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

WP10536

GAP ANALYSIS REPORT

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

Inception Report

Executive Summary

The National Water Act of South Africa (1998) requires that all water resources are protected in order to secure their future and sustainable use. It describes how all significant water resources (surface water, wetlands, groundwater and estuaries) should be classified and used/protected accordingly. The purpose of Resource Quality Objectives (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 (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:

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

The RQOs for water resources in South Africa are determined by implementing a seven step procedure (DWA, 2011). This report presents the approach adopted to address the synchronisation requirements and the gap analyses procedures of the RQO determination procedure for the Olifants WMA, and the outcomes of the assessment. The synchronisation phase presents the manner in which the RQO and WRC processes has been aligned so that RQOs and Water Resource Classification (WRC) classes can be gazetted together as integral parts of the South African Integrated Water Resource Management (IWRM) process for the Olifants WMA. The availability of information required to determine RQOs for rivers, dams (or lakes), wetlands and groundwater by the WRC study, and other sources of information, have been evaluated in this report. The report also presents mitigation measures.

The synchronisation process involves consideration of the outcomes of the WRC study which include MCs and RECs that have been generated for nodes within IUAs. The RQO process will allow for the MCs and RECs to be maintained so that ultimately both the WRC Management Classes and RQOs can be gazetted as integral parts of the South African Integrated Water Resource Management (IWRM) process for the Olifants Catchment without conflict.

The synchronisation and gap analyses have identified numerous limitations that may affect the RQO determination procedure and the aligned or synchronised requirements for the RQO and WRC process. A detailed summary of the identified gaps in information and proposed solutions to these gaps is presented in Table 1. The principle limitations identified by the synchronisation and gap analyses pertain to:

- The vision of the catchment lacks the detail required by the RQO process to identify and demarcate RUs, identify resource (rivers, dams, wetlands and groundwater) attributes or sub-components. The RQO procedure includes a visioning exercise which is generally required to build on existing visioning information from the Reserve and WRC process. The scope of this RQO study specifically excluded a visioning exercise which thus does not allow for information gaps in the visioning exercise to be addressed. To address this limitation additional resource use and protection information will be incorporated into the study during the process of the study. Care will be taken not to affect the WRC outcomes which are considered to be fixed by that procedure.
- The limited consideration of groundwater, wetland and dam resources by the WRC procedure (DWA, 2013) which should be considered with rivers in the RQO process. To address these limitations a

desktop literature review will be undertaken to build on available information from these resources and include this information in the RQO determination process.

Table 1: Summary of the information gaps identified in the study as well as proposed solutions to address these gaps.

	Component			
	Rivers	Wetlands	Groundwater (GW)	Dams
Step 1. Delineating IUAs and RUs	• IUAs already delineated with biophysical nodes as foundation for RUs.			
	• Limitation: RUs for rivers not delineated. • Solution: GIS assessment of nodes, contours vs. IUAs. RUs will be delineated, based on nodes and include associated terrestrial components delineated to catchment boundaries.	• Limitation: No wetland RUs delineated. • Limitation: Wetland RUs need to be delineated by type and aligned to IUAs boundaries. • Solution: Sufficient information available for wetland RU delineation.	• Limitation: No GW RUs delineated. • Limitation: GW RUs need to be delineated by type and aligned to IUAs boundaries. • Solution: GIS assessment of GW types vs. IUAs. GW RUs will then be delineated within existing IUAs.	• Limitation: Although dams make up an important part of IUAs 2,5 & 7, no dam RUs delineated. • Solution: Dam RUs to be delineated for large dams using available GIS data within existing IUAs and small dams (aka. Farm dams) will be considered within river RUs.
Step 2. Setting vision	• Visioning exercise was undertaken on an IUA scale as part of the socio-economic assessment, this includes the establishment of the economic model which analysed economic prosperity, social wellbeing and the socio-economic implications of the six scenarios. In addition the Management Classes and NECs will be used to generate vision information for IUAs.			
	• Limitation: IUA specific user and protection vision information for RU prioritisation is required.	• Limitation: The ecosystem service use requirements of stakeholders for wetlands was not undertaken in the WRC study.	• Limitation: The ecosystem service use requirements of stakeholders for GW was not undertaken in the WRC study.	• Limitation: Very little visioning information on a site scale is available for the dam RU evaluations.
		• Limitation: REC data is largely specific to rivers and can only loosely be used to infer ecological state information for wetland, dams and groundwater components.		
	• Solution: The MCs and REC data and findings of additional studies as well as published literature will be considered to address this limitation. In addition, directed stakeholder engagement exercise will take place during RQO step 4 to select and prioritisation sub-components/criteria for prioritised RUs for components.			
Step 3. Prioritising RUs	• RU prioritisation tool will be used with ecosystem attribute criteria based on rivers. • Technical protection and use information required for RU prioritisation is available from WRC study	• An amended RU prioritisation tool with wetland specific attribute criteria will be used.	• An amended RU prioritisation tool with GW specific attribute criteria will be used.	• An amended RU prioritisation tool with dams specific attribute criteria will be used. • Technical information pertaining to role of dams to maintain flows is available as well

	• Limitation: Additional ecological and user information is required from other sources.			as water storage and associated IBT requirements.
		• Limitation: Ecological and user information, not available in WRC study is needed for prioritisation. Available literature and specialist knowledge will be used to address this limitation.		
	• Limitation: location specific vision information is unavailable to prioritise RUs. Available literature and specialist knowledge will be used to address this limitation. • Applicable visions generated from WRC study (see step 2) will be used to contribute to this step.			
Step 4. Prioritising sub-components and selecting indicators	• The RU Evaluation Tool will be used to evaluate river sub-components for the protection and use of ecosystem attributes. • Existing data from WRC study (for rivers) will contribute to the completion of this step. • Limitation: Available information is insufficient to allow for important users and their requirements to be identified for prioritised RUs.	• The RU Evaluation Tool will be used to evaluate wetland sub-components for the protection and use of ecosystem attributes.	• Approach described by Colvin et al. (2004) to prioritise sub-components and to select GW specific indicators.	• The RU Evaluation Tool will be used to evaluate dam sub-components for the protection and use of ecosystem attributes.
		• Limitation: Data pertaining to ecological state and user requirements of ecosystems (wetlands, GW & dams) and threats from WRC study is required. • Solution: Carry out desktop data gathering survey of ecological state and user requirement information and threats to ecosystems (wetlands, GW & dams) in Olifants.		
	• Solution: Directed stakeholder engagement exercise required to identify use and protection requirements for prioritised RUs and identify sub-components for RQO determination and RQO indicators.			
Step 5. Developing draft RQOs and Numerical Limits	• Limitation: The numerical limits for RQOs will be primarily be determined using available ecospec and userspec information from the WRC study. In addition a wealth of regional and international literature is available to facilitate with the establishment of Numerical Limits for RQOs. After the completion of the RQO data may still be unavailable and or insufficient for the establishment of Numerical Limits. These limitations will not affect the RQOs but the Numerical Limits for the RQOs. • Solution: Data requirements for RQO Numerical Limit establishment can be obtained by carrying out biophysical field surveys in the study area and through focused field and laboratory experiments for example. These measures can only be identified and carried out after the RQOs have been established. No field surveys and or experiments to generate Numerical Limits for RQOs for which data is unavailable are proposed for this study. The study will however propose recommendations for measures to be carried out to provide Numerical Limits for RQOs that are established in the study for which these data is unavailable.			

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

Gap Analysis Report

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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

Gap Analysis Report

1 INTRODUCTION

The RQO determination process is a tool or measure (described by the Water Act) that is applied within the context of the National Water Resource Strategy and catchment management strategies (NWA, Act 108 of 1998). The purpose of the RQO determination process is to establish objectives that describe, among other things, the quantity, pattern and timing of instream flow; water quality; the character and condition of riparian habitat, and the characteristics and condition of the aquatic biota in order to protect the resource (DWA, 2011). The RQOs take account of user requirements in order to allow for sustainable utilisation of the resource (DWAF, 2004). The process is carried out following the determination of the Reserve, the Water Resource Classification process and the establishment of a Management Class (MC) for riverine, estuarine, dam and groundwater resources (NWA, Act 108 of 1998). The National Water Resources Strategy (NWRS) describes the linkages between the Class of the Resource, Ecological Reserve and Resource Quality Objectives (DWAF, 2004). In particular it is recognised that while the outcomes of the Reserve (Reserve determination study) establishes the quantity and quality of water required to meet basic human needs and to protect aquatic environments, RQOs provide numerical and/or descriptive statements about the biological, chemical and physical attributes that characterise a resource for the level of protection defined by its class as defined through the WRC process (DWAF, 2007).

Within the RQO process the synchronisation assessment considers the manner in which the RQO and WRC processes will be aligned so that RQOs and WRC classes can ultimately be gazetted together as integral parts of the South African Integrated Water Resource Management (IWRM) process. The gap analysis evaluates the availability of information required to determine RQOs for rivers, dams (or dams), wetlands and groundwater components from the WRC study and supporting documents. Through the synchronisation and gap analyses component the requirements for the determination of valid RQOs are evaluated. The information requirements of the RQOs determination process are be met by the WRC process and supporting measures (such as the Reserve studies) which usually precede the RQO determination process. During the RQO determination process the delineation and prioritisation of RUs, the identification of resource attributes within RUs, their prioritisation and the establishment of objectives for these attributes depends on the availability and detail of ecosystem service use, protection information and stakeholder requirements. The source of this should incorporate local expertise and knowledge of ecosystem processes and use scenarios. As such the validity of the RQO determination process is influenced by the detail at which the WRC process and the associated visioning exercises were undertaken, including the objectivity of this exercise during the WRC process. For the determination of suitable RQOs the visions for each resource component (rivers, dams, wetlands and groundwater), within each IUA must be explicit (nature and location of vision) and allow for an acceptable balance between the use and conservation of resources with allowance for growth and development according to the established MCs. Visions for IUAs that will be refined during the RQO process to prioritise RUs and select ecosystem attributes for RQO determination, must include stakeholder requirements and Ecospecs and Userspecs considerations.

The Olifants Water Management Area (WMA) extends across three of South Africa's provinces (Gauteng, Mpumalanga and Limpopo) and includes the Olifants River and all of its tributaries including the; Wilge, Elands, Ga-Selati, Klein Olifants, Steelpoort, Blyde, Klaserie and Timbavati

Rivers (excluding the Letaba River catchment). The Olifants River is a tributary of the Limpopo River which extends across southern Africa and is shared by South Africa, Botswana, Zimbabwe and Mozambique. The Olifants River is presently one of the most threatened river systems in South Africa (Van Vuuren, 2009; Ballance et al., 2001). Reports of unexplained fish and crocodile deaths within the catchment, including recently in the Kruger National Park have abounded for several years and have received a fair amount of attention (Van Vuuren, 2009). The Olifants WMA is of major national strategic and economic importance, contributing to a large portion of South Africa's Gross Domestic Product. The catchment transcends through a myriad of different ecoregions from the grasslands of the highveld ecoregion in Gauteng to the lowveld in Limpopo and Mpumalanga. A wide variety of ecosystem services exist in the catchment including products (including mineral resources), regulatory services and various aesthetic services for example. These ecosystem services are being used by a wide variety of users including mining and industrial sector, agriculture sector, tourism and local informal and formal communities (DWA, 2013).

From 2012 the Department of Water Affairs initiated the WRC study to classify significant water resources in the Olifants WMA (DWA, 2013). This involved the application of the Water Resource Classification (WRC) system to ensure that the water resources in the Olifants River Catchment are protected and sustained while development can continue. The study resulted in the establishment of WRC Management Classes (MC) for 13 Integrated Units of Analyses (IUAs) in the catchment. The purpose of these MCs were to The purpose of the MC once set, is to establish clear goals relating to the quantity and quality of the relevant water resource in order to facilitate a balance between protection and use of water resources (DWA, 2013). The resulting MCs can now be translated into Resource Quality Objectives (RQOs) that will specify the targets to maintain the MCs.

The synchronisation component of this report focusses on the use of the newly derived Management Classes pertaining to the Integrated Unit of Analysis (IUAs) from the Water Resource Classification Study (WRC study) for the RQO process (DWA, 2011; DWA, 2013). This includes the use of defined RUs for the RQO determination within existing IUAs from the WRC. Thereafter the RQO process has been synchronised with the vision, recommended ecological categories and management classes obtained from the WRC (DWA, 2013). The Gap Analysis component of this report includes a review of the data and information gaps which may affect the determination of RQO and proposes actions or mitigation measures to address gaps identified for the RQO process to be competed.

2 SCOPE OF WORK

The Institute of Natural Resources (INR) has been commissioned by the Department of Water Affairs (DWA) to determine the Resources Quality Objectives (RQOs) for all significant water resources (rivers, wetlands, dams and groundwater) within the Olifants Water Management Area. Following the outcome of the Water Resource Classification (WRC) process (DWA, 2013) for the Olifants River that includes steps 1 and 2 of the RQO process (DWA, 2011) the objectives established for the study includes:

- select priority Resource Units (RUs) that have been identified by the relevant WRC process (part of step 1),
- applying steps 3 to 7 of the RQO process and,
- provision of final RQOs for the Olifants WMA that can be Gazetted by DWA.

The study was initiated in August 2012 and planned to be completed by September 2014. This report constitutes the gap analysis and synchronization report for the Inception Phase (Phase 1) of the project.

3 RESOURCE QUALITY OBJECTIVES DETERMINATION PROCEDURES

The seven step RQO determination procedure established by DWA (2011) is being used as the basis for guiding the gap analysis component of this report, and specifically how this relates to the alignment with the classification process (Figure 1). This procedure will be applied to all water resources including rivers, dams, wetlands and groundwater ecosystems considered in this case study. Some adaptations to the river focused RQO DWA (2011) determination procedures have been incorporated into this case study to allow for the determination of RQOs for dams, wetlands and groundwater resources (Figure 1). The groundwater component of the RQO determination procedures incorporate the approach established by Colvin et al. (2004) and Parsons and Wentzel (2007). Steps relevant to the gap analysis of the RQO development process include steps 1 to 5 and are presented below. Where applicable information requirements of the RQO process that should be available from the WRC process according to the scope of work for this study has been highlighted.

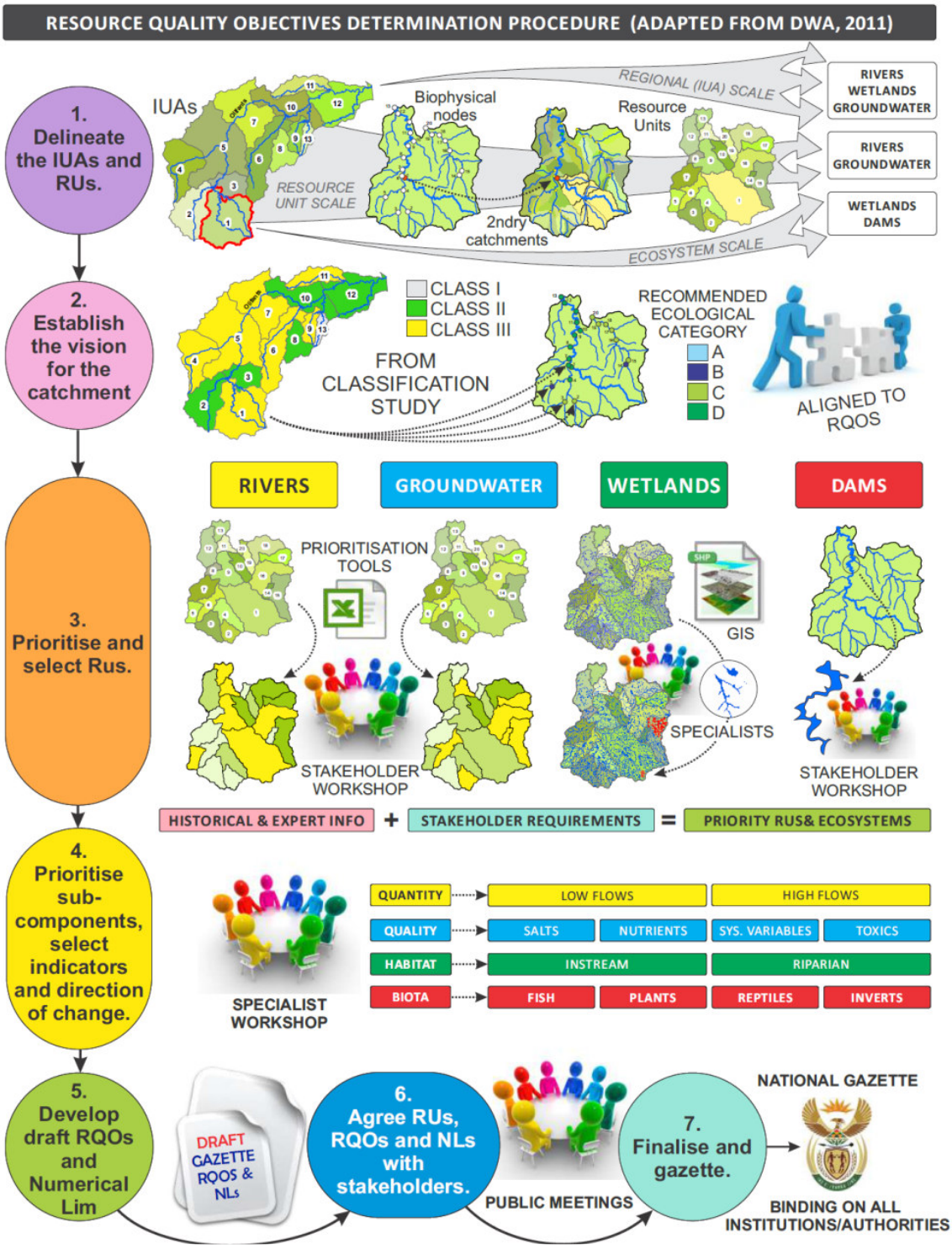

Figure 1: Schematic representation of the Resource Quality Objectives determination procedure implemented in this study.

3.1 STEP 1. DELINEATE THE INTEGRATED UNITS OF ANALYSIS AND RESOURCE UNITS

The first step of the RQO procedure requires that the Integrated Units of Analysis IUAs and RUs are delineated. For this study, Integrated Units of Analysis (IUAs) for all significant water resources (rivers, dams, wetlands and groundwater) were established by the WRC study (DWA, 2011b). The Resource Units (RUs) will be delineated in this study to allow alignment between the RQOs and Management Class. This will be achieved by using the river/hydrology etc. nodes or modelling points from the WRC study. This initial step is vital to ensure that the outputs of the WRC study can be correctly extrapolated within the RQO procedure to the various RUs which will ultimately result in RQOs that are synchronised with WRC study outputs.

3.2 STEP 2. ESTABLISH A VISION FOR THE CATCHMENT AND KEY ELEMENTS FOR THE IUAS

The visioning process provides stakeholders with an opportunity to voice their desires regarding the future state of water resource characteristics. The visioning process is undertaken at an IUA and WMA level and allows for RU specific visions to be established. Through the WRC the outcomes of the recommended ecological category state (REC) assessment for all bio-physical/hydro nodes for rivers in the study area will be used to construct a vision for rivers in each RU. The visioning information for the IUAs and RUs will be obtained from the WRC process. These visions should consider all significant water resources including rivers, dams, wetlands and groundwater. The visioning process undertaken within the WRC process should simply be synchronised with the RQO process.

3.3 STEP 3. PRIORITISE AND SELECT PRELIMINARY RESOURCE UNITS FOR RQO DETERMINATION

Following the selection of RUs (Step 1), the prioritisation and selection of Resource Units for RQO determination will be undertaken for each component considered in the study independently. This process will make use of the Resource Unit Prioritisation Tool (DWA, 2011) for rivers without amendment but will contain unique evaluation criteria for wetlands, dams and in particular groundwater components. Through this step available use requirements (based on social and economic values) and protection (ecological importance and sensitivity) information from the WRC study will be used to identify important RUs for each component. The effectiveness of this tool is dependent on a thorough understanding of the use and protection scenarios of each component within the catchment. This necessitates the involvement of local regulators, conservators and scientists (experts) for wetland, groundwater, dam and rivers in the study area.

3.4 STEP 4. PRIORITISE SUB-COMPONENTS FOR RQO DETERMINATION, SELECT INDICATORS FOR MONITORING AND PROPOSE THE DIRECTION OF CHANGE

For this step a technical workshop will be held with the RQO Project Team, ideally members of the WRC study Team and key stakeholders with specialist expertise to evaluate the RUs, develop the RQOs and Numerical Limits for RQOs. This workshop will include representative specialists for rivers, dams, wetlands and groundwater. This step makes use of the Resource Unit Evaluation Tool (DWA, 2011) to determine the RQOs for the prioritised Resource Units. It is important to note that that while separate tools with unique criteria specific to the component being assessed will be used for each component, the process is essentially the same. RQO determination for groundwater will be undertaken by applying Steps 1 to 4 as detailed in Colvin et al. (2004). These include:

1. Broadly characterising the groundwater resource
2. Defining the aquifer attributes which support or limit the identified uses

3. Defining the risk to uses with respect to hazards present in the catchment and aquifer vulnerability
4. Selecting key measurable indicators which relate to the resource itself or landuse impacts

Of particular importance in this step is to understand the trade-offs that have been made in the WRC study between different social, ecosystem, and economic aspects. The involvement of the Water Resource Classification Project Team in this evaluation process will facilitate an understanding of these trade-offs and ensure that the outcomes of the two processes are aligned. It is also vital that the outcomes of the process, in respect of the proposed magnitude and direction of change, are aligned between RUs. This step will be undertaken in conjunction with Step 5 through a technical specialist workshop.

3.5 STEP 5. DEVELOP DRAFT RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS

This step involves developing draft RQOs and Numerical Limits for these RQOs. At this stage Present Ecological State (PES) information for the sub-components and indicators identified in the previous step (Step 4) will be extracted from the relevant documentation to facilitate this procedures. This process will draw on the known integrated ecological status or EcoSpecs for each Ecological Category (EC) for the resource produced in the Ecological Reserve for the Olifants. This step will be undertaken for rivers, dams and wetlands. Groundwater will follow Step 5 of Colvin et al. (2004) which requires quantifying the reference conditions, present status, sustainability threshold and variability of the resource indicators. Step 6 and 7 of Colvin et al. (2004) will also be undertaken during this step and will include a description of the management actions that may be necessary to assure the maintenance of different levels of modification and setting the value for the RQO.

The RQO procedure recommends that directed field surveys/campaigns are undertaken to collect ecological information where not available. In this case substantial ecological state information already exists for riverine ecosystems in particular which may necessitate the collection of ecological information for the establishment of numerical limits for wetlands and dams only. The scope of works for this study does not allow for any field surveys to collects ecological information. However, should the need arise for additional data collection; this will be discussed with DWA. The level at which to set the RQOs will be determined in line with the outcomes of the WRC study.

4 SYNCHRONISATION AND GAP ANALYSIS

4.1 SYNCHRONISATION OF THE WRC PROCEDURE WITH RQOS

The synchronisation process involves consideration of the outcomes of the WRC study which include MCs and RECs that have been generated for nodes within IUAs in the WRC study. The RQO process will allow for the MCs and RECs generated from the WRC to be maintained so that ultimately both the WRC study findings and RQOs can be gazetted together as integral parts of the South African Integrated Water Resource Management (IWRM) process for the Olifants Catchment.

4.2 DATA AND INFORMATION GAPS WHICH MAY AFFECT THE DETERMINATION OF RQOS

The gap analysis component of the study is based on the first five steps of the RQO process as follows:

- Requirements for step 1: delineation of IUAs and RUs (for detailed overviews refer to Appendix 1 (rivers), Appendix 2 (dams), Appendix 3 (wetlands) and Appendix 4 (groundwater).
- Requirements for step 2: catchment vision.
- Requirements for step 3: prioritise and select preliminary resource units for RQO determination (for detailed overviews refer to Appendix 5 (rivers), Appendix 6 (dams), Appendix 7 (wetlands) and Appendix 8 (groundwater)).
- Requirements for step 4: prioritise sub-components for RQO determination and select indicators for monitoring (for detailed overviews refer to Appendix 9 (rivers and dams) Appendix 10 (groundwater).
- Requirements for step 5: develop draft RQOs and numerical limits

4.2.1 REQUIREMENTS FOR STEP 1: DELINEATION OF IUAS AND RUS

The first step of the RQO process requires the delineation of Integrated Units of Analysis (IUAs) and Resource Units (RUs). A total of 13 IUAs have already been identified as part of the Olifants WRC study (

, **Error! Reference source not found.**).These existing IUAs will be used in the development of RQOs for the Olifants catchment to ensure alignment between the two processes. In addition, much of the literature presents information per sub-area or zone. The Olifants Water Management Area (WMA) is commonly divided into four sub-areas or zones; the Upper Olifants, Middle Olifants, Lower Olifants and Steelpoort sub-areas. The delineation of these sub-areas is as follows:

- Upper Olifants Catchment constitutes the catchment of the Olifants River down to Loskop Dam.
- Middle Olifants Catchment comprises the catchment of the Olifants River downstream from the Loskop Dam to the confluence with the Steelpoort River.
- Steelpoort Catchment corresponds to drainage region of the Steelpoort River.
- Lower Olifants Catchment represents the catchment of the Olifants River between the Steelpoort confluence and the Mozambique border.

Table 1: Integrated Units of Analysis (IUAs) and Nodes identified for the Olifants WMA as part of the water resources classification (WRC) process, and associated quaternary catchments from DWA, 2013.

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

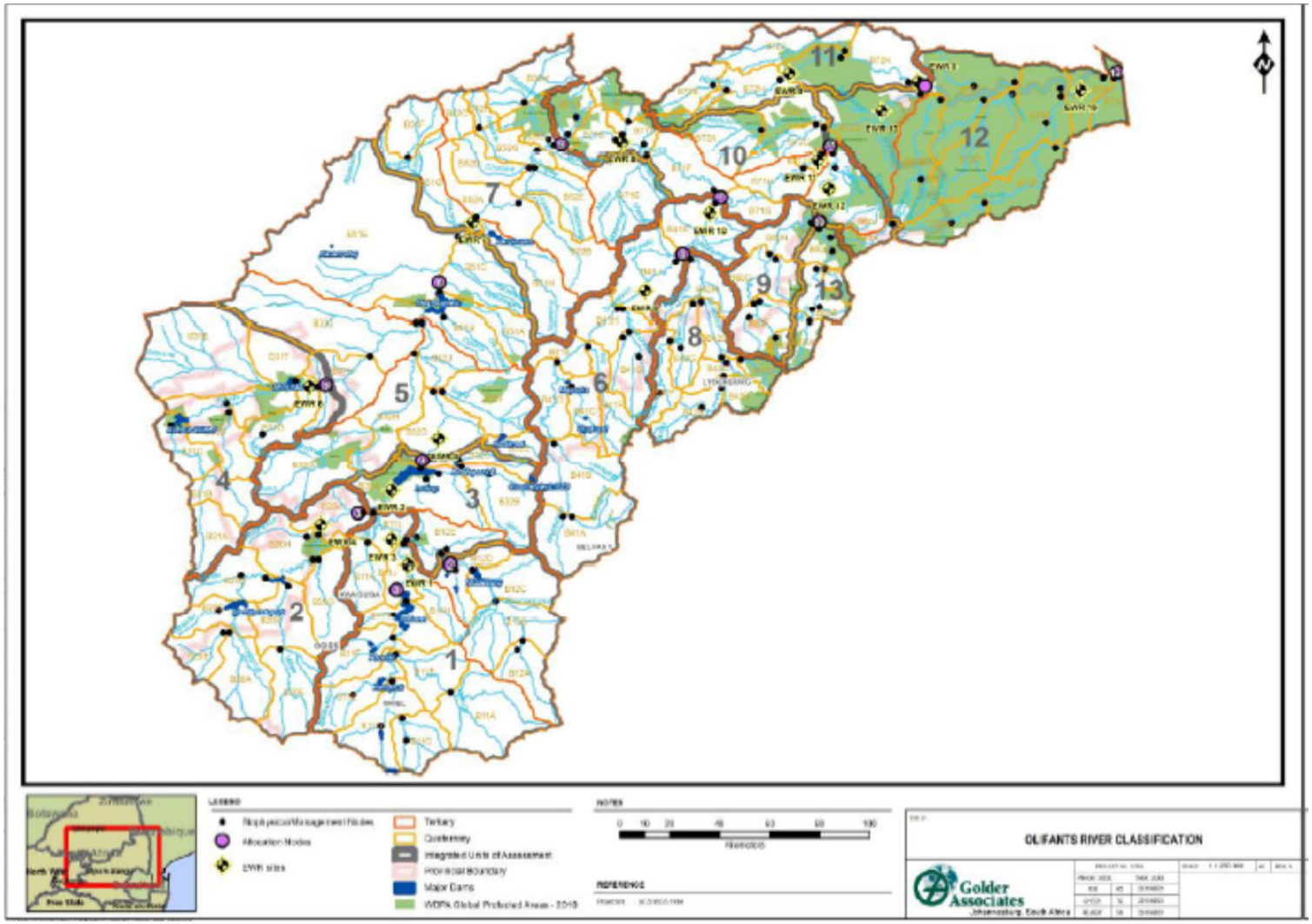

Figure 2: The Olifants River Catchment with Integrated Units of Analysis (IUAs) demarcated and associated quaternary catchments (DWA, 2013).

RIVERS

The WRC study has identified hydronodes which were utilised during the yield modelling undertaken as part of the WRC study (DWA, 2013). These nodes were selected according to bio-physical, management, water quality and specific protection considerations. The area between hydronodes along a river reach together with the surrounding terrestrial area represents a Resource Unit. While the WRC study has clearly identified the aquatic component of the RU (i.e. the area between the hydronodes along a river reach), the terrestrial component of the RUs will be captured spatially in the RQO RU delineation process. This will involve the use of secondary or (sub-quaternery) quaternary catchment along the contours which intersect the hydronodes. Sufficient information exists to undertake this task. However, it is important to note that although the WRC study has given some consideration to wetlands, groundwater and dams in the identification of hydronodes, the focus was primarily on rivers. Thus, the information relevant to RUs for rivers is largely sufficient however RUs for wetlands, groundwater and dams still need to be explicitly delineated during the RQO determination process. The RQO process will therefore identify RUs for these water resources and relate them back to the relevant hydronodes. The proposed processes and associated data gaps to achieve this are detailed per water resource below.

The WRC study has identified a total of 121 nodes for the Olifants WMA including key nodes and desktop biophysical nodes. Key nodes equate to the EWR sites and the selection process of these sites followed the Reserve site selection process. The WRC study however noted that large sections of the catchment were still unaccounted for and therefore selected additional desktop biophysical nodes. The selections of these desktop biophysical nodes were selected following consideration of historical studies including the Reserve studies and the National Freshwater Ecosystem Priority Areas (NFEPA). The WRC study states that every effort was made to select nodes that fairly represent different conditions and operational procedures in the catchment. These confidence issues will affect the RQO determination process as well.

The area between the nodes along a river reach together with the surrounding terrestrial area represents a RU. While the WRC study has clearly identified the aquatic component of the RU (i.e. the area between the nodes along a river reach), it did not demarcate the RUs as applicable to wetlands and groundwater i.e. the adjacent terrestrial landscape making up the entire river basin. These RUs will be captured spatially using a Geographical Information Systems (GIS) approach in the RQO process (Appendix 1). This RU delineation process will be achieved by dividing the Secondary catchment boundaries along the contours which intersect the nodes. Sufficient information exists to undertake this task. Thus, the information relevant to RUs for rivers is largely sufficient however RUs for wetlands, groundwater and dams still need to be explicitly delineated.

DAMS

Within this study two IUAs specifically address the existence of large licenced dams including Loskop Dam (IUA 3) and Flag Boshielo Dam (IUA 5). Depending on the location and importance of these dams, dams will be prioritised on an ecosystem scale. Although the major dams, which will be considered in the RQO study, have largely been considered within the delineation process of the IUAs, and that sample nodes have generally been positioned below the major dams, no dam RUs are available from the WRC study (Appendix 2) (DWA, 2011). Sufficient information is available however for the dams to be defined within the study area using available DWA-RQS spatial dam data & dam management information (DWAF, 1999; DWA, 2013a; DWA, 2013b). In the absence of any direction from the WRC study or from DWA, the dams will be positioned within existing IUAs to maintain the classification of water resources in the catchment i.e. the same MC applied to the rivers will apply to the dams.

WETLANDS

Wetlands will be delineated on a regional and ecosystem scale in this RQO determination stduy. These ecosystems were limited in the WRC study which affects the availability of information to establish a vision for wetlands in the process (DWA, 2013) (Appendix 3). The Olifants classification process does address limited socio-economic and ecological issues pertaining to wetlands but has only based the location and type of wetlands considered in the study on the NFEPA study (DWA, 2013). The wetlands considered in the Olifants classification reports include:

- Many vulnerable wetlands exist in the upper reaches of the Olifants catchment
- Vulnerable Rand high veld grassland NFEPA wetlands
- Central sandy bushveld and Loskop mountain bushveld (vulnerable) NFEPA wetlands
- Wetland and wetland clusters in quaternary catchments: B41A, B41B, B41F, B41G, B50B, B52F, B52G, B60C, B71C, B73A and B73J.

Other data sources that contain spatial referenced wetland inventory data including the NFEPA and wetland inventory data for conservation planning will be used to delineate wetland RUs within existing IUA (DWA, 2011) for the RQO assessment.

GROUNDWATER

Groundwater RUs were not explicitly delineated as part of the WRC study process and only limited spatial groundwater information related to existing IUAs is available from the ISP document (DWAF, 2004). Although some importance of groundwater resources are mentioned in the WRC study, such as the aquifer in IUA 5 (Middle Olifants up to Flag Boshielo Dam) and the Springbok Flats aquifer, these aquatic resources have generally been excluded from the WRC study. The RU delineation procedure for groundwater will involve an evaluation process where available data including the aquifer regions (DWA, 2001), 1:250 000 geological maps (CGS, 1986), 1:500 000 hydrogeological maps (DWA, 1999) (DWA, 2003), DWA NGA raw data and DWA GRA II (DWA, 2005) will be considered. Thus the RUs will be delineated in a manner that allows for the classification of water resources in the catchment within each IUA to be applied to the groundwater RUs.

4.2.2 REQUIREMENTS FOR STEP 2: CATCHMENT VISION

A key step in the RQO process is to align the diverse and competing interests in the resource into a collective desired future state. “A catchment vision is a collective statement from all stakeholders of their future aspirations of the relationship between the stakeholders and the water resources in the catchment” (DWAF, 2009b:10). In the WRC study the socio-economic conditions of the study area were evaluated by carrying out an economic model to evaluate the social and economic consequences to various stakeholders by alternative MC scenarios (generally based on flows). Within this step the ecosystem services of the catchment were defined and their uses were related to the economic prosperity and social wellbeing of stakeholders (DWA, 2013). Within the final WRC report the MC per IUA and a Nested Ecological Category (NEC) is available. This could be accepted as the vision at a broad level. In the RQO procedure (DWA, 2011), provision is made for a visioning exercise, which would be undertaken in the absence of a visioning process in the WRC study. There are however a number of limitations and limitations in equating the visioning process with the MC. These include the following:

- The MC provides a very minimal vision for a catchment. The overall catchment vision would be based on the number of IUAs which fall into a particular Class. For example, if most of the IUAs in the catchment fall into a Class II Management Class then the vision for a large part of the catchment would be to maintain a balance of ecological function and integrity (DWA, 2006). The rest of the catchment may be designated to extensive alteration of the water resource possibly limiting water based recreation activities and requiring monitoring to guard against further degradation (DWA, 2006).
- In this particular WRC study specific MCs have not been prescribed for wetlands, dams and groundwater.

- Although information on sub-components or ecosystem attributes (e.g. quality of water required to maintain biodiversity in a wetland) cannot be inferred from the MC this information will be obtained from the RECs which contributed to the establishment of the MCs.
- Only one other explicit vision appears to have been developed for the Olifants catchment. This vision was developed by the Olifants River Forum and sets out "to promote community participation in the protection, use, development, conservation, management and control of the water resources in the Olifants river catchment area."

4.2.3 REQUIREMENTS FOR STEP 3: PRIORITISE AND SELECT PRELIMINARY RESOURCE UNITS FOR RQO DETERMINATION

Currently within the RQO methodology the RU prioritisation tool has been established to prioritise RUs for riverine ecosystems primarily. Although designed for rivers, the criteria that this tool is based on can also be adapted to allow for dam and groundwater prioritisation process. However, currently no methodology is available within the RQO process for the prioritisation of wetland ecosystems. It is proposed that a similar approach as that developed used for other resources in the RQO process be followed. This would entail the identification of suitable ecosystem use, protection and process criteria to facilitate the prioritisation process. In consideration of the availability of data from the WRC study for this step, each component can be reviewed as follows.

RIVERS

While data required to assess strategic requirements and activities contributing to the economy can be extracted from the WRC study and other available reports, this information is usually presented at an IUA level, additional data sources such as the rapid secondary catchment scale Present Ecological State and Ecological Importance and Sensitivity (PES/EIS) assessment outcomes will be used to address these information limitations (DWA, 2013). Stakeholders with local scale information will also be consulted to provide information for this process within the context of the established Management Classes from the WRC so that the process can be aligned. The assessment of the importance of each RU to ecological components requires the consideration of the following criteria:

- Does the RU have a high EIS?
- Does the RU have an A/B Nested Ecological Category and / or PES?
- Is the RU categorised as a support or priority area in NFEPA?
- Has the RU been identified as a priority in terms of provincial or fine-scale aquatic biodiversity conservation plans?

Present Ecological State and Ecological Importance and Sensitivity assessment data per quaternary catchment is available from the 1999 study which was updated during 2011 per sub-quaternary level through a DWA study. This information was utilised during the WRC study for the rivers where no Reserve studies were done. Information relevant to the REC and NFEPA priority and support areas can be extracted from the 2013 PES/EIS assessment (DWA, 2013) WRC study and NFEPA respectively. Sufficient detailed ecological information exists at a fine enough scale to enable the assessment of the ecological importance of each RU with high confidence.

Information related to threats posed to water resource quality for both users and the environment can be extracted from land-use maps of the catchment and the desktop PES/EIS study (2013) and other sources of information. This study provides detailed information at a sub-quaternary river reach scale of possible impacts and threats to water resources in the catchment.

WETLANDS

Wetland resources were not assessed at an ecosystem level or prioritized for inclusion in the classification process. Having said this however, a range of information is available that could be used to inform the prioritization and selection of wetland units for RQO determination. Available data sets include:

- **Wetland Freshwater Ecosystem Priority Areas**: These areas were identified as part of the National Freshwater Ecosystem Priority Areas Project which effectively prioritized wetlands necessary to meet national wetland targets on the basis of modeled PES, protection status and available species information.
- **Mpumulanga Aquatic Conservation Plan**: The ecosystem status of sub-catchments was determined using Present Ecological State and loss of natural habitat in each sub-catchment as surrogate measures of healthy rivers, tributaries and wetlands. From this analysis, the irreplaceability value of each sub-catchment was identified. This provides a useful indication of the importance of different sub-catchments in meeting provincial aquatic biodiversity targets.
- **Mpumulanga Terrestrial Conservation Plan**: Whilst focussed primarily on terrestrial areas, the terrestrial analysis considered wetlands, including selected pans and wetlands with unique biodiversity in the biodiversity features used. This plan therefore also serves to highlight some of the wetlands of highest conservation significance.
- **A study of the wetlands in the Upper Olifants River Catchment commissioned by CoalTech**: The map produced provides an indication of the different types of wetlands that occur in the upper catchment and their extent. The study, which is considered equivalent to a low to very low confidence desktop ecological category assessment, has provided an indication of the Present Ecological State (PES) of the wetlands in the upper catchment, based on a range that extends from wetlands that are considered to be in a pristine state through to wetlands that are considered critically and irreversibly modified.
- **Prioritised areas for wetland rehabilitation**: A range of mining companies have been required to offset their impacts to wetlands by rehabilitating and protecting other wetlands in the catchment. While the location of such sites is not centralized, there is a need to ensure that these offset sites are not degraded by future landuse activities. Working for Wetlands have also worked on a range of wetlands in the catchment which should be considered when considering future catchment management scenarios.
- **WETwin Project**: The focus of this project was to promote the integration of wetlands into river basin management. Within this study an assessment was undertaken to evaluate the current state and relative value of a range of ecosystem services provided by wetlands at a quaternary catchment level. The results provide an indication of the current state of wetlands and relative value of goods and services provided by wetlands in the catchment.

GROUNDWATER

Currently no groundwater component specific RU prioritisation methodology is available. It is proposed that a similar approach to that used for the prioritisation of other resources within the RQO process be followed. This would entail the identification of suitable ecosystem use, protection and process criteria against which groundwater resource units could be evaluated for prioritisation. An initial assessment of possible data for the current criteria is detailed below:

- The importance of each ground water RU to users. Suitable information (WRC study) and other sources (DWA, 2004) exists to allow for the assessment of groundwater userspecs. This information can be evaluated to allow for the initial prioritisation of groundwater RUs.
- The level of threat posed to water resource quality for users. Although very little information pertaining to the state of groundwater RUs is available from the WRC, other sources of information (DWA, 2005), should allow for a low confidence assessment of the quality of groundwater RUs which would contribute to the prioritisation of these systems.

- The level of threat posed to water resource quality for the environment. Similarly limited information pertaining to the level of threats to groundwater ecosystems is available from the WRC. A desktop threat assessment of groundwater RUs for the study area can however be undertaken to contribute to this step.
- Practical considerations associated with each groundwater ecosystem's RUs must be considered during the RQO determination process. Groundwater ecosystems are dynamic and relatively (compared with surface aquatic ecosystems) difficult to monitor and manage. To ensure that the management and monitoring requirements for these ecosystems are practical, following RQO determination, considerations of access and management opportunities will be evaluated during this step.

Details of the specific data requirements and suitability of the available data to assess each of these criteria have been provided in Appendix 5. A summary of the data suitability is provided below:

- The potential of a groundwater RU to support a range of criteria pertaining to ecosystem services and ecological processes is used to evaluate the importance of a RUs. These criteria will be established in the study based on available information.
- Insufficient information, in respect of strategic requirements, is provided in the WRC Status Quo report for groundwater ecosystems to enable an assessment of this criterion at a RU Scale. A desktop literature survey is required to allocate available information to delineated groundwater RUs and then to established RU specific information for other groundwater RUs.
- For groundwater RUs, limited ecosystem services information is available from the WRC however there are other sources of information which can be used to establish Userspec information for groundwater RUs.

To establish an acceptable balance between the use and protection of groundwater ecosystems, through the establishment of appropriate RQOs for this component, information pertaining to the desired protection of these ecosystems is required. Currently only the MCs and RECs that are based on surface ecosystems are available for IUAs in the study area. This information may be indirectly related to the state of groundwater resources but case specific information for prioritised groundwater resources may be required.

DAMS

Within this step dam ecosystems will be prioritised according to their relative importance within each IUAs. Within each IUA, the prioritisation of ecosystems with respect to dams requires the consideration of a range of dam component appropriate criteria (adapted from riverine ecosystems) including:

- The importance of each ecosystem to users
- The level of threat posed to water resource quality for users
- The importance of each ecosystem to ecological components
- The level of threat posed to water resource quality for the environment
- The identification of ecosystem for which management action should be prioritised
- An assessment of practical considerations associated with RQO determination for each ecosystem.

Details of the specific data requirements and suitability of the available data to assess each of these criteria have been provided in Appendix 6. A summary of the data suitability is provided below. Similarly to rivers, in consideration of the importance of ecosystem to users, each ecosystem is assessed to determine whether or not it provides or supports:

- Important cultural services
- Livelihoods of vulnerable communities
- Strategic requirements or international obligations

- Supporting and/or regulating services
- Activities contributing to the economy
- Other dam specific criteria

Sufficient information pertaining to the role of dams for; the maintenance of ecological flow requirements and for water supply (domestic, environmental (including Reserve), agricultural and industrial use) is generally provided in the WRC and or available from dam operating rules and other sources of information (DWAF, 1999; DWA, 2011; DWA, 2013a; DWA, 2013b). Although the WRC specifically addresses the storage and supply of water services of dams, many other ecosystem services including supply of additional natural products (e.g. vegetation and fish) and ecological services (assimilation capacity of wastes and associated water quality mitigation, sediment trapping services and maintenance of ecologically important aquatic animals) have not been addressed in the WRC. This information is generally available from other sources (DWAF, 1999; DWA, 2011; DWA, 2013a; DWA, 2013b for example), and will be considered for this into this study.

The assessment of the importance of each dam ecosystems to the ecological component would require a desktop evaluation of available biophysical information from dam ecosystems which should include stakeholder engagement to verify and update available biophysical information. With this information consideration of a range of dam ecosystem specific criteria will contribute to the prioritisation process.

4.2.4 REQUIREMENTS FOR STEP 4: PRIORITISE SUB-COMPONENTS FOR RQO DETERMINATION AND SELECT INDICATORS FOR MONITORING

During step 4 of the RQO process the prioritisation of sub-components for RQO determination and the selection of appropriate indicators is undertaken. This will include the use of the RU Evaluation Tool. Two key criteria are assessed during this step:

- The impact of current and anticipated future use on water resource components
- The requirements of important user groups/stakeholders

This information is ultimately used to facilitate the selection of ecosystem attributes and or sub-components for RQO determination for which RQOs can be determined, and to establish the desired direction of change for selected sub-components.

During this step the impact of current and anticipated future use requirements are evaluated which requires:

- Assessing the importance of activities that are driving resource change
- Determining the anticipated level of impact on each sub-component
- Determining the cumulative level of impact on each sub-component
- Determining the anticipated consequences of the impacting activities on each sub-component.

Information on impacting activities will be extracted from historical data and from the rapid PES/EIS study for example (DWA, 2013). This information is presented at a sub-quaternary scale and is suitable for consideration within RUs.

The second sub-step in prioritising sub-components for RQO determination involves identifying ecosystem service user groups, classifying the importance of these groups and determining which sub-components which are important to them. These user group types include both ‘protection of the water resource’ and ‘water resource dependent activities’. *This sub-step will be aligned with the outputs of the WRC study to ensure synchronisation between the WRC process and the RQO*

determination study. Consideration will be given to those user groups which were identified as important within the WRC study. There may however be specific user groups at a RU level, for which an RQO should be set, that are not explicitly listed within the WRC study.

Additional information in respect of 'protection of the resource' will be extracted from available literature. Ecological Reserve studies undertaken in the Olifants catchment include data on various components including fish, inverts, vegetation, flows and quality. Various levels of information are available per selected RU. These include:

- Detailed information on some of the components (quantity, habitat and biota) where high confidence Reserve studies have been undertaken. The information on the water quality component will however need to be addressed as the results are at a desktop level study.
- Quantity requirements are available for all the identified hydronodes in the WRC study.
- The PES, EI and ES from the 2011 desktop study with the various metrics that were scored will be available. The PES metrics include habitat modifications and continuity, riparian wetland zone modification and continuity, flow and quality modifications and were scored from 0 (no impact) to 5 (critical impact). Some information on habitat diversity linked to geomorphological zones is also available. Detailed information on fish, macroinvertebrates, riparian/wetland vegetation and riparian/wetland vertebrates per sub-reach is available from data captured on the Rivers and Fish databases of DWA, included the information obtained by the RHP. Additional information was also collated during the PES study from specialists that have undertaken bio-monitoring or other aquatic studies in the catchment, including EIA studies.
- The information contained in conservation plans, NFEPA and other ecological studies were incorporated in the desktop PES study and was also used during the WRC process.

Information in respect of 'water resource dependent activities' would usually have been gathered during the visioning exercise. In the absence of this information, the identification and subsequent rating of the importance of users groups as well as the aspirations of each user group will be obtained during a directed stakeholder engagement exercise which is proposed to be undertaken during step 2 of this study. Addition information will be used to contribute to this evaluation including:

- Resource Water Quality Objectives (RWQOs) for the Olifants Catchment. RWQOs are available per management unit from the recent EWR study.
- The socio-economic report available as part of the WRC study provides the value of cultural, provisioning and regulating services. This information is provided per Management Unit and will need to be adjusted for the priority RUs.
- Water availability studies and the reconciliation strategy provide detailed information on water use, user groups and user requirements. This information was captured in the WRYM and used during the WRC study.

RIVERS

Although information in respect of 'water resource dependent activities' has partially been gathered during the visioning exercise of the WRC for rivers, information in the WRC study is not at a RU scale which is required for this step (Appendix 5). To obtain this information a focused specialist stakeholder engagement exercises will be undertaken to the study area to specifically generate information pertaining to water resource dependent activities and or requirements for prioritised RUs (refer to step 3). In addition, the identification and subsequent rating of the importance of users groups as well as the aspirations of each user group will be validated during the directed stakeholder engagement exercise.

DAMS

For dam ecosystems, step 4 of the RQO process also entails the prioritisation of sub-components for RQO determination and the selection of appropriate indicators (Appendix 6). This requires the use of a modified RU Evaluation Tool for dam ecosystems. Two key criteria are assessed during this step:

- The impact of current and anticipated future use on the dam RU
- The requirements of important user groups

This information is ultimately used to facilitate the selection of sub-components for RQO determination and to establish the desired direction of change for selected sub-components. The impact of current and anticipated future use requires:

- Assessing the importance of activities that are driving resource change
- Determining the anticipated level of impact on each sub-component
- Determining the cumulative level of impact on each sub-component
- Determining the anticipated consequences of the impacting activities on each sub-component.

Information on impacting activities from the WRC study will be evaluated and used for this section. This information is presented at dam ecosystem level and is therefore adequate to enable the assessment to be undertaken at a suitable scale. Similarly to rivers, additional data may be extracted from dam operation rules or management plans and other reports such as the Water Reconciliation Strategy, the RWQO's, rapid PES/EIS assessment and the ISPs where available will be incorporated, however it must be acknowledged that this information will not have the credibility associated with the WRC process and was unfortunately not considered by that process.

The second sub-step in prioritising sub-components for RQO determination entails identifying which groups are using the resource, classifying the importance of these groups and determining which sub-components are important to them. These user group types include both 'protection of the water resource' and 'water resource dependent activities'. This sub-step will be aligned with the outputs of the WRC study. Careful consideration will therefore be given to those user groups which were identified as important within the WRC study. There may however be specific user groups at a RU level, for which an RQO will be set, that are not explicitly listed within the WRC study. Historical information and outcomes from the directed stakeholder engagement exercise will be used to inform this step.

WETLANDS

As with rivers, the prioritisation of sub-components in respect of wetland resources requires an understanding of potential impacts and user requirements of the selected resources (Appendix 7). This information is likely to be largely lacking for wetlands in the study area. During this step we recommend that a sub-set of wetlands are selected for RQO determination, while consideration should also be given to setting catchment-level RQO's in line with the management class for the catchment. Historical information and findings from the directed stakeholder engagement exercise will be used for this step.

GROUNDWATER

Similarly, following the establishment of RUs for groundwater and the prioritisation of these RUs within IUAs, an understanding of potential impacts and user requirements for groundwater RUs is required to prioritise sub-components within groundwater RUs (Appendix 8). Although this information is not available from the WRC it may be generated from other sources of information including findings of existing assessments being undertaken by groundwater socio-economists and ecologists. The directed stakeholder engagement exercises planned for other parts of this project can also be used in this section to obtain RU specific use requirements for prioritised RUs (refer to step 3). Within this step it may also be necessary to broaden the information review of groundwater ecosystem processes

from the study area to national and possibly international sources so that the importance of sub components can be evaluated and used to establish RQOs for the prioritised wetlands in the study area.

4.2.5 REQUIREMENTS FOR STEP 5: DEVELOP DRAFT RQOS AND NUMERICAL LIMITS

Draft RQOs and their associated Numerical Limits (NL) will be determined for the selected-sub-components within RUs for all resources considered in the study, during this step (Appendix 9 and 10). These NLs will be directly related to the characteristics of the water resource. There is a large amount of Ecospec information generated through the NWRS process, and a wealth of published data which will be used for the generation of NLs for RQOs. Following the generation of RQOs some additional information requirements for NL establishment may be required which can only be evaluated after the RQOs are established.

RIVERS

Data in respect of ecospecs and userspecs for rivers is available from the WRC study. Although this information is detailed per IUA and may not be sufficient for use on a RU scale, it is provided in very broad terms for broad categories which may be suitable for the study. This includes ecospec information such as state of aquatic biological communities and indicator components of these communities which may be used for the establishment of NLs for RQOs. Similarly the physical requirements of the rivers in the study area including water quality, quantity and habitat state requirements are well defined which will all be used in the RQO determination study. Userspec information is limited but does include information on the nature and location of ecosystem service use activities. Additional data may be extracted from the Water Resource Quality Objectives, water availability studies and reconciliation strategies. Additional ecological specifications for some components are available from the published reports and articles. Consideration will be given to whether this data can be extrapolated to other RUs. In addition, where available, the relevant data for different metrics within each of the components will be extracted from the PES/EIS study, conservation plans and NFEPA.

DAMS

Although the userspecs of dam ecosystems that pertain to the storage and supply of water and the associated irrigation requirements is available from the WRC study, not other userspeces or any ecospecs from dams are available. After RQOs for dams have been determined, NLs will be based on dam structure and function information from published literature.

WETLANDS

While there is desktop information on the PES of most wetlands in the catchment, ecospecs and other information is likely to be lacking for prioritized wetland areas. Information on quantity and quality of water can probably be extrapolated from existing river studies (if selected wetlands are associated with main-stem rivers). There is additional published data pertaining to the structure and functions of wetland ecosytems which can be used to establish NLs for the RQOs determined in this study. There may be a need to collect baseline information on habitats and biota if meaningful RQOs are to be set for these sub-components. Should this requirement arise after RQO establishment it will be addressed after the establishment of the RQOs. In consideration of user requirements which can contribute to the establishment of NLs for RQOs, users are often directly linked to the wetland (e.g. farmers grazing on the wetland or local communities harvesting natural resources from the wetland). Understanding user requirements is therefore likely to require direct engagement with local users which can be achieved during the directed stakeholder engagement exercise proposed to be carried out in the study.

GROUNDWATER

Groundwater ecosystems were generally excluded from the WRC study. As a result there is very little userspec information that pertains to groundwater ecosystems and no ecospec information. Although limited, the available information may be used to define NL for RQOs. The wealth of groundwater specific structure and function information from literature is available and will be used in the study to establish NLs for RQOs.

5 PROPOSED MITIGATION MEASURES

For the completion of the RQO determination process for the Olifants WMA the following actions are proposed to fill the identified gaps in the available information and data:

- To address vision limitations in the study, DWA and stakeholder requirements will be evaluated, justified and incorporated into the study as the RQO procedural steps are undertaken. There is however no option to override or conflict with the outcomes of the WRC by altering the MC or REC.
- To address the information gap for step 3 which is the process of prioritising and selecting preliminary resource units for RQO determination an extensive review of local, regional and international literature will be undertaken as well as consultation with local and regional component experts.
- The information gap for step 4 will be addressed by inviting participation of established specialists with local knowledge of the component/sub-component being addressed.
- For the information gap potentially affecting step 5, which includes the establishment of numerical limits for RQOs, no actions can be taken at this time to allow for the mitigation of this potential gap. Only when the RQOs have been established will the information requirements for this gap be addressed. However once RQOs have been determined, then data gaps to support establishment of numerical limits will have to be addressed on a case by case basis.

6 GENERAL CONCLUSIONS & IMPLICATIONS FOR RQO DETERMINATION PROCESS

The synchronisation and gap analyses have identified elements that may affect the confidence of the RQO determination procedure and the alignment or synchronisation requirements for the RQO and WRC process. A detailed summary of the identified information gaps and proposed solutions to these gaps is presented in Table 1. The principle limitations of the synchronisation and gap analyses are:

- The vision of the catchment lacks the detail required by the RQO process to identify and demarcate RUs for all resources (rivers, dams, wetlands and groundwater) considered in the study. The RQO procedure includes a visioning exercise which is generally required to build on existing visioning information from the Reserve and WRC process. Although the scope of this RQO study excludes a visioning exercise, use and protection requirements from stakeholders will be evaluated during the study and used for RQO establishment. However it is not within the mandate of the RQO process to conflict with the outcomes of the WRC process, so the vision has to be clarified within the scope of the classification.
- The limited consideration of groundwater, wetland and dam resources in the WRC study affects the RQO determination process. To address this limitation, extensive reviews of available information will be undertaken and used in the study.

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8 APPENDIX

Appendix 1: GAP analyses summary for Step 1 of the RQO process for the Olifants River Catchment: River component.

RIVERS			
Criteria	Data availability (WRCS)	Other sources	Suitability
Existence of IUAs	Yes	NA	Sufficient: high confidence
Node locations within IUAs	Available	NA	Sufficient: high confidence
Delineated RUs	No	Available	Sufficient: high confidence

Appendix 2: GAP analyses summary for Step 1 of the RQO process for the Olifants River Catchment: Dams component.

DAMS			
Criteria	Data availability (WRCS)	Other sources	Suitability
Existence of IUAs	Yes	NA	Sufficient: high confidence
Node locations associated with dams within IUAs	Nodes usually located upstream or downstream of all major dams.	Additional DWA-RGS data & dam management information available	Sufficient: high confidence
Delineated RUs/ecosystems	No	DWA-RGS data & dam management plans can be used	Sufficient: moderate confidence

Appendix 3: GAP analyses summary for Step 1 of the RQO process for the Olifants River Catchment: Wetlands component.

WETLANDS			
Criteria	Data availability (WRCS)	Other sources	Suitability
Delineated RUs/ecosystems	Significant wetlands have not been specifically identified (simple reference to NFEPA coverage)	Catchment Wetland Inventory, Mpumalanga and Gauteng Provinces (Upper catchment) NFEPA Wetlands Coverage	Sufficient: Moderate confidence (Wetland coverage is sufficient (NFEPA dataset) although incorporation of finer scale mapping would be useful)

Appendix 4: GAP analyses summary for Step 1 of the RQO process for the Olifants River Catchment: Groundwater component.

GROUND WATER			
Criteria	Data availability (WRCS)	Other sources	Suitability
Delineated RUs/ecosystems	Limited	Vegter groundwater maps; 1:250 000 geological maps, 1:500 000 hydrogeological maps, DWA NGA, DWA GRA II	Sufficient: moderate confidence

Appendix 5: GAP analyses summary for Step 3 of the RQO process for the Olifants River Catchment: River component.

RIVERS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit within IUA				
	RU location	Yes	Sufficient: High	
Importance for users (Current & anticipated future use)				
	Cultural service provision of RU	No	Sufficient: Low	Olifants WMA Reconciliation Strategy, Water Resources Yield Model inputs and Upper Olifants RWQOs. Available literature will be considered.
	NB RUs that support livelihoods of communities	No	Sufficient: Low	Limitation: Detailed but at IUA level. Available literature will be considered.
	RUs for strategic requirements/ int. obligations	Yes	Sufficient: High	
	RUs with supporting and regulating services	No	Sufficient: Moderate	Limitation: Detailed but at IUA level. Available literature will be considered.
	Economically NB RUs	No	Sufficient: High	Limitation: Detailed but at IUA level
Threat posed to users				
	Level of threat posed to users	Yes	Sufficient: Low	Desktop PES/EIS, Reserve
Ecological Importance				
	RU with high EIS	Yes	Sufficient: High	
	RUs with A/B NEC and / or PES	Yes	Sufficient: High	Reserve studies
	RUs identified with NFEPA	Yes	Sufficient: High	
	RUs with other biodiversity conservation plans	Yes	Sufficient: Low	Mpumalanga conservation plan and Aquatic plans
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	Yes	Sufficient: Low	Desktop PES/EIS
Management Considerations				
	RUs with PES lower than a D Category	Yes	Sufficient: High	Reserve Docs, EWR
Practical Considerations				

RU with monitoring data/site/facility	Yes	Sufficient: Low	WRC Team specialists, Olifants River Forum, Biomonitoring sites available
Accessibility of resource unit for monitoring	Yes	Sufficient: Low	WRC Team specialists, Google Earth, Rapid Reserve Docs
Safety risk associated with monitoring RU	Yes	Sufficient: Low	WRC Team specialists, Catchment Managers/DWA Regional Offices

Appendix 6: GAP analyses summary for Step 3 of the RQO process for the Olifants River Catchment: Dams component.

DAMS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit				
	RU location	Yes	Sufficient: High	DWA-RQS data and dam operation plans
Importance for users (Current & anticipated future use)				
	NB RUs that durectly support livelihoods of communities	Limited	Sufficient: Low	Dam operation rules and limited additional Userspec information specific to some dams. Available literature will be considered.
	RUs for strategic requirements/ int. obligations	Yes	Sufficient: High	Dam operation rules/requirements
	RUs that contribute to instream flows	Yes	Sufficient: High	
	Economically NB RUs	Limited	Sufficient: Low	Some additional information available from local management plans. ISP plans. Available literature will be considered.
Threat posed to users				
	Level of threat posed to users	Limited	Sufficient: Low	Published literature, local conservation and management plans. Available literature will be considered.
Ecological Importance				
	RU with high EIS	No	Insufficient	Regional conservation plans
	RUs with A/B NEC and / or PES	No	Insufficient	Regional conservation plans
	RUs identified with NFEPA	Yes	Sufficient: Low	Available literature will be considered.
	RUs with other biodiversity conservation plans	Yes	Sufficient: Low	Available literature will be considered.
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	Limited	Sufficient: Low	WRCS considered ability of dams to store water and contribute to IFRs.
Management Considerations				
	RUs with PES lower than a D Category	No	Insufficient	Regional conservation plans
Practical Considerations				

RU with monitoring data/site/facility	Yes	Sufficient: Low	Available literature will be considered.
Accessibility of resource unit for monitoring	Yes	Sufficient: Low	Available literature will be considered.
Safety risk associated with monitoring RU	Yes	Sufficient: Low	Available literature will be considered.

Appendix 7: GAP analyses summary for Step 3 of the RQO process for the Olifants River Catchment: Wetlands component.

WETLANDS				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit				
	RU location	Yes	Sufficient: Low	Available literature will be considered.
Importance for users (Current & anticipated future use)				
	NB RUs that durectly support livelihoods of communities	No	Insufficient	Low confidence assessment can be undertaken to evaluate the livelihood support role of wetlands. Available literature will be considered.
	Resource units that provide **supporting and regulating services**	No	Insufficient	Could calculate a desktop value based on (i) potential to provide services and (ii) demand for services (WET-Win Project).
	Economically NB RUs	No	Insufficient	Available literature will be considered.
Threat posed to users				
	Level of threat posed to users	No	Insufficient	Could assess based on "Pressure" from upstream land uses as described above.
Ecological Importance				
	RU with high EIS	No	Insufficient	NFEPA wetland coverage
	RUs with A/B NEC and / or PES	No	Sufficient: Low	NFEPA wetland coverage
	RUs identified with NFEPA	No	Sufficient: High	NFEPA wetland coverage
	RUs with other biodiversity conservation plans	No	Sufficient: High	Mpumulanga Aquatic Conservation Plan, Ramsar sites, Protected areas, Protected area expansion stratergies, Threat Status of wetland vegetation group (NFEPA) and Wetlands targeted by WFWetlands
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	No	Insufficient	As per level of threat posed to users
Management Considerations				
	RUs with PES lower than a D Category	Yes	Sufficient: Low	NFEPA wetland coverage
Practical Considerations				
	RU with monitoring data/site/facility	Yes	Sufficient: Low	Would need to overlay with Reserve sites and sites where WFWetlands are busy.

Accessibility of resource unit for monitoring	Yes	Sufficient: Low	Would need to interpret based on proximity to roads (Suggest too difficult for initial screening)
Safety risk associated with monitoring RU	No	Insufficient	Would need to interpret based on landcover (Suggest too difficult for initial screening)

Appendix 8: GAP analyses summary for Step 3 of the RQO process for the Olifants River Catchment: Groundwater component.

GROUND WATER				
Criteria	Sub-criteria	Data availability (WRCS)	Suitability	Other sources
Position of resource unit				
	RU location	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data
Importance for users (Current & anticipated future use)				
	NB RUs that durectly support livelihoods of communities	No	Insufficient	Technical reports (ISP), DWA NGA, DWA GRA II data
	RUs for strategic requirements/ int. obligations	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data
	RUs that contribute to instream flows	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data
	Economically NB RUs	No	Insufficient	WUA's, Technical reports, Municipalities
Threat posed to users				
	Level of threat posed to users	No	Insufficient	WUA's, Technical reports, Municipalities
Ecological Importance				
	RU with high EIS	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data
	RUs with other biodiversity conservation plans	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data
Threat faced by ecological component of the RU				
	RUs with threats to ecological components	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data
Management Considerations				
	RUs with PES lower than a D Category	No	Sufficient: Low	Technical reports (ISP), DWA NGA, DWA GRA II data

Appendix 9: GAP analyses summary for Step 4 of the RQO process for the Olifants River Catchment: River and Dams component.

RIVERS & DAMS					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
1. Identify and assess the impact of current and anticipated future use on water resource components (Impacting activities tab)					
	a. Assess the importance of activities in driving resource change	List of the associated activities per RU	Yes	ISP, RWQO, Water Reconciliation Strategy	Sufficient: High
	b. Determine the anticipated level of impact on each sub-component	Rating/Score	Yes	ISP, RWQO, Water Reconciliation Strategy	Sufficient: High
	c. Determine the cumulative level of impact on each sub-component	Subcomponents assessed and ratings	Yes	ISP, RWQO, Water Reconciliation Strategy	Sufficient: High
	d. Determine the anticipated consequences of the impacting activities on each sub-component	Breakdown of activity and sub-component degrader	Yes	Details of the Olifants Water Conservation and Water Demand Management and Integrated Water Quality Management Plan	Sufficient: Low
2. Identify requirements of important user groups					
	a. Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types	List of the protection users (conservation largely) and sectors/developments dependent on the water resource	Partial: Yes for protection users and scant for dependent activity	l/use maps, IDP, Conservation Plans EIS in w/sheet and G&S spread sheets	Sufficient: Low
	b. Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities'	Fish and bird species mentioned in certain IUAs& Rus but no ratings	No	FRAI Reports, Biodiversity Conservation plans etc. and users such as ESKOM and SASOL. Specialist consultation required.	Insufficient
	c. Summarise the aspirations of each important user group	Aspirations/Vision	No	Provincial conservation targets/visions. Specialist consultation required.	Insufficient
	d. Review Present State information		YES		Sufficient: High
	e. Propose the desired direction and magnitude of change for each sub-component for important user-groups	Detailed sub-component changes/ vision for the water resource	No	Sector Development Plans, IDP, Conservation targets. Specialist consultation required.	Insufficient
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
3. Selection of sub-components for RQO determination					
	a. Review the Ecosystem and User Prioritisation ratings	Quality, Quantity, Habitat and Biota Indicators	Yes for Ecosystem	PES/EIS, Reserve, Socio-economic reports	Insufficient
	b. Select sub-components and associated indicators for RQO determination		No	Reports detailing water quality and biological issues in the Olifants WMA. Specialist consultation required.	Insufficient

Appendix 10: GAP analyses summary for Step 4 of the RQO process for the Olifants River Catchment: Dams component.

DAMS					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
1. Identify and assess the impact of current and anticipated future use on water resource components (Impacting activities tab)					
	a. Assess the importance of activities in driving resource change	List of the associated activities per RU	Limited	ISP, RWQO, Water Reconciliation Strategy	Sufficient: Low
	b. Determine the anticipated level of impact on each sub-component	Rating/Score	Limited	ISP, RWQO, Water Reconciliation Strategy	Sufficient: Low
	c. Determine the cumulative level of impact on each sub-component	Subcomponents assessed and ratings	Limited	ISP, RWQO, Water Reconciliation Strategy	Sufficient: Low
	d. Determine the anticipated consequences of the impacting activities on each sub-component	Breakdown of activity and sub-component degrader	Yes	Details of the Olifants Water Conservation and Water Demand Management and Integrated Water Quality Management Plan	Sufficient: High

DAMS					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
2. Identify requirements of important user groups					
	a. Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types	List of the protection users (conservation largely) and sectors/developments dependent on the water resource	Limited	l/use maps, IDP, Conservation Plans EIS in w/sheet and G&S spread sheets. Specialist consultation required.	Insufficient
	b. Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities'	Ecological state of dams.	Limited	FAI Reports, Biodiversity Conservation plans etc. and users such as ESKOM and SASOL. Specialist consultation required.	Insufficient
	c. Summarise the aspirations of each important user group	Aspirations/Vision	No	Provincial conservation targets/visions. Specialist consultation required.	Insufficient
	d. Review Present State information	Ecological state of dams.	YES	FRAI Reports, Biodiversity Conservation plans etc. and users such as ESKOM and SASOL. Specialist consultation required.	Sufficient: High
	e. Propose the desired direction and magnitude of change for each sub-component for important user-groups	Detailed sub-component changes/ vision for the water resource	No	Sector Development Plans, IDP, Conservation targets. Specialist consultation required.	Insufficient

3. Selection of sub-components for RQO determination				
a. Review the Ecosystem and User Prioritisation ratings	Quality, Quantity, Habitat and Biota Indicators	No	Current ecological state of dams.	Insufficient
4. Establish the desired direction of change for selected sub-components				
a. Where applicable, understand the trade-offs that have been made between user groups in the Water Resource Classification	Unavailable	No	Use "Impacts" info as surrogate. Specialist consultation required.	Insufficient
b. Propose an acceptable direction of change for each selected sub-component c. Align the outcomes of each RU assessment across the catchment	Dep on selected sub-component, see text in report	No	Current ecological state of dams. Specialist consultation required.	Insufficient

Appendix 11: GAP analyses summary for Step 4 of the RQO process for the Olifants River Catchment: Wetlands component.

WETLANDS					
Step	Sub-step	Data requirements	Availability in WRCS	Other	Suitability
1. Identify and assess the impact of current and anticipated future use on water resource components (Impacting activities tab)					
	a. Assess the importance of activities in driving resource change		Insufficient	WET-Win "Pressure Levels" outputs, Land cover dataset, Mining licences & potential Google Earth analysis and WARMS database	Sufficient: Low
	b. Determine the anticipated level of impact on each sub-component		Insufficient	As above	Sufficient: Low
	c. Determine the cumulative level of impact on each sub-component		Insufficient	Desktop PES / EIA tables, Available water quality data and Available wetland assessment information	Sufficient: Low
	d. Determine the anticipated consequences of the impacting activities on each sub-component		Insufficient	Expert interpretation	Sufficient: Low
2. Identify requirements of important user groups					
	a. Identify important user groups within the 'protection of the water resource' and 'water resource dependent activity' user group types		Insufficient	Land cover dataset Google Earth analysis. Specialist consultation required.	Insufficient
	b. Rate the importance of sub-components for the 'protection of the water resource' and 'water resource dependent activities'		Insufficient	Conservation: Can be informed by available data (e.g. Desktop PES/EIS, Conservation Plans etc.) User Groups: Can be informed by a basic understanding of sectors but will require local consultation. Specialist consultation required.	Insufficient

c. Summarise the aspirations of each important user group		Insufficient	Specialist consultation required.	Insufficient
d. Review Present State information		Insufficient	NFEPA. Specialist consultation required.	Insufficient
e. Propose the desired direction and magnitude of change for each sub-component for important user-groups		Insufficient	Specialist consultation required.	Insufficient
3. Selection of sub-components for RQO determination				
a. Review the Ecosystem and User Prioritisation ratings		Insufficient	Specialist consultation required.	
b. Select sub-components and associated indicators for RQO determination		Insufficient	Select based on importance of sub-components and an understanding of financial constraints associated with implementing a monitoring programme	

WETLANDS				
Step Sub-step	Data requirements	Availability in WRCS	Other	Suitability
4. Establish the desired direction of change for selected sub-components				
a. Where applicable, understand the trade-offs that have been made between user groups in the WRC		Sufficient: L	Could base this on the wetland related objectives proposed at a catchment level	
b. Propose an acceptable direction of change for each selected sub-component		Insufficient	N/A	Insufficient
c. Align the outcomes of each RU assessment across the catchment		Insufficient	Wetland Specialist & Project team	

Appendix 12: GAP analyses summary for Step 4 of the RQO process for the Olifants River Catchment: Groundwater component.

GROUND WATER				
Step Sub-step	Data requirements	Availability in WRCS	Other	Suitability
Broadly characterise the groundwater resource:				
The flow system as defined by climate and geology, with recharge and discharge areas	Vegter groundwater maps; 1:250 000 geological maps, 1:500 000 hydrogeological maps, DWA NGA, DWA GRA II	No	Vegter groundwater maps; 1:250 000 geological maps, 1:500 000 hydrogeological maps, DWA NGA, DWA GRA II	Sufficient: low
Present status and degree of impact	DWA NGA, DWA GRAII, WMS, WARMS	No	DWA NGA, DWA GRAII, WMS, WARMS	Sufficient: low
Reference conditions	DWA NGA, DWA GRAII, WMS, WARMS	No	DWA NGA, DWA GRAII, WMS, WARMS	Sufficient: low
Current and future uses	WARMS, DWA GRAII, ISP	No	WARMS, DWA GRAII, ISP	Sufficient: low
Define the critical characteristics or attributes of groundwater which support or limit the identified uses.				
Sub-steps	DWA NGA, DWA GRAII, WMS, Technical reports	No	DWA NGA, DWA GRAII, WMS, Technical reports	Sufficient: low
Define the risk to uses with respect to hazards present in the catchment and aquifer vulnerability.				

Sub-steps	DWA NGA, DWA GRAII, WMS, Technical reports	No	DWA NGA, DWA GRAII, WMS, Technical reports	Sufficient: low
From the critical attributes, select key measurable indicators which relate to the resource itself or land-use impacts, and which will enable sustainable management of groundwater.				
Sub-steps	DWA NGA, DWA GRAII, WMS, Technical reports	No	DWA NGA, DWA GRAII, WMS, Technical reports	Sufficient: low