjust it lower.

Table 7.2: Summary of water resource categories for the PES Configuration (from the updated PES 2011)

PES configuration								
Quaternary	**Incremental Category**	**Cumulative Category**	**Quaternary**	**Incremental Category**	**Cumulative Category**	**Quaternary**	**Incremental Category**	**Cumulative Category**
E10A	D	D	E23C	D	D	E32B	D	D
E10B	D	D	E23D	D	D	E32C	D	D
E10C	D	D	E23E	D	D	E32D	D	D
E10D	D	C	E23F	D	D	E32E	D	D
E10E	D	C	E23G	D	D	E33A	D	D
E10F	D	C	E23H	D	D	E33B	D	D
E10G	C	C	E23J	D	D	E33C	C	C
E10H	C	C	E23K	D	D	E33D	D	D
E10J	C	C	E24A	D	D	E33E	D	D
E10K	C	C	E24B	D	D	E33F	C	C
E21A	D	B	E24C	D	D	E33G	D	C
E21B	C	C	E24D	D	D	E33H	D	C
E21C	C	C	E24E	D	D	E40A	D	C
E21D	D	D	E24F	D	D	E40B	C	C
E21E	D	D	E24G	D	D	E40C	D	C
E21F	D	D	E24H	D	D	E40D	D	D
E21G	C	C	E24J	D	D	F60A	C	C
E21H	D	D	E24K	D	D	F60B	C	C
E21J	D	D	E24L	D	D	F60C	C	C
E21K	D	D	E24M	D	D	F60D	C	C
E21L	D	D	E31A	D	D	F60E	C	C
E22A	D	D	E31B	D	D	G30A	C	C
E22B	D	D	E31C	D	D	G30B	C	C
E22C	D	D	E31D	D	D	G30C	C	C
E22D	D	D	E31E	D	D	G30D	C	C
E22E	D	D	E31F	D	D	G30E	C	C
E22F	D	D	E31G	D	D	G30F	C	C
E22G	D	D	E31H	D	D	G30G	C	C
E23A	D	D	E32A	D	D	G30H	C	C
E23B	D	D						

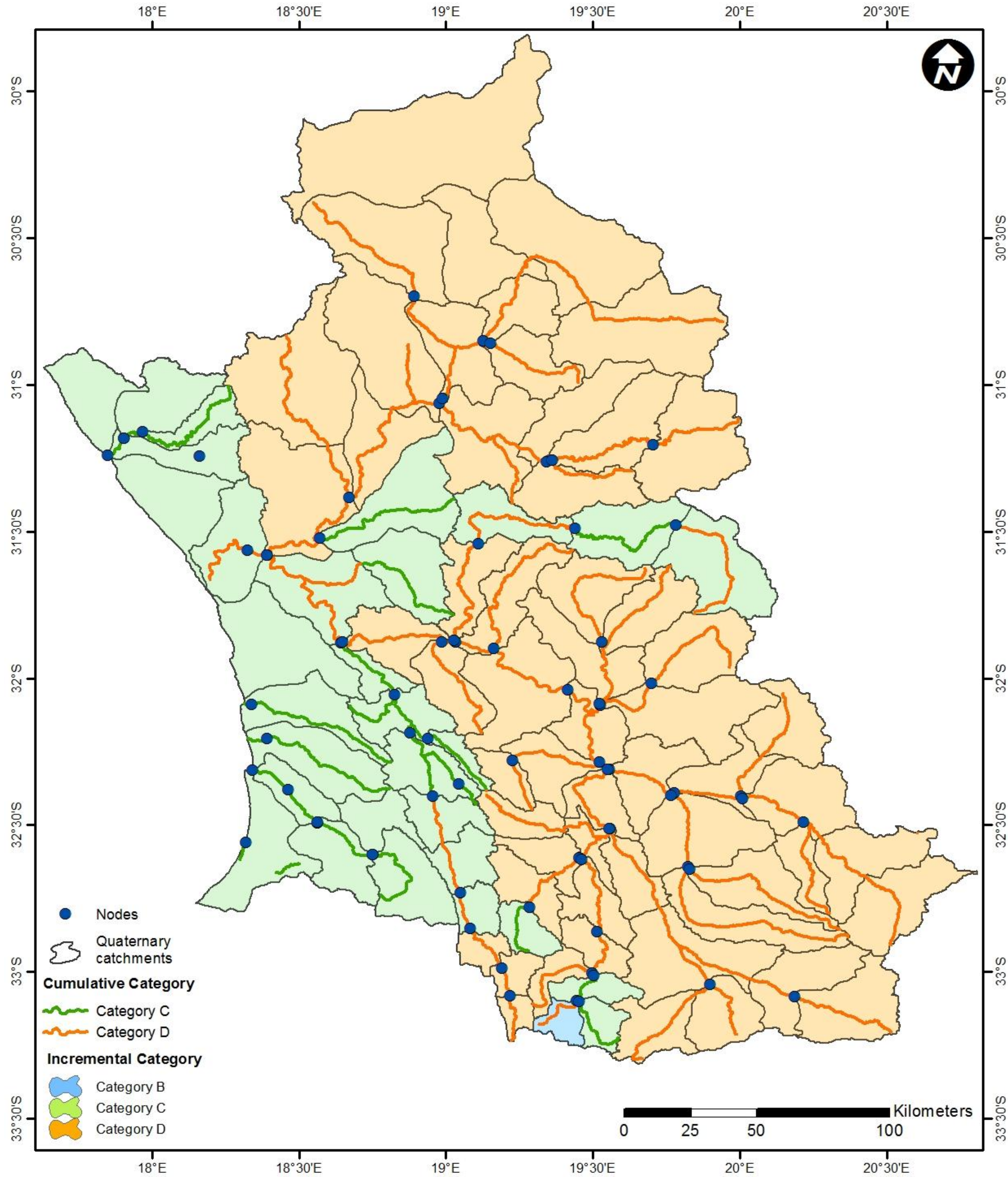

Figure 7.3.1: Scenario 2 - Present Ecological Status (PES) Configuration indicating the selected cumulative and incremental ecological categories

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
48	E21A		0			B		11.668		11.668	11.668	0.000	3	
49	E21B		0			C		0.217		0.217	0.217	0.000	2	
46	E21C		2	49,48		C		0.226	0.18	11.931	8.168	3.763	2	2
45	E21D		0			E/F		6.490		6.490	6.490	0.000	1	
43	E21E		2	46,45		E/F		0.181	0.40	18.202	11.890	6.312	1	1
39	E21F		1	43		E/F		0.264	0.71	17.756	12.059	5.697	1	1
41	E21G		0			C		10.994		10.994	10.994	0.000	2	
38	E21H	E21J	1	41		E/F		11.026	0.15	21.870	31.989	-10.119	1	1
37	E21K	E21L	2	38,39		E/F		0.325	0.60	39.351	30.314	9.037	1	1
50	E22C	E22D	0			E/F		0.601		0.601	0.302	0.299	1	
36	E22A	E22B E22E E22F	1	50		E/F		3.154	1.77	1.985	2.308	-0.323	1	1
28	E22G		2	37,36		E/F		0.791	1.26	40.867	32.464	8.403	1	1
32	E23A	E23B E23C E23D	0			E/F		2.991		2.991	2.991	0.000	1	
31	E23E		0			E/F		0.666		0.666	0.666	0.000	1	
29	E23F		2	32,31		E/F		0.558	0.56	3.655	4.215	-0.560	1	1
30	E23G	E23H E23J	1	29		E/F		2.716		6.371	2.716	3.655	1	
27	E23K		2	28,30		E/F		0.675	0.84	47.073	39.666	7.407	1	1
25	E24A		0			E/F		0.510		0.510	0.510	0.000	1	
26	E24B		1	25		E/F		0.935	0.49	0.955	1.445	-0.490	1	1
21	E24C	E24D	0			D		3.553		3.553	3.554	-0.001	1	
22	E24E	E24F E24G	0			E/F		3.762		3.762	7.315	-3.553	1	
20	E24H		4	27,26,21,		D		1.040	2.00	54.383	51.048	3.335	1	1
19	E24J		1	20		D		2.322	1.61	55.095	53.340	1.755	1	1
16	E24K		1	19		E/F		1.393		56.488	60.513	-4.025	1	
12	E40A	E40B	0			C		5.159		5.159	2.946	2.213	2	
11	E40C		1	12		C		1.057	1.38	4.836	6.817	-1.981	2	1
17	E40D		1	11		E/F		1.085	1.33	4.591	5.430	-0.839	1	1
15	E24L		2	16,17		D		1.052	2.01	60.121	62.376	-2.255	1	
14	E24M		1	15		E/F		1.149	1.77	59.500	63.252	-3.752	1	1
47	E10A		0			D		7.834		7.834	7.834	0.000	1	
44	E10B		1	47		E/F		9.309	0.11	17.033	17.465	-0.432	1	1
42	E10C		1	44		E/F		7.268	0.21	24.091	24.770	-0.679	1	1
40	E10D		1	42		C		6.985	0.28	30.796	48.621	-17.825	2	1
33	E10E	E10F	1	40		C		16.884	0.77	46.910	74.392	-27.482	2	1
24	E10H		0			C		6.284		6.284	6.284	0.000	2	
23	E10G	E10J	2	33,24		C		23.326	2.16	74.360	104.295	-29.935	2	2
13	E10K		1	23		C		1.586	0.73	75.216	105.956	-30.740	2	2
4	E32A	E32B E32C	0			E/F		1.040		1.040	1.040	0.000	1	
2	E31B	E31C E31D E31E	0			E/F		0.314		0.314	0.314	0.000	1	
1	E31G		0			E/F		0.089		0.089	0.089	0.000	1	
3	E31F	E31H E32E	3	4,2,1		E/F		0.490	0.20	1.733	2.354	-0.621	1	1
5	E33A	E33B	1	3		E/F		0.426	0.05	2.109	2.354	-0.245	1	1
8	E33C	E33D E33E	1	5		C		0.671	0.10	2.680	2.024	0.656	2	2
9	E33F	E33G	2	14,13		C		0.960	1.30	134.376	4.381	129.995	2	2
7	E33H		2	8,9		C		0.084	0.34	136.800	198.931	-62.131	2	1
Est	E33H		1	7		C		0.084		136.884	198.931	-62.047	2	1

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
	F60A		0			C		0.035		0.035	0.035	0.000	2	
	F60B		0			C		0.031		0.031	0.031	0.000	2	
	F60C	F60B	0			C		0.062	0.07	0.023	0.062	-0.039	2	2
58	F60D	F60C	0			C		0.051	0.20	-0.149	0.145	-0.294	2	2
	F60E		0			C		0.009		0.009	0.009	0.000	2	
51	G30A		0			C		1.922		1.922	1.922	0.000	2	
55	G30B		0			C		3.113		3.113	3.113	0.000	2	
54	G30C		0			C		3.720		3.720	3.720	0.000	2	
53	G30D	G30B G30C	2	54,55		C		2.815	0.55	9.098	9.706	-0.608	2	2
52	G30E	G30D	1	53		C		1.347	0.74	9.705	11.077	-1.372	2	2
56	G30F		0			C		2.553		2.553	2.553	0.000	2	
57	G30G		0			C		1.021		1.021	1.021	0.000	2	
	G30H		0			C		1.349		1.349	1.349	0.000	2	

Figure 7.3.2: Scenario 2 - Present Ecological Status (PES) Configuration

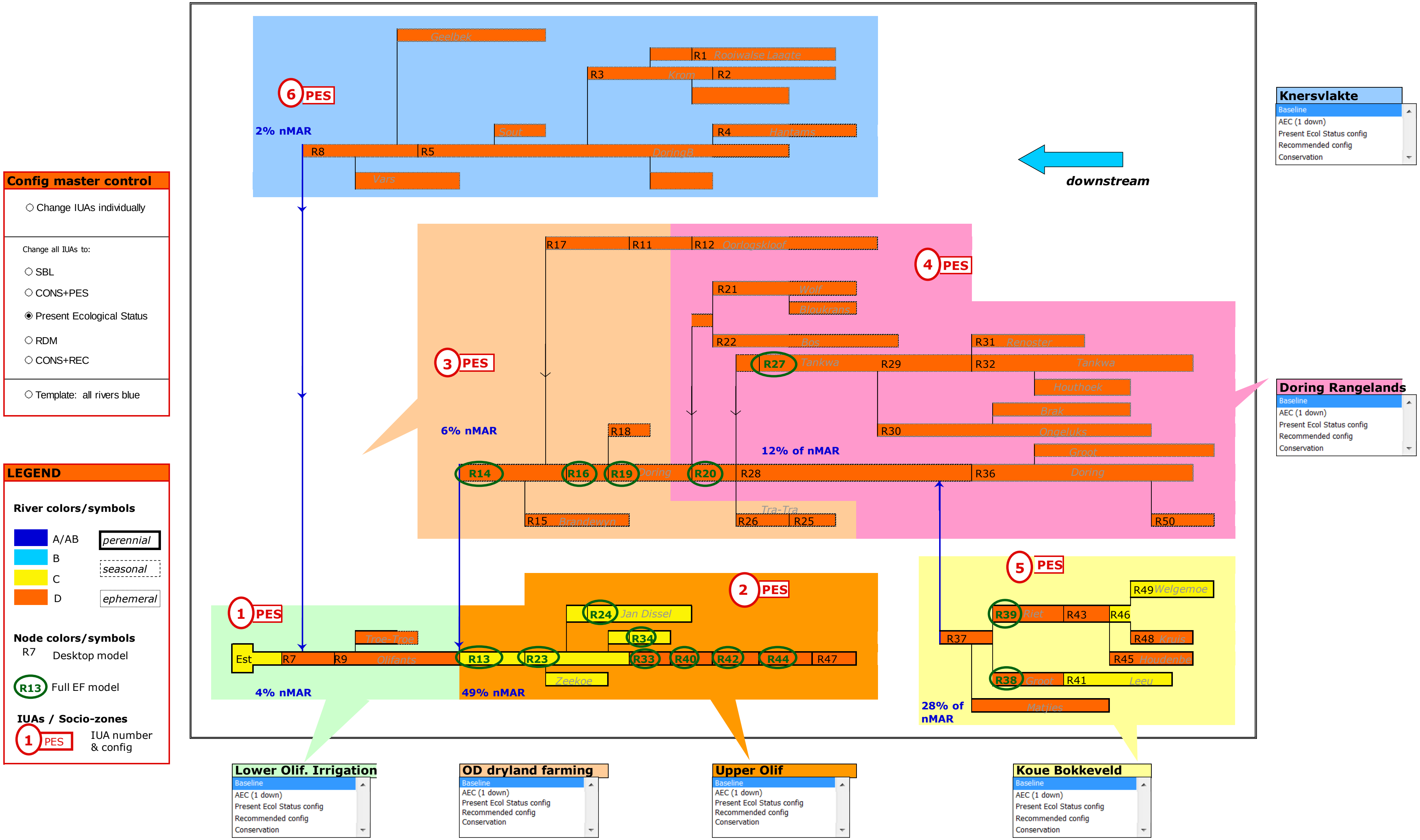

Figure 7.3.2: Scenario 2 - Present Ecological Status (PES) Configuration

7.2.3. RDM (approved ecological Reserve) scenario

In 2007, following the development of the classification system and pilot testing, the preliminary EWRs and preliminary water resource classes for the Olifants Doring Catchment was approved by the Director-General of the DWA. These EWRs and classes were based on the recommended water resource class configuration from the pilot testing of the classification procedure. The summary of the approved EWRs and water resource classes is provided in Table 7.3. These EWRs and resource classes were utilised, together with the approved Reserves for the Sandveld, to generate a configuration for RDM – Scenario 3 (Figure 7.4). This configuration indicates that there is a deficit of flows for some of the quaternary catchments. The approved Reserves (EWRs) however also included an additional condition relevant to the incremental catchments that the tributaries feeding the main stem should be maintained such that they can contribute either 20%, 40%, 60% or 80% of their flow to the main stem (See highlighted cells in Table 7.3 below).

Table 7.3: Approved ecological Reserve (EWRs) and preliminary resource classes for the Olifants Doring Catchment

Quat catch	Water Resource	nMAR (MCM)	Cumulative Reserve requirement (MCM)	Cumulative Reserve requirement (%MAR)	Incremental Reserve requirement (MCM)	Incremental Reserve requirement (%MAR)	Confidence level	Resource class
E10A	Olifants	61.373	8.336	13.58	12.280	20.0	Low	D – Largely modified
E10B	Olifants	131.157	27.858	21.24	41.880	32.0	Medium/low	B – largely natural
E10C	Olifants	180.907	71.427	39.48	29.880	16.5	Medium/low	B – largely natural
E10D	Olifants	229.932	31.173	13.56	9.800	4.3	Medium/low	C – moderately modified
E10E / E10F (EWR 1)	Olifants	331.551	88.403	26.66	21.000	6.3	High	D – Largely modified
E10H	Jan Dissels	33.507	7.119	21.25	27.640	82.5	Medium/low	C – moderately modified
E10G & H(scaled)	Jan Dissels	46.205	6.883	14.990	-	-	Medium/low	D – Largely modified
E10G E10J	Olifants	467.369	63.974	13.69	12.700	2.7	Low	D – Largely modified
EWR 3	Rondegat	7.45	3.239	43.47	-	-	High	B – largely natural
E21A	Kruis	34.884	4.351	12.47	6.980	20.0	Low	D – Largely modified
E21B	Welgemoed	26.936	5.216	19.36	10.760	40.0	Low	C – moderately modified
E21C	Winkelhaak	86.750	16.786	19.35	10.000	11.5	Low	C – moderately modified
E21D	Houdenbeks	45.369	5.659	12.47	9.080	20	Low	D – Largely modified
E21E	Riet	151.708	29.459	19.42	11.760	7.8	Low	C – moderately modified
E21F	Riet	168.254	35.738	21.24	9.900	6.0	Low	C – moderately modified
E21G	Groot/Leeu	30.561	6.218	20.35	12.240	40.0	Low	C – moderately modified
E21H E21J (EWR 6)	Groot	137.858	60.33	43.76	45.504	33.0	High	B/C – largely natural/ moderately modified
E21K/ E21L	Maatjies	278.509	55.108	19.79	18.240	6.5	Low	C – moderately modified
E22A / E22B / E22E / E22F	Doring	39.642	10.459	26.38	8.960	22.6	Low	B – largely natural
E22C / E22D	Doring	17.323	3.077	17.76	6.920	40.0	Low	C – moderately modified
E22G	Doring	319.264	145.595	45.60	0.880	0.3	Medium/low	B – largely natural
E23A / E23B /	Tankwa	20.083	3.531	17.58	8.040	40	Low	C – moderately modified

E23C / E23D								
E23E	Tankwa	6.6	1.164	17.64	2.640	40	Low	C – moderately modified
E23F	Tankwa/Renoster	27.201	4.786	17.60	0.100	0.4	Low	C – moderately modified
E23G E23H E23J	Ongeluks	35.171	6.177	17.56	3.200	9.1	Low	C – moderately modified
E23K	Tankwa	319.793	38.942	12.18	0.100	0.03	Low	D – Largely modified
E24A	Tra-tra	17.310	4.658	26.91	10.380	60.0	Low	B – largely natural
E24B	Tra-tra	27.583	7.397	26.82	6.180	22.4	Low	B – largely natural
E24C E24D	Bos	15.922	2.816	17.69	6.360	40.0	Low	C – moderately modified
E24E E24F E24G	Wolf	13.793	2.440	17.69	5.520	40.0	Low	C – moderately modified
E24H (EWR 4)	Doring	421.47	192.205	45.60	1.600	0.4	High	B – largely natural
E24J	Doring	401.440	183.070	45.60	8.120	2.0	Medium/low	B – largely natural
E24K (EWR 5)	Doring	509.621	232.405	45.60	6.120	1.2	High	B – largely natural
E24L	Brandewyn	462.055	91.202	19.74	9.360	2.0	Low	C – moderately modified
E24M	Doring	471.872	215.190	45.60	5.880	1.3	Medium/low	B – largely natural
E31B E31C E31D E31E	Kromme	3.091	0.807	26.12	1.860	60.0	Low	B – largely natural
E31F E31H E32E	Kromme	12.351	2.204	17.85	0.880	7.1	Low	C – moderately modified
E31G	Kromme	0.681	0.118	17.30	0.160	23.5	Low	C – moderately modified
E32A E32B E32C	Hantams	8.576	1.532	17.86	3.440	40.0	Low	C – moderately modified
E33A E33B	Sout	19.218	3.399	17.69	0.260	1.4	Low	C – moderately modified
E33C E33D E33E	Sout	22.265	4.056	18.22	0.600	2.7	Low	C – moderately modified
E33F E33G	Hol	949.760	118.937	12.52	1.160	0.1	Low	D – Largely modified
E33H	Olifants	972.643	130.360	13.4	0.120	0.1	Low	D – Largely modified
E40A E40B	Oorlogskloof	13.354	2.368	17.73	2.680	20.0	Low	C – moderately modified
E40C	Oorlogskloof	20.117	5.367	26.68	2.720	13.5	Low	B – largely natural
E40D	Oorlogskloof/Koebee	27.071	7.239	26.74	2.800	10.3	Low	B – largely natural
Estuary	Olifants	1055	597	56	0.120	0.01	High	C – moderately modified

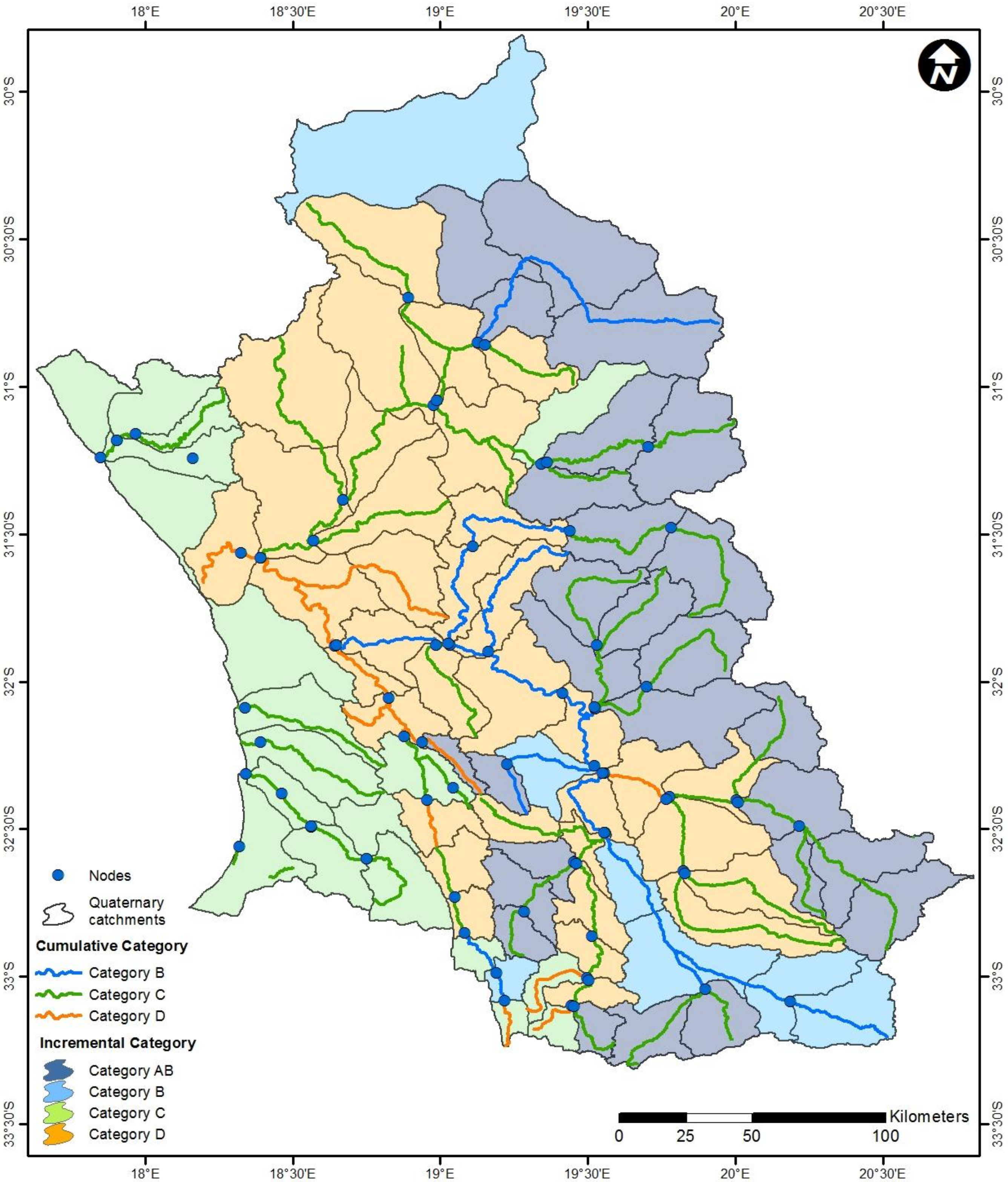

Figure 7.4.1: Scenario 3 - RDM (approved ecological Reserve) scenario indicating the selected cumulative and incremental ecological categories

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
48	E21A		0			B		7.848		7.848	7.848	0.000	2	
49	E21B		0			C		0.398		0.398	0.398	0.000	4	
46	E21C		2	49,48		C		0.226	0.18	8.292	5.285	3.007	1	2
45	E21D		0			E/F		9.996		9.996	9.996	0.000	2	
43	E21E		2	46,45		E/F		0.284	0.40	18.172	11.890	6.282	1	2
39	E21F		1	43		E/F		0.406	0.71	17.868	12.059	5.809	1	2
41	E21G		0			C		19.967		19.967	19.967	0.000	4	
38	E21H	E21J	1	41		E/F		16.979	0.15	36.796	89.155	-52.359	4	2
37	E21K	E21L	2	38,39		E/F		0.509	0.60	54.573	30.314	24.259	1	2
50	E22C	E22D	0			E/F		1.737		1.737	0.874	0.863	4	
36	E22A	E22B E22E E22F	1	50		E/F		7.417	1.77	7.384	5.427	1.957	3	3
28	E22G		2	37,36		E/F		1.693	1.26	62.390	32.464	29.926	1	3
32	E23A	E23B E23C E23D	0			E/F		4.696		4.696	4.695	0.001	2	
31	E23E		0			E/F		1.045		1.045	1.045	0.000	2	
29	E23F		2	32,31		E/F		0.876	0.56	6.057	4.215	1.842	1	2
30	E23G	E23H E23J	1	29		E/F		4.265		10.322	4.264	6.058	2	
27	E23K		2	28,30		E/F		0.675	0.84	72.547	39.666	32.881	1	1
25	E24A		0			E/F		1.197		1.197	1.197	0.000	3	
26	E24B		1	25		E/F		2.193	0.49	2.900	3.390	-0.490	3	3
21	E24C	E24D	0			D		8.337		8.337	8.337	0.000	3	
22	E24E	E24F E24G	0			E/F		5.902		5.902	11.477	-5.575	2	
20	E24H		4	27,26,21,		D		1.040	2.00	88.726	118.359	-29.633	3	1
19	E24J		1	20		D		5.350	1.61	92.466	53.340	39.126	1	3
16	E24K		1	19		E/F		1.393		93.859	60.513	33.346	1	
12	E40A	E40B	0			C		9.479		9.479	5.413	4.066	4	
11	E40C		1	12		C		1.057	1.38	9.156	4.345	4.811	1	1
17	E40D		1	11		E/F		1.085	1.33	8.911	5.430	3.481	1	1
15	E24L		2	16,17		D		1.052	2.01	101.812	62.376	39.436	1	
14	E24M		1	15		E/F		2.644	1.77	102.686	63.252	39.434	1	3
47	E10A		0			D		7.834		7.834	7.834	0.000	1	
44	E10B		1	47		E/F		21.183	0.11	28.907	39.888	-10.981	3	3
42	E10C		1	44		E/F		11.140	0.21	39.837	56.375	-16.538	3	2
40	E10D		1	42		C		10.684	0.28	50.241	31.623	18.618	1	2
33	E10E	E10F	1	40		C		16.884	0.77	66.355	48.429	17.926	1	1
24	E10H		0			C		4.097		4.097	4.097	0.000	1	
23	E10G	E10J	2	33,24		C		23.326	2.16	91.618	104.295	-12.677	2	2
13	E10K		1	23		C		1.031	0.73	91.919	68.976	22.943	1	1
4	E32A	E32B E32C	0			E/F		3.004		3.004	3.004	0.000	4	
2	E31B	E31C E31D E31E	0			E/F		0.908		0.908	0.908	0.000	4	
1	E31G		0			E/F		0.089		0.089	0.089	0.000	1	
3	E31F	E31H E32E	3	4,2,1		E/F		0.772	0.20	4.573	2.354	2.219	1	2
5	E33A	E33B	1	3		E/F		0.175	0.05	4.698	2.354	2.344	1	2
8	E33C	E33D E33E	1	5		C		0.671	0.10	5.269	1.288	3.981	1	2
9	E33F	E33G	2	14,13		C		0.611	1.30	193.916	2.786	191.130	1	1
7	E33H		2	8,9		C		0.084	0.34	198.929	128.079	70.850	1	1
Est	E33H		1	7		C		0.084		199.013	198.931	0.082	2	1

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	CumulativeFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
	F60A		0			C		0.035		0.035	0.035	0.000	2	
58	F60D	F60C F60B	0			C		0.144	0.20	-0.056	0.145	-0.201	2	2
	F60E		0			C		0.009		0.009	0.009	0.000	2	
51	G30A		0			C		1.922		1.922	1.922	0.000	2	
55	G30B		0			C		3.113		3.113	3.113	0.000	2	
54	G30C		0			C		3.720		3.720	3.720	0.000	2	
53	G30D	G30B G30C	2	54,55		C		9.648	0.55	15.931	9.706	6.225	2	2
52	G30E	G30D	1	53		C		4.162	0.74	19.353	11.077	8.276	2	2
56	G30F		0			C		2.553		2.553	2.553	0.000	2	
57	G30G		0			C		1.021		1.021	1.021	0.000	2	
	G30H		0			C		1.349		1.349	1.349	0.000	2	

Figure 7.4.2: RDM (approved ecological Reserve) scenario

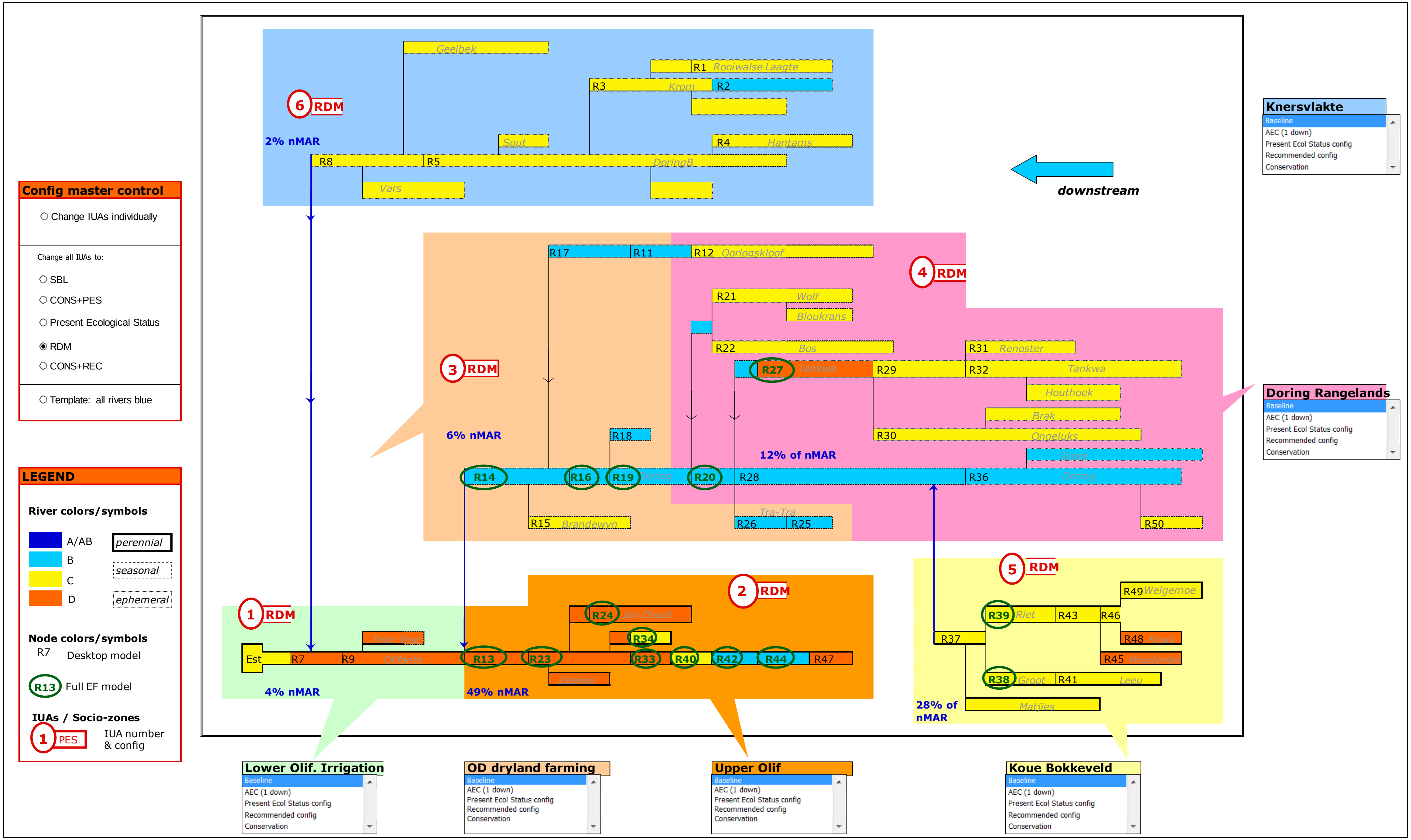

Figure 7.4.2: Scenario 3 - RDM (approved Ecological Reserve) Configuration

7.2.4. Conservation targets and Recommended Ecological Category (REC 1999) scenario

The National Freshwater Ecosystem Priority Areas (FEPA) project was utilised to generate a configuration that is intended to address freshwater biodiversity conservation targets within the WMA.

River FEPAs (Figure 7.5) are intended to achieve biodiversity targets for river ecosystems and threatened fish species, and were identified in rivers that are currently in a good condition. The FEPA guidelines indicate these rivers should remain in a good condition in order to contribute to national biodiversity goals and support sustainable use of water resources. In some cases the river FEPAs may also still require some rehabilitation.

Wetland FEPAs (Figure 7.5) were identified using ranks that were based on a combination of special features and modelled wetland condition. Although wetland condition was a factor in selection of wetland FEPAs, wetlands did not have to be in a good condition (A or B ecological category) to be chosen as a FEPA. Wetland FEPAs currently in an A or B ecological condition should be managed to maintain their good condition. Those currently in a condition lower than A or B should be rehabilitated to the best attainable ecological condition. Estuary FEPAs are the national priority estuaries identified in the National Biodiversity Assessment.

The FEPAs Implementation Guidelines indicate that the FEPA should inform the water resource classification system and process in the following ways:

- River, wetland and estuary FEPAs should be regarded as significant water resources;
- The location of FEPAs should be used to prioritise the allocation of resource unit nodes, which should be sited immediately downstream of the FEPA;
- Water-use scenarios should include at least one scenario that achieves the desired condition for FEPAs; and
- In examining the social, economic and ecological trade-offs of different water-use scenarios (and the impact each will have on future ecological condition of significant water resources), the consequences of not protecting a FEPA should be factored into the ecological assessment.

The FEPA rivers and wetlands are as listed in Table 7.4. The ‘rules’ applied to generating the configuration (Figure 7.6.1, 7.6.2 and 7.6.3) were as follows:

- The river FEPAs should aim to achieve an A/B category;
- The wetland FEPA also to achieve an A/B where possible but at least not result in any further degradation (i.e. REC (1999) category); and
- Fish support areas to have no further degradation (i.e. retain REC (1999) category).

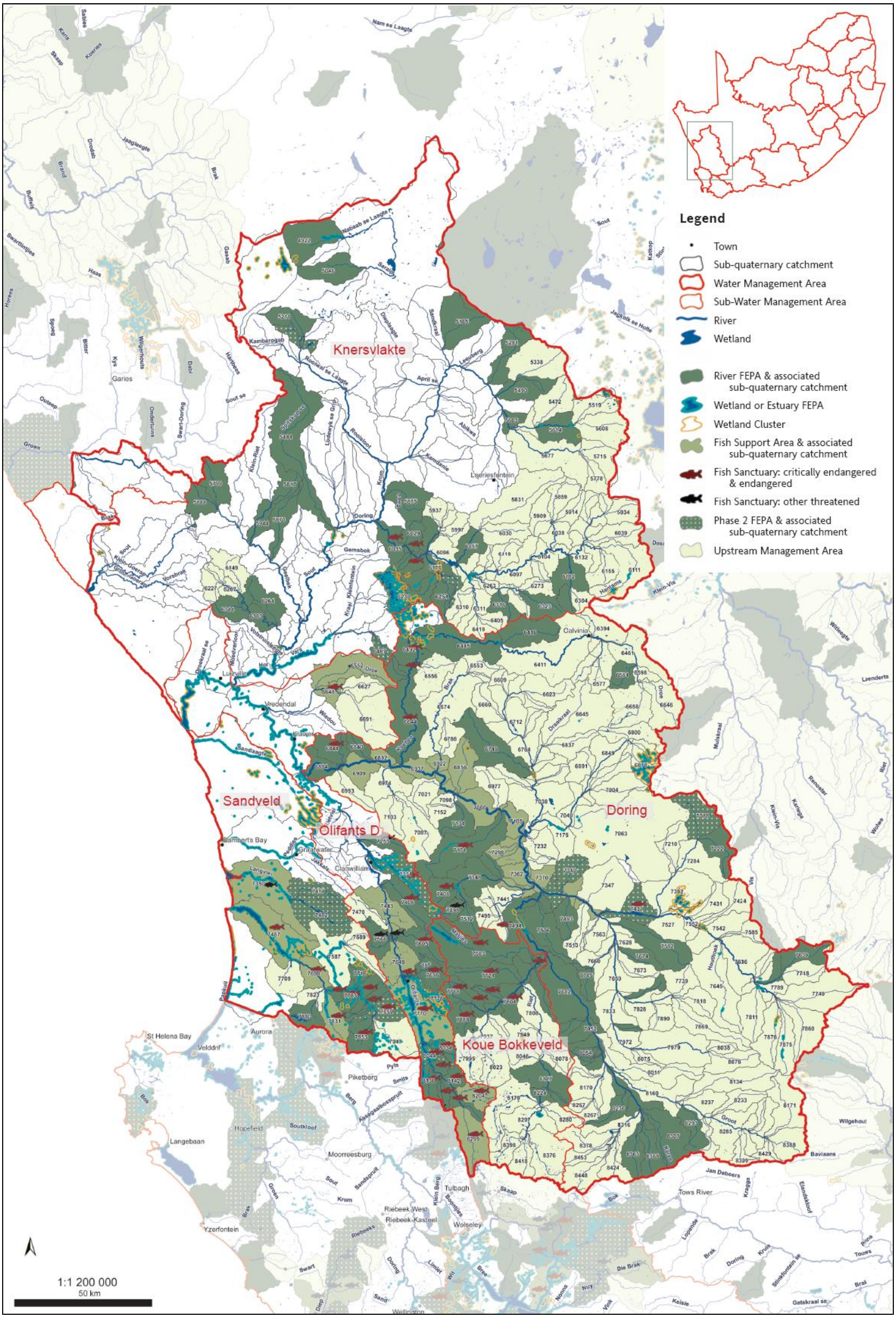

Figure 7.5: River and wetland FEPA map for the Olifants Doorn WMA (CSIR, 2011)

Table 7.4: Summary of water resource categories for the Conservation targets Configuration

Conservation configuration											
QUAT	**River FEPA units count**	**Fish support areas: count of units**	**Count of FEPA wetlands**	**Incremental Category**	**Cumulative Category**	**QUAT**	**River FEPA units count**	**Fish support areas: count of units**	**Count of FEPA wetlands**	**Incremental Category**	**Cumulative Category**
E10A	0	1	0	D	D	E24G	1	1	2	AB	AB
E10B	5	2	0	AB	AB	E24H	2	7	0	AB	AB
E10C	6	1	22	AB	AB	E24J	6	12	4	AB	AB
E10D	5	1	32	AB	AB	E24K	3	5	0	AB	AB
E10E	6	3	72	AB	AB	E24L	4	4	4	AB	AB
E10F	6	5	0	AB	AB	E24M	5	3	8	AB	AB
E10G	4	2	0	AB	AB	E31A	4	0	34	AB	AB
E10H	5	0	27	AB	AB	E31B	4	0	19	AB	AB
E10J	1	0	11	AB	AB	E31C	6	0	1	AB	AB
E10K	1	0	44	AB	AB	E31D	0	0	0	D	D
E21A	0	0	0	D	B	E31E	0	0	0	D	D
E21B	0	0	0	C	C	E31F	1	0	0	AB	AB
E21C	2	0	2	AB	AB	E31G	2	0	0	AB	AB
E21D	3	1	0	AB	AB	E31H	3	0	0	AB	AB
E21E	3	0	0	AB	AB	E32A	4	0	10	AB	AB
E21F	9	0	3	AB	AB	E32B	2	0	4	AB	AB
E21G	3	2	0	AB	AB	E32C	7	0	8	AB	AB
E21H	9	2	0	AB	AB	E32D	2	0	0	AB	AB
E21J	10	0	0	AB	AB	E32E	11	0	187	AB	AB
E21K	7	0	7	AB	AB	E33A	4	0	1	AB	AB
E21L	8	0	0	AB	AB	E33B	3	0	13	AB	AB
E22A	0	0	0	D	D	E33C	5	1	88	AB	AB
E22B	2	0	0	AB	AB	E33D	6	0	0	AB	AB
E22C	3	0	0	AB	AB	E33E	4	0	98	AB	AB
E22D	6	0	0	AB	AB	E33F	3	3	0	AB	AB
E22E	15	0	0	AB	AB	E33G	3	2	95	AB	AB
E22F	10	0	0	AB	AB	E33H	1	0	104	AB	AB
E22G	7	2	9	AB	AB	E40A	2	0	0	AB	AB
E23A	1	0	9	AB	AB	E40B	5	0	1	AB	AB
E23B	3	0	5	AB	AB	E40C	7	0	133	AB	AB
E23C	1	0	4	AB	AB	E40D	5	3	0	AB	AB
E23D	3	0	36	AB	AB	F60A	0	0	2	C	C
E23E	2	0	0	AB	AB	F60B	2	0	0	AB	AB
E23F	0	1	1	D	D	F60C	1	0	4	AB	AB
E23G	3	0	0	AB	AB	F60D	0	0	1	C	C
E23H	3	0	0	AB	AB	F60E	0	0	10	C	C
E23J	7	1	0	AB	AB	G30A	1	2	104	AB	AB
E23K	3	5	0	AB	AB	G30B	8	2	126	AB	AB
E24A	7	0	4	AB	AB	G30C	6	4	18	AB	AB
E24B	8	6	2	AB	AB	G30D	6	3	9	AB	AB
E24C	1	0	69	AB	AB	G30E	0	3	64	C	C
E24D	0	0	17	D	D	G30F	0	2	48	C	C
E24E	1	0	0	AB	AB	G30G	0	2	23	C	C
E24F	1	0	2	AB	AB	G30H	0	0	90	C	C

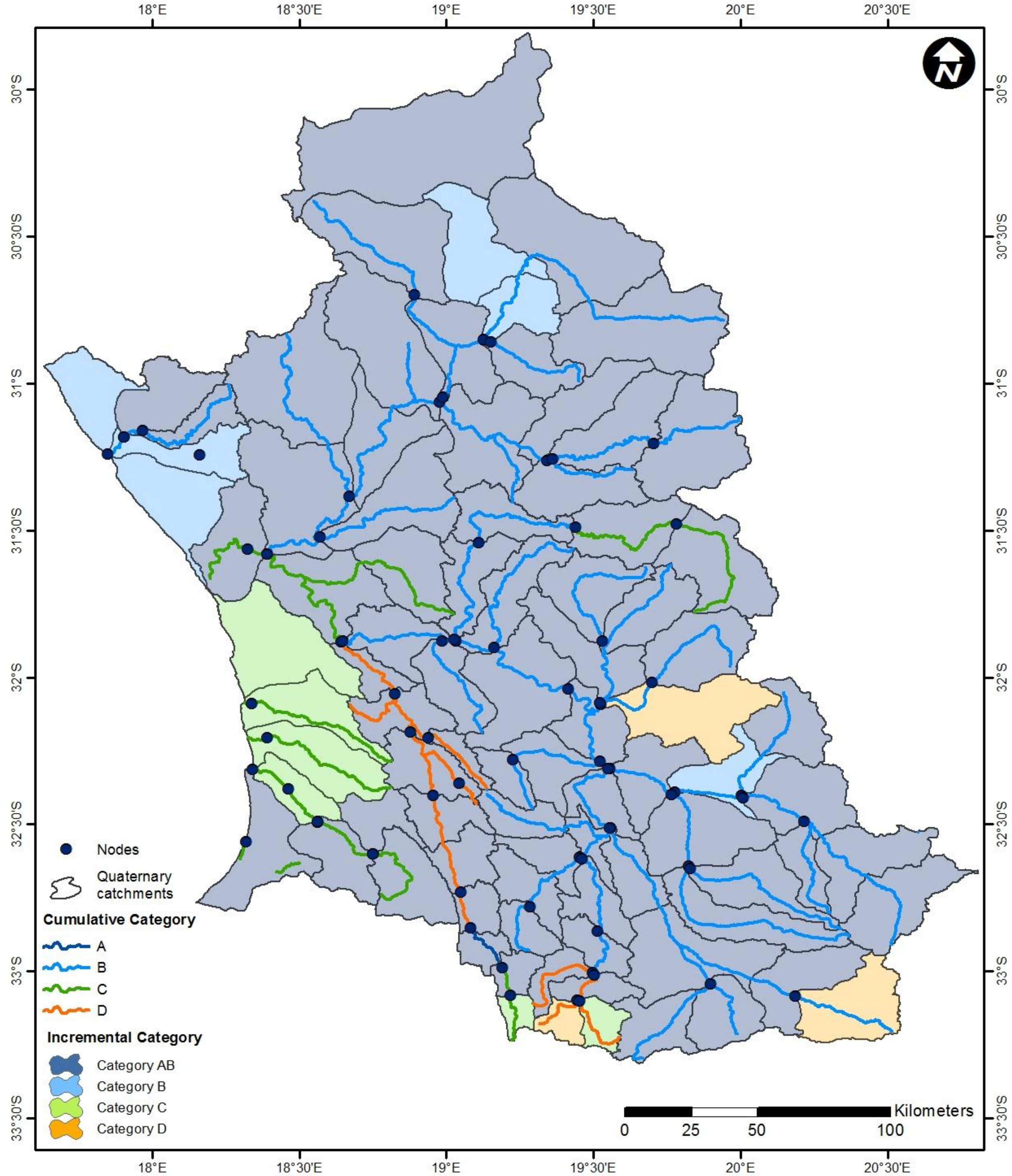

Figure 7.6.1: Scenario 4 - Conservation targets and recommended Ecological Categories (REC 1999) scenario indicating the selected cumulative and incremental ecological categories

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	IncremFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
48	E21A		0			B		5.096		5.096	5.096	0.000	1	
49	E21B		0			C		0.217		0.217	0.217	0.000	2	
46	E21C		2	49,48		C		0.416	0.18	5.549	14.861	-9.312	4	4
45	E21D		0			E/F		18.154		18.154	18.154	0.000	4	
43	E21E		2	46,45		E/F		0.523	0.40	23.826	33.385	-9.559	4	4
39	E21F		1	43		E/F		0.739	0.71	23.855	33.924	-10.069	4	4
41	E21G		0			C		19.967		19.967	19.967	0.000	4	
38	E21H	E21J	1	41		E/F		30.835	0.15	50.652	89.155	-38.503	4	4
37	E21K	E21L	2	38,39		E/F		0.937	0.60	74.844	85.128	-10.284	4	4
50	E22C	E22D	0			E/F		1.737		1.737	0.874	0.863	4	
36	E22A	E22B E22E E22F	1	50		E/F		9.115	1.77	9.082	2.308	6.774	1	4
28	E22G		2	37,36		E/F		2.242	1.26	84.908	91.890	-6.982	4	4
32	E23A	E23B E23C E23D	0			E/F		8.629		8.629	8.630	-0.001	4	
31	E23E		0			E/F		1.920		1.920	1.920	0.000	4	
29	E23F		2	32,31		E/F		0.558	0.56	10.547	4.215	6.332	1	1
30	E23G	E23H E23J	1	29		E/F		7.823		18.370	7.837	10.533	4	
27	E23K		2	28,30		E/F		1.947	0.84	104.385	113.133	-8.748	4	4
25	E24A		0			E/F		1.471		1.471	1.471	0.000	4	
26	E24B		1	25		E/F		2.694	0.49	3.675	4.166	-0.491	4	4
21	E24C	E24D	0			D		10.244		10.244	10.244	0.000	4	
22	E24E	E24F E24G	0			E/F		10.846		10.846	21.090	-10.244	4	
20	E24H		4	27,26,21,		D		1.040	2.00	128.190	145.009	-16.819	4	1
19	E24J		1	20		D		2.322	1.61	128.902	53.340	75.562	1	1
16	E24K		1	19		E/F		1.393		130.295	60.513	69.782	1	
12	E40A	E40B	0			C		5.159		5.159	2.946	2.213	2	
11	E40C		1	12		C		1.057	1.38	4.836	6.817	-1.981	2	1
17	E40D		1	11		E/F		1.085	1.33	4.591	5.430	-0.839	1	1
15	E24L		2	16,17		D		1.052	2.01	133.928	62.376	71.552	1	
14	E24M		1	15		E/F		1.149	1.77	133.307	63.252	70.055	1	1
47	E10A		0			D		7.834		7.834	7.834	0.000	1	
44	E10B		1	47		E/F		25.925	0.11	33.649	48.789	-15.140	4	4
42	E10C		1	44		E/F		20.276	0.21	53.715	69.073	-15.358	4	4
40	E10D		1	42		C		19.415	0.28	72.850	88.437	-15.587	4	4
33	E10E	E10F	1	40		C		43.160	0.77	115.240	135.545	-20.305	4	4
24	E10H		0			C		11.422		11.422	11.422	0.000	4	
23	E10G	E10J	2	33,24		C		42.552	2.16	167.054	190.522	-23.468	4	4
13	E10K		1	23		C		2.887	0.73	169.211	193.093	-23.882	4	4
4	E32A	E32B E32C	0			E/F		3.004		3.004	3.004	0.000	4	
2	E31B	E31C E31D E31E	0			E/F		0.908		0.908	0.908	0.000	4	
1	E31G		0			E/F		0.257		0.257	0.257	0.000	4	
3	E31F	E31H E32E	3	4,2,1		E/F		1.418	0.20	5.387	6.805	-1.418	4	4
5	E33A	E33B	1	3		E/F		0.320	0.05	5.657	6.805	-1.148	4	4
8	E33C	E33D E33E	1	5		C		1.230	0.10	6.787	3.720	3.067	4	4
9	E33F	E33G	2	14,13		C		1.762	1.30	302.980	8.054	294.926	4	4
7	E33H		2	8,9		C		0.243	0.34	309.670	363.208	-53.538	4	4
Est	E33H		1	7		C		0.197		309.867	296.547	13.320	3	3

Node	Quaternary Single	Multiple			Ecol Category (Node) D C B A/B	PES	CumulativeFlow Category D C B A/B	Increm input	Channel evap	Cumul flow	EWR at node	Balance	Linked to Ecol Categ controls	
	F60A		0			C		0.053		0.053	0.053	0.000	3	
58	F60D	F60C F60B	0			C		0.263	0.20	0.063	0.216	-0.153	3	4
	F60E		0			C		0.014		0.014	0.014	0.000	3	

51	G30A		0			C		3.496		3.496	3.496	0.000	4	
55	G30B		0			C		5.654		5.654	5.654	0.000	4	
54	G30C		0			C		6.081		6.081	6.081	0.000	4	
53	G30D	G30B G30C	2	54,55		C		16.847	0.55	28.032	9.706	18.326	2	4
52	G30E	G30D	1	53		C		4.162	0.74	31.454	11.077	20.377	2	2
56	G30F		0			C		2.553		2.553	2.553	0.000	2	
57	G30G		0			C		1.021		1.021	1.021	0.000	2	
	G30H		0			C		1.349		1.349	1.349	0.000	2	

Figure 7.6.2: Scenario 4: Conservation targets scenario and REC (1999)

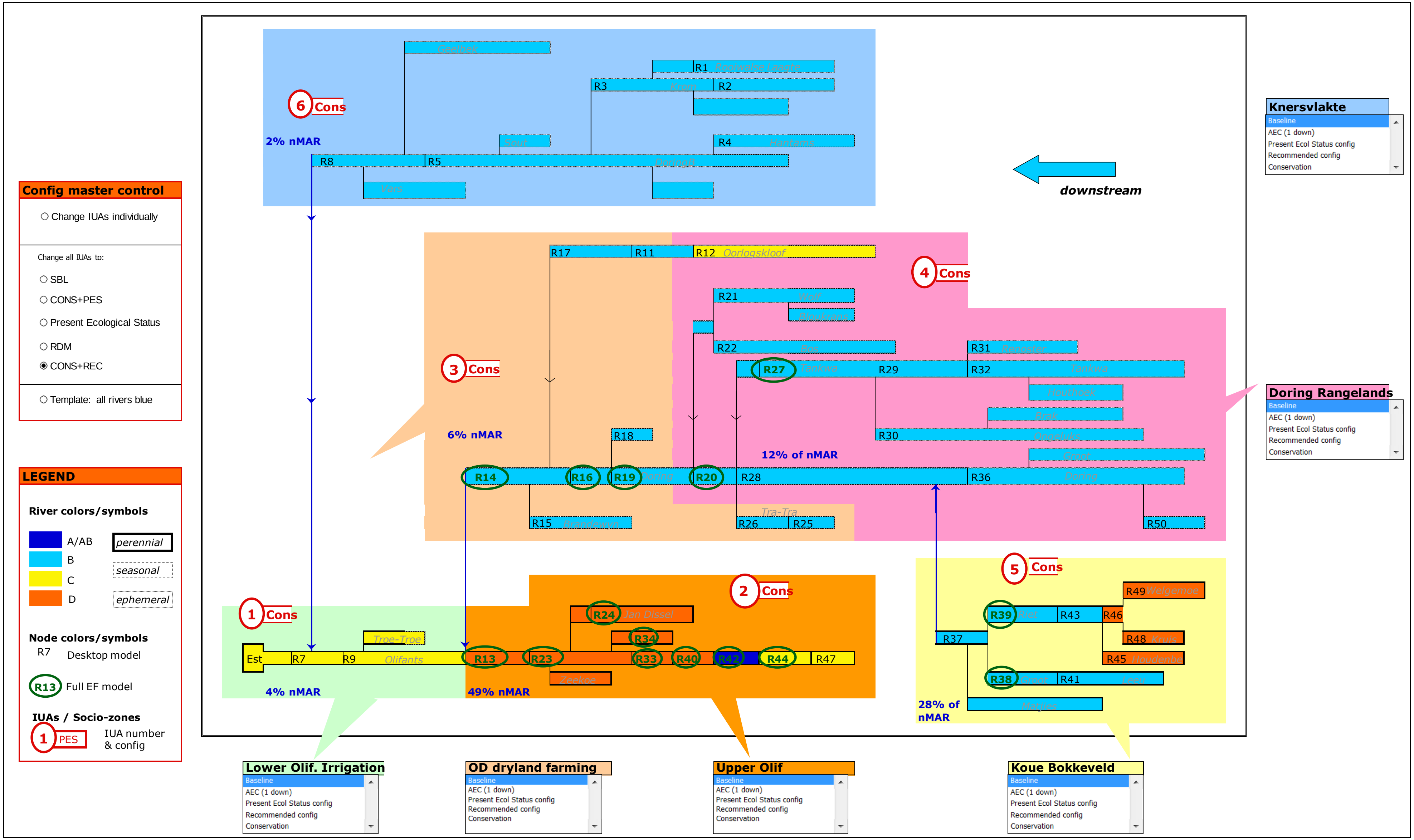

Figure 7.6.2: Scenario 4 - Conservation targets configuration **and REC (1999)**

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