DETERMINATION OF RESOURCE QUALITY OBJECTIVES IN THE OLIFANTS WATER MANAGEMENT AREA (WMA4)

WP10536

RESOURCE UNIT DELINEATION REPORT

REPORT NUMBER: RDM/WMA04/00/CON/RQO/0113

OCTOBER 2013

FINAL

water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Published by

Department of Water Affairs

Private Bag X313

Pretoria, 0001

Republic of South Africa

Tel: (012) 336 7500/ +27 12 336 7500

Fax: (012) 336 6731/ +27 12 336 6731

Department of Water Affairs (DWA). 2012. **Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): RESOURCE UNIT DELINEATION REPORT. Report No.: RDM/WMA04/00/CON/RQO/0113.** Chief Directorate: Water Ecosystems. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14.(iii). Pietermaritzburg, South Africa.

Prepared by:

Institute of Natural Resources

Institute of Natural Resources NPC
PO Box 100396, Scottsville, 3209, South Africa
67 St Patricks Road, Scottsville, Pietermaritzburg, 3201

Title:	*Resource Unit Delineation Report*
Authors:	*Dr. Chris Dickens, Dr. Gordon O'Brien, Dr. Nick Rivers-Moore, Mrs. Catherine Pringle, Dr. Ranier Dennis, Ms. Retha Stassen, Mr. Doug Macfarlane, Mr. Regan Rose, Mr. Leo Quale, Mrs. Melissa Wade, Ms. Pearl Mzobe, Ms. Pearl Gola, Mrs. S Oosthuizen, Dr. Peter Wade.*
***Project Name**:*	*Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4)*
DWS Report No:	*RDM/WMA04/00/CON/RQO/0113*
***Status of Report**:*	*Final*
First Issue:	*October 2013*
Final Issue:	*October 2014*

Professional Service Providers: *Institute of Natural Resources NPC*

Approved for the Professional Service Providers by:

……………………………………….. ……………………………………

Dr Chris Dickens *Date*

Project Leader

DEPARTMENT OF WATER AND SANITATION (DWS)

Directorate: Water Resource Classification

Approved for DWS by:

……………………………………….. ……………………………………

Ms Ndileka Mohapi *Date*

Chief Director: Water Ecosystems

DOCUMENT INDEX

Reports as part of this project:

INDEX NO	REPORT NO	REPORT TITLE
01	RDM/WMA04/00/CON/RQO/0112	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): INCEPTION REPORT
02	RDM/WMA04/00/CON/RQO/0212	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): GAP ANALYSIS REPORT
03	**RDM/WMA04/00/CON/RQO/0113**	**Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4); RESOURCE UNIT DELINEATION REPORT**
04	RDM/WMA04/00/CON/RQO/0213	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): RESOURCE UNIT PRIORITISATION REPORT
05	RDM/WMA04/00/CON/RQO/0114	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): SUB-COMPONENT PRIORITISATION AND INDICATOR SELECTION REPORT
06	RDM/WMA04/00/CON/RQO/0214	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT
07	RDM/WMA04/00/CON/RQO/0314	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): CLOSE OUT REPORT

MANAGEMENT COMMITTEE

Project Management Committee

Name Surname	Organisation	Component
Adaora Okonkwo	Department of Water and Sanitation	Water Resource Classification
Barbara Weston	Department of Water and Sanitation	Reserve Requirements
Boitumelo Sejamoholo	Department of Water and Sanitation	Resource Directed Measures Compliance
Chris Dickens	Institute of Natural Resources	Project Team
Didi Masoabi	Golder Associates	Middle Vaal RQOs Study Team
Ephraim Matseba	Department of Water and Sanitation	Gauteng Regional Office
Gordon O'Brien	Institute of Natural Resources	Project Team
Jackie Jay	Department of Water and Sanitation	Water Resource Planning Systems
Jurgo van Wyk	Department of Water and Sanitation	Water Resource Planning Systems
Lebo Mosoa	Department of Water and Sanitation	Water Resource Planning Systems
Lee Boyd	Golder Associates	Middle Vaal RQOs Study Team
Mahadi Mofokeng	Department of Water and Sanitation	Northern Cape Regional Office
Malise Noe	Department of Water and Sanitation	Resource Protection and Waste
Mbali Dlamini	Department of Water and Sanitation	Mpumalanga Regional Office
Mfundi Biyela	Department of Water and Sanitation	Free State Regional Office
Motau Sepadi	Department of Water and Sanitation	Limpopo Regional Office
Nadine Slabbert	Department of Water and Sanitation	Resource Quality Services
Nancy Motebe	Department of Water and Sanitation	Reserve Requirements
Ndileka Mohapi	Department of Water and Sanitation	Water Ecosystems
Patiswa Mnqokoyi	Zitholele Consulting	Middle Vaal RQOs Study Team
Pearl Gola	Institute of Natural Resources	Project Team
Priya Moodley	Golder Associates	Middle Vaal RQOs Study Team
Sadimo Manamela	Department of Water and Sanitation	Resource Directed Measures Compliance
Seef Rademeyer	Department of Water and Sanitation	National Water Resources Planning
Shane Naidoo	Department of Water and Sanitation	Water Resource Classification
Sindiswa Sonjica	Department of Water and Sanitation	Free State Regional Office
Stanford Macevele	Department of Water and Sanitation	Mpumalanga Regional Office
Steven Shibambu	Department of Water and Sanitation	Limpopo Regional Office
Sydney Nkuna	Department of Water and Sanitation	Mpumalanga Regional Office
Tendani Nditwani	Department of Water and Sanitation	National Water Resources Planning
Tendayi Mkombe	Department of Water and Sanitation	National Water Resources Planning
Tovhowani Nyamande	Department of Water and Sanitation	Water Resource Classification
Trevor Coleman	Golder Associates	Middle Vaal RQOs Study Team
Vusumzi Mema	Department of Water and Sanitation	Resource Directed Measures Compliance
Yakeen Atwaru	Department of Water and Sanitation	Reserve Requirements

Project Team

Name Surname	Organisation	Role
Catherine Pringle	Institute of Natural Resources (NPC)	Specialist Scientist, RQO Determination
Chris Dickens	Institute of Natural Resources (NPC)	Project Leader and Specialist Scientist
Douglas Macfarlane	Eco-Pulse	Specialist Scientist: Wetlands
Gordon O'Brien	Institute of Natural Resources (NPC)	Project Manager and Specialist Scientist
Leo Quale	Institute of Natural Resources (NPC)	Scientist: RQO Determination
Melissa Wade	Jeffares and Green (Pty) Ltd	Scientist: RQO Determination
Nick Rivers-Moore	Institute of Natural Resources (NPC)	Project Manager and Specialist Scientist
Pearl Gola	Institute of Natural Resources (NPC)	Scientist: RQO Determination
Pearl Mzobe	Institute of Natural Resources (NPC)	Scientist: RQO Determination
Peter Wade	Consulting	Specialist Scientist: Water Quality
Ranier Dennis	North West University	Specialist Scientist: Groundwater
Regan Rose	Geowater IQ (Pty) Ltd	Specialist Scientist: Groundwater
Retha Stassen	Consulting	Specialist Scientist: Hydrology
Sian Oosthuizen	Institute of Natural Resources (NPC)	Scientist: RQO Determination

Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4) - WP10536

Resource unit Declination Report

Executive Summary

The Resource Quality Objectives (RQOs) determination procedures for the Olifants Water Management Area (WMA) involved the application of the seven step framework established by the Department of Water Affairs in 2011 (DWA, 2011). Although the procedures involve defining the resource, setting a vision, determination of RQOs and NLs, gazetting this and then moving to implementation, monitoring and review before starting the process all over again, some of these steps were achieved in the Water Resource Classification Study and were not repeated in this study. The procedural steps established for this case study to determine RQOs for rivers, groundwater, dams and wetland resources in the WMA include:

- Step 1. Delineate the Integrated Units of Analyses (IUAs) and Resource Units (RUs).
- Step 2. Establish a vision for the catchment and key elements for the IUAs.
- Step 3. Prioritise and select RUs and ecosystems for RQO determination.
- Step 4. Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change.
- Step 5. Develop draft RQOs and Numerical Limits.
- Step 6. Agree Resource Units, RQOs and Numerical Limits with stakeholders.
- Step 7. Finalise and Gazette RQOs.

Components of steps 1 and 2 were available from the WRC study to which this RQO determination process was aligned. This report documents the delineation of the IUAs and RUs for RQO determination in the Olifants WMA (Step 1).

A total of 13 IUAs were already identified as part of the Olifants WRC study and these existing IUAs were used in the development of RQOs for the Olifants WMA. The delineation process resulted in a total of 121 RUs selected for the rivers component which was also used for the groundwater component. Numerous wetlands and dams were delineated that will be prioritised during step 4 of the RQO process.

Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4) - WP10536

Inception Report

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

Acronym	Meaning
Al	Aluminium
As	Arsenic
$CaCO_3$	Calcium Carbonate
Cd	Cadmium
Chl-a	Chlorophyll a
Cl	Chlorine
Cr(VI)	Hexavalent chromium
Cu	Copper
DOC	Dissolved organic carbon
DRM	Desktop Reserve Model
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements
F	Fluorine
FEPA	Freshwater Ecosystem Priority Areas
FRAI	Fish Response Assessment Index
GIS	Geographical Information Science
Hg	Mercury
□g/l	Micrograms per litre
IBA	Important Bird Areas
IRHI	Index of Reservoir Habitat Impairment
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resources Management Plan
KNP	Kruger National Park
m^3/s	Cubic meters per meter (cumecs)
MAR	Mean Annual Runoff
MC	Management Class
mg/l	Milligrams per litre
MIRAI	Macroinvertebrate Response Assessment Index
Mn	Manganese
NFEPA	National Freshwater Ecosystem Priority Areas
NL	Numerical Limit
NO_2	Nitrite
NO_3	Nitrate
NTU	Turbidity
NWA	National Water Act
NWRS	National Water Resource Strategy
O_2	Oxygen

Pb	Lead
PES	Present Ecological State
pH	power of hydrogen
PO_4	Phosphate
RDM	Resource Directed Measures
REC	Recommended Ecological Category
REC	Recommended ecological category
RHAM	Rapid Habitat Assessment Method
RHP	River Health Programme
RO	Regional Office
RQOs	Resource Quality Objectives
RR	Reporting rates
RU / RUs	Resource Unit/s
RUET	Resource Unit Evaluation Tool
RUPT	Resource Unit Prioritisation Tool
SASS5	South African Scoring System version 5
Se	Selenium
SPI	Specific Pollution sensitivity Index
TDS	Total Dissolved Solids
TIN	Total Inorganic Nitrogen
TPC	Threshold of Probable Concern
VEGRAI	Vegetation Response Assessment Index
VMAR	Virgin Mean Annual Runoff
WE	Water Ecosystems
WMA	Water Management Area
WRC	Water Resource Classification
WWTW	Waste Water Treatment Works
Zn	Zinc

DEFINITION OF PROJECT SPECIFIC ACRONYMS:

EWR – Ecological Water Requirements is synonymous with the ecological component of the Reserve as defined in the Water Act (1998).

IUA – Integrated Unit of Analysis or spatial units that will be defined as significant resources (as prescribed by the NWA).They are finer-scale units aligned to watershed boundaries, in which socio-economic activities are likely to be similar.

MC – The Management Class is set by the WRC and describes the degree of alteration that resources may be subjected to.

REC – Recommended Ecological Category – this is a recommendation purely from the ecological perspective designed to meet a possible future state.

RU – Resource Unit is a stretch of river that is sufficiently ecologically distinct to warrant its own specification of Ecological Water Requirements

WRC – Water Resources Classification is a procedure required by the Water Act 1998 that produces a MC per IUA for all water resources.

Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4) - WP10536

Resource Unit Delineation Report

1 INTRODUCTION

The rationale for requiring RQOs, their components, their applicability and implementation procedures emanate from the National Water Act of South Africa (NWA, 1998). The Water Act (1998) requires that all water resources are protected in order to secure their future and sustainable use. It lays out a plan where each significant water resources (surface water, wetlands, groundwater and estuaries) are classified according to a WRC System. In the process, the Reserve is also determined for the water resource, i.e. the amount of water, and the quality of water, that is required to sustain both the ecosystem and provide for basic human needs. This Reserve then contributes to the Classification of the resource. This classification results in a Management Class and associated RQOs for water resources, which gives direction for future management activities in the WMA. According to the Water Act (NWA, 1998), the purpose of RQOs are to establish clear goals relating to the quality of the relevant water resources and stipulates that in determining RQOs a balance must be sought between the need to protect and sustain water resources and the need to use them (sensu DWA, 2011). Thus the "working part" of the Classification of water resources, is the RQOs that are produced. These are numerical and narrative descriptors of conditions that need to be met in order to achieve the required management scenario as provided during the resource classification. Such descriptors relate to the:

(a) quantity, pattern, timing, water level and assurance of instream flow
(b) water quality including the physical, chemical, and biological characteristics of the water
(c) character and condition of the instream and riparian habitat; and
(d) characteristics, condition and distribution of the aquatic biota (DWA, 2011).

This section of the RQO determination procedure includes the delineation of the IUAs and RUs for the Olifants WMA (Step 1; DWA, 2011). Integrated Units of Analysis are finer-scale units aligned to watershed boundaries, in which socio-economic activities are likely to be similar. These homogenous units provide a useful indication of similar impacts in different areas of the catchment which should be considered in the determination of RQOs. A RU, on the other hand, is a stretch of river that is sufficiently ecologically distinct to warrant its own specification of Ecological Water Requirements (EWR). Resource Units are nested within IUAs and in the RQO process, are aligned to IUA boundaries. There are normally several RUs within a single IUA.

2 SCOPE OF THE STUDY

The study entails the determination of Resource Quality Objectives (RQOs) for all significant water resources (rivers, wetlands, dams (or lakes) and groundwater ecosystems) in the Olifants Water Management Area (WMA). The RQO determination procedure established by DWA (2011) has been implemented to determine RQOs in this case study. The RQO determination procedure is based on a seven step framework including (DWA, 2011; Figure 1):

- Step 1. Delineate the Integrated Units of Analysis (IUAs) and define the Resource Units (RUs)
- Step 2. Establish a vision for the catchment and key elements for the IUAs
- Step 3. Prioritise and select preliminary Resource Units for RQO determination
- Step 4. Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change
- Step 5. Develop draft RQOs and Numerical Limits
- Step 6. Agree Resource Units, RQOs and Numerical Limits with stakeholders
- Step 7. Finalise and Gazette RQOs

In 2013 the Department of Water Affairs completed the Water Resource Classification (WRC) study for the Olifants WMA which included the delineation IUAs and established a vision for the catchment and key elements for the IUAs (DWA, 2013). This resulted in the determination of Management Classes for each IUA and Recommended Ecological Categories for biophysical nodes selected to represent the riverine ecosystem in the WMA. These outcomes met the IUA delineation requirements for the study and provided the vision information, including Management Classes for the study. As such this study did not include these components but rather adopted the outcomes from the WRC study (DWA, 2013). Apart from these components that were obtained from the WRC study, some developments/adaptations were made to the DWA (2011) RQO determination procedure to the groundwater, wetland and dam components of the study in particular. This report documents the approach adopted and the outcomes of the implementation of Step 1 of the RQO determination procedure (DWA, 2011).

3 METHODOLOGY

3.1 RESOURCE QUALITY OBJECTIVES METHODOLOGY OVERVIEW

The Resource Quality Objectives determination procedures established by DWA (2011) were implemented in this study. This included the implementation of the seven-step procedural framework which is repeatable and as such allows for an adaptive management cycle with additional steps (Figure 1). Overall the procedure involved defining the resource, setting a vision, determining RQOs and Numerical Limits (NLs), gazetting the RQOs and NLs and then moving to implementation, monitoring and review of these RQOs and NLs before starting the process all over again. A summary of the procedural steps established for this case study, with some adaptations that were required to include groundwater, dams and wetland resources include:

- **Step 1. Delineate the IUAs and RUs:** In this case study IUAs were obtained from the Water Resource Classification (WRC) study (DWA, 2012) and applied to all water resources considered in the study (rivers, wetlands, dams and groundwater ecosystems). Three spatial levels for resources were considered for RQO determination in this case study:
  - Regional (IUA) scale assessments were considered for rivers, wetlands and groundwater resources in the study.
  - Resource Unit scale assessments that were aligned to biophysical nodes obtained from the WRC study (DWA, 2012) were considered for river and groundwater resources alone.
  - Ecosystem scale assessments were considered for wetland and dam ecosystems/resources in the study.

  The RU delineation procedure initially involved the identification of sub-quaternary reaches of rivers in the WMA for each biophysical node obtained from the WRC study. The RU delineation process then involved amalgamating the upstream associated sub-quaternary reaches of riverine ecosystems, and their associated catchment areas. As a result, the number of RUs selected for the study was identical to and could later be aligned to the information associated with the biophysical nodes from the WRC study. The delineation procedure for ecosystem scale resource assessment involved the use of Geographical Information System (GIS) spatial ecosystem data.
- **Step 2. Establish a vision for the catchment and key elements for the IUAs:** The stakeholder requirements and their associated outcomes, which include the Management Classes for IUAs and RECs for RUs from the WRC study, were adopted as the vision for this study (DWA, 2012). No further visioning process was appropriate as this could have conflicted with the WRC process. The WRC outcomes were skewed towards river resources in the WMA which necessitated obtaining additional information for the other resources considered in the study (i.e. wetlands, dams and groundwater ecosystems). This additional information is highlighted in the applicable reports.
- **Step 3. Prioritise and select RUs and ecosystems for RQO determination:** This step involved the use of existing ecological specifications (EcoSpecs) and user specifications (UserSpecs) information from the Olifants Reserve and WRC studies. This information was used to implement the RU Prioritisation Tool for rivers (DWA, 2011) and the new RU Prioritisation Tools developed for groundwater RUs as part of this study. Wetland ecosystem prioritisation involved the implementation of a new GIS based prioritisation approach developed for the study and dam ecosystem prioritisation was based on a desktop assessment of available user- and eco-spec information. During this step, RU and ecosystem prioritisation stakeholder participation workshops were carried out during which available information was discussed and amended according to available local information regarding the protection and use requirements for the WMA. During these RU and ecosystem prioritisation stakeholder workshops, consensus was reached to select the final lists of prioritised RUs and ecosystems for the RQO determination process.
- **Step 4. Prioritise sub-components for RQO determination, select indicators for monitoring and propose the direction of change:** This step included the hosting of a range of specialist workshops for rivers, dams, wetlands and groundwater resources where RU Evaluation Tools were used to select sub-components for RQO determination, select indicators and propose the direction of change. The RU Evaluation Tools used for wetlands, dams and groundwater were developed for the study. This

information was then used to develop draft RQOs and Numerical Limits in the next step. The relevant activities of this step were:

4.1 Identify and assess the impact of current and anticipated future use on water resource components
4.2 Identify requirements of important user groups
4.3 Selection of sub-components for RQO determination
4.4 Establish the desired direction of change for selected sub-components
4.5 Complete the information sheet for the Resource Unit Evaluation Tool

- **Step 5. Develop draft RQOs and Numerical Limits**: This step was based on the outcomes of the RU and ecosystem prioritisation step (Step 4). From the outcomes of the RU and ecosystem prioritisation step, draft RQOs were established and provided to recognised specialists to establish NLs that were generally quantitative descriptors of the different components of the resource (such as the water quantity, quality, habitat and biota). These descriptors were designed to give a quantitative measures of the RQOs (DWA, 2011). Although the NLs may have had some uncertainty associated with them and were not originally intended for gazetting (DWA, 2011), they were considered for gazetting in the study at the request of the Department of Water and Sanitation (DWS) Chief Directorate: Legal Services. Refer to the RQO and NL reports for more information. The relevant activities of this step were:

5.1 Carry over sub-component and indicator information from the Resource Unit Evaluation Tool
5.2 Extract available data to determine the present state for selected sub-components and indicators
5.3 Assess the suitability of the data
5.4 Where necessary, collect data to determine the Present State for selected indicators
5.5 Determine the level at which to set RQOs
5.6 Set appropriate draft RQOs
5.7 Set appropriate draft Numerical Limits in line with the draft RQO
5.8 Determine confidence in the RQOs and process

- **Step 6. Agree on Resource Units, RQOs and Numerical Limits with stakeholders:** This component included the consideration of RQO and NL outcomes with stakeholders prior to the initiation of the gazetting process. The relevant activities of this step were:

6.1 Notify stakeholders and plan the workshop
6.2 Present and refine the Resource Unit selection with stakeholders
6.3 Present the sub-components and indicators selected for the RQO determination
6.4 Present the proposed direction of change and associated rationale
6.5 Present and revise RQOs and Numerical Limits

- **Step 7. Finalise and Gazette RQOs:** This component of the RQO determination process is still to be carried out. A Legal Notice was developed as a part of this study for submission to Chief Directorate: Legal Services of the DWS for gazetting.

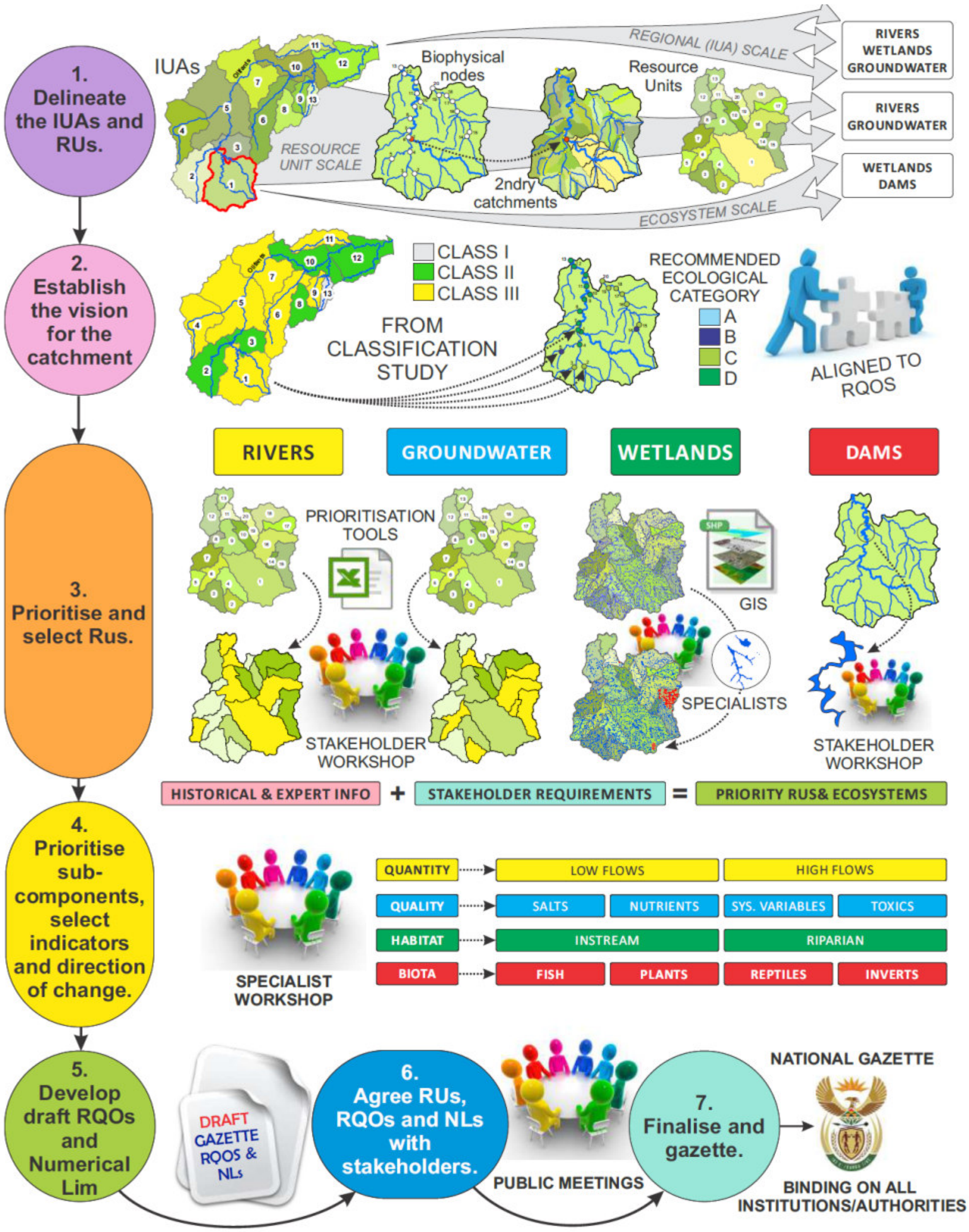

Figure 1: Schematic summary of the RQO determination procedure (adapted from DWA, 2011) which was implemented in this study.

3.2 RESOURCE UNIT DELINEATION OVERVIEW

The first step of the RQO process requires the delineation of IUAs and RUs. A total of 13 IUAs have already been identified as part of the Olifants WRC study (Table 1 and Figure 2).These existing IUAs have been used in the development of RQOs for the Olifants WMA.

Table 1: IUAs identified for the Olifants WMA as part of the WRC process (DWA, 2013), and associated quaternary catchments

IUA	Delineation	Quaternary Catchment
1	Upper Olifants River catchment	B11A, B11B, B11C, B11D, B11E, B11F, B11G, B11H, B11J, B11K, B11L, B12A, B12B, B12C, B12D
2	Wilge River catchment area	B20A, B20B, B20C, B20D, B20E, B20F, B20G, B20H, B20J
3	Selons River area including Loskop Dam	B12E, B32A, B32B, B32C
4	Elands River catchment area	B31A, B31B, B31C, B31D, B31E, B31F, B31G
5	Middle Olifants up to Flag Boshielo Dam	B32D, B31H, B31J, B32E, B32F, B32G, B32H, B32J, B51A, B51B, B51C, B51D, B51E
6	Steelpoort River catchment	B41A, B41B, B41C, B41D, B41E, B41F B41G, B41H, B41J, B41K
7	Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	B51F, B51G, B51H, B52A, B52B, B52C, B52D, B52E, B52F, B52G, B52H, B52J
8	Spekboom catchment	B42A, B42B, B42C, B42D, B42E, B42F B42G, B42H
9	Ohrigstad River catchment area	B60E, B60F, B60G,B60H
10	Lower Olifants	B60J, B71A, B71B, B71C, B71D, B71E, B71F, B71G, B71H, B71J, B72A, B72B, B72C
11	Ga-Selati River area	B72E, B72F,B72G, B72H, B72J, B72K
12	Lower Olifants within Kruger National Park	B72D, B73A, B73B, B73C, B73D, B73E B73F, B73G, B73H, B73J
13	Blyde River catchment area	B60A,B60B, B60C, B60D

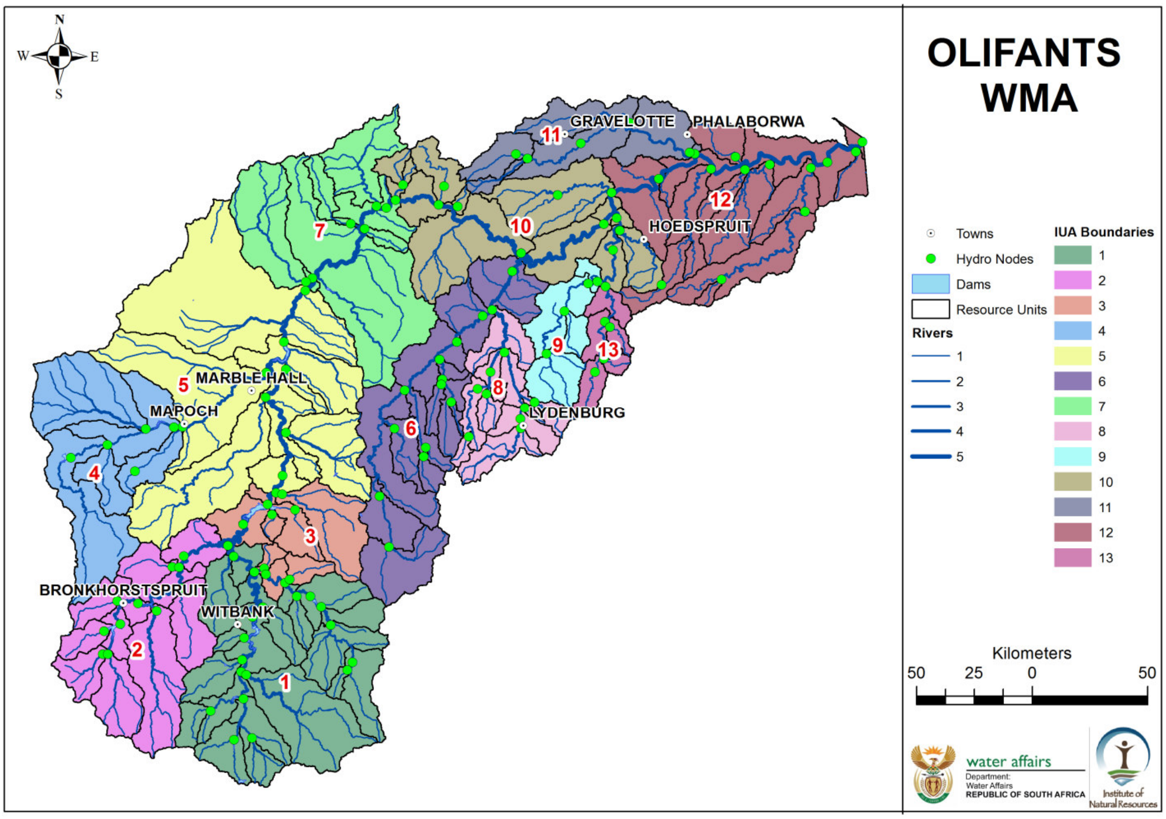

Figure 2: The location of IUAs in the Olifants WMA

The following approaches have been applied in the delineation of Resource Units for rivers, wetlands, dams and groundwater.

3.3 RIVER RESOURCE UNIT DELINEATION FOR THE OLIFANTS WMA

The WRC study identified a total of 121 nodes for the Olifants WMA. These nodes were utilised for yield modelling and were selected based on bio-physical, management, water quality and specific protection considerations. For the purposes of the RQO study however, the terrestrial area associated with the node was also delineated to provide an areas based river resource unit. This was necessary to facilitate an assessment of the socio-economic data and associated users requirements as well as the potential impacts of different land uses on water resources. The following key steps were undertaken as part of this delineation process.

3.3.1 DATA GATHERING

Spatial data for the Olifants WMA was obtained from Ms. Priya Moodley (Golder Associates) who was part of the Olifants WMA Classification Team (see Table 2). The spatial data was made available in ESRI's File Geodatabase format.

Table 2: Spatial data obtained from the WRC study for use in the delineation of River RUs for the Olifants WMA.

Feature Geodatabase Feature Dataset	File Geodatabase Feature Class
Base Data	WDPA Protected Areas
Monitoring Data	*EWR Sites*, *Hydro Nodes*, *Integrated Units of Assessment*, Nodes, *Rapid Reserve Sites*
NFEPA	Ecosystem Areas, River Condition, Wetland Clusters, Wetlands
Surface Water	Major Dams, *Major Rivers*, *Quaternary Catchments*

*italics font shows data used in resource unit delineation

3.3.2 ALIGNMENT WITH THE WRC STUDY

Resource Unit delineation was conducted at the sub-quaternary scale as this level of spatial representation provides greater resolution of the data. Furthermore, the sub-quaternary scale has been used in other projects by the DWA. Therefore, working at this scale ensures that data from various projects is transferrable thereby minimizing scale discrepancies and providing a homogenous platform for data analysis.

Members of the RQO team also met with Ms Retha Stassen (who was a team member of the Olifants WMA WRC study), to discuss the methodology applied in identifying nodes in the WRC study. Information derived from this discussion was used to fix hydro nodes to the correct locations e.g. some nodes carry information for the outlet of the IUA. This information was spatially corrected.

The Ecologically Sustainable Baseline Configuration (ESBC) Scenario Report for the Olifants WMA (DWA, 2011) indicates that 121 river nodes were identified during the classification process. However the spatial data provided indicated only 104 hydro nodes. The corresponding rapid, intermediate and comprehensive reserve points were then added to provide the 121 hydro nodes detailed in the WRC study reports. A new shapefile with the classification names for these 121 hydro nodes was created.

3.3.3 DATA PROCESSING

Using ArcMap™ the above-mentioned layers (Table 2) were added into the document and symbolized accordingly. Thereafter, sub-quaternaries that intersected the IUAs were selected. The intersect function was used to ensure that adjacent sub-quaternary catchments that were part of the WMA were not excluded. The output of this step yielded sub-quaternary catchments that were within the IUAs. An edit session was entered into with the sub-quaternary layer as the layer to perform editing functions. Sub-quaternary catchments were merged to provide the RUs. The rivers and nodes within the IUAs provided the basis for resource unit delineation as the river catchments were followed i.e. the watershed area was included (quaternary catchments were also used to verify the validity of the delineated RU). The detailed steps undertaken as part of the River RU delineation process are detailed in Appendix 1.

3.3.4 REVISION AND AMENDMENTS OF DATA

Once the data processing was complete, a number of challenges were encountered. Firstly, the use of sub-quaternary catchments as the units of assessment indicated delineation problems of IUAs in the Olifants WMA. In some instances (e.g. IUA7), catchments needed to be allocated to a different IUA due to topographic, river pattern and sub-quaternary locality issues. This necessitated the altering of some of the IUA boundaries from the WRC study to align with the sub-quaternary boundaries.

In addition, the delineation of a RU assumed that a single node would be present per RU as each node has a corresponding Present Ecological State (PES) and REC. However, from the initial data processing it became apparent that some RUs had more than one node in them. This necessitated splitting some of the initial RUs.

3.4 WETLAND ECOSYSTEM DELINEATION FOR THE OLIFANTS WMA

Step 1 of the RQO process includes defining RUs. Here, the objective is to gather all available information for the catchment concerned and then to delineate resource units for wetland ecosystems. The challenge here, is to prioritize and select wetlands that are important and significant at the scale of the assessment being undertaken. Guidance provided in the RQO manual suggests that the Decision Support System for Wetland Reserve Determinations (DWAF, 1999) be used to inform this process. This suggests that wetlands meeting the following criteria should be considered as a minimum:

- Ramsar wetlands or wetlands with potential Ramsar status;
- Wetlands with national or provincial protected status;
- Large wetlands providing important ecological services (*e.g.* flood attenuation, crop production etc);
- Large freshwater dams;
- Large wetlands fed by water sources on which major developments are planned which could cause irreversible damage to the wetlands; and
- Wetlands supporting important populations of endangered species.

While some of these features can be identified from available spatial datasets, size of wetlands mapped, (which is one of the primary discriminators suggested) is largely a function of the scale of mapping and the level of classification applied. As a result, using size of mapped wetland units as a surrogate for importance is not a reliable attribute (at least from a GIS analysis perspective). At a coarse scale, clear wetland features may be identified as discrete units and mapped accordingly. With more detailed mapping, the connections between obvious wetland areas can be identified, and can result in the amalgamation of many smaller wetlands mapped at a courser scale. Equally, classification at increasingly fine levels helps to differentiate between wetland types but results in contiguous wetlands being cut into a number of sub-units which cannot be easily identified from available GIS datasets. This point is clearly demonstrated in the upper reaches of the Olifants catchment where two levels of mapping have been undertaken. These were:

- An inventory of wetlands in the Upper Olifants catchment (Exigent Engineering Consultants, 2006): This was based on available datasets but refined based on aerial photo interpretation.
- The NFEPA wetland layer developed as part of the National Wetland Inventory (CSIR, 2011): This was based on the National Landcover and refined using available 1:5000 data and additional finer-scale datasets where available.

The differences in wetland coverages are clearly visible in Figure 3, below. This shows how the extent of wetland areas mapped has increased in response to finer-scale mapping[1]. A comparison of datasets for the Upper Olifants is also provided in Table 3 and further emphasises the differences between available wetland coverages.

[1] Note: Fairly fine scale mapping had previously been completed for a WRC project in the eastern section of the Upper Olifants catchment (Palmer *et al*., 2002). This information had been included in the NFEPA coverage and the NFEPA wetland layer therefore reflects a higher mapping accuracy that that available for the western sections of the catchment.

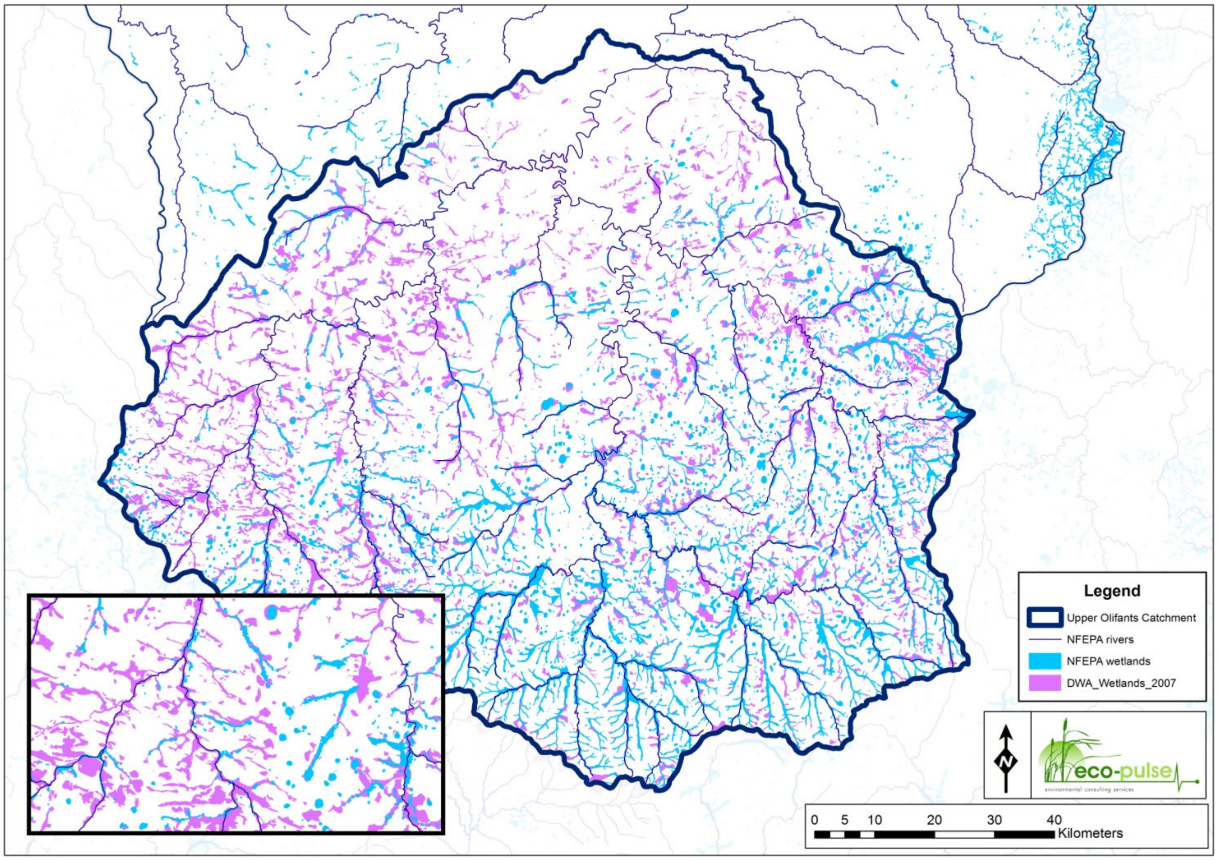

Figure 3: Overview of two datasets available for the Upper Olifants catchment.

Table 3: Comparison of two wetland datasets available for the Upper Olifants catchment.

GIS Data Set	Number of Wetlands	Area of wetlands (Ha)
NFEPA Wetland Coverage (CSIR, 2011)	6956	76809
Exigent Wetland Coverage (Exigent, 2006)	4460	214889

The attribute information available for available data sources is also important to inform the prioritization and selection process. Key here, is information on the ecological importance and sensitivity of wetland systems. In the case of available NFEPA data, the following attribute information has specific relevance:

- **Wetland condition**: This was modelled based on available Landcover data around wetland systems and informed by the condition of associated rivers where information was available.
- **Important wetlands in Mpumulanga**: Here, important wetlands including peatlands were identified by Mervyn Lotter (Mpumulanga Tourism & Parks Authority)
- **Expert-identified important wetland systems**: This includes wetlands containing exceptional biodiversity importance; good intact examples of particular wetland types, and wetlands in which Working for Wetlands has undertaken rehabilitation work[2].
- **Wetlands located in proximity to threatened frog localities**;
- **Wetlands within catchments highlighted for crane conservation**;
- **Rank of wetlands**: The final ranking of wetlands giving their relative importance based on available criteria;
- **Wetland FEPAS**: Priority wetlands (Freshwater Ecosystem Priority Areas) identified for meeting National Freshwater Ecosystem Targets.

[2] Note that this has not been updated with the latest available WFWetlands information

Despite the relatively poor resolution of mapping, this datasets does provide very useful information on the ecological importance and sensitivity of water resources that can be used to inform the identification of significant water resources for RQO determination.

The Exigent Wetland Coverage, while only restricted to the upper Olifants catchment also includes useful attribute data that includes:

- **Type**: This includes six wetland types including perennial pans, non-perennial pans, seepage, floodplain riparian, non-floodplain riparian and artificial wetlands.
- **Threats:** These include disturbance such as agriculture, infrastructure, developments and damming noted from aerial photography.
- **Connectivity**: Here, five categories were included to indicate the connectivity of the wetland to other wetlands.
- **Status:** This includes five categories indicating the status of the wetland are on a gradient from 1 to 5, with 1 indicating a wetland that is destroyed and 5 a wetland in pristine condition[3]. While providing an indication of current condition it has been flagged as one of the most inaccurate attributes (based simply on aerial photography interpretation).
- **Red Data species[4]**: This includes the number of Red Data species observed in the wetlands as well as other important species associated with the wetland types. Data is presented as number of species in each taxonomic group (e.g. 2 mammals, 7 birds).
- **Important species**: The important species include protected species included in the Mpumalanga Nature Conservation Act, as well as the Transvaal Nature Conservation Ordinance, as well as Near Threatened and Data Deficient species. The species in this table are not site-specific, but the species that may utilise the wetland type.
- **Functions:** This simply highlights the functions likely to be performed by each of the wetland types.
- **Bird number:** The number of bird species observed in the wetland are noted. This includes both Red Data and common bird species.
- **Observed Red Data species**: The bird species observed in the wetland, and included in one of the three Red Data threat categories.
- **Observed important species**: Bird species of concern observed in the wetland, including Near Threatened and Data Deficient species.
- **Dominant vegetation:** Notes of distinctive vegetation groups occurring in wetlands that were noted from the field verification exercise.

While this layer clearly has some limitations, it certainly maps wetlands at a much finer resolution that the NFEPA wetland layer.

For the purposes of this project, a decision was therefore made to use the Exigent data to delineate wetlands in the Upper Olifants while the NFEPA wetland layer was used for the remainder of the catchment.

3.5 DAM ECOSYSTEM DELINEATION FOR THE OLIFANTS WMA

Dams are single units within main stem rivers or tributaries. Off-channel dams are not associated with any rivers and are usually filled by the transfer of water from a nearby river system or dam. No specific tool was developed or used for the delineation of the dams of the Olifants catchment. Various data bases and reports were used to identify the dams in the Olifants catchment. Some of the main sources of information included:

- DWA Hydrological Information System (HIS)
- Water Situation Assessment Model (WSAM)

[3] While not the same as the standard DWAF PES classes, it should be quite straight-forward to transform this data into a more useable format if necessary.
[4] The Red Data species and important species attributes are not site-specific, but based on the wetland type. The status of the wetland was not taken into account.

- Internal Strategic Perspective (ISP) study, 2004
- Reconciliation strategy, 2008
- Any other relevant reports (Water Resources Classification study, Reserve studies, etc.)

The above information and the following rules were used to delineate the various dams:

i. Plotting of the larger dams (farm dams were excluded)
ii. Delineation using the full supply areas of the dams
iii. These delineations were overlaid with the resource units and all resource units associated with the dams were identified for further use in steps 4 and 5 of the RQO process
iv. The dam wall was used as the endpoint per dam.

3.6 GROUNDWATER RESOURCE UNIT AND ECOSYSTEM DELINEATION FOR THE OLIFANTS WMA

The delineation of Resource Units was based on surface drainage areas. In general surface water reporting to DWA is based on quaternary catchment boundaries. This is done for various reasons which include:

- DWA In-house models utilise quaternary boundaries
- The WMA comprise of a subset of quaternary boundaries

Groundwater does not report to quaternary boundaries or resource units for the purpose of this document. This is due to the fact that aquifers are aligned with the geology rather than surface drainage regions. A comparison of the surface geology and the resource units are shown in Figure 4 which clearly illustrate the variability of the geology that occurs within the respective resource units.

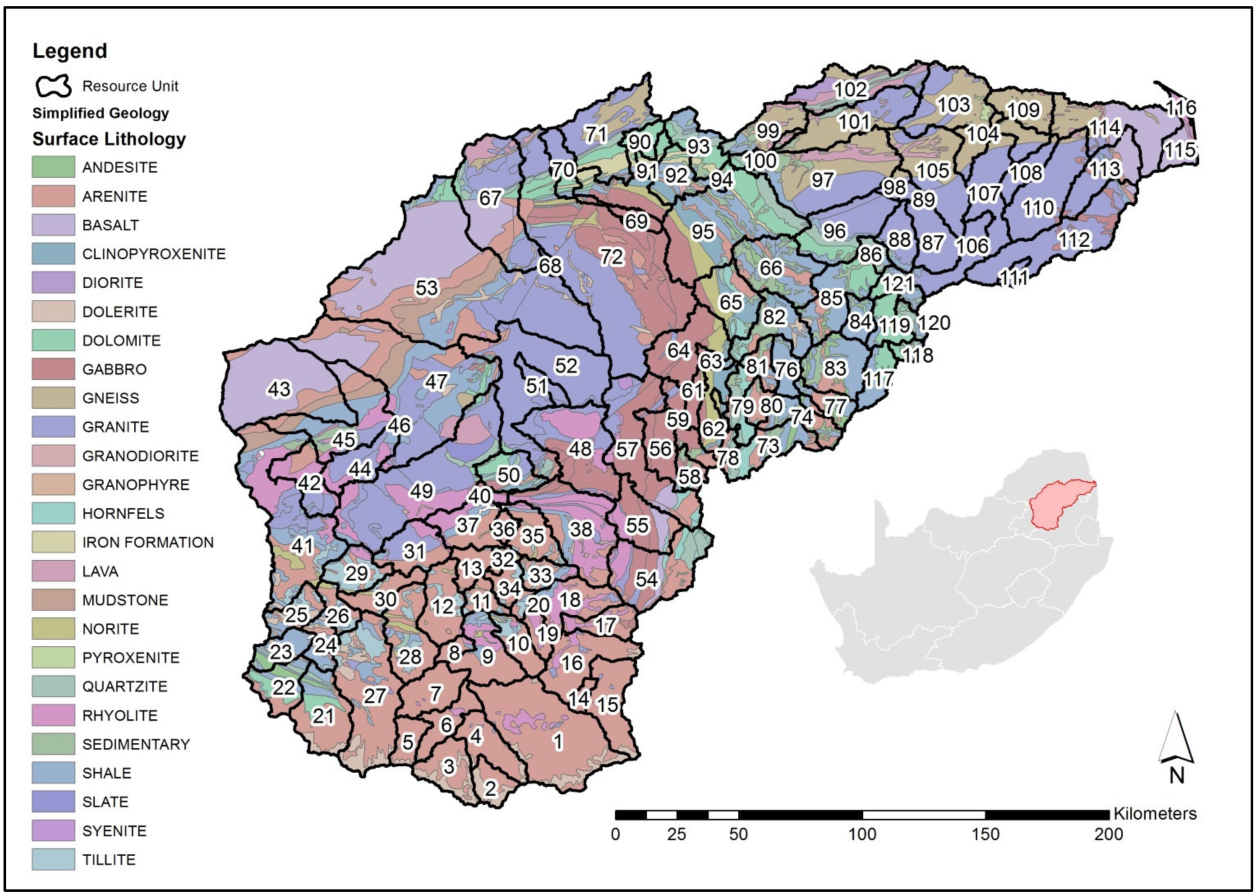

Figure 4: Surface geology vs. resource unit boundaries

General assumptions made to report groundwater within surface catchments (e.g. groundwater reserve determinations on quaternary boundary) are as follows:

- Shallow groundwater will follow the regional topography and surface water catchment boundaries will act as natural groundwater divides (Figure 5 (1)).
- Deeper groundwater will follow the deeper regional groundwater flow (Figure 5 (2) and (3)).
- The net groundwater flow through the surface catchment is assumed to be zero.

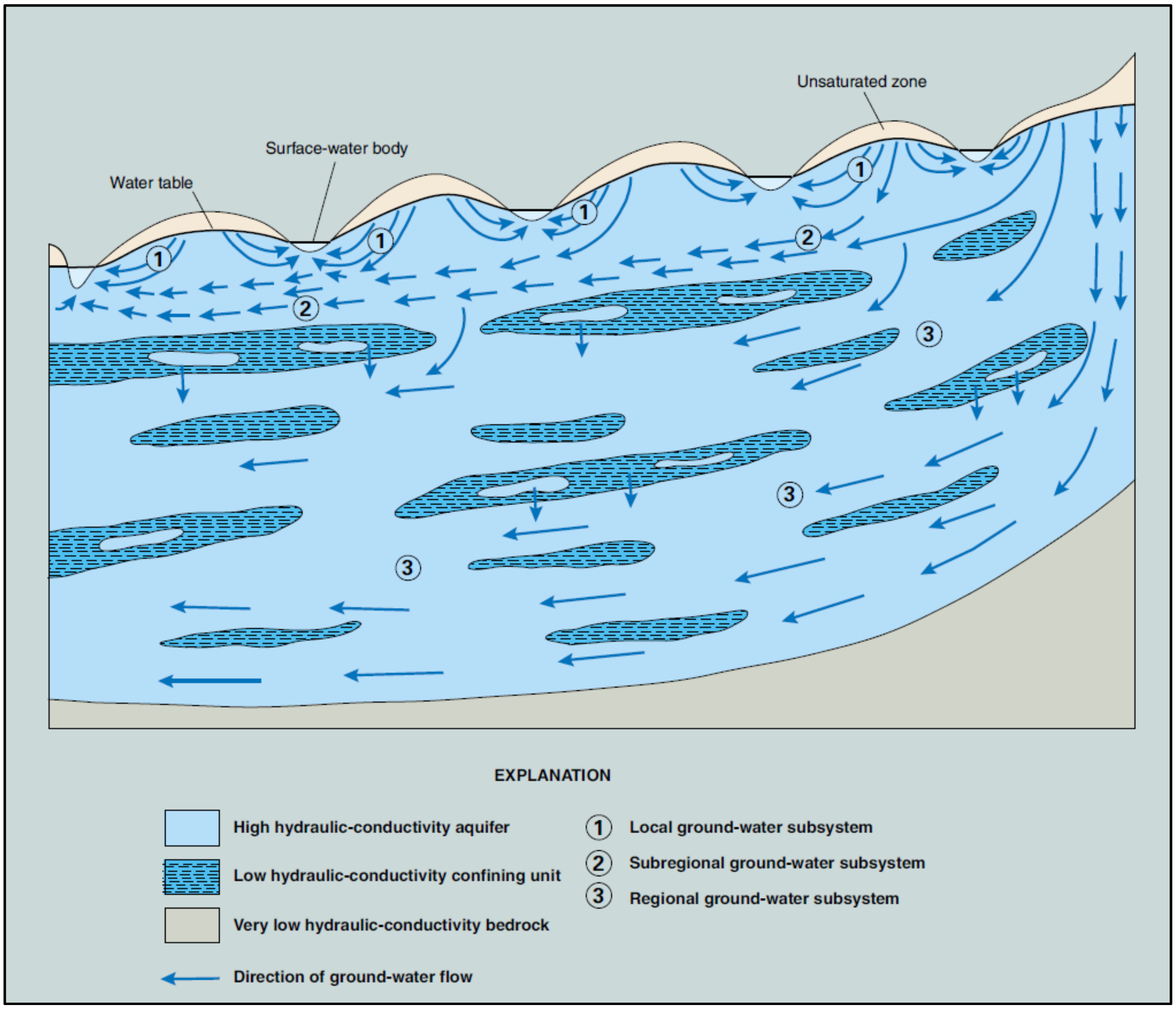

Figure 5: Groundwater flow systems (USGS, 1999)

4 FINDINGS

4.1 RIVER RESOURCE UNITS FOR THE OLIFANTS WMA

A total of 121 River RUs were delineated for the Olifants WMA (Figure 4). The location of these River RUs and associated biophysical nodes is shown in Figure 5. The IUA, biophysical node and corresponding river as well as the PES, REC (as required by the WRC) for each RU, and the management class for each respective IUA, is detailed in Table 3.

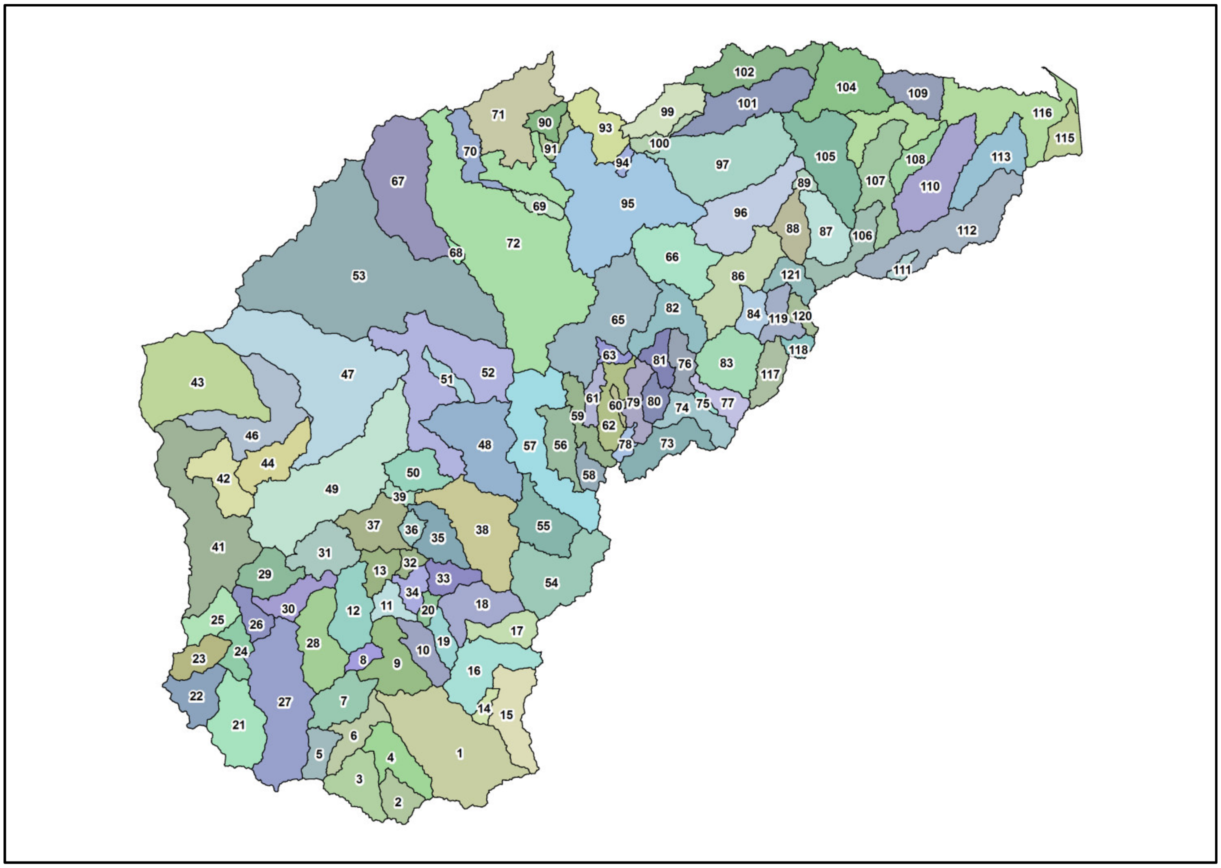

Figure 6: River Resource Units delineated for the Olifants WMA

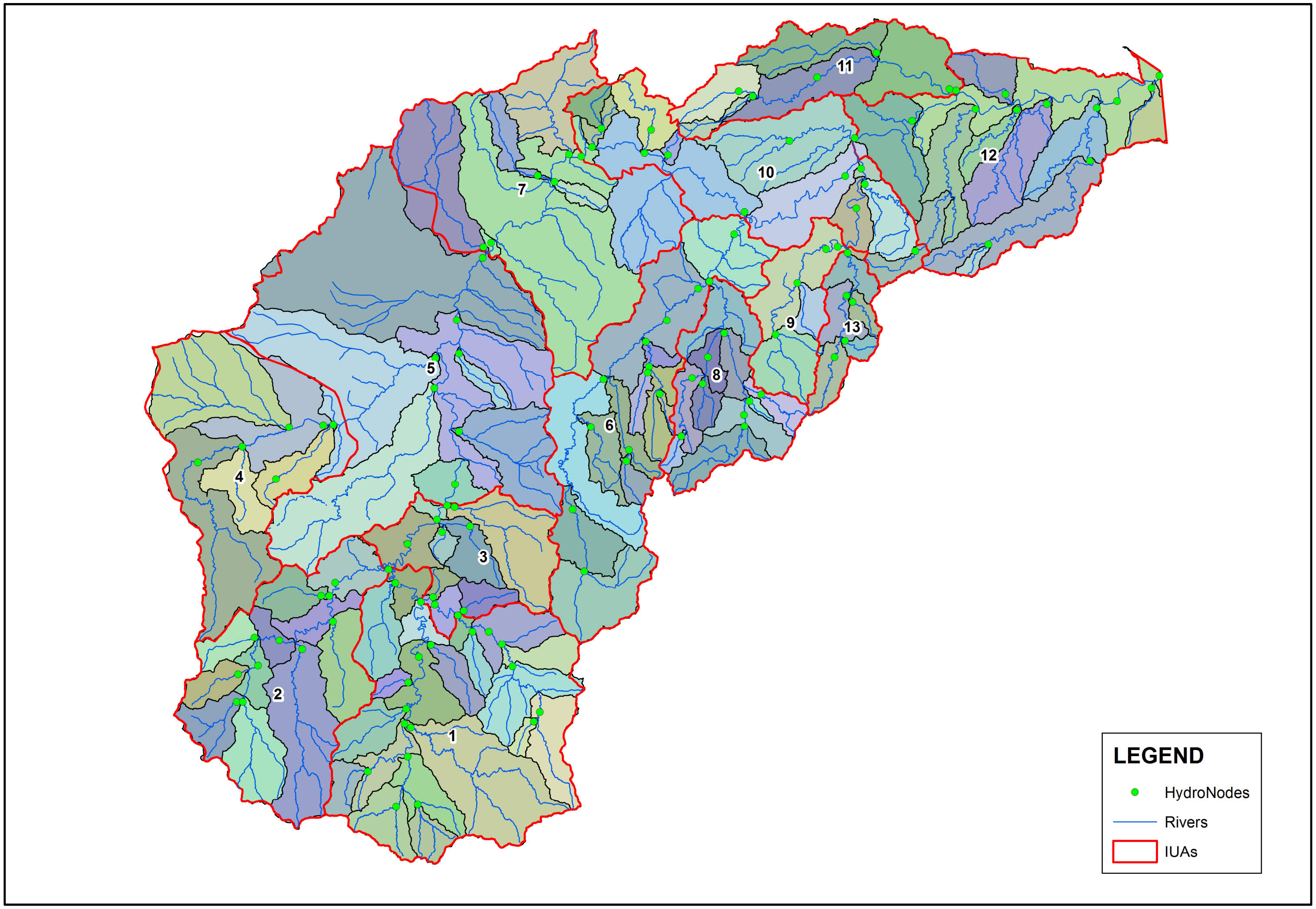

Figure 7: River Resource Units, IUAs and hydro nodes for the Olifants WMA

Table 4: Summary data for each River Resource Unit delineated in the Olifants WMA

IUA	Class for IUA	RU number	Hydro Node number	River Name	PES	REC
1. Upper Olifants River catchment	III	RU1	HN1	Olifants (confluence with Steenkoolspruit)	C	C
		RU2	HN2	Piekespruit (confluence with Steenkoolspruit)	B	B
		RU3	HN3	Dwars-indieWegspruit (confluence with Trichardtspruit)	C	C
		RU4	HN4	Steenkoolspruit (outlet of quaternary)	D	D
		RU5	HN5	Blesbokspruit (confluence with Rietspruit)	B	B
		RU6	HN6	Steenkoolspruit (confluence with Olifants)	D	D
		RU7	HN7	Olifants (outlet of quaternary)	D	D
		RU8	HN8	Noupoortspruit (EWR site – NOU-EWR1) (existing)	C/D	C/D
		RU9	HN9	Olifants (releases from Witbank Dam)	D	D
		RU10	HN10	Spookspruit (confluence with Olifants)	C	C
		RU11	HN11	Olifants (EWR site 1 – EWR1) (existing)	E	D
		RU12	HN12	Klipspruit (confluence with Olifants)	E	D
		RU13	HN13		B	B
		RU14	HN14	Boschmansfontein (confluence with Klein Olifants)	C	C
		RU15	HN15	Klein Olifants (outlet of quaternary)	C	C
		RU16	HN16	Klein Olifants (outlet of quaternary)	D	D
		RU17	HN17	Klein Olifants (EWR site – OLI-EWR1) (Rapid site)	C	C
		RU18	HN18	Klein Olifants (releases from Middelburg Dam)	D	D
		RU19	HN19	Vaalbankspruit (confluence with Klein Olifants)	D	D
		RU20	HN20	Klein Olifants (outlet of quaternary)	D	D

IUA	Class for IUA	RU number	Hydro Node number	River Name	PES	REC
2. Wilge River catchment area	II	RU21	HN21	Bronkhorstpruit (outlet of quaternary)	C	C
		RU22	HN22	Koffiespruit (confluence with Bronkhorstspruit)	C	C
		RU23	HN23	Osspruit (inflow to Bronkhorstspruit Dam)	D	D

		RU24	HN24	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)	C	C
		RU25	HN25	Hondespruit (confluence with Bronkhorstspruit)	C	C
		RU26	HN26	Bronkhorstpruit (confluence with Wilge)	C	C
		RU27	HN27	Wilge (confluence with Bronkhorstspruit	C	C
		RU28	HN28	Saalboomspruit (confluence with Wilge)	C	C
		RU29	HN29	Grootspruit (confluence with Wilge)	C	C
		RU30	HN30	Wilge (outlet of quaternary)	B	B
		RU31	HN31	Wilge (EWR site – EWR4, outlet of IUA2) (existing)	C	C
3. Selons River area including Loskop Dam	II	RU32	HN32	Doringboomspruit (confluence with Klein Olifants)	B	B
		RU33	HN33	Keeromspruit (confluence with Klein Olifants)	C	C
		RU34	HN34	Klein Olifants (EWR site – EWR3) (existing)	C	C
		RU35	HN35	Kranspoortspruit (EWR site – OLI-EWR3) (Rapid site)	B	B
		RU36	HN36	Boekenhoutloop (inflow to Loskop Dam)	B	B
		RU37	HN37	Olifants (EWR site – EWR2) (existing)	C	C
		RU38	HN38	One node at confluence of Selons with Olifants in B32C. Included: Klipspruit (confluence with Selons) Kruis (confluence with Selons) Selons (confluence with Olifants)	B	B
		RU39	HN39	Olifants (releases from Loskop Dam)	D	D
		RU40	HN40	Olifants (outlet of quaternary – outlet of IUA3)	D	D
4. Elands River catchment area	III	RU41	HN41	One node at outlet of B31C, releases from Rust de Winter Dam. Included:B31A (Elands) B31B (Hartbeesspruit) B31C (Elands)	C	C

		RU42	HN42	Enkeldoringspruit (confluence with Elands)	C	C
		RU43	HN43	Elands (releases from Mkumbe Dam)	C	C
		RU44	HN44	Kameel (upper part only	D	D
		RU45	HN45	Elands (EWR site – EWR6) (existing)	D	D
		RU46	HN46	Elands (outlet of quaternary – outlet of IUA4)	E	D
5. Middle Olifants up to Flag Boshielo Dam	III	RU47	HN47	Elands (outlet of quaternary, confluence with Olifants)	E	D
		RU48	HN48	One node at confluence with Olifants in B32F. Included: B32E (Bloed), B32F (Doringpoortloop, Diepkloof and Bloed)	B	B
		RU49	HN49	One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) B32H (Mametse and Moses)	C	C
		RU50	HN50	Olifants (EWR site – EWR5) (existing)	C	C
		RU51	HN51	Puleng (upper part only)	B	B
		RU52	HN52	Olifants (releases from Flag Boshielo Dam)	D	D
		RU53	HN53	Olifants (outlet of quaternary– outlet of IUA5)	D	D
6. Steelpoort River catchment	III	RU54	HN54	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit	C	C
		RU55	HN55	Steelpoort (EWR site – OLI-EWR2) (Rapid site)	C	C
		RU56	HN56	Masala (confluence with Steelpoort), including Tonteldoos and Vlugkraal)	C	C
		RU57	HN57	Steelpoort (inflow to De Hoop Dam)	C	C
		RU58	HN58	Draaikraalspruit (confluence with Klip)	B	B
		RU59	HN59	Klip (EWR site – OLI-EWR4) (Rapid site)	C	C

		RU60	HN60	Kraalspruit (confluence with Groot Dwars)	B	B
		RU61	HN61	Klein Dwars (Confluence with Groot Dwars)	D	D
		RU62	HN62	Upper reaches of Dwars (before mining impacts)	C	C
		RU63	HN63	Dwars (EWR site – DWS-EWR1) (existing)	B/C	B/C
		RU64	HN64	Steelpoort	D	D
		RU65	HN65	Steelpoort (EWR site – EWR9) (existing)	D	D
		RU66	HN66	Steelpoort (EWR site – EWR10) (existing) (confluence with Olifants – outlet of IUA6)	D	D
7. Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River	III	RU67	HN67	Upper Nkumpi (outlet of quaternary)	C	C
		RU68	HN68	Olifants (EWR site – EWR7) (existing)	E	D
		RU69	HN69	Palangwe (confluence with Olifants)	C	C
		RU70	HN70	Hlakaro (outlet)	C	C
		RU71	HN71	Mphogodima (confluence with Olifants)	C	C
		RU72	HN72	Olifants (outlet of quaternary – outlet of IUA7)	D	D
8. Spekboom catchment	II	RU73	HN73	One node for Dorpspruit at outlet of B42B. Included: Hoppe se Spruit (confluence) Doringbergspruit (confluence)	C	C
		RU74	HN74	Dorpspruit (EWR site – OLI-EWR9) (Rapid site)	C/D	C/D
		RU75	HN75	Potloodspruit (confluence with Dorps)	C	C
		RU76	HN76	Dorps (confluence with Spekboom)	C	C
		RU77	HN77	Spekboom (EWR site – OLI-EWR6) (Rapid site)	C	C
		RU78	HN78	Potspruit (confluence with Watervals)	C	C
		RU79	HN79	Watervals (releases from Buffelskloof Dam)	C	C
		RU80	HN80	Rooiwalhoek-se-Loop (confluence with Watervals)	B	B
		RU81	HN81	Watervals (EWR site – OLI-EWR5) (Rapid site)	C	C

		RU82	HN82	Spekboom (outlet of quaternary – outlet of IUA 8)	B	B
9. Ohrigstad River catchment area	III	RU83	HN83	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary)	D	D
		RU84	HN84	Vyehoek (confluence with Ohrigstad)	C	C
		RU85	HN85	Ohrigstad (EWR site – OLI-EWR8) (Rapid site)	C	C
		RU86	HN86	Ohrigstad (outlet of quaternary – outlet of IUA9)	D	D
10. Lower Olifants	II	RU87	HN87	Sandspruit, including Rietspruit and Qunduhlu	B	B
		RU88	HN88	Blyde (EWR site – EWR12) (existing)	B	B
		RU89	HN89	Blyde (confluence with Olifants)	C	C
		RU90	HN90	Paardevlei (confluence with Tongwane)	B	B
		RU91	HN91	Tongwane (confluence with Olifants)	B	B
		RU92	HN92	Olifants (EWR site – EWR8) (existing)	D	D
		RU93	HN93	Mohlapitse (upper reaches)	B	B
		RU94	HN94	Kgotswane (confluence with Olifants)	B	B
		RU95	HN95	Olifants (confluence with Steelpoort)	D	D
		RU96	HN96	Olifants (EWR11, confluence with Blyde) (existing)	E	D
		RU97	HN97	Makhutswi, including Moungwane and Malomanye	C	C
		RU98	HN98	Olifants (outlet – outlet of IUA10)	C	C
11. Ga-Selati River area	III	RU99	HN99	Ngwabatse (confluence with Ga-Selati)	D	D
		RU100	HN100	Ga-Selati (outlet of quaternary)	C	C
		RU101	HN101	Ga-Selati (EWR site – EWR14a) (existing)	C	C
		RU102	HN102	Molatle (confluence with Ga-Selati)	B	B
		RU103	HN103	Ga-Selati (EWR site – EWR14b) (existing)	E	D

		RU104	HN104	Ga-Selati (outlet of quaternary – outlet of UIA11)	E	D
12. Lower Olifants within Kruger National Park	II	RU105	HN105	Olifants (EWR site – EWR13) (existing)	C	C
		RU106	HN106	Klaserie (EWR site – OLI-EWR7) (Rapid site)	B/C	B/C
		RU107	HN107	Klaserie (confluence with Olifants)	C	C
		RU108	HN108	Tsiri (confluence with Olifants)	B	B
		RU109	HN109	Tshutshi (confluence with Olifants)	B	B
		RU110	HN110	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	B	B
		RU111	HN111	Sesete (confluence with Timbavati)	B	B
		RU112	HN112	Timbavati (outlet of quaternary)	B	B
		RU113	HN113	Timbavati, including Shisakashonghondo	B	B
		RU114	HN114	Olifants (EWR site – EWR16) (existing)	C	C
		RU115	HN115	Hlahleni (confluence with Olifants)	A	A
		RU116	HN116	Olifants (outlet of quaternary – outlet of IUA12)	C	C
13. Blyde River catchment area	I	RU117	HN117	Blyde (confluence with Lisbon)	C	C
		RU118	HN118	Lisbon, including Heddelspruit and Watervalspruit	B	B
		RU119	HN119	Blyde (outlet of quaternary)	B	B
		RU120	HN120	Treur (EWR site – TRE-EWR1) (existing)	A/B	A/B
		RU121	HN121	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	B	B

4.2 WETLAND ECOSYSTEMS FOR THE OLIFANTS WMA

The combined coverage of delineated wetlands from the Exigent and NFEPA datasets is indicated in Figure 8.

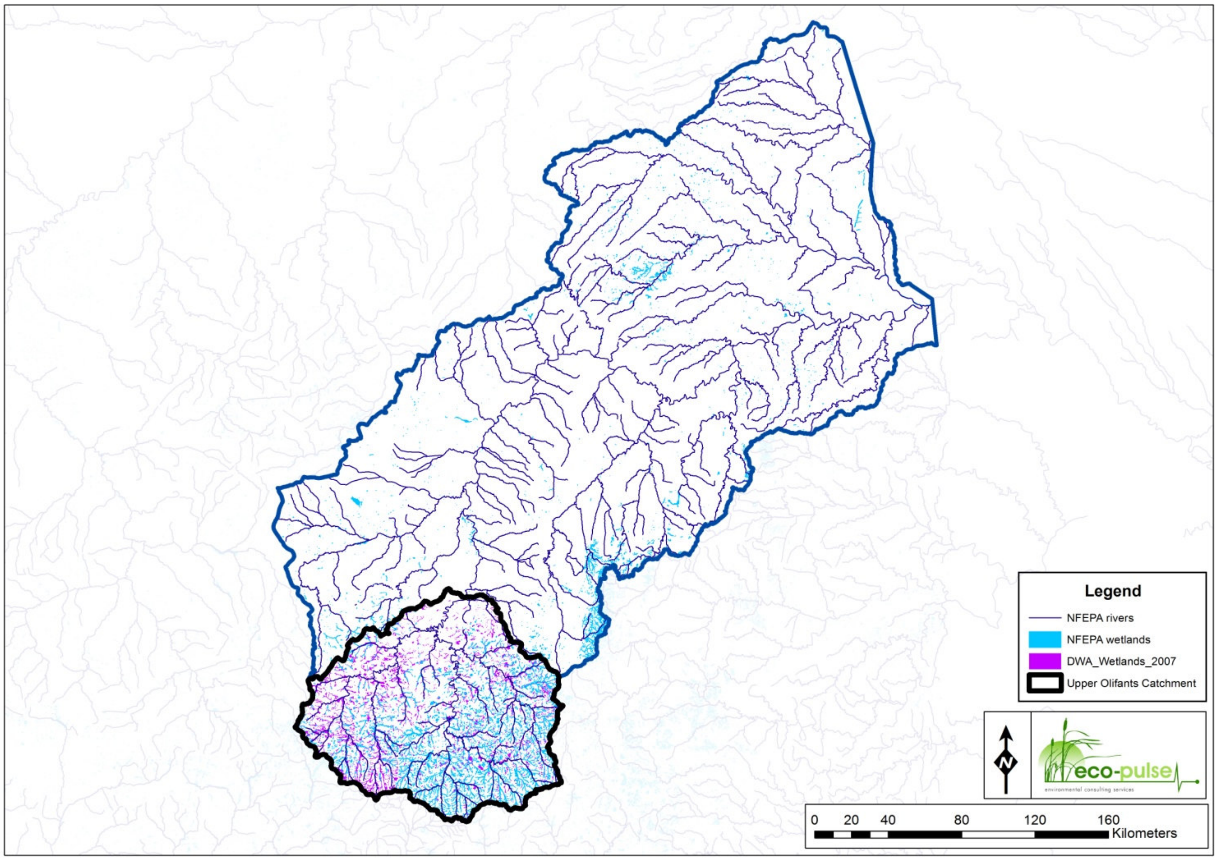

Figure 8: Delineation of wetlands in the Olifants catchment based on available datasets.

4.3 DAM ECOSYSTEMS FOR THE OLIFANTS WMA

The approach resulted in a large number of dams being delineated that will be prioritised during step 4 of the RQO process. These delineated dams are listed in the following tables below:

- Dams delineated from the DWA HIS database as presented in Table 5.
- Major dams delineated using WSAM as presented in Table 6.
- Minor dams delineated using WSAM as presented in Table 7.
- Dams delineated based on the ISP study as presented in Table 8.
- Dams delineated from the reconciliation strategy as presented in Table 9.

Table 5: Dams delineated from the DWS HIS database

DWS Number	River and Dam
B1R001	Olifants River @ Witbank Dam
B1R002	Little Olifants River @ Middelburg Dam
B2R001	Bronkhorstspruit @ Bronkhorstspruit Dam
B3R001	Elands River @ Rust De Winter Dam
B3R002	Olifants River @ Loskop Dam
B3R003	Bloed River @ Rooikraal Dam
B3R004	Selons River @ Roodepoort Dam
B3R005	Elands River @ Rhenosterkop Dam (Mkhombo)
B4R001	Tonteldoos River @ Tonteldoos Dam
B4R002	Vlugkraal River @ Vlugkraal Dam
B4R004	Waterval River @ Buffelskloof Dam

DWS Number	River and Dam
B5R002	Olifants River @ Flag Boshielo Dam
B6R001	Ohrigstad River @ Ohrigstad Dam
B6R003	Blyde River @ Blyderivierpoort Dam
B7R001	Klaserie River @ Klaserie Dam
B7R002	Olifants River @ Phalaborwa Barrage
B7R003	Ngwabitsi River @ Tours Dam

Table 6: Major dams delineated using WSAM

Dam Name	Quaternary catchment	Full Supply Capacity (m^3)	Full Supply Area (ha)
KROMFONTEIN LOWER (WILGE) COFFER DAM	B11B	13000	30
TRICHARDTSFONTEIN DAM	B11D	15200	245.9
KROMFONTEIN MIDDLE COFFER DAM	B11E	18000	40
KROMFONTEIN UPPER (MIDDLEDRIFT)	B11E	6000	150
WITBANK DAM	B11G	104019	1211.2
DOORNPOORT DAM	B11J	9180	180
BOSCHMANSKOP NO 1 & 2 DAM	B12B	14400	185
MIDDELBURG DAM	B12C	48435	468
BRONKHORSTSPRUIT DAM	B20C	57913	860.9
RUST DE WINTER DAM	B31C	27206	473.3
RHENOSTERKOP DAM (Mkhombo)	B31F	206000	3624
LOSKOP DAM	B32A	374308	2427.7
ROODEPOORT DAM	B32B	1800	16.7
ROOIKRAAL DAM	B32F	2100	89.7
DER BROCHEN DAM	B41G	7300	85
LOLA MONTES DAM-LEBOWA	B51B	1400	26
FLAG BOSHIELO DAM	B51B	105000	1287.7
ONDER-GOMPIES DAM	B51F	9112	91
PIETGOUWS DAM-LEBOWA	B51H	6500	117
LEPELLANE DAM	B52B	1150	71
CHUNIESPOORT DAM	B52C	3365	59
BLYDERIVIERSPOORT DAM	B60D	56050	247.6
OHRIGSTAD DAM	B60E	14416	99.2
PHALABORWA BARRAGE	B72D	2600	169
TOURS DAM	B72E	5500	56.3
KLASERIE DAM (JANWASSENAAR)	B73A	5608	118

Table 7: Minor dams delineated using WSAM

Dam Name	Quaternary catchment	Capacity (10^6m^3)	Surface Area (ha)
OXBOW PLUGWALLS DAM	B11B	0	0
AANGEWYS DAM	B11C	240	13
WILDEBEESTFONTEIN RESERVOIR	B11D	50	1
SYFERFONTEIN DAM	B11D	600	28
TWEEDRAAI DAM	B11D	18000	245
KRAPFONTEIN DAM	B11D	3375	60
ROODEPOORTSLURRY DAM	B11E	5500	28

Dam Name	Quaternary catchment	Capacity ($10^6 m^3$)	Surface Area (ha)
120ML DAM	B11G	133	4
SCHOONGEZICHT DAM	B11K	54	3
HARTBEESTSPRUIT DAM	B11K	236	10
LEEUWPOORT DAM NO.2	B11K	107	0
NAVIGATION DAM	B11K	203	8
WONDERBOOM DAM	B11L	120	4
KROMDRAAI DAM	B12E	220	1
GOEDGEDACHT DAM	B20A	660	0
WITKLIP BOTTOM DAM	B20A	230	22
OSSPRUIT NO.2 DAM	B20C	100	3
OSSPRUITNO.1 DAM	B20C	65	2
GROENFONTEIN DAM	B20C	58	3
WACHTEENBIETJIESKOP	B20D	130	2
RHENOSTERFONTEIN DAM	B20D	280	0
NOOITGEDINK DAM	B20D	76	0
BUCKER DAM	B20D	150	3
RUSTFONTEIN DAM	B20D	207	0
KENDAL POWER STATION: DIRTYWATER DAM	B20E	226	8
KENDAL POWER STATION: CLEANWATER DAM	B20E	90	3
KENDAL POWER STATION: EMERGENCY DAM	B20E	55	2
KENDAL POWER STATION TERMINAL RESERVOIRS 1&2	B20E	412	9
ZONDAGSFONTEIN DAM	B20E	200	12
CHRISBOSHOFF DAM	B20E	100	20
LAKESIDE DAM NO.1	B20E	135	11
WELTEVREDEN DAM	B20E	200	10
VAN DYKS PUT DAM	B20F	100	4
HEUVELFONTEIN DAM	B20F	202	7
DOORNRUG-OPGAAR DAM	B20G	70	3
CLEWER DAM	B20G	292	9
DOORNRUG DAM	B20G	174	6
A.M.VANROOYEN DAM	B20G	62	4
WILGE RIVER DAM (PREMIER MINE)	B20H	1690	72
MABALINGWESPA DAM	B20J	30	0
ONVERWACHTNO.1 DAM	B31A	189	8
KROMDRAAI INDUSTRIAL WATER DAM	B31D	1136	26
KROMDRAAI FLOOD DIVERSION DAM	B31D	2900	18.7
VERGENOEG OLD TAILINGS DAM	B31D	0	0
ZOETDOORNLAAGTE DAM1	B31E	200	20
TYRONE DAM	B31E	300	20
WALCHREN DAM	B31E	800	40
BALA DAM	B31E	100	10
DEKUILNO.1- DAM	B31E	100	5
DEKUILNO.2- DAM	B31E	200	10
ZOETDOORNLAAGTE DAM2	B31E	130	2
UYSKRAAL-ONDER DAM	B31J	180	0.3
UYSKRAAL-BO DAM	B31J	100	2
UYSKRAAL-MIDDEL DAM	B31J	300	5
MOOIPLAAS DAM	B32A	200	10

Dam Name	Quaternary catchment	Capacity (10^6m^3)	Surface Area (ha)
DE VOETPADKLOOF DAM	B32A	76	1
TWEEFONTEIN	B32A	70	3
KRANSPOORT DAM	B32A	83	5
QUESTEK DAM NO.3	B32A	220	4
VARSCHWATER DAM	B32F	2068	9
AUTHER HENRY PILLMAN DAM	B32F	80	1
KLEINBUB DAM	B32F	134	4
GEMSBOKFONTEIN DAMNO.2	B32G	206	0
GEMSBOKFONTEIN DAMNO.1	B32G	75	0
BLOEMPOORT DAM	B32H	210	7
WINKEL	B32J	164	10.3
TRANSVAAL ALLOYS SLIMES DAM	B41A	175	4
SPITSKOP DAM	B41A	150	5
BELFAST DAM	B41A	4390	138
LEEUWKLIP DAM	B41A	525	8
LEEUWKLIP-SLIK NO.2-DAM	B41A	180	3
VLAKPLAAS DAM	B41A	76	4
HADECO DAM	B41A	373	7
ONSEIE DAM	B41B	120	4
BLINKWATER DAM1	B41B	60	0
CORNELIUS DAM	B41B	60	3
CUTWATER DAM	B41B	170	7
WITBOOI DAM	B41B	400	10
TONTELDOOS DAM	B41C	630	17.7
VLUGKRAAL DAM	B41C	438	12
MAPOCH'S DAM	B41C	639	7.6
SPITSKOP DAM	B41E	752	42
INYONI DAM	B41G	500	16
DE KRAAL DAM D	B41G	172	6
DE KRAAL DAM H	B41G	450	16
DREISELEN DAM	B41H	1170	10
KALKFONTEIN DAM	B41H	200	6
TWEEFONTEIN MINE RETURN WATER DAM	B41H	75	2
OLIFANTSPOORTJE DAM	B41J	67	3
TUBATSE DAM	B41J	400	6
LYDENBURG TOWN DAM	B42B	1290	13.1
NOOITGEDACHT NR2 DAM	B42D	147	8
BUFFELSKLOOF DAM	B42F	538	60.73
MAHLANGU DAM	B51A	880	15
BUFFELS DOORN DAM- LEBOWA	B51C	3150	58
KROKODILHEUWEL	B51C	130	7
MOOIGELEGEN DAM	B51E	250	5
KLIPSPRINGERDAM	B51E	402	9
BO-GOMPIES DAM	B51F	2504	35
MOGOTO DAM	B51G	2730	18
MODDERFONTEINDAM	B51G	194	4
VERGELEGEN DAM- LEBOWA	B51H	1550	37
NKADIMENG DAM- LEBOWA	B52B	2800	72
MOLEPO DAM	B52H	4520	52

Dam Name	Quaternary catchment	Capacity (10^6m^3)	Surface Area (ha)
T.G.M.E. SLIMES PROJECT DAM	B60A	16	0.1
PAARDEKRAAL DAM NO.1	B60E	90	2
VLAKFONTEIN DAM	B60F	250	4
MANTSIBISPRUIT	B60F	338	9
CALIFORNIA DAM- LEBOWA	B60H	230	8
WELVERDIEND DAM	B60J	294	9
BAVARIA- LEIDAM	B60J	175	6
BAVARIA NO.2- DAM	B60J	110	4
PORTS GATE CITRUS DAM-A	B71H	90	40
KETTINGSPRUIT	B72A	70	2.7
GOOSEN DAM	B72H	730	5
HARMONIE DAM	B72H	660	0
BOGART DAM	B72H	312	5
SELATI DAM	B72H	720	26
H.T.MAGNETITE STORAGE DAM	B72K	4746	103
FOSKOR MAGNETITE TAILINGS DAM	B72K	8700	87
LO-TIMAGNETITE STORAGE DAM	B72K	733	16
FEDMIS GYPSUM DAM-A	B72K	416	0
FEDMIS GYPSUM DAM-B	B72K	478	0
MAIN RETURN WATER TAILINGS DAM	B72K	9000	183
HOPE DAM NO.2	B72K	193	8
FOSKOR NORTHERN TAILINGS DUMP DAM-A	B72K	1900	0
GRAVELOTTE EMERALD MINE SLIMES DAM	B72K	400	1
FEDMIS DETENTION DAM	B72K	165	5
LOOLE DAM	B72K	326	12
VAN RYSSEN- POLLUTION CONTROL	B72K	1127	20
SABLE DAM	B73C	221	22
NDLOPFU STUWAL	B73C	105	5
VICTOR WILKENS DAM (PERUDAM)	B73D	270	5
ARGYLE DAM	B73D	220	8
SOBELI DAM	B73D	260	4
ARGYLE NO.2- STUWAL	B73D	165	10
JAYDEE-STUWAL	B73D	204	5
PIETGROBLER DAM	B73G	700	35

Table 8: Dams delineated based on the ISP study

Dam Name	Quaternary catchment	River	FSC (10^6m^3)
Athlone	B12D	Du Toitsspruit	5.3
Belfast Dam	B41A		4.4
Blyderivierspoort	B60J	Blyde	56.5
Bronkhorstspruit	B20C	Bronkhorstspruit	57.9
Buffelsdoorn	B51C		3.4
Buffelskloof	B42F	Watervals	5.4
Chuniespoort	B52D		3.1
Doornpoort	B11J	Olifants	9.2
Flag Boshielo	B51B	Olifants	103
Gompies - Lower	B51G		9.1
Gompies - Upper	B51G		2.3

Dam Name	Quaternary catchment	River	FSC ($10^6 m^3$)
Klaserie	B73A	Klaserie	5.8
Krapfontein	B11D		3.4
Kromdraai	B31D		1.1
Lola Montes	B51B		1.4
Loskop	B32A	Olifants	374.3
Lydenburg	B42B	Sterk	1.1
Middelburg	B12C	Klein Olifants	48.4
Mogoto	B51G	Mogoto	2.9
Molepo	B52H		4.5
Nkadimeng	B52B		2.8
Ohrigstad	B60E	Ohrigstad	14.4
Phalaborwa Barrage	B72D	Olifants	5.7
Piet Gouws	B51H		4.4
Wilge (Premier Mine)	B20H	Wilge	1.7
Mkhombo (Rhenosterkop)	B31F	Elands	205.8
Rietspruit	B11E		4.6
Rooikraal	B32A	Bloed	2.1
Rust De Winter	B31C	Elands	27.2
Speculatie	B12B		1.8
Tours Dam	B72J	Ngwabisi	5.6
Tweedraai	B11D		18
Witbank	B11G	Olifants	104

Table 9: Dams delineated based on the Reconciliation strategy

Dam Name	FSC ($10^6 m^3$)
Upper	
Bronkhorstspruit	58.9
Middelburg	48.4
Wilge (Premier Mine)	1.6
Witbank	104
Loskop	374.3
Rust de Winter	27.3
Mkhombo with Weltevreden weir	205.8
Middle	
Flag Boshielo	1788
De Hoop	374.4
Buffelskloof	5.4
Der Bruchen	9
Belfast	5.5
Lydenburg	1.1
Lower	
Ohrigstad	13.2
Blyderivierspoort	54.6
Phalaborwa Barrage	5.7

5 LIMITATIONS AND UNCERTAINTIES

SOME OF THE KEY LIMITATIONS WHICH MAY INFLUENCE THE CONFIDENCE OF THE DELINEATION PROCESS WHICH SHOULD BE CONSIDERED WHEN IMPLEMENTING THESE PRIORITY RUS AND ECOSYSTEMS INCLUDE:

5.1 RIVERS

- There is an observed conflict between the IUA and RU boundaries. To address this problem, it is recommended that in future the delineation of IUAs be based on sub-quaternary (quinery) catchment boundaries.

5.2 WETLANDS

- Delineation was largely dependent on available NFEPA wetland data. While this was the only publically available dataset for the study area, it is known to substantially under-represent the distribution of wetlands in the catchment[5].
- Whilst a wide range of wetland assessments (including wetland delineation) have been undertaken by consultants in the catchment, this information is not readily available due to (i) confidentiality clauses with clients and (ii) the disaggregated nature of the data that makes data acquisition difficult.

5.3 GROUNDWATER

- Very little information is available to adequately delineate confined groundwater ecosystems in particular in the study area.
- The delineation process demonstrates how groundwater ecosystems do not conform to surface ecosystems which were used as a template for groundwater delineation.

5 Based on extensive work in the catchment, Wetland Consulting Services have found that hillslope seepage wetlands are under-represented by up to 60% in some areas of the catchment (Gary Marnerwick, *pers. comm.*.)

6 WAY FORWARD

The RUs provide the smallest discrete, manageable unit and are therefore important in the context of all other steps of the RQO process. However, given the large number of RUs within a selected catchment it is not possible to monitor all of these. The next step (Step 3) of the RQO process therefore entails a rationalisation process to prioritise and select the most useful Resource Units for RQO determination. The RUs detailed in the current report will therefore form the basis of this prioritisation process.

7 ACKNOWLEDGEMENTS

Contributions to this section of the RQO determination study were made by specialists from the Department of Water Affairs who provided spatial data and direction to the study team.

8 REFERENCES

Exigent Engineering Consultants, 2006. Upper Olifants River Catchment Wetland Inventory, Mpumalanga and Gauteng Provinces. Unpublished report for Coaltech 2020. 165pp.

Palmer, R.W., Turpie, J., Marneweck, G.C. & Batchelor, A.L. 2002. Ecological and economic evaluation of wetlands in the Upper Olifants River catchment, South Africa. WRC Report no. 1162/1/02.

CSIR. 2011. National Freshwater Ecosystem Priority Areas (NFEPA) Project. NFEPA Wetland Layer. GIS Coverage. Council for Scientific and Industrial Research, Pretoria, South Africa.

Department of Water Affairs, 2011. Procedures to develop and implement resource quality objectives. Department of Water Affairs, Pretoria, South Africa.

Department of Water Affairs (DWA). 2012a. Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): INCEPTION REPORT. Report No.: RDM/WMA04/00/CON/RQO/0112. Chief Directorate: Water Ecosystems: Compliance. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14 (i). Pietermaritzburg, South Africa

Department of Water Affairs (DWA). 2012b. Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): GAP ANALYSIS REPORT. Report No.: RDM/WMA04/00/CON/RQO/0212. Chief Directorate: Water Ecosystems: Compliance. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14 (ii). Pietermaritzburg, South Africa.

Department of Water Affairs (DWA). 2013a. Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): RESOURCE UNIT DELINEATION REPORT. Report No.: RDM/WMA04/00/CON/RQO/0113. Chief Directorate: Water Ecosystems: Compliance. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14 (iii). Pietermaritzburg, South Africa.

Department of Water Affairs (DWA). 2013b. Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): RESOURCE UNIT PRIORITISATION REPORT. Report No.: RDM/WMA04/00/CON/RQO/0213. Chief Directorate: Water Ecosystems: Compliance. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14 (iv). Pietermaritzburg, South Africa.

Department of Water Affairs, South Africa, January 2013. Classification of Significant Water
Resources in the Olifants Water Management Area (WMA 4): Management Classes of the Olifants
WMA. Report No: RDM/WMA04/00/CON/CLA/0113

Department of Water and Sanitation (DWS). 2014a. Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): SUB-COMPONENT PRIORITISATION AND INDICATOR SELECTION REPORT. Report No.: RDM/WMA04/00/CON/RQO/0114. Chief Directorate: Water Ecosystems: Compliance. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14 (v). Pietermaritzburg, South Africa.

Department of Water and Sanitation (DWS). 2014b. Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT. Report No.: RDM/WMA04/00/CON/RQO/0214. Chief Directorate: Water Ecosystems: Compliance. Study No.: WP10536. Prepared by the Institute of Natural Resources (INR) NPC. INR Technical Report No.: INR 492/14 (vi). Pietermaritzburg, South Africa

Department of Water Affairs and Forestry (DWAF), 1999. Resource Directed Measures for Protection of Water Resources. Volume 4: Methods for the Determination of the Ecological Reserve for Wetland Ecosystems. Pretoria, South Africa

9 APPENDIX

APPENDIX A: SUMMARY OF THE DETAILED STEPS APPLIED IN DELINEATING RIVER RESOURCE UNITS.

Preparation

1) Open ArcMap 10 ™ and select new map
2) Add the following layers: sub-quaternaries, quaternary catchments, IUAs, Nodes, EWR sites and Rivers
3) Select> Select by location> select features from sub-quaternary catchments >source layer: IUA> Spatial selection method: Target layer (s) features intersect the Source layer feature > OK
4) Close dialog box
5) Right click the sub-quaternary catchment layer > Selection> Create layer from selected features (this creates a new layer in the table of contents)
6) Right click on the new layer and export the data to a shapefile with the name of the WMA as the prefix e.g. Olifants_SubQuats
7) Add the data as a layer in the map

Editing (*ensure that the layers are in the correct projection before editing)

1) Right click on the WMA_SubQuats layer > Edit Features> Start Editing
2) Using the river pattern and nodes, select sub-quaternaries that form the river catchment. Note: This step can involve integrating more than one river catchment to a resource unit.
3) When the sub-quaternaries feeding to hydronode x have been selected click Editor > Merge (do this step as necessary for resource unit delineation)
4) Delete subquats that do not fall within the IUA or have a significant portion of their area outside the WMA.
5) Editor > Save Edits Stop editing.

Resource Units have now been delineated.

Attribute table

Once the resource units were delineated, the following fields were added to the table: resource unit number (RU_Num), IUA, Area (km2) and Perimeter (km). The resource number was assigned by the hydro node in the particular resource unit.