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

WP10536

RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT

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07	RDM/WMA04/00/CON/RQO/0314	Determination of Resource Quality Objectives in the Olifants Water Management Area (WMA4): CLOSE OUT REPORT

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

Executive Summary

The National Water Act (Act No. 36 of 1998) (NWA) sets out to ensure that water resources are used, managed and controlled in such a way that they benefit all users. To achieve this, the NWA prescribes a series of measures which are intended to ensure comprehensive protection of water resources so that they can be used in a sustainable manner. The Act states that these measures are to be developed progressively within the context of the National Water Resource Strategy (NWRS) and catchment management strategies. In particular the Act provides for:

- the setting of the Reserve (completed in 2004),
- the classification of significant water resources (completed in 2012) and,
- the determination of Resource Quality Objectives (this study).

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. Although the procedures involve defining the resource, setting a vision, determination of RQOs and Numerical Limits (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 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 NLs.
- 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 RQOs and associated NLs which give effect to the RQOs for the Olifants WMA. In addition the supplementary information for these RQOs and NLs are provided (Step 5 and 6). The components and sub-components for which RQOs and NLs were provided include:

- Quality components including low and high flow sub-components.
- Quantity components including nutrients, salts, system variables, toxicants and pathogen sub-components.
- Habitat components including instream and riparian habitat sub-components.
- Biota components including fish, plants, mammals, birds, amphibians and reptiles, periphyton, invertebrates and diatom sub-components.

Through this step a total of 494 RQOs were determined for the Olifants WMA:

- A total of 212 RQOs were determined for river resources.
- A total of 80 RQOs were determined for wetlands resources.
- A total of 69 RQOs were determined for dam resources.
- A total of 133 RQOs were determined for groundwater resources.

Table 1 provides a summary of the hydrological nodes, river names and their associated Present Ecological State (PES) and Recommended Ecological Category (REC) within each IUA as well as the management class for the IUA. Table 2 provides a summary of all the sub-components for which RQOs and NLs were determined for each IUA.

Table 1: Summary of the Integrated Units of Analyses, Management Classes, Hydrological nodes (and Resource Unit RU numbers), river names and the associated Present (PES) and Recommended (REC) ecological categories.

IUA	Class for IUA	Hydro Node and RU	River Name	PES	REC
1. Upper Olifants River catchment	III	1	Olifants (confluence with Steenkoolspruit)	C	C
		2	Piekespruit (confluence with Steenkoolspruit)	B	B
		3	Dwars-indieWegspruit (confluence with Trichardtspruit)	C	C
		4	Steenkoolspruit (outlet of quaternary)	D	D
		5	Blesbokspruit (confluence with Rietspruit)	B	B
		6	Steenkoolspruit (confluence with Olifants)	D	D
		7	Olifants (outlet of quaternary)	D	D
		8	Noupoortspruit (EWR site – NOU-EWR1) (existing)	C/D	C/D
		9	Olifants (releases from Witbank Dam)	D	D
		10	Spookspruit (confluence with Olifants)	C	C
		11	Olifants (EWR site 1 – EWR1) (existing)	E	D
		12	Klipspruit (confluence with Olifants)	E	D
		13		B	B
		14	Boschmansfontein (confluence with Klein Olifants)	C	C
		15	Klein Olifants (outlet of quaternary)	C	C
		16	Klein Olifants (outlet of quaternary)	D	D
		17	Klein Olifants (EWR site – OLI-EWR1) (Rapid site)	C	C
		18	Klein Olifants (releases from Middelburg Dam)	D	D
		19	Vaalbankspruit (confluence with Klein Olifants)	D	D
		20	Klein Olifants (outlet of quaternary)	D	D
2. Wilge River catchment area	II	21	Bronkhorstpruit (outlet of quaternary)	C	C
		22	Koffiespruit (confluence with Bronkhorstspruit)	C	C
		23	Osspruit (inflow to Bronkhorstspruit Dam)	D	D
		24	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)	C	C
		25	Hondespruit (confluence with Bronkhorstspruit)	C	C
		26	Bronkhorstpruit (confluence with Wilge)	C	C
		27	Wilge (confluence with Bronkhorstspruit	C	C
		28	Saalboomspruit (confluence with Wilge)	C	C
		29	Grootspruit (confluence with Wilge)	C	C
		30	Wilge (outlet of quaternary)	B	B
		31	Wilge (EWR site – EWR4, outlet of IUA2) (existing)	C	C
3. Selons River area including Loskop Dam	II	32	Doringboomspruit (confluence with Klein Olifants)	B	B
		33	Keeromspruit (confluence with Klein Olifants)	C	C
		34	Klein Olifants (EWR site – EWR3) (existing)	C	C
		35	Kranspoortspruit (EWR site – OLI-EWR3) (Rapid site)	B	B
		36	Boekenhoutloop (inflow to Loskop Dam)	B	B
		37	Olifants (EWR site – EWR2) (existing)	C	C
		38	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
		39	Olifants (releases from Loskop Dam)	D	D
		40	Olifants (outlet of quaternary – outlet of IUA3)	D	D
4. Elands River catchment area	III	41	One node at outlet of B31C, releases from Rust de Winter Dam. Included:B31A (Elands) B31B (Hartbeesspruit) B31C (Elands)	C	C
		42	Enkeldoringspruit (confluence with Elands)	C	C
		43	Elands (releases from Mkumbe Dam)	C	C

		44	Kameel (upper part only	D	D
		45	Elands (EWR site – EWR6) (existing)	D	D
		46	Elands (outlet of quaternary – outlet of IUA4)	E	D
5. Middle Olifants up to Flag Boshielo Dam	III	47	Elands (outlet of quaternary, confluence with Olifants)	E	D
		48	One node at confluence with Olifants in B32F. Included: B32E (Bloed), B32F (Doringpoortloop, Diepkloof and Bloed)	B	B
		49	One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) B32H (Mametse and Moses)	C	C
		50	Olifants (EWR site – EWR5) (existing)	C	C
		51	Puleng (upper part only)	B	B
		52	Olifants (releases from Flag Boshielo Dam)	D	D
		53	Olifants (outlet of quaternary– outlet of IUA5)	D	D
6. Steelpoort River catchment	III	54	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) Langspruit, including Lakenvleispruit and Kleinspruit	C	C
		55	Steelpoort (EWR site – OLI-EWR2) (Rapid site)	C	C
		56	Masala (confluence with Steelpoort), including Tonteldoos and Vlugkraal)	C	C
		57	Steelpoort (inflow to De Hoop Dam)	C	C
		58	Draaikraalspruit (confluence with Klip)	B	B
		59	Klip (EWR site – OLI-EWR4) (Rapid site)	C	C
		60	Kraalspruit (confluence with Groot Dwars)	B	B
		61	Klein Dwars (Confluence with Groot Dwars)	D	D
		62	Upper reaches of Dwars (before mining impacts)	C	C
		63	Dwars (EWR site – DWS-EWR1) (existing)	B/C	B/C
		64	Steelpoort	D	D
		65	Steelpoort (EWR site – EWR9) (existing)	D	D
		66	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	67	Upper Nkumpi (outlet of quaternary)	C	C
		68	Olifants (EWR site – EWR7) (existing)	E	D
		69	Palangwe (confluence with Olifants)	C	C
		70	Hlakaro (outlet)	C	C
		71	Mphogodima (confluence with Olifants)	C	C
		72	Olifants (outlet of quaternary – outlet of IUA7)	D	D
8. Spekboom catchment	II	73	One node for Dorpspruit at outlet of B42B. Included: Hoppe se Spruit (confluence) Doringbergspruit (confluence)	C	C
		74	Dorpspruit (EWR site – OLI-EWR9) (Rapid site)	C/D	C/D
		75	Potloodspruit (confluence with Dorps)	C	C
		76	Dorps (confluence with Spekboom)	C	C
		77	Spekboom (EWR site – OLI-EWR6) (Rapid site)	C	C
		78	Potspruit (confluence with Watervals)	C	C
		79	Watervals (releases from Buffelskloof Dam)	C	C
		80	Rooiwalhoek-se-Loop (confluence with Watervals)	B	B
		81	Watervals (EWR site – OLI-EWR5) (Rapid site)	C	C
		82	Spekboom (outlet of quaternary – outlet of IUA 8)	B	B
9. Ohrigstad River catchment area	III	83	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary)	D	D
		84	Vyehoek (confluence with Ohrigstad)	C	C
		85	Ohrigstad (EWR site – OLI-EWR8) (Rapid site)	C	C
		86	Ohrigstad (outlet of quaternary – outlet of IUA9)	D	D
10. Lower Olifants	II	87	Sandspruit, including Rietspruit and Qunduhlu	B	B
		88	Blyde (EWR site – EWR12) (existing)	B	B
		89	Blyde (confluence with Olifants)	C	C

		90	Paardevlei (confluence with Tongwane)	B	B
		91	Tongwane (confluence with Olifants)	B	B
		92	Olifants (EWR site – EWR8) (existing)	D	D
		93	Mohlapitse (upper reaches)	B	B
		94	Kgotswane (confluence with Olifants)	B	B
		95	Olifants (confluence with Steelpoort)	D	D
		96	Olifants (EWR11, confluence with Blyde) (existing)	E	D
		97	Makhutswi, including Moungwane and Malomanye	C	C
		98	Olifants (outlet – outlet of IUA10)	C	C
11. Ga-Selati River area	III	99	Ngwabatse (confluence with Ga-Selati)	D	D
		100	Ga-Selati (outlet of quaternary)	C	C
		101	Ga-Selati (EWR site – EWR14a) (existing)	C	C
		102	Molatle (confluence with Ga-Selati)	B	B
		103	Ga-Selati (EWR site – EWR14b) (existing)	E	D
		104	Ga-Selati (outlet of quaternary – outlet of UIA11)	E	D
12. Lower Olifants within Kruger National Park	II	105	Olifants (EWR site – EWR13) (existing)	C	C
		106	Klaserie (EWR site – OLI-EWR7) (Rapid site)	B/C	B/C
		107	Klaserie (confluence with Olifants)	C	C
		108	Tsiri (confluence with Olifants)	B	B
		109	Tshutshi (confluence with Olifants)	B	B
		110	Nhlaralumi, including Machaton, Nyameni and Thlaralumi	B	B
		111	Sesete (confluence with Timbavati)	B	B
		112	Timbavati (outlet of quaternary)	B	B
		113	Timbavati, including Shisakashonghondo	B	B
		114	Olifants (EWR site – EWR16) (existing)	C	C
		115	Hlahleni (confluence with Olifants)	A	A
		116	Olifants (outlet of quaternary – outlet of IUA12)	C	C
13. Blyde River catchment area	I	117	Blyde (confluence with Lisbon)	C	C
		118	Lisbon, including Heddelspruit and Watervalspruit	B	B
		119	Blyde (outlet of quaternary)	B	B
		120	Treur (EWR site – TRE-EWR1) (existing)	A/B	A/B
		121	Blyde (inflow to Blyderivierpoort Dam – outlet of IUA13)	B	B

Table 2: Integrated Units of Analyses (IUAs) for which Resource Quality Objectives (RQOs) were determined.

IUA		RIVERS				WETLANDS	DAMS				GROUND WATER
		Quantity	Quality	Habitat	Biota		Quantity	Quality	Habitat	Biota	
1. Upper Olifants River catchment		X	X	X	X	X	X	X		X	X
2. Wilge River catchment area		X	X	X	X	X	X	X		X	X
3. Selons River area including Loskop Dam		X	X	X	X	X	X	X		X	X
4. Elands River catchment area		X		X	X	X	X	X		X	X
5. Middle Olifants up to Flag Boshielo		X	X	X	X	X	X	X		X	X

Dam											
6. Steelpoort River catchment		X	X	X	X	X	X	X		X	X
7. Middle Olifants below Flag Boshielo Dam to upstream of Steelpoort River		X		X	X	X	X				X
8. Spekboom catchment		X	X	X	X	X	X	X			X
9. Ohrigstad River catchment area		X		X	X	X	X	X		X	X
10. Lower Olifants		X	X	X	X	X	X			X	X
11. Ga-Selati River area		X	X	X	X	X	X			X	X
12. Lower Olifants within Kruger National Park		X	X	X	X	X	X				X
13. Blyde River catchment area		X	X	X	X	X	X				X

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

Resource Quality Objectives and Numerical Limits 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
μg/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 Quality Objectives and Numerical Limits 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 development of the RQOs and associated NLs (Step 5 and 6; DWA, 2011).

Step 5 in the study included the development of the draft RQOs and NLs for the sub-components and indicators that were selected during Step 4. The RQOs are essentially narrative but sometimes broadly quantitative descriptions of the resource and include the requirements necessary for achieving the objectives. Step 6 follows on Step 5 where the outcomes from Steps 3, 4 and 5 are presented to stakeholders in a workshop process. The aim of this step is to verify and refine:

- The prioritisation of Resource Units for RQO determination.
- The selection of sub-components and indicators for RQOs, and the proposed direction of change for these.
- The Draft RQOs and NLs.

The final RQOs and NLs are then published by way of government notice in the government gazette Step 7.

2 SCOPE OF THE STUDY

The study entails the determination of RQOs for all significant water resources (rivers, wetlands, dams (or lakes) and groundwater ecosystems) in the Olifants 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 IUAs and define the 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 NLs
- 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 for the development of the RQOs and NLs as set out in Step 5 and 6 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.

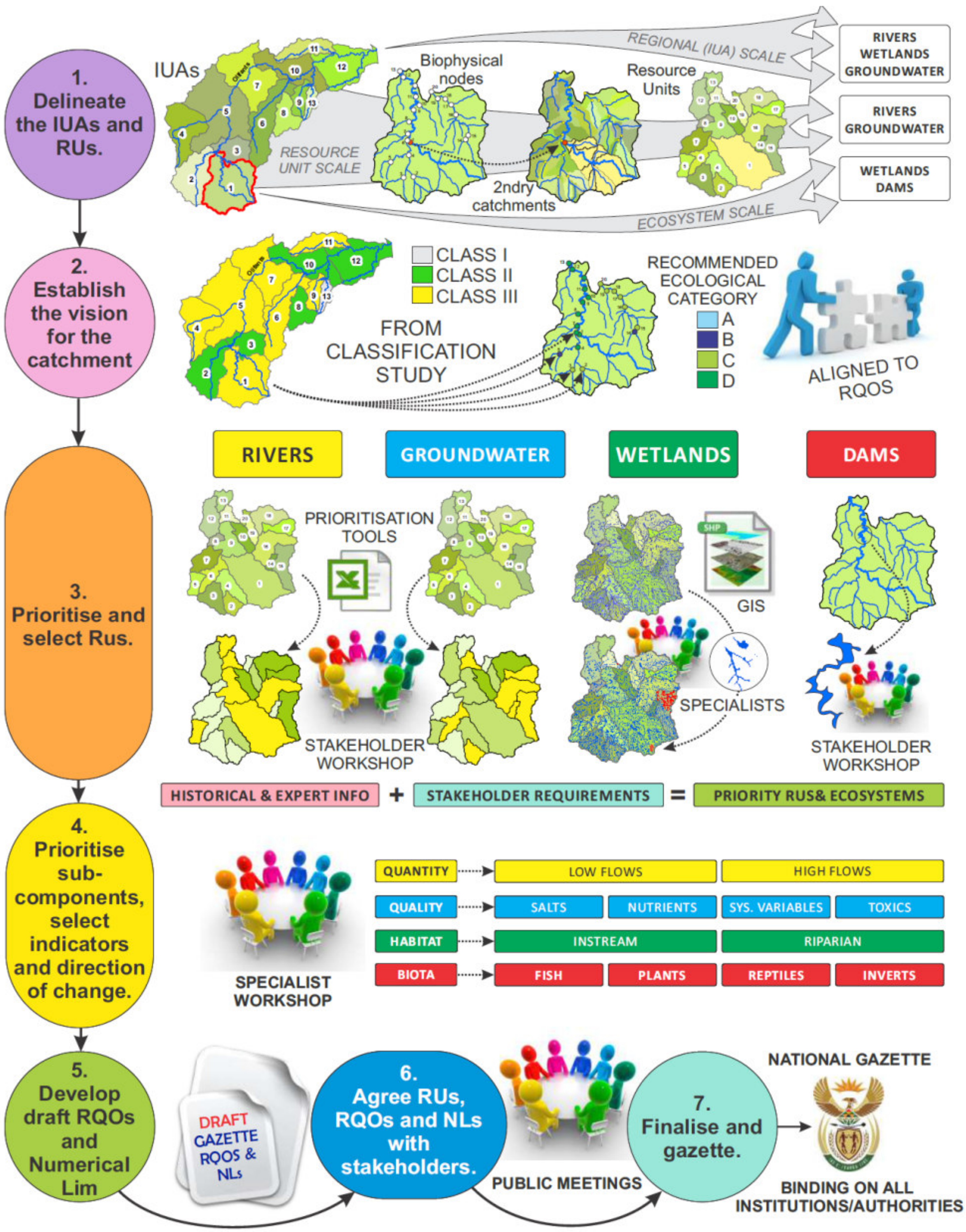

Figure 1: Schematic summary of the RQO determination procedure (adapted from DWA, 2011) which was implemented in this study.

3.2 RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS OVERVIEW AND GAPS

As indicated, following the completion of the sub-component and indicator information phase (Step 4) for all resources considered in the study, the outcomes of the application of the Resource Unit Evaluation Tool (RUET) include a list of sub-components and indicators selected for RQOs and their associated 'EcoSpec', 'UserSpecs' or 'Integrated measure' associations which is used for RQO development (Step 5). Following the selection of RQOs, NLs which are generally quantitative descriptors of the different components/sub-components of the resource such as the water quantity, quality, habitat and biota were established. These descriptors were designed to give a quantitative measure of the RQOs and are associated with some uncertainties (DWA, 2011). The RQOs and NLs were established after consideration of the following:

- Available data to evaluate the present state for selected sub-components and indicators for RQO determination.
- Suitability of the data available for RQO and NL selection.
- Determine the level at which to set RQOs
    - Carry over the proposed direction of change from the RUET.
    - Consider the requirements defined by the WRC.
    - Review the stakeholder aspirations and translate into Numerical Limits.

Available data to evaluate the present state for selected sub-components and indicators for RQO determination: Available data which may assist in determining the present state of selected sub-components/indicators has been reviewed prior to RQO determination. This information has been used to determine the level at which to set RQOs, as it relates the present state of each sub-component to reference conditions. The PES of a water resource is expressed in terms of its bio-physical components including:

- Drivers (Physico-chemical, geomorphology, hydrology, instream and riparian habitat) which provide a particular physical habitat template.
- Biological responses (fish, riparian vegetation, aquatic invertebrates, diatoms, amphibians and reptiles for e.g.)

Where available, data has been used to contribute to the development of RQOs and associated NLs. There are however numerous examples of driver and responder components/sub-components that were selected for RQO determination for which no present ecological state and on occasion indicator information are available. This may have occurred for example where an uncommon indicator such as birds and selected as sub-components for the riparian habitat (components) for the study for which no information is available. For these occasions a specialist with local knowledge was commissioned to assess available literature, proposed indicators (if unavailable) and select NLs (Refer to the appendix).

Assess the suitability of the data: In addition, the suitability of available data for sub-components and indicators was considered in the study. Where suitable, the data was used to determine the present state of the selected indicators and select RQOs. Alternatively, specialists with local knowledge were commissioned to carry out desktop evaluations of available information to select PES'. Data suitability considerations incorporated in the study according to DWA (2011) included:

- The age of the data
- The techniques and methods used
- The format of data
- The season in which it was collected
- Whether the data has been extrapolated

To determine the level at which to set RQOs were to be set, the proposed direction of change from the RUET was considered as well as the requirements defined by the WRC for the component so that the outcomes could be synchronised with the WRC. And finally, consideration of the stakeholder aspirations to translate RQO endpoints into NLs were made. The following process was followed:

- Carry over the proposed direction of change from the Resource Unit Evaluation Tool: Step 4 of the RQO process entailed proposing the most appropriate and feasible direction and magnitude of change for each of the selected sub-components. This information should be carried forward to this sub-step as it provides an indication of the level at which to set the respective RQOs.
- Consider the requirements defined by the Water Resource Classification: The REC and MCs available from the WRC were initially considered. During this component REC would be matched with the EcoStatus from the Ecological Reserve and or any other available information.
- Review the stakeholder aspirations and translate into Numerical Limits: During Step 4, the aspirations of stakeholders for management of specific components were identified. These aspirations informed the 'proposed direction of change' for each of the components and also influenced the final selection of sub-components for RQO determination. These aspirations have also been captured, in part, in the rationales for selecting a particular sub-component.

Set appropriate draft RQOs and Numerical Limits in line with the draft RQOs

The established RQOs included contextual information to reflect the direction of change of a particular sub-component and/or indicator. They also included the reason for the selection of component, sub-component and/or indicator and the rationale for the level at which it has been set. This contextual information is available in the supplementary tables provided below. Numerical Limits translate the narrative RQOs into numerical values which can be monitored and assessed for compliance of RQO implementation (DWA, 2011). These NLs considered feasibility assessments undertaken by specialists with local experience in this study (refer to appendix).

3.3 PUBLIC MEETING PROCESS

The draft RQOs and NLs were presented to stakeholders of the study at a series of public meetings as follows (Appendix 2):

- Public meeting #1: 12 March 2014, Protea Hotel, eMalahleni, Mpumalanga.
- Public meeting #2: 13 March 2014, Mopane Country Lodge, Phalaborwa, Limpopo.
- Public meeting #3: 20 May 2014, Indlela Country Estate eMalahleni, Mpumalanga.

The presentations contained two components including an introductory and background section and a breakaway group discussions section for the RQO and NL considerations. The introduction section included the presentation of the following components:

- Resource Quality Objectives within Water resource management in South Africa
- Introduction to the process of determining Resource Quality Objectives
- Determination of RQOs in the Olifants Water Management Area
- Water resources considered:
- Rivers, Wetlands, Dams & Groundwater
- Components and subcomponents
- Draft RQOs and Numerical limits

The breakaway group discussions considered:

- Catchment orientation, land uses type and water resource location considerations.
- Summary RQO outcome maps for major water resources considered:
- Rivers, Wetlands, Dams & Groundwater
- Draft RQO considerations and recommendations

Stakeholders were provided with an opportunity to query draft RQOs and NLs. All comments were captured, evaluated and where appropriate changes needed to be made they were. This resulted in some changes to various steps of the RQO determination process and draft RQO and NL outcomes. These changes have been clearly identified in the report where the change has relevance.

4 FINDINGS

The RQOs and NLs that were determined for the Olifants WMA as well as the supplementary information are presented per resource considered (Figure 2 and Figure 3).

4.1 RIVER RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS FOR THE OLIFANTS WMA

The outcomes of the RQO and NL determination of the sub-components and indicators for the river component of the RQO determination study for the Olifants WMA, including a summary of additional supplementary information are provided as follows:

- RQOs for regional rivers in the Olifants WMA are presented in Table 3.
- RQOs for the river water quantity component are presented in Table 4.
- RQOs for the river water quality component are presented in Table 5.
- RQOs for the river water habitat component are presented in Table 6.
- RQOs for the river water biota component are presented in Table 7.
- Supplementary information for the river water quantity component is presented in Table 8.
- Supplementary information for the river water quality component is presented in Table 9.
- Supplementary information for the river water habitat component is presented in Table 10.
- Supplementary information for the river water biota component is presented in Table 11.

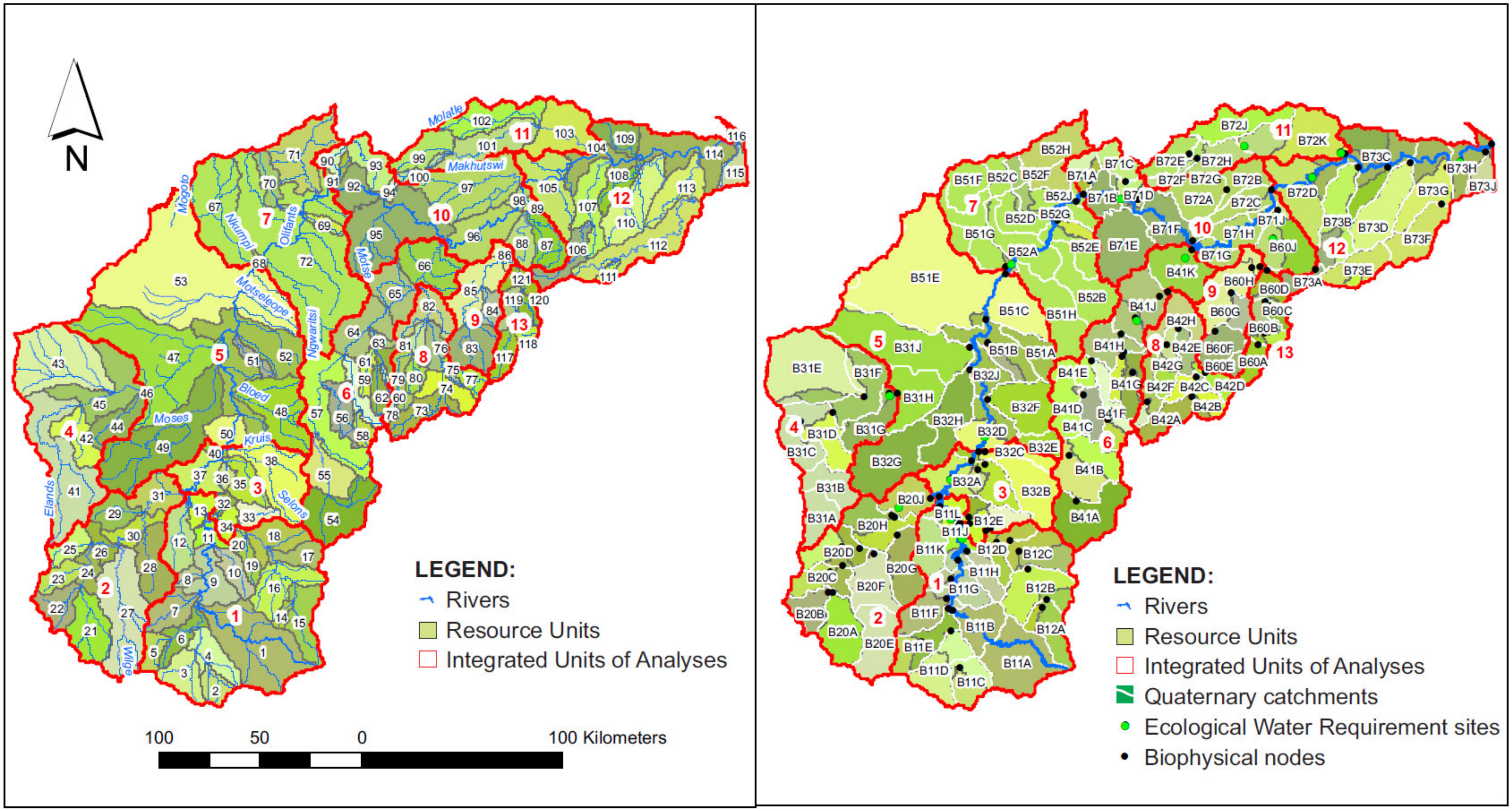

Figure 2: Map of the Integrated Units of Analysis (IUAs), Resource Units (RUs), rivers, Ecological Water Requirement Sites (EWR) and Biophysical Node sites and associated quaternary catchments in the study area.

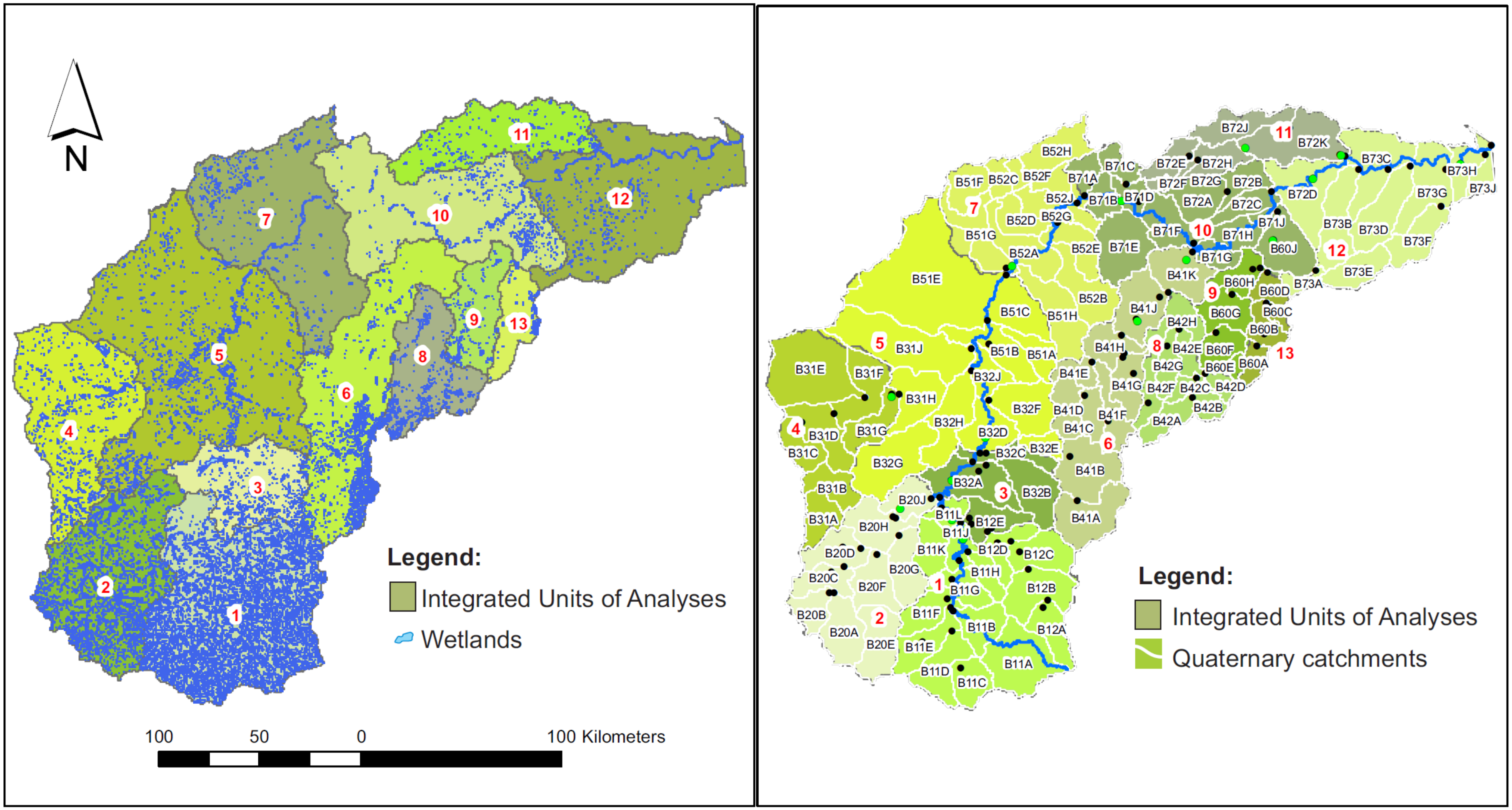

Figure 3: Map of the Integrated Units of Analysis (IUAs), wetlands and associated quaternary catchments in the study area.

4.1.1 RIVER RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 3: RQOs for REGIONAL RIVER in the Olifants WMA

IUA	RQO
1	The water quality, quantity and habitat of the headwater streams in this IUA are heavily impacted on by landuse and mining activities. Increasing nutrients, salts and likely toxins are having a negative impact on the ecosystem and need to be managed at a D or better ecological category so that instream ecosystem structure and functioning is not suppressed. The loss of alkalinity in the water as a result of mining activities poses a threat of acidification of the ecosystem, thus alkalinity concentrations must be kept high enough to prevent this from happening. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. Riparian habitat is also negatively impacted in the IUA and needs to be maintained in a D or better ecological category. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below. The consumption of fish in this IUA must not pose a threat to human health
2	The rivers in this headwater catchment IUA are being negatively impacted on by landuse activities, where the habitat in particular but also the water quality needs to be maintained in a D ecological category or better if the river is to continue to provide ecosystem services. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
3	Upstream mining and wastewater impacts are placing pressure on the system which is also impacted by the upstream dam. Increasing nutrients, salts and likely toxins are having a negative impact on the ecosystem and need to be managed so that instream ecosystem structure and functioning is not suppressed below a D category. The loss of alkalinity in the water as a result of mining activities poses a threat of acidification of the ecosystem, thus alkalinity concentrations must be kept high enough to prevent this from happening. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
4	The rivers in this IUA are generally in a suitable state with limited agriculture and urban area impacts. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
5	Upstream activities are stressing the ecosystem through the reduction of flows and pollution of the water. Flows need to be maintained in a D or better ecological category. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The instream and riparian habitats as well as the consequent biota are also important in this IUA and must be improved in most cases to a D or better ecological category from present conditions. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
6	Many of the streams in this IUA are stressed in almost all respects, having inadequate flow, poor water quality (mostly due to salt contamination but also nutrients) with poor habitats and associated biota. Many of these systems are presently at below the sustainable level and no sub-component should be allowed to be below a D category. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
7	The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
8	In this IUA the consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
9	Low flows in particular in this IUA are under stress and must be maintained at least at a category D level if the habitat is to be maintained in a condition sufficient for the important fish populations which must be also at least at a category D level. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
10	Many of the smaller tributaries in this IUA contain ecologically important fish species that must be maintained by maintaining the instream habitat of the tributaries in the IUA in at least a D category. In the larger rivers, inadequate flows and excessive sediments are impacting negatively on the instream habitat which is in turn impacting negatively on the instream biota. The flows and water quality must be maintained in a D ecological category or better in this IUA. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
11	Upstream activities are having an impact on the system via the lack of low flows, build-up of toxics and salt and sedimentation of the instream channel. All of these aspects should be managed to be at least at a D category as must the stream habitats. The consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
12	This lowermost IUA exists partly in the Kruger National Park where special protection conditions are necessary. The upstream activities have reduced flows and increased sedimentation to unacceptable levels and both of these must be increased to at least a D category. The riparian habitat is one zone that can be managed partly by non-instream controls of the water flow and quality and must be improved in some areas to at least a D category but should be nearly natural in the Park. Fish are important in the instream and must be managed to at least a D category. The consumption of

	fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.
13	In this IUA the consumption of fish harvested from rivers in the IUA must not pose a threat to human health. The recommended ecological category (REC) of any river reach as described in the Classification (Annexure A) must be adhered to unless superseded by the detailed Resource Quality Objectives for the RUs below.

Table 4: RQOs for RIVER WATER QUANTITY in priority RUs in the Olifants WMA

RIVER WATER QUANTITY												
IUA	Class	River	RU	Node	REC	Component	Sub Component	RQO	Indicator/ measure	Numerical Limits		
1	III	Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D	Quantity	Low Flows	Low flows should be improved in order to maintain the river habitat for the ecosystem and ecotourism.	1. EWR maintenance low and drought flows: Olifants EWR1 in B11J VMAR = 184.5x106m^3 PES=D category*		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)
										Oct	0.150 (99)	0.161 (99)
										Nov	0.272 (90)	0.185 (99)
										Dec	0.360 (80)	0.146 (99)
										Jan	0.447 (99)	0.675 (80)
										Feb	0.549 (99)	0.692 (90)
										Mar	0.442 (80)	0.261 (90)
										Apr	0.361 (80)	0.204 (90)
										May	0.249 (80)	0.164 (90)
										Jun	0.171 (80)	0.127 (99)
										Jul	0.130 (99)	0.131 (99)
										Aug	0.103 (80)	0.153 (70)
										Sep	0.091 (80)	0.073 (99)
	III	Klipspruit (confluence with Olifants	RU12	12	D	Quantity	Low Flows	Low flows are necessary to dilute and carry away waste and to support ecosystem functioning.	1. EWR maintenance low and drought flows: Klipspruit at confluence with Olifants in B11L VMAR = 25.65x10^{6}m^3 PES=D category*		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)
										Oct	0.034 (90)	0.030 (99)
										Nov	0.038 (90)	0.034 (99)
										Dec	0.042 (80)	0.022 (99)
										Jan	0.046 (90)	0.041 (99)
										Feb	0.055 (90)	0.048 (99)
										Mar	0.051 (90)	0.046 (99)
										Apr	0.051 (90)	0.045 (99)
										May	0.047 (80)	0.034 (99)
										Jun	0.047 (80)	0.035 (99)
										Jul	0.044 (90)	0.037 (99)
										Aug	0.039 (90)	0.035 (99)
										Sep	0.035 (70)	0.008 (99)
	III	Olifants	RU13	13	B	Quantity	Low Flows	Low flows should be improved in order to maintain the river habitat for the ecosystem and ecotourism.	1. EWR maintenance low and drought flows: Olifants in B11L VMAR = 307.36x10^{6}m^3 PES=D category*		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)
										Oct	0.280 (90)	0.241 (99)
										Nov	0.455 (90)	0.391 (99)
										Dec	0.589 (90)	0.507 (99)
										Jan	0.721 (90)	0.620 (99)

										Feb	0.882 (90)		0.759 (99)
										Mar	0.732 (90)		0.624 (99)
										Apr	0.631 (80)		0.428 (99)
										May	0.478 (90)		0.412 (99)
										Jun	0.367 (90)		0.316 (99)
										Jul	0.298 (90)		0.256 (99)
										Aug	0.243 (90)		0.209 (99)
										Sep	0.211 (90)		0.181 (99)
2	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31	B	Quantity	Low Flows	Low flows need to be improved in order to maintain river habitat and the ecosystem.	1. EWR maintenance low and drought flows: Wilge EWR4 in B20J VMAR = 175.59x10^{6}m^3 PES=B category*	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
										Oct	0.806 (50)		0.206 (99)
										Nov	1.094 (60)		0.269 (99)
										Dec	1.235 (60)		0.298 (99)
										Jan	1.476 (60)		0.350 (99)
										Feb	1.862 (60)		0.436 (99)
										Mar	1.733 (60)		0.405 (99)
										Apr	1.528 (50)		0.362 (99)
										May	1.277 (50)		0.307 (99)
										Jun	1.121 (50)		0.275 (99)
										Jul	0.961 (60)		0.239 (99)
										Aug	0.802 (60)		0.205 (99)
										Sep	0.696 (60)		0.183 (99)
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quantity	Low Flows	Low flows should be improved in order to maintain ecosystem functioning and ecotourism.	1. EWR maintenance low and drought flows: Klein Olifants in B12E VMAR = 81.54x10^{6}m^3 PES=C/D category*	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
										Oct	0.135 (70)		0.071 (99)
										Nov	0.227 (80)		0.100 (99)
										Dec	0.313 (80)		0.160 (99)
										Jan	0.394 (80)		0.200 (99)
										Feb	0.467 (80)		0.237 (99)
										Mar	0.384 (80)		0.161 (99)
										Apr	0.324 (70)		0.162 (99)
										May	0.257 (70)		0.119 (99)
										Jun	0.200 (70)		0.103 (99)
										Jul	0.167 (70)		0.087 (99)
										Aug	0.134 (70)		0.070 (99)
										Sep	0.112 (70)		0.046 (99)
	II	Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	C	Quantity	Low and High Flows	Low flows need to be improved to maintain the ecosystem	1. EWR maintenance low and high flows and drought flows: Olifants EWR5 in B32D VMAR = 571.1x10^{6}m3 PES=C category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	1.110 (70)	0.636 (99)	0.742 (99)
										Nov	1.682 (80)	0.941 (99)	2.691 (80)
										Dec	2.040 (80)	1.129 (99)	4.385 (80)
										Jan	2.471 (70)	1.357 (99)	6.616 (70)
										Feb	3.042 (80)	1.664 (99)	1.492 (99)
								High flows (freshets)		Mar	2.667 (70)	1.460 (99)	2.720 (90)

								must be provided to maintain cues for fish		Apr	2.323 (70)	1.161 (99)	0.975 (99)
										May	1.842 (70)	1.023 (99)	
										Jun	1.473 (70)	0.830 (99)	
										Jul	1.233 (70)	0.701 (99)	
										Aug	1.009 (70)	0.582 (99)	
										Sep	0.876 (70)	0.514 (99)	
4	III	Elands (outlet of quaternary - outlet of IUA4)	RU46	46	D	Quantity	Low and High Flows	Low flows need to be improved in order to provide for the ecosystem and basic human needs.	1. EWR maintenance low and high flows and drought flows: Elands EWR6 in B31G VMAR = 60.32X10^{6}m3 PES=D category*		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	0.077 (99)	0.077 (99)	0.064 (99)
										Nov	0.121 (90)	0.113 (99)	0.392 (90)
										Dec	0.133 (99)	0.133 (10)	0.492 (80)
										Jan	0.173 (99)	0.173 (99)	0.956 (70)
										Feb	0.196 (99)	0.196 (99)	0.199 (99)
										Mar	0.176 (99)	0.176 (99)	0.360 (90)
								High flows (freshets) must be provided to maintain the ecosystem and replenish natural storage.		Apr	0.148 (90)	0.136 (99)	0.161 (99)
										May	0.113 (99)	0.113 (99)	
										Jun	0.095 (99)	0.095 (99)	
										Jul	0.084 (99)	0.084 (99)	
										Aug	0.076 (99)	0.076 (99)	
										Sep	0.070 (99)	0.070 (99)	
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Quantity	Low and High Flows	Low flows need to be improved in order to provide for the ecosystem and basic human needs...	1. EWR maintenance low and high flows and drought flows: Elands in B31J VMAR = 84.09X10^{6}m3 PES=D category*		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	0.108 (99)	0.108 (99)	0.084 (99)
										Nov	0.171 (90)	0.154 (99)	0.504 (80)
										Dec	0.186 (99)	0.186 (99)	0.630 (80)
										Jan	0.238 (99)	0.238 (99)	1.191 (80)
										Feb	0.277 (99)	0.277 (99)	0.264 (99)
										Mar	0.247 (99)	0.247 (99)	0.476 (90)
								High flows (freshets) must be provided to maintain the ecosystem and replenish natural storage.		Apr	0.205 (99)	0.193 (99)	0.197 (99)
										May	0.155 (99)	0.155 (99)	
										Jun	0.130 (99)	0.130 (99)	
										Jul	0.115 (99)	0.115 (99)	
										Aug	0.103 (99)	0.103 (99)	
										Sep	0.094 (99)	0.094 (99)	
	III	One node at confluence with Olifants. Included: B32G (Moses) and B32H (Mametse and Moses)	RU49	49	C	Quantity	Low Flows	The low flows should be improved to maintain ecosystem functioning	1. EWR maintenance low and drought flows: Moses River in B32H VMAR = 35.53x10^{6}m3 PES=C category*		Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.073 (70)		0.042 (99)
										Nov	0.107 (80)		0.060 (99)
										Dec	0.122 (80)		0.068 (99)
										Jan	0.126 (70)		0.069 (99)
										Feb	0.163 (70)		0.089 (99)
										Mar	0.156 (70)		0.085 (99)
										Apr	0.145 (70)		0.079 (99)
										May	0.117 (70)		0.065 (99)

										Jun	0.103 (70)	0.058 (99)
										Jul	0.088 (70)	0.050 (99)
										Aug	0.077 (70)	0.044 (99)
										Sep	0.068 (70)	0.039 (99)
	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Quantity	Low Flows	The low flows should be improved to maintain ecosystem functioning and also to provide for users in the dry season.	1. EWR maintenance low and drought flows: Olifants EWR7 in B51C VMAR = 726.64x10^6m3 PES=D category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.556 (99)	0.556 (99)
										Nov	0.849 (99)	0.849 (99)
										Dec	1.007 (99)	1.007 (99)
										Jan	1.214 (99)	1.214 (99)
										Feb	1.499 (99)	1.499 (99)
										Mar	1.303 (99)	1.303 (99)
										Apr	1.140 (99)	1.140 (99)
										May	0.888 (99)	0.888 (99)
										Jun	0.726 (99)	0.726 (99)
										Jul	0.611 (99)	0.611 (99)
										Aug	0.514 (99)	0.514 (99)
										Sep	0.457 (99)	0.457 (99)
	III	Olifants (outlet of quaternary - outlet of IUA5)	RU53	53	D	Quantity	Low Flows	The low flows should be improved to maintain ecosystem functioning and also to provide for users.	1. EWR maintenance low and drought flows: Olifants in B51E VMAR = 726.06x10^6m3 PES=D category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.556 (99)	0.556 (99)
										Nov	0.849 (99)	0.849 (99)
										Dec	1.007 (99)	1.007 (99)
										Jan	1.214 (99)	1.214 (99)
										Feb	1.499 (99)	1.499 (99)
										Mar	1.303 (99)	1.303 (99)
										Apr	1.140 (99)	1.140 (99)
										May	0.888 (99)	0.888 (99)
										Jun	0.726 (99)	0.726 (99)
										Jul	0.611 (99)	0.611 (99)
										Aug	0.514 (99)	0.514 (99)
										Sep	0.457 (99)	0.457 (99)
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Quantity	Low Flows	Low flows must be maintained to provide for the ecosystem and the angling industry.	1. EWR maintenance low and drought flows: Grootspruit in B41A VMAR = 41.97x10^6m3 PES=C category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.157 (70)	0.086 (99)
										Nov	0.242 (70)	0.058 (99)
										Dec	0.319 (70)	0.172 (99)
										Jan	0.418 (80)	0.224 (99)
										Feb	0.529 (70)	0.282 (99)
										Mar	0.446 (70)	0.224 (99)
										Apr	0.417 (70)	0.220 (99)
										May	0.322 (70)	0.146 (99)
										Jun	0.251 (70)	0.138 (99)
										Jul	0.189 (70)	0.105 (99)

										Aug	0.157 (70)	0.089 (99)
										Sep	0.143 (70)	0.082 (99)
	III	Steelpoort (inflow to De Hoop Dam)	RU57	57	C	Quantity	Low Flows	Low flows must be maintained for ecosystem functioning.	1. EWR maintenance low and drought flows: Steelpoort in B41E VMAR = 117.01x10^6m3 PES=C category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.442 (70)	0.235 (99)
										Nov	0.680 (70)	0.154 (99)
										Dec	0.887 (70)	0.486 (99)
										Jan	1.160 (70)	0.629 (99)
										Feb	1.464 (70)	0.791 (99)
										Mar	1.233 (10)	0.620 (99)
										Apr	1.147 (70)	0.602 (99)
										May	0.891 (70)	0.396 (99)
										Jun	0.701 (70)	0.389 (99)
										Jul	0.528 (70)	0.298 (99)
										Aug	0.441 (70)	0.252 (99)
										Sep	0.401 (70)	0.232 (99)
	III	Upper reaches of Dwars (before mining impacts)	RU62	62	C	Quantity	Low Flows	Low flows must be maintained for ecosystem functioning. .	1. EWR maintenance low and drought flows: Dwars River in B41G VMAR = 24.41x10^6m□ PES=C category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.061 (60)	0.034 (99)
										Nov	0.095 (80)	0.051 (99)
										Dec	0.121 (70)	0.064 (99)
										Jan	0.142 (70)	0.075 (99)
										Feb	0.179 (70)	0.093 (99)
										Mar	0.158 (70)	0.071 (99)
										Apr	0.145 (70)	0.076 (99)
										May	0.118 (70)	0.062 (99)
										Jun	0.094 (70)	0.050 (99)
										Jul	0.072 (70)	0.039 (99)
										Aug	0.061 (70)	0.034 (99)
										Sep	0.056 (70)	0.031 (99)
	III	Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D	Quantity	Low Flows	Low flows must be maintained for ecosystem functioning and for irrigation and rural and peri-urban users.	1. EWR maintenance low and drought flows: Steelpoort EWR10 in B41K VMAR = 342.75x10^6m□ PES=D category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.532 (99)	0.532 (99)
										Nov	0.843 (99)	0.843 (99)
										Dec	1.073 (99)	1.073 (99)
										Jan	1.324 (99)	1.324 (99)
										Feb	1.642 (99)	1.642 (99)
										Mar	1.405 (99)	1.405 (99)
										Apr	1.251 (99)	1.251 (99)
										May	1.002 (99)	1.002 (99)
										Jun	0.801 (99)	0.801 (99)
										Jul	0.621 (99)	0.621 (99)
										Aug	0.529 (99)	0.529 (99)
										Sep	0.495 (99)	0.495 (99)

7	III	Olifants (outlet of quaternary - outlet of IUA7)	RU72	72	D	Quantity	Low and High Flows	Low flows must be maintained for ecosystem functioning. High flows must be maintained for ecosystem functioning.	1. EWR maintenance low and high flows and drought flows: Olifants in B52J VMAR = 799.74x10^{6}m□ PES=D category*	Maintenance low flows (m^3/s)		Drought flows (m^3/s)	Freshets (m^3/s)
										Oct	0.596 (99)	0.596 (99)	0.881 (90)
										Nov	0.949 (99)	0.949 (99)	3.927 (80)
										Dec	1.131 (99)	1.131 (99)	5.984 (80)
										Jan	1.370 (99)	1.370 (99)	8.989 (60)
										Feb	1.696 (99)	1.696 (99)	2.014 (99)
										Mar	1.456 (99)	1.456 (99)	3.637 (80)
										Apr	1.250 (99)	1.250 (99)	1.213 (99)
										May	0.954 (99)	0.954 (99)	
										Jun	0.776 (99)	0.776 (99)	
										Jul	0.649 (99)	0.649 (99)	
										Aug	0.547 (99)	0.547 (99)	
										Sep	0.487 (99)	0.487 (99)	
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Quantity	Low Flows	Low flows must be maintained to provide for fish and agriculture.	1. EWR maintenance low and drought flows: Spekboom in B42H VMAR = 148.99x10^{6}m□ PES=B category*	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
										Oct	0.598 (60)		0.315 (99)
										Nov	0.932 (60)		0.476 (99)
										Dec	1.193 (70)		0.601 (99)
										Jan	1.445 (70)		0.722 (99)
										Feb	1.771 (70)		0.881 (99)
										Mar	1.507 (70)		0.751 (99)
										Apr	1.348 (60)		0.676 (99)
										May	1.117 (70)		0.565 (99)
										Jun	0.922 (60)		0.472 (99)
										Jul	0.719 (60)		0.373 (99)
										Aug	0.610 (60)		0.321 (99)
										Sep	0.571 (60)		0.303 (99)
9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary)	RU83	83	D	Quantity	Low and High Flows	Low flows must be maintained so that they provide for fish and the ecosystem. High flows need to provide cues for fish breeding.	1. EWR maintenance low and high flows and drought flows: Ohrigstad River in B60F VMAR = 35.64x10^{6}m□ PES=D category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	0.052 (80)	0.052 (80)	0.007 (99)
										Nov	0.067 (80)	0.067 (80)	0.054 (90)
										Dec	0.086 (70)	0.086 (70)	0.112 (70)
										Jan	0.110 (60)	0.110 (60)	0.109 (80)
										Feb	0.165 (50)	0.165 (50)	0.448 (30)
										Mar	0.149 (60)	0.149 (60)	0.109 (90)
										Apr	0.123 (70)	0.123 (70)	0.059 (99)
										May	0.093 (80)	0.093 (80)	
										Jun	0.082 (80)	0.082 (80)	
										Jul	0.068 (80)	0.068 (80)	
										Aug	0.058 (80)	0.058 (80)	
										Sep	0.053 (80)	0.053 (80)	
	III	Ohrigstad (EWR site - OLI-EWR8) (Rapid site)	RU86	86	C	Quantity	Low and High Flows	Low flows must be improved so that they provide for fish and	1. EWR maintenance low and high flows and drought flows: Ohrigstad	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)

								the ecosystem.	River OLI-EWR8 in B60H VMAR = 65.49x10^6m□ PES=C category*	Oct	0.176 (60)	0.063 (99)	0.020 (99)
										Nov	0.244 (50)	0.085 (99)	0.159 (80)
										Dec	0.326 (50)	0.112 (99)	0.319 (70)
										Jan	0.420 (50)	0.143 (99)	0.298 (80)
										Feb	0.663 (50)	0.222 (99)	1.269 (60)
										Mar	0.595 (50)	0.199 (99)	0.298 (90)
								High flows need to provide cues for fish breeding.		Apr	0.473 (60)	0.160 (99)	0.156 (99)
										May	0.353 (60)	0.121 (99)	
										Jun	0.295 (60)	0.102 (99)	
										Jul	0.239 (70)	0.084 (99)	
										Aug	0.198 (60)	0.070 (99)	
										Sep	0.178 (60)	0.064 (99)	
10	II	Olifants (confluence with Steelpoort)	RU95	95	D	Quantity	Low and High Flows	Low flows need to be improved to maintain the ecosystem	1. EWR maintenance low and high flows and drought flows: Olifants in B71F VMAR = 937.93x10^6m□ PES=D category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	0.783 (99)	0.783 (99)	1.128 (90)
										Nov	1.169 (99)	1.169 (99)	5.189 (80)
										Dec	1.380 (99)	1.380 (99)	8.158 (60)
										Jan	1.674 (99)	1.674 (99)	4.216 (80)
										Feb	2.137 (99)	2.137 (99)	14.982 (60)
								High flows need to be improved to maintain the ecosystem.		Mar	1.906 (99)	1.906 (99)	4.216 (80)
										Apr	1.658 (99)	1.658 (99)	2.028 (90)
										May	1.302 (99)	1.302 (99)	
										Jun	1.073 (99)	1.073 (99)	
										Jul	0.898 (99)	0.898 (99)	
										Aug	0.761 (99)	0.761 (99)	
										Sep	0.680 (99)	0.680 (99)	
	II	Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D	Quantity	Low and High Flows	Low flows must support the ecosystem structure and function.	1. EWR maintenance low and high flows and drought flows: Olifants EWR11 in B71J VMAR = 1321.9x10^6m□ PES=D category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	2.959 (80)	1.576 99()	0.340 (99)
										Nov	4.420 (80)	2.353 (99)	1.713 (99)
										Dec	5.358 (80)	2.853 (99)	2.760 (99)
										Jan	6.468 (80)	3.444 (99)	1.426 (99)
										Feb	8.217 (80)	4.376 (99)	5.091 (99)
										Mar	7.345 (80)	3.911 (99)	1.426 (99)
								High flows must be maintained for ecosystem functioning.		Apr	6.450 (80)	3.434 (99)	0.701 (99)
										May	5.095 (80)	2.713 (99)	
										Jun	4.139 (80)	2.204 (99)	
										Jul	3.396 (80)	1.808 (99)	
										Aug	2.886 (80)	1.537 (99)	
										Sep	2.623 (80)	1.397 (99)	
	II	Makhutswi, including Moungwana and Malomanye	RU97	97	C	Quantity	Low Flows	Low flows must be maintained to provide for basic human needs.	1. EWR maintenance low and drought flows: Makhutsi River in B72A VMAR = 38.01x10^6m□ PES=C category*	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
										Oct	0.130 (50)		0.000
										Nov	0.144 (50)		0.004 (99)

										Dec	0.173 (50)		0.004 (99)
										Jan	0.258 (50)		0.004 (99)
										Feb	0.435 (50)		0.000
										Mar	0.415 (50)		0.000
										Apr	0.330 (50)		0.000
										May	0.236 (50)		0.000
										Jun	0.206 (50)		0.000
										Jul	0.179 (70)		0.000
										Aug	0.159 (60)		0.000
										Sep	0.142 (50)		0.000
	II	Olifants (outlet - outlet of IUA10)	RU98	98	C	Quantity	Low and High Flows	Low flows must be maintained so that they provide for the ecosystem. High flows must provide for the ecosystem.	1. EWR maintenance low and high flows and drought flows: Olifants in B72C VMAR = 1755.5x10^{6}m□ PES=C category*		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	5.645 (60)	2.148 (99)	0.654 (99)
										Nov	8.016 (70)	2.978 (99)	3.383 (99)
										Dec	9.747 (70)	3.573 (99)	5.806 (90)
										Jan	11.956 (70)	4.341 (99)	3.425 (99)
										Feb	15.848 (70)	5.713 (99)	12.616 (90)
										Mar	14.484 (70)	5.219 (99)	3.425 (99)
										Apr	13.039 (60)	4.724 (99)	1.824 (99)
										May	10.333 (60)	3.777 (99)	
										Jun	8.401 (60)	3.112 (99)	
										Jul	6.783 (60)	2.543 (99)	
										Aug	5.729 (70)	2.177 (99)	
										Sep	5.194 (60)	1.997 (99)	
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	103	D	Quantity	Low Flows	Low flows are important for the maintenance of the ecosystem.	1. EWR maintenance low and drought flows: Ga-Selati EWR14b in B72K VMAR = 72.74x10^{6}m□ PES=D category*		Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.122 (70)		0.001 (99)
										Nov	0.138 (60)		0.001 (99)
										Dec	0.192 (60)		0.001 (99)
										Jan	0.350 (50)		0.001 (99)
										Feb	0.744 (60)		0.003 (99)
										Mar	0.608 (50)		0.003 (99)
										Apr	0.378 (70)		0.002 (99)
										May	0.200 (70)		0.001 (99)
										Jun	0.178 (70)		0.001 (99)
										Jul	0.156 (70)		0.001 (99)
										Aug	0.141 (70)		0.001 (99)
										Sep	0.132 (7)		
	III	Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104	D	Quantity	Low Flows	Low flows are important for the maintenance of the ecosystem.	1. EWR maintenance low and drought flows: Ga-Selati EWR14b in B72K VMAR = 72.74x10^{6}m^3 PES=D category*		Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
										Oct	0.122 (60)		0.001 (99)
										Nov	0.138 (60)		0.001 (99)
										Dec	0.192 (60)		0.001 (99)
										Jan	0.350 (50)		0.001 (99)

										Feb	0.744 (60)		0.003 (99)
										Mar	0.608 (50)		0.003 (99)
										Apr	0.378 (70)		0.002 (99)
										May	0.200 (60)		0.001 (99)
										Jun	0.178 (70)		0.001 (99)
										Jul	0.156 (70)		0.001 (99)
										Aug	0.141 (70)		0.001 (99)
										Sep	0.132 (70)		
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Quantity	Low and High Flows	Low flows must be improved to maintain ecosystem structure and function.	1. EWR maintenance low and high flows and drought flows: Olifants EWR13 in B72B VMAR = 1762.2x10^{6}m^3 PES=C category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	3.940 (70)	2.149 (99)	0.598 (99)
										Nov	5.592 (70)	2.979 (99)	3.093 (99)
										Dec	6.802 (80)	3.576 (99)	5.317 (90)
										Jan	8.351 (70)	4.347 (99)	3.141 (99)
										Feb	10.994 (70)	5.683 (99)	11.515 (90)
								High flows must be maintained to support ecosystem structure and function.		Mar	10.125 (70)	5.231 (99)	3.141 (99)
										Apr	9.105 (70)	4.729 (99)	1.665 (99)
										May	7.209 (70)	3.778 (99)	
										Jun	5.860 (70)	3.112 (99)	
										Jul	4.732 (70)	2.544 (99)	
										Aug	3.998 (70)	2.179 (99)	
										Sep	3.625 (70)	1.999 (99)	
	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Quantity	Low and High Flows	Low flows must be maintained for ecosystem structure and function.	1. EWR maintenance low and high flows and drought flows: Olifants EWR16 in B73H VMAR = 1918.3x10^{6}m^3 PES=C category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	3.785 (70)	1.762 (99)	0.478 (99)
										Nov	5.335 (70)	2.426 (99)	2.502 (99)
										Dec	6.544 (70)	2.935 (99)	4.432 (90)
										Jan	8.179 (70)	3.630 (99)	2.765 (99)
										Feb	11.144 (70)	4.905 (99)	10.622 (90)
								High flows must be maintained for ecosystem structure and functioning.		Mar	10.150 (70)	4.468 (99)	2.765 (99)
										Apr	8.945 (70)	3.960 (99)	1.391 (99)
										May	6.942 (70)	3.104 (99)	
										Jun	5.614 (70)	2.545 (99)	
										Jul	4.545 (70)	2.085 (99)	
										Aug	3.851 (70)	1.790 (99)	
										Sep	3.500 (70)	1.646 (99)	
13	I	Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Quantity	Low and High Flows	Lows flows are essential for protection of this ecosystem.	1. EWR maintenance low and high flows and drought flows: Blyde River in B60D VMAR = 283.9x10^{6}m^3 PES=B category*	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
										Oct	1.559 (60)	0.512 (99)	0.091 (99)
										Nov	1.776 (60)	0.573 (99)	0.436 (99)
										Dec	2.036 (60)	0.638 (99)	0.996 (99)
										Jan	2.550 (60)	0.774 (99)	1.390 (90)
										Feb	3.534 (60)	1.044 (99)	5.124 (80)
								High flows are		Mar	3.408 (60)	1.000 (99)	1.390 (99)

								essential to maintain the protected status of this ecosystem.		Apr	3.230 (60)	0.957 (99)	1.139 (99)
										May	2.793 (60)	0.838 (99)	
										Jun	2.546 (60)	0.776 (99)	
										Jul	2.076 (70)	0.648 (99)	
										Aug	1.776 (70)	0.569 (99)	
										Sep	1.632 (70)	0.534 (99)	

**Per Rule Table (Appendix B)*

Table 5: RQOs for RIVER WATER QUALITY in priority RUs in the Olifants WMA

RIVER WATER QUALITY											
IUA	**Class**	**River**	**RU**	**Node**	**REC**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**	**95th Percentiles**
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	Nutrients	Nutrient concentrations must be maintained in the river at mesotrophic or better levels	Phosphate(PO_4)*	≤ 0.125 mg/L P	0.04
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 4.00 mg/L N	0.16
									Total Ammonia*	≤ 0.100 mg/L N	0.20
		Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D			Nutrient concentrations should be improved to prevent nuisance conditions for ecotourism.	Phosphate(PO_4)*	≤ 0.125 mg/L P	3,1
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 4.00 mg/L N	15
									Total Ammonia*	≤ 0.100 mg/L N	0.9
		Klipspruit (confluence with Olifants)	RU12	12	D			The nutrient concentrations need to be improved for the ecosystem and users.	Phosphate (PO_4)*	≤ 0.125 mg/L P	0.026
		Olifants	RU13	13	B			Nutrient concentrations should be improved to maintain the ecosystem and ecotourism.	Nitrate (NO_3) & Nitrite (NO_2)*	≤ 0.70 mg/L N	No data
									Phosphate (PO_4)*	≤ 0.015 mg/L P	No data
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quality	Nutrients	Nutrients need to be improved to support the ecosystem.	Phosphate (PO_4)*	≤ 0.025 mg/L P	4.6
									Nitrate (NO_3) & Nitrite (NO_2)*	≤ 1.00 mg/L N	13.5
									Ammonium*	≤ 0.073 mg/L N	13.7
5	III	One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Quality	Nutrients	The nutrient condition should be improved to support the ecosystem and users.	Phosphate (PO_4)*	≤ 0.025 mg/L P	0.0925
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Quality	Nutrients	The nutrient concentrations should be maintained to support the ecosystem and trout industry.	Nitrate (NO_3) & Nitrite (NO_2)*	≤ 1.00 mg/L N	0.2
									Phosphate (PO_4)*	≤ 0.025 mg/L P	0.1

		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	64	D			Nutrients should be maintained to support the ecosystem.	Phosphate (PO_4)*	≤ 0.125 mg/L P	0.028
9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary) and Ohrigstad (outlet of quaternary - outlet of IUA9)	RU83 RU86	83 and 86	D	Quality	Nutrients	Nutrients need to be minimised in order to ensure that the system is maintained in a mesotrophic condition.	Nitrate (NO_3)*	≤ 4.00 mg/L N	
									Phosphate (PO_4)*	≤ 0.125 mg/L P	
1	III	Olifants (releases from Witbank Dam) and Olifants (EWR site 1 - EWR1) (existing)	RU9 RU11	9 and 11	D	Quality	Salts	Salt concentrations need to be maintained at levels where they do not render the ecosystem unsustainable.	Sulphates*	≤ 500 mg/L	196
									Electrical conductivity*	≤ 111 mS/m	73
		Olifants	RU13	13	B			Salt concentrations need to be maintained at levels where they do not render the ecosystem unsustainable.	Sulphates*	≤ 80 mg/L	No data
									Electrical conductivity*	≤ 55 mS/m	No data
	III	Klipspruit (confluence with Olifants)	RU12	12	D			Salt concentrations need to be improved to protect the ecosystem, for basic human needs, vegetable and livestock watering.	Electrical conductivity*	≤ 111 mS/m	137
									Sulphates*	≤ 500 mg/L	575
2	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31	C	Quality	Salts	Overall salt and sulphate concentrations need to be improved to so that they do not threaten the ecosystem or agricultural users.	Sulphates*	≤ 200 mg/L	278
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quality	Salts	Salts need to be improved to support aquatic organisms.	Sulphates*	≤ 200 mg/L	318.4
									Electrical conductivity*	≤ 85 mS/m	108.1
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			Concentrations and also maxima of salt in particular sulphate should be maintained so that they allow for a sustainable ecosystem.	Sulphates*	≤ 500 mg/L	0.033
									Electrical conductivity*	≤ 111 mS/m	No data
5	III	Olifants (releases from Flag Boshielo Dam) and Olifants (outlet of quaternary - outlet of IUA5)	RU52 and RU53	52 and 53	D	Quality	Salts	Overall salt and sulphate concentrations need to be maintained to support the ecosystem and users of the water.	Sulphates*	≤ 500 mg/L	No data
									Electrical conductivity*	≤ 111 mS/m	No data
6	III	Upper reaches of Dwars (before mining impacts)	RU62	62	C	Quality	Salts	Salts should be improved to support the ecosystem.	Electrical conductivity*	≤ 85 mS/m	No data
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	130	D	Quality	Salts	Salts should be improved to support the ecosystem.	Electrical conductivity*	≤ 111 mS/m	270
		Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104				Salts should be improved to support the ecosystem.	Electrical conductivity*	≤ 111 mS/m	270
									Sulphates*	≤ 500 mg/L	747
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	System Variables	Alkalinity must be maintained at concentrations which do not allow for a dramatic rise in acidity.	Alkalinity*	≥ 60 mg/L $CaCO_3$	114.649
									Turbidity*	≤ 10 NTU	Not measured
									Dissolved oxygen*	≥ 4 mg/L O_2	Not measured
		Klipspruit (confluence with Olifants)	RU12	12	D			Temperature and dissolved oxygen levels should not over-stress the ecosystem. Alkalinity should be stabilised at present	Temperature*	≤ abs(dev from ambient)	No data

								concentrations or ideally improved to prevent acidification of the river.		4.0	
									Dissolved oxygen*	≥ 4 mg/L O_2	No data
									Alkalinity*	≥ 60 mg/L $CaCO_3$	73.8
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quality	System Variables	The alkalinity should be improved to prevent acidification of the river.	Alkalinity*	≥ 60 mg/L $CaCO_3$	258.3
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			Dissolved oxygen should be maintained. Alkalinity must not decrease and thus allow for acidification of the river.	Temperature*	≤ abs(dev from ambient) 4.0	148.9
									Dissolved oxygen*	≥ 4 mg/L O_2	51
									Alkalinity*	≥ 60 mg/L $CaCO_3$	0.9
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Quality	System Variables	Temperatures and dissolved oxygen are important to maintain the ecosystem and trout industry in particular and must be improved.	Temperature*	≤ abs(dev from ambient) 2.0	No data
									Dissolved oxygen*	≥ 6 mg/L O_2	No data
7	III	Olifants (outlet quaternary - outlet of IUA7)	RU72	72	D	Quality	System Variables	Sediment concentrations should not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on water institutions.	Suspended solids*	≤ 50.0 mg/L	No data
10	II	Olifants (confluence with Steelpoort)	RU95	95	D	Quality	System Variables	Sediment concentrations should not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on water institutions.	Turbidity (NTUs)*	≤ 10 NTU	No data
		Olifants (outlet - outlet of IUA10)	RU98	98	C				Suspended solids*	≤ 25.0 mg/L	No data
		Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D			Sediment concentrations should thus not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on fitness for use for water institutions.	Suspended solids*	≤ 50.0 mg/L	No data
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	103	D	Quality	System Variables	Sedimentation must not excessively impact on habitat state.	Suspended solids*	≤ 50.0 mg/L	No data
		Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104				Sedimentation must not excessively impact on habitat state.	Alkalinity*	≥ 60 mg/L $CaCO_3$	404
									Turbidity*	≤ 10 NTU	No data
									Temperatures*	≤ abs(dev from ambient) 4.0	No data

									Dissolved oxygen*	≥ 4 mg/L O_2	No data
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Quality	System Variables	Sediment concentrations should not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on fitness for use for water institutions.	Suspended solids*	≤ 25.0 mg/L	No data
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C			Sediment loads must be reduced so that sedimentation does not negatively impact on habitat state.	Suspended solids*	≤ 25.0 mg/L	No data
									Turbidity (NTUs)*	≤ 10 NTU	No data
13	I	Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Quality	System Variables	The sediment situation should be improved to support the protected status of this river.	Turbidity (NTUs)*	≤ 1 NTU	No data
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	Toxins	Toxicity levels must comply with the fitness for use which is acceptable for lifetime consumption (Class 1#) after treatment in the existing infrastructure.	F*	≤ 3.00 mg/L	0.7459
									Al*	≤ 0.150 mg/L	Not measured
									As*	≤ 0.130 mg/L	Not measured
									Cd hard*	≤ 5.0 µg/L	Not measured
									Cr(VI)*	≤ 200 µg/L	Not measured
									Cu hard*	≤ 8.0 µg/L	Not measured
									Hg*	≤ 1.70 µg/L	Not measured
									Mn*	≤ 1.300 mg/L	Not measured
									Pb hard*	≤ 13.0 µg/L	Not measured
									Se*	≤ 0.030 mg/L	Not measured
									Zn*	≤ 36.0 µg/L	Not measured
									Chorine*	≤ 5.0 µg/L free Cl	Not measured
									Endosulfan*	≤ 0.20 µg/L	Not measured
									Atrazine*	≤ 100.0 µg/L	Not measured
		Klipspruit (confluence with Olifants)	RU12	12	D	Quality	Toxins	Toxics should not be allowed to negatively impact on the ecosystem.	F*	≤ 3.00 mg/L	0.8
									Al*	≤ 0.150 mg/L	No data
									As *	≤ 0.130 mg/L	No data
									Cd hard*	≤ 5.0 µg/L	No data

									Cr(VI)*	≤ 200 µg/L	No data
									Cu hard*	≤ 8.0 µg/L	No data
									Hg**	≤ 1.70 µg/L	No data
									Mn*	≤ 1.300 mg/L	No data
									Pb hard*	≤ 13.0 µg/L	No data
									Se*	≤ 0.030 mg/L	No data
									Zn*	≤ 36.0 µg/L	No data
									Chorine*	≤ 5.0 µg/L free Cl	No data
									Endosulfan*	≤ 0.20 µg/L	No data
									Atrazine*	≤ 100.0 µg/L	No data
2	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31	C	Quality	Toxins	Toxics should not be allowed to negatively impact on the ecosystem or agricultural users.	F*	≤ 2.50 mg/L	0.5
									Al*	≤ 0.105 mg/L	No data
									As*	≤ 0.095 mg/L	No data
									Cd hard*	≤ 3.0 µg/L	No data
									Cr(VI)*	≤ 121 µg/L	No data
									Cu hard*	≤ 6.0 µg/L	No data
									Hg*	≤ 0.97 µg/L	No data
									Mn*	≤ 0.990 mg/L	No data
									Pb hard*	≤ 9.5 µg/L	No data
									Se*	≤ 0.022 mg/L	No data
									Zn*	≤ 25.2 µg/L	No data
									Chorine*	≤ 3.1 µg/L free Cl	No data
									Endosulfan*	≤ 0.13 µg/L	No data
									Atrazine*	≤ 78.5 µg/L	No data
3	II	Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D	Quality	Toxins	The concentrations of toxic substances must be improved to minimise toxic effects on the ecosystem and other users of the system.	F*	≤ 3.00 mg/L	0.5
									Al*	≤ 0.150 mg/L	No data
									As*	≤ 0.130 mg/L	No data
									Cd hard*	≤ 5.0 µg/L	No data
									Cr(VI)*	≤ 200 µg/L	No data
									Cu hard*	≤ 8.0 µg/L	No data
									Hg*	≤ 1.70 µg/L	No data
									Mn*	≤ 1.300 mg/L	No data
									Pb hard*	≤ 13.0 µg/L	No data
									Se*	≤ 0.030 mg/L	No data

									Zn*	≤ 36.0 µg/L	No data
									Chorine*	≤ 5.0 µg/L free Cl	No data
									Endosulfan*	≤ 0.20 µg/L	No data
									Atrazine*	≤ 100.0 µg/L	No data
5	III	One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Quality	Toxins	Toxic concentrations must not become excessive for the ecosystem and users.	F*	≤ 3.00 mg/L	1.192
									Al*	≤ 0.150 mg/L	No data
									As*	≤ 0.130 mg/L	No data
									Cd hard*	≤ 5.0 µg/L	No data
									Cr(VI)*	≤ 200 µg/L	No data
									Cu hard*	≤ 8.0 µg/L	No data
									Hg*	≤ 1.70 µg/L	No data
									Mn*	≤ 1.300 mg/L	No data
									Pb hard*	≤ 13.0 µg/L	No data
									Se*	≤ 0.030 mg/L	No data
									Zn*	≤ 36.0 µg/L	No data
									Chorine*	≤ 5.0 µg/L free Cl	No data
									Endosulfan*	≤ 0.20 µg/L	No data
									Atrazine*	≤ 100.0 µg/L	No data
6	III	Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D	Quality	Toxins	Toxics should be minimised to reduce the risk of human health and ecosystem impairment.	F*	≤ 2.00 mg/L	0.394
									Al*	≤ 0.063 mg/L	No data
									As*	≤ 0.058 mg/L	No data
									Cd hard*	≤ 1.6 µg/L	No data
									Cr(VI)*	≤ 68 µg/L	No data
									Cu hard*	≤ 4.9 µg/L	No data
									Hg*	≤ 0.53 µg/L	No data
									Mn*	≤ 0.680 mg/L	No data
									Pb hard*	≤ 5.8 µg/L	No data
									Se*	≤ 0.013 mg/L	No data
									Zn*	≤ 14.4 µg/L	No data
									Chorine*	≤ 1.8 µg/L free Cl	No data
									Endosulfan*	≤ 0.08 µg/L	No data
									Atrazine*	≤ 48.8 µg/L	No data
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Quality	Toxins	Toxicity levels must be minimised to protect community users and also fish.	F*	≤ 3.00 mg/L	Insufficient data

									Al*	≤ 0.150 mg/L	No data
									As*	≤ 0.130 mg/L	No data
									Cd hard*	≤ 5.0 µg/L	No data
									Cr(VI)*	≤ 200 µg/L	No data
									Cu hard*	≤ 8.0 µg/L	No data
									Hg*	≤ 1.70 µg/L	No data
									Mn*	≤ 1.300 mg/L	No data
									Pb hard*	≤ 13.0 µg/L	No data
									Se*	≤ 0.030 mg/L	No data
									Zn*	≤ 36.0 µg/L	No data
									Chorine*	≤ 5.0 µg/L free Cl	No data
									Endosulfan*	≤ 0.20 µg/L	No data
									Atrazine*	≤ 100.0 µg/L	No data
11	III	Ga-Selati (EWR site - EWR14b) (existing) and Ga-Selati (outlet of quaternary -outlet of IUA11)	RU103 RU104	103 and 104	D	Quality	Toxins	Toxicity must not pose a threat to local users.	F*	≤ 2.50 mg/L	3.5
									Al*	≤ 0.105 mg/L	No data
									As*	≤ 0.095 mg/L	No data
									Cd hard*	≤ 3.0 µg/L	No data
									Cr(VI)*	≤ 121 µg/L	No data
									Cu hard*	≤ 6.0 µg/L	No data
									Hg*	≤ 0.97 µg/L	No data
									Mn*	≤ 0.990 mg/L	No data
									Pb hard*	≤ 9.5 µg/L	No data
									Se*	≤ 0.022 mg/L	No data
									Zn*	≤ 25.2 µg/L	No data
									Chorine*	≤ 3.1 µg/L free Cl	No data
									Endosulfan*	≤ 0.13 µg/L	No data
									Atrazine*	≤ 78.5 µg/L	No data
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Quality	Toxins	Toxicity levels must not pose a threat to local users.	F*	≤ 2.50 mg/L	Insufficient data
									Al*	≤ 105 µg/L	No data
									As*	≤ 95 µg/L	No data
									Cd hard*	≤ 3.0 µg/L	No data
									Cr(VI)*	≤ 121 µg/L	No data
									Cu hard*	≤ 6.0 µg/L	No data
									Hg*	≤ 0.97 µg/L	No data
									Mn*	≤ 50 µg/L	No data

									Pb hard*	≤ 9.5 µg/L	No data
									Se*	≤ 2.0 µg/L	No data
									Zn*	≤ 2.0 µg/L	No data
									Chorine*	≤ 3.1 µg/L free Cl	No data
									Endosulfan*	≤ 0.13 µg/L	No data
									Atrazine*	≤ 78.5 µg/L	No data
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Quality	Pathogens	Concentrations of pathogens should be maintained at levels where downstream use is not compromised.	*E.coli**	≤ 130 counts/100 ml	No data
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Quality	Pathogens	Concentrations of pathogens should be maintained at levels where downstream use is not compromised.	*E.coli**	≤ 130 counts/100 ml	No data
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Quality	Pathogens	Concentrations of pathogens should be maintained at levels where downstream use is not compromised.	*E.coli**	≤ 130 counts/100 ml	No data
**as per standard methods of America Water Works Association (www.awwa.org)*											

Table 6: RQOs for RIVER HABITAT in priority RUs in the Olifants WMA

RIVER HABITAT										
IUA	**Class**	**River**	**RU**	**Node**	**REC**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**
1	III	Olifants (releases from Witbank Dam) and Klipspruit (confluence with Olifants)	RU9 RU12	9 and 12	D	Habitat	Instream Habitat	The instream habitat should be maintained in a suitable state to support the ecosystem.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
		Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D			Instream habitat needs to be improved to support the ecosystem and for ecotourism users.		RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification Score >60), and or maintenance of habitat for indicator species.
		Olifants	RU13	13	B					
2	II	Bronkhorstpruit (outlet from Nronkhorstspruit Dam)	RU24	24	C	Habitat	Instream Habitat	This habitat should be maintained to support the ecosystem, biodiversity, ecotourism and recreation.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification Score >60), and or maintenance of habitat for indicator species.
		Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31				The instream habitat should be maintained to support the ecosystem especially mammals, birds and amphibians/reptiles.		RHAM findings equate to ecosystem in a ≥C/D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Habitat	Instream Habitat	Instream habitat needs to be improved to support the ecosystem and for ecotourism users.	State of instream habitat according to Rapid Habitat	RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification
		Olifants (outlet of quaternary -	RU40	40	D					

		outlet of IUA3)							Assessment Method (RHAM)	Score >60), and or maintenance of habitat for indicator species.
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes and sustainable use.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes and maintain sustainable use of ecosystem services.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C					RHAM findings equate to ecosystem in a ≥C/D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Habitat	Instream Habitat	The habitat should be improved to maintain aquatic biodiversity and the trout industry.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification Score >60), and or maintenance of habitat for indicator species.
		Steelpoort (inflow to De Hoop Dam)	RU57	57	C	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification Score >60), and or maintenance of habitat for indicator species.
		Upper reaches of Dwars (before mining impacts)	RU62	62	C	Habitat	Instream Habitat	The habitat and in particular flows should be maintained to support ecosystem processes.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification Score >60), and or maintenance of habitat for indicator species.
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
7	III	Olifants (outlet quaternary - outlet of IUA7)	RU72	72	D	Habitat	Instream Habitat	The habitat should be maintained in a suitable state to support ecosystem processes and associated biota especially in relation to sedimentation.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes especially for fish.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥B category (equivalent to EcoClassification Score >80), and or maintenance of habitat for indicator species.
9	III	One node at outlet of B60F.	RU83	83	D	Habitat	Instream	The habitat should be improved to	State of instream	RHAM findings equate to

		Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary) and Ohrigstad (outlet of quaternary - outlet of IUA9)	RU86	and 86			Habitat	support ecosystem processes especially for fish.	habitat according to Rapid Habitat Assessment Method (RHAM)	ecosystem in a ≥C/D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
10	II	Olifants (confluence with Steelpoort) and Olifants (ERW11, confluence with Blyde) existing)	RU95 RU96	95 and 96	D	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes and associated biota especially in relation to sedimentation.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
		Olifants (outlet - outlet of IUA10)	RU98	98	C					
	II	Makhutswi, including Moungwana and Malomanye	RU97	97	C	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes in relation to sedimentation.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥C category (equivalent to EcoClassification Score >60), and or maintenance of habitat for indicator species.
11	III	Ga-Selati (EWR site - EWR14b) (existing) and Ga-Selati (outlet of quaternary - outlet of IUA11)	RU103 RU104	103 and 104	D	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes especially in relation to sedimentation and water quality modification.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Habitat	Instream Habitat	The habitat should be maintained to support ecosystem processes and associated biota in relation to sedimentation.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				Instream habitat needs to be maintained to contribute to the attainment of the recommended integrated C EcoStatus category as required by the WRC study.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥C/D category (equivalent to EcoClassification Score >40), and or maintenance of habitat for indicator species.
13	I	Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Habitat	Instream Habitat	A healthy instream habitat is essential for this ecosystem and should be maintained.	State of instream habitat according to Rapid Habitat Assessment Method (RHAM)	RHAM findings equate to ecosystem in a ≥B category (equivalent to EcoClassification Score >80), and or maintenance of habitat for indicator species.
1	III	Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D	Habitat	Riparian	The riparian habitat must be maintained as suitable for tourism and as habitat for biota.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥B/C category (equivalent to EcoClassification Score >60)
		Olifants	RU13	13	B					
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Habitat	Riparian	The riparian habitat must be maintained as suitable for tourism and as habitat for biota.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥B/C category (equivalent to EcoClassification Score >60)
1	III	Klipspruit (confluence with Olifants)	RU12	12	D	Habitat	Riparian	The riparian habitat must be maintained to buffer the aquatic ecosystem from land-use impacts.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥D category (equivalent to EcoClassification Score >40)

2	III	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)	RU24	24	C	Habitat	Riparian	The riparian habitat must be maintained to support biodiversity important for ecotourism and recreational purposes.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥C/D category (equivalent to EcoClassification Score >40)
	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31				The riparian habitat must be maintained as suitable habitat for biota.		VEGRAI (Level III) in ≥ C category (equivalent to EcoClassification Score >60)
5	III	Olifants (releases from Flag Boshielo Dame) and Olifants (outlet of quaternary - outlet of IUA5)	RU 52, 53	52 and 53	D	Habitat	Riparian	The riparian habitat must be maintained to support biota and ecosystem functions and provide benefits to local and downstream communities.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥C/D category (equivalent to EcoClassification Score >40)
6	III	Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU 66	66	D	Habitat	Riparian	The riparian habitat must be maintained to facilitate the assimilation of waste, provide habitat for aquatic biota and buffer the aquatic ecosystem from land-use impacts.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥D category (equivalent to EcoClassification Score >40)
7	III	Olifants (outlet of quaternary - outlet at IUA7)	RU72	72	D	Habitat	Riparian	The riparian habitat should be maintained to support biota and ecosystem functions, particularly sediment retention and the stabilisation of banks.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥D category (equivalent to EcoClassification Score >40)
10	II	Olifants (confluence with Steelpoort) and Olifants (ERW11, confluence with Blyde) existing)	RU95 RU96	95 and 96	D	Habitat	Riparian	The riparian vegetation must be maintained/improved to provide habitat for instream and riparian biota and to support ecosystem functions, particularly the stabilisation of banks.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥D category (equivalent to EcoClassification Score >40)
		Olifants (outlet of quaternary - outlet of IUA10)	RU98	98	C					
11	III	Ga-Selati (EWR site - EWR1b) (existing) and Ga-Selati (outlet of quaternary - outlet of IUA11)	RU 103, 104	103 and 104	D	Habitat	Riparian	The riparian vegetation must be maintained to provide habitat for instream and riparian biota and to support ecosystem functions, particularly the stabilisation of banks.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level IV) in ≥D category (equivalent to EcoClassification Score >40)
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Habitat	Riparian	The riparian habitat should be maintained to support biota and ecosystem functions, particularly sediment retention and the stabilisation of banks.	The high flow period, when floods are likely, should be avoided.	VEGRAI (Level III) in ≥D category (equivalent to EcoClassification Score >40)
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				The riparian vegetation must be improved to ensure that the biodiversity of KNP is retained and the EcoStatus category required by the WRC study is met.		VEGRAI (Level IV) in ≥A/B category (equivalent to EcoClassification Score >80)

Table 7: RQOs for RIVER BIOTA in priority RUs in the Olifants WMA

RIVER BIOTA

IUA	Class	River	RU	Node	REC	Component	Sub Component	RQO	Indicator/ measure	Numerical Limits
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Biota	Fish	Fish community wellbeing must be maintained to sustainable levels.	State of fish populations according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))
2	II	Bronkhorstspruit (outlet from Bronkhorstspruit Dam) and Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU24 RU31	24 31	C	Biota	Fish	Fish communities should be maintained so that they include viable populations of ecologically important species.	State of fish populations according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥60 (≥C category (equivalent to EcoClassification Score >60))
									State of critical instream habitat for the Bushveld small-scale yellowfish *(Labeobarbus polylepis)* and the Stargazer mountain catfish *(Amphilius uranoscopus)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
		Wilge (confluence with Bronkhorstspruit)	RU27	27					State of critical instream habitat for the Bushveld small-scale yellowfish *(Labeobarbus polylepis)* and the Stargazer mountain catfish *(Amphilius uranoscopus)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
3	II	Kranspoortspruit (EWR site - EWR3) (existing)	RU35	35	B	Biota	Fish	Fish communities should be improved so that they include viable populations of ecologically important species.	State of critical instream habitat for the Hyphen barb (*Barbus sp.*) and the Stargazer mountain catfish *(Amphilius uranoscopus)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			Provision of suitable flows, water quality, habitat and ecological cues to maintain species is required to improve the state to better than sustainable levels.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥50 (≥C/D category (equivalent to EcoClassification Score >40))
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Biota	Fish	The fish condition should be maintained to sustainable levels in support of the ecosystem and for community use.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Biota	Fish	The fish condition should be maintained to sustainable levels in support of the ecosystem and for	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))

								community use.		
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Biota	Fish	The fish condition should be maintained to sustainable levels in support of the ecosystem and for community use.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥60 (≥C category (equivalent to EcoClassification Score >60))
		Olifants (releases from Flag Boshielo Dame)	RU52	52	D	Biota	Fish	Fish communities should be improved so that they include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥60 (≥C category (equivalent to EcoClassification Score >60))
									State of critical instream habitat for the local mudfish and yellowfish (*Lebeo spp.* and *Labeobarbus spp.*) according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
		Olifants (outlet of quaternary - outlet of IUA5)	RU53	53					State of critical instream habitat for the local mudfish and yellowfish (*Lebeo spp.* and *Labeobarbus spp.*) according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Biota	Fish	Fish communities should be maintained to support the ecosystem and angling industry.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥60 (≥C category (equivalent to EcoClassification Score >60))
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D			Fish communities should be improved to support the ecosystem and as food for local communities.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥50 (≥C/D category (equivalent to EcoClassification Score >40))
7	III	Olifants (outlet quaternary - outlet of IUA7)	RU72	72	D	Biota	Fish	Fish communities should be maintained to support the ecosystem and as food for local communities.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥50 (≥C/D category (equivalent to EcoClassification Score >40))
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Biota	Fish	Fish communities should be maintained to a good condition and should include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥80 (≥B category (equivalent to EcoClassification Score >80))
									State of critical instream habitat for the local Southern dwarf minnow *(Opsaridium peringueyi)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥B ecological category (equivalent to EcoClassification Score >80).
9	III	One node at outlet of	RU83	83	D	Biota	Fish	Fish communities should be	State of fish communities	FRAI Score ≥40 (≥D category

		B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary)						maintained so that they include viable populations of ecologically important species.	according to Fish Response Assessment Index (FRAI) Score.	(equivalent to EcoClassification Score >40))
									State of critical instream habitat for the Barbus sp. "Ohrigstad" according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥B ecological category (equivalent to EcoClassification Score >80).
	III	Ohrigstad (outlet of quaternary - outlet of IUA9)	RU86	86	D	Biota	Fish	Fish communities should be maintained so that they include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥50 (≥C/D category (equivalent to EcoClassification Score >40))
									State of critical instream habitat for the *Barbus sp.* "Ohrigstad" according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥B ecological category (equivalent to EcoClassification Score >80).
10	II	Blyde (EWR site - EWR12) (existing)	RU88	88	B	Biota	Fish	Fish communities should be maintained so that they include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥80 (≥B category (equivalent to EcoClassification Score >80))
									State of critical instream habitat for the local Southern dwarf minnow *(Opsaridium peringueyi)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥B ecological category (equivalent to EcoClassification Score >80).
		Mohlapitse (upper reaches)	RU93	93		Biota	Fish	Fish communities should be maintained so that they include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥80 (≥B category (equivalent to EcoClassification Score >80))
									State of critical instream habitat for the Shortspine catlet *(Chiloglanis pretoriae)* and the local Southern dwarf minnow *(Opsaridium peringueyi)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥B ecological category (equivalent to EcoClassification Score >80).
		Olifants (confluence with Steelpoort)	RU95 RU98	95 98	D	Biota	Fish	The fish community must be kept in a sustainable condition.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))
		Olifants (EWR11, confluence with Blyde) (existing)	RU96	96						
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	103	D	Biota	Fish	The fish community must be kept in a sustainable condition including providing access to upper Ga-Selati.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))

		Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104					State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Biota	Fish	The fish community must be kept in a sustainable condition.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				Fish communities should be maintained/improved so that they include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥40 (≥D category (equivalent to EcoClassification Score >40))
									State of critical instream habitat for the local tigerfish population *(Hydrocynus vittatus)* according to Rapid Habitat Assessment Method (RHAM).	Maintenance of critical habitat for indicator species in a state equivalent to ≥B ecological category (equivalent to EcoClassification Score >80).
13	I	Blyde (confluence with Lisbon)	RU117	117	C	Biota	Fish	Fish communities should be improved so that they include viable populations of ecologically important species.	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥80 (≥B category (equivalent to EcoClassification Score >80))
									Population structure of Treur River barb *(Barbus treurensis),* using electrofishing and small mesh and large mesh seine netting.	Maintenance of critical habitat for indicator species in ≥B ecological category (equivalent to EcoClassification Score >80).
		Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Biota	Fish	Fish communities should be maintained in a good condition so that they include viable populations of ecologically important species. .	State of fish communities according to Fish Response Assessment Index (FRAI) Score.	FRAI Score ≥80 (≥B category (equivalent to EcoClassification Score >80))
									Population structure of Treur River barb *(Barbus treurensis),* using electrofishing and small mesh and large mesh seine netting.	Maintenance of critical habitat for indicator species in ≥B ecological category (equivalent to EcoClassification Score >80).
1	III	Olifants (EWR site 1 - EWR1) (existing) and Klipspruit (confluence with Olifants)	RU11 and RU12	11 and 12	D	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained at sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to ≥D ecological category (equivalent to EcoClassification Score >40).
		Olifants	RU13	13	B			Aquatic invertebrates must be maintained at sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the	MIRAI Score ≥D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to

									SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	≥D ecological category (equivalent to EcoClassification Score >40).
2	II	Bronkhorstpruit (outlet from Nronkhorstspruit Dam) and Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU24 RU31	24 and 31	C	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained to healthy levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥C category (equivalent to EcoClassification Score >60) and maintenance of critical habitat for invertebrates in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Biota	Aquatic invertebrates	Aquatic invertebrates must be improved to healthy levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥C/D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to ≥C/D ecological category (equivalent to EcoClassification Score >40).
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D				State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥C category (equivalent to EcoClassification Score >60) and maintenance of critical habitat for invertebrates in a state equivalent to ≥D ecological category (equivalent to EcoClassification Score >40).
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained to sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to ≥D ecological category (equivalent to EcoClassification Score >40).
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained/improved to sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to ≥D ecological category (equivalent to EcoClassification Score >40).
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C					
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and	RU54	54	C	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained at sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the	MIRAI Score ≥C/D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state

		Langspruit, including Lakenvleispruit and Kleinspruit							SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	equivalent to ≥C/D ecological category (equivalent to EcoClassification Score >40).
		Steelpoort (inflow to De Hoop Dam) and Upper reaches of Dwars (before mining impacts)	RU57 RU62	57 and 62				Aquatic invertebrates must be maintained to healthy levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥C category (equivalent to EcoClassification Score >60) and maintenance of critical habitat for invertebrates in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D			Aquatic invertebrates must be maintained to sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to ≥D ecological category (equivalent to EcoClassification Score >40).
11	II	Ga-Selati (EWR site - EWR14b) (existing) and Ga-Selati (outlet of quaternary -outlet of IUA11)	RU103 RU104	103 and 104	D	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained to sustainable levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥D category (equivalent to EcoClassification Score >40) and maintenance of critical habitat for invertebrates in a state equivalent to ≥D ecological category (equivalent to EcoClassification Score >40).
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Aquatic invertebrates	Aquatic invertebrates must be maintained to healthy levels.	State of aquatic invertebrates according to Macroinvertebrate Response Assessment Index (MIRAI) Score, using the SASS5 sampling method and maintenance of critical habitat according to Rapid Habitat Assessment Method (RHAM).	MIRAI Score ≥C category (equivalent to EcoClassification Score >60) and maintenance of critical habitat for invertebrates in a state equivalent to ≥C ecological category (equivalent to EcoClassification Score >60).
5	III	Olifants (releases from Flag Boshielo Dam) and Olifants (outlet of quaternary - outlet if IUA5)	RU52 RU53	52 and 53	D	Biota	Diatoms	Diatom communities should be maintained at sustainable levels indicating an ecosystem in similar condition.	Diatom community structure according to Specific Pollution sensitivity Index (SPI) Score, using sampling method as per Taylor et al (2005).	SPI score ≥C/D category (equivalent to EcoClassification Score >40)
9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary) and Ohrigstad (outlet of quaternary - outlet of	RU83 RU86	83 and 86	D	Biota	Diatoms	Diatom communities should be maintained at sustainable levels indicating an ecosystem in similar condition.	Diatom community structure according to Specific Pollution sensitivity Index (SPI) Score, using sampling method as per Taylor et al (2005).	SPI score ≥C/D category (equivalent to EcoClassification Score >40)

		IUA9)								
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Diatoms	Diatom communities should be maintained to health levels indicating an ecosystem in similar condition.	Diatom community structure according to Specific Pollution sensitivity Index (SPI) Score, using sampling method as per Taylor et al (2005).	SPI score ≥C category (equivalent to EcoClassification Score >60)
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Periphyton	Periphyton must be in a condition which does not reflect eutrophic conditions.	Diatoms as indicator of water quality impacts on periphyton according to Specific Pollution sensitivity Index (SPI) Score	SPI-Score of 8.9-9.1
7	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Biota	Birds	Riparian and aquatic bird communities must be maintained in a suitable ecological state.	Community structure based on diversity and abundance**	Outcomes must be related to ≥C/D category (equivalent to EcoClassification Score >40)
		Olifants (outlet of quaternary - outlet of IUA5)	RU53	53						
		Olifants (outlet of quaternary - outlet of IUA7)	RU72	72						
10	II	Olifants (confluence with Steelpoort)	RU95	95	D	Biota	Birds	Riparian and aquatic bird communities must be maintained in a suitable ecological state.	Community structure based on diversity and abundance**, and habitat requirements for indicator species.	Outcomes must be related to ≥C/D category (equivalent to EcoClassification Score >40) and indicator habitat in largely natural ≥C ecological category (equivalent to EcoClassification Score >60) with at least 10 species of aquatic birds present.
		Olifants (EWR11, confluence with Blyde) (existing)	RU96	96						Outcomes must be related to ≥B category (equivalent to EcoClassification Score >80) and indicator habitat in largely natural ≥B ecological category (equivalent to EcoClassification Score >80) with at least 30 species of aquatic birds present.
10	II	Olifants (outlet of quaternary - outlet of IUA10)	RU98	98	C	Biota	Birds	Riparian and aquatic bird communities must be maintained in a suitable ecological state.	Community structure based on diversity and abundance**, and habitat requirements for indicator species.	Outcomes must be related to ≥B category (equivalent to EcoClassification Score >80) and indicator habitat in largely natural ≥B ecological category (equivalent to EcoClassification Score >80) with at least 35 species of aquatic birds present.
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Biota	Birds	Riparian and aquatic bird communities must be maintained in a suitable ecological state.	Community structure based on diversity and abundance**, and habitat requirements for indicator species.	Outcomes must be related to ≥B category (equivalent to EcoClassification Score >80) and indicator habitat in largely natural ≥B ecological category (equivalent to EcoClassification Score >80) with at

										least 45 species of aquatic birds present.
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				Riparian and aquatic bird communities must be maintained in a suitable ecological state.	Community structure based on diversity and abundance**, and habitat requirements for indicator species.	Outcomes must be related to ≥B category (equivalent to EcoClassification Score >80) and indicator habitat in largely natural ≥A/B ecological category (equivalent to EcoClassification Score >80) with at least 45 species of aquatic birds present.
5	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Biota	Amphibians and Reptiles	A viable population of crocodiles must be maintained.	Population structure assessment using validated methodologies.	Annual successful recruitment required and local population must maintain >150 individual animals.
		Olifants (outlet of quaternary - outlet of IUA5)	RU53	53	D	Biota	Amphibians and Reptiles	A viable population of crocodiles must be maintained.	Population structure assessment using validated methodologies.	Annual successful recruitment of more than >150 individual animals.
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Amphibians and Reptiles	Amphibians and reptiles should be maintained in near natural condition.	Community structure using validated methodologies based on diversity and abundance of indicator species.	In the case of crocodiles: hatchlings and yearlings 5-8% of the total population; pre-reproductive (2-5 year old) 30% of total population; reproductive (5-40 year old) 45-47% of total population; dominant animals (40- >90 year old) 8-10% of total population (approximately 7% of the total population is unsized because these individuals were unspotted or difficult to spot.)
									Annual successful recruitment required (crocodiles)	Annual successful recruitment of more than >200individual animals.
7	III	Olifants (outlet at quaternary - outlet at IUA7)	RU72	72	D	Biota	Plants	The populations of rare and endemic plant species and those used by local people must be maintained.	Wellbeing of selected plant species according to population structure * and Vegetation Response Assessment Index (VEGRAI).	VEGRAI (Level IV) in ≥C category (equivalent to EcoClassification Score >60) and no significant shift in community structures.
10	II	Olifants (confluence at Steelpoort)	RU95	95						
10	II	Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D	Biota	Mammals	The local Hippopotamus population must remain in a viable state.	Hippopotamus and other riparian mammals population structure using approved methodologies. Hippo census with a helicopter.	Hippos in this reach should not become less than 6 individuals of at least 5 cows and one bull.
		Olifants (outlet - outlet of IUA10)	RU98	98	C					
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Biota	Mammals	The local Hippopotamus population must remain in a viable state.	Hippopotamus and other riparian mammals population structure using approved methodologies. Hippo census with a helicopter.	Hippos in this reach should not become less than 6 individuals of at least 5 cows and one bull.
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				The local Hippopotamus population must remain in a viable state.	Hippopotamus and other riparian mammals population structure using approved methodologies. Hippo census	Hippos in this reach should not become less than 6 individuals of at least 5 cows and one bull.

									with a helicopter.	
*** Data obtained from bird clubs and conservation authorities and measured as per methods prescribed by Avian Demography Unit, Department of Statistical Sciences University of Cape Town or Birdlife SA.*										

4.1.2 SUPPLEMENTARY INFORMATION FOR THE RIVER RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 8: Supplementary information for RIVER WATER QUANTITY in priority RUs in the Olifants WMA.

RIVER WATER QUANTITY										
IUA	**Class**	**River**	**RU**	**Node**	**REC**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**	**Reference**
1	III	Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D	Quantity	Low Flows	Low flows are necessary to maintain the river habitat for ecotourism and the ecosystem. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001
	III	Klipspruit (confluence with Olifants	RU12	12	D	Quantity	Low Flows	Low flows in this river are negatively affected by industrial and urban users and is having a significant impact on ecosystem functioning. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWA, 2012
	III	Olifants	RU13	13	B	Quantity	Low Flows	Low flows are necessary to maintain the river habitat for ecotourism and to maintain the ecosystem. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001 (extrapolated from Olifants EWR1 in B11J)

2	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31	B	Quantity	Low Flows	Low flows are necessary to maintain the river habitat and so to maintain the ecosystem. These are under threat from upstream activities including agriculture and urban areas. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quantity	Low Flows	Flow alterations by dam releases together with abstractions for agriculture activities have reduced the flows in this river. This is impacting negatively on the ecosystem functioning as well as on ecotourism. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001 (extrapolated from Klein Olifants EWR3 in B12E)
	II	Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	C	Quantity	Low and High Flows	Low flows are under stress due to Loskop Dam upstream, releases and abstraction for agriculture. This is having a negative impact on the ecosystem which is presently being compromised by insufficient flows. Percentiles associated with low flows specify duration requirements. High flows are important to maintain ecosystem functionality especially to mitigate the negative impacts of inadequate low flows and to provide ecological cues for fish. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.	Not Applicable	DWAF, 2001
4	III	Elands (outlet of quaternary -	RU46	46	D	Quantity	Low and	Low flows and in particular the timing of such low flows, are	Not Applicable	DWAF, 2001

		outlet of IUA4)					High Flows	necessary to maintain the ecosystem and to meet basic human needs. This is being negatively impacted by Mkhombo Dam releases for agriculture, urban developments and informal settlements. Percentiles associated with low flows specify duration requirements.		
								Freshets should be ensured in the river to improve the ecosystem that is negatively impacted by Mkhombo Dam upstream. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.		
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Quantity	Low and High Flows	Low flows and in particular the timing of such low flows, are necessary to maintain the ecosystem and to meet basic human needs. This is being negatively impacted by Mkhombo Dam releases for agriculture, urban developments and informal settlements. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001 (extrapolated from Elands EWR6 in B31G)
								Freshets should be ensured in the river to improve the ecosystem that is negatively impacted by Mkhombo Dam upstream. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.		
	III	One node at confluence with Olifants. Included: B32G (Moses) and B32H (Mametse and Moses)	RU49	49	C	Quantity	Low Flows	Low flows are important to maintain the ecosystem structure and function, however the demands by agriculture are high. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWA, 2012
	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Quantity	Low Flows	Releases from Flag Boshielo Dam are having impacts on the low flows which are important for maintenance of the ecosystem and for provision of water for users especially in the dry season. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001

	III	Olifants (outlet of quaternary - outlet of IUA5)	RU53	53	D	Quantity	Low Flows	Releases from the upstream Flag Boshelo Dam are having impacts on the low flows which are important for maintenance of the ecosystem and for provision of water for users especially in the dry season. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001 (extrapolated from Olifants EWR7 in B51C)
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Quantity	Low Flows	Abstraction for agriculture & flow modification by forestry predominantly has resulted in poor low flows which are considered to be insufficient to maintain the ecosystem functionality and local trout industry which is the major local tourism/recreational activity. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWA, 2012
	III	Steelpoort (inflow to De Hoop Dam)	RU57	57	C	Quantity	Low Flows	Low flows are important for maintenance of the ecosystem structure and function, however they are being impacted by mines and irrigated agriculture. Percentiles associated with low flows specify duration requirements.	Not Applicable	Rapid Reserve as part of WRC study, extrapolated from OLI-EWR2 in B41B
	III	Upper reaches of Dwars (before mining impacts)	RU62	62	C	Quantity	Low Flows	Low flows are important for maintaining ecosystem structure and function and for peri-urban users however	Not Applicable	Intermediate Ecological Reserve

								they are presently under stress due to mining activities in the catchment. Percentiles associated with low flows specify duration requirements.		assessment (BKS 2008)
	III	Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D	Quantity	Low Flows	Low flows are important for ecosystem structure and function and also for irrigated agriculture, rural and peri-urban communities. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001
7	III	Olifants (outlet of quaternary - outlet of IUA7)	RU72	72	D	Quantity	Low and High Flows	Abstraction by multiple users including water institutions, agriculture and peri-urban users affecting the low flows. Percentiles associated with low flows specify duration requirements. Freshets are essential for maintenance of the ecosystem . The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.	Not Applicable	DWAF, 2001 (extrapolated from Olifants EWR8 in B71B)
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Quantity	Low Flows	Urban use and irrigated agriculture are placing stress on the volume of water in the system. This is a FEPA fish support area which requires suitable low flows to provide refuge for fish. Percentiles associated with low flows specify duration requirements.	Not Applicable	Rapid Reserve as part of WRC study, extrapolated from OLI-EWR5 in B42G

9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary)	RU83	83	D	Quantity	Low and High Flows	Low flows are in a poor condition and yet are needed to maintain fish in particular but the ecosystem as a whole as well. Percentiles associated with low flows specify duration requirements. Freshets are also required to provide cues for fish breeding. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.	Not Applicable	Rapid Reserve as part of WRC study, extrapolated from OLI-EWR8 in B60H
	III	Ohrigstad (EWR site - OLI-EWR8) (Rapid site)	RU86	86	C	Quantity	Low and High Flows	Low flows are in a poor condition and yet are needed to maintain fish in particular but the ecosystem as a whole as well. Percentiles associated with low flows specify duration requirements. Freshets are also required to provide cues for fish breeding	Not Applicable	Rapid Reserve as part of WRC study - OLI-EWR8 in B60H
10	II	Olifants (confluence with Steelpoort)	RU95	95	D	Quantity	Low and High Flows	Abstraction by multiple users including water institutions, agriculture and peri-urban users affecting the low flows. Percentiles associated with low flows specify duration requirements. Freshets are essential for maintenance of the ecosystem. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.	Not Applicable	DWAF, 2001 (extrapolated from Olifants EWR8 in B71B)
	II	Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D	Quantity	Low and High Flows	Low flows are impacted by upstream abstractions and dam releases. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001

								Freshets are essential for maintenance of the ecosystem. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.		
	II	Makhutswi, including Moungwana and Malomanye	RU97	97	C	Quantity	Low Flows	This is a highly seasonal river with rural/peri-urban communities that depend on local water resources for basic human needs. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWA, 2012
	II	Olifants (outlet - outlet of IUA10)	RU98	98	C	Quantity	Low and High Flows	Low flows are impacted by upstream abstractions and dam releases. Percentiles associated with low flows specify duration requirements. Freshets are essential for maintenance of the ecosystem. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.	Not Applicable	DWAF, 2001 (extrapolated from Olifants EWR13 in B72D)
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	103	D	Quantity	Low Flows	Upstream agriculture, mining and releases from WWTW are having a negative impact on low flows. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001

	III	Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104	D	Quantity	Low Flows	Upstream agriculture, mining and releases from WWTW are having a negative impact on low flows. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Quantity	Low and High Flows	Low flows are impacted by upstream abstractions and dam releases. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001
								Freshets are essential for maintenance of the ecosystem. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.		
	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Quantity	Low and High Flows	Low flows are impacted by upstream abstractions and dam releases. Percentiles associated with low flows specify duration requirements.	Not Applicable	DWAF, 2001
								Freshets are essential for maintenance of the ecosystem. The high flow requirements include flood and freshet flows and their associated flow duration requirements which are defined by the percentiles associated with the numerical limits of flows.		
13	I	Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Quantity	Low and High Flows	This RU is prioritised for protection of the natural ecosystem. Percentiles associated with low flows specify duration requirements.	Not Applicable	IUCN, 2008

								Provision of the freshets are critical for maintaining the protected status of the ecosystem . To maintain the minimum flow in the river the standard 99 percentile rule has been applied which requires that discharge does not reduce below this threshold.		

Table 9: Supplementary information for RIVER QUALITY in priority RUs in the Olifants WMA.

RIVER WATER QUALITY											
IUA	**Class**	**River**	**RU**	**Node**	**REC**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**		**Reference**
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	Nutrients	Stress from upstream polluters requires that nutrient concentrations be maintained in the river at mesotrophic or better levels thus minimising water treatment costs and protecting ecosystem functioning. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate(PO_4)*	0.075 mg/L P	DWAF, 2008
									Nitrate (NO_3) & Nitrite (NO_2)*	2.50 mg/L N	
									Total Ammonia*	86 µg/L N	
		Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D			High nutrient concentrations are putting pressure on the ecosystem functioning and appearance of the river for tourism. Nutrient concentrations should be maintained at a C category where such nuisance conditions are not fostered. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate(PO_4)*	0.075 mg/L P	DWAF, 2008
									Nitrate (NO_3) & Nitrite (NO_2)*	2.50 mg/L N	
									Total Ammonia*	86 µg/L N	
		Klipspruit (confluence with Olifants)	RU12	12	D			High concentrations of nutrients are placing stress on the ecosystem and reducing fitness for use. These nutrients are associated with eMalahleni communities and Wastewater Treatment Works. The nutrient concentrations thus need to be improved to a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate (PO_4)*	0.075 mg/L P	DWAF, 2008
		Olifants	RU13	13	B			High nutrient concentrations are putting pressure on the ecosystem functioning and appearance of the river for tourism. Nutrient concentrations should be maintained at a C category where such	Nitrate (NO_3) & Nitrite (NO_2)*	0.48 mg/L N	DWAF, 2008
									Phosphate (PO_4)*	0.010 mg/L P	

								nuisance conditions are not fostered. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quality	Nutrients	Stresses from upstream Wastewater Treatment Works are changing the instream ecosystem. Nutrients need to be maintained in a C category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate (PO_4)*	0.020 mg/L P	DWAF, 2008
									Nitrate (NO_3) & Nitrite (NO_2)*	0.85 mg/L N	
									Ammonium*	58 µg/L N	
5	III	One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Quality	Nutrients	High nutrient enrichment from upstream Wastewater Treatment Works and agriculture may be affecting important ecological processes and fitness for use. Source from Wastewater Treatment Works, agriculture activities. The nutrient condition should be improved to a C category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate (PO_4)*	0.020 mg/L P	DWAF, 2008
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Quality	Nutrients	Nutrient stresses associated with Wastewater Treatment Works in this relatively intolerant area of the Steelpoort have been identified. Excessive nutrients are negatively impacting on ecosystem structure and function and the local trout fishing industry and associated ecotourism. The nutrient concentrations should be maintained in a C/D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Nitrate (NO_3) & Nitrite (NO_2)*	0.85 mg/L N	DWAF, 2008
									Phosphate (PO_4)*	0.020 mg/L P	
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	64	D			Excessive nutrient enrichment is present in this RU mainly from upstream Wastewater Treatment Works. This is threatening the ecosystem so the nutrients should be maintained in a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate (PO_4)*	0.075 mg/L P	DWAF, 2008
9	III	One node at outlet of B60F. Included: Kranskloofspruit,	RU83 RU86	83 and 86	D	Quality	Nutrients	Nutrients need to be minimised in order to ensure that the system is maintained in a mesotrophic C/D category. Where available the 95%ile of	Nitrate (NO_3)*	2.50 mg/L N	DWAF, 2008

		Mantshibi, Ohrigstad (outlet of quaternary) and Ohrigstad (outlet of quaternary - outlet of IUA9)						observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			
								Nutrients need to be minimised in order to ensure that the system is maintained in a mesotrophic C/D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Phosphate (PO_4)*	0.075 mg/L P	DWAF, 2008
1	III	Olifants (releases from Witbank Dam) and Olifants (EWR site 1 - EWR1) (existing)	RU9 RU11	9 and 11	D	Quality	Salts	Salts: There is a progressive increase in salt concentrations including sulphate due to upstream mines. Salt concentrations need to be maintained at D category level. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Sulphates*	350 mg/L	Golder Associates, 2013
								There is a progressive increase in salt concentrations including sulphate due to upstream mines. Salt concentrations need to be maintained at D category level. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Electrical conductivity*	98 mS/m	DWAF, 2008
		Olifants	RU13	13	B			There is a progressive increase in salt concentrations including sulphate due to upstream mines. Salt concentrations need to be maintained at D category level. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Sulphates*	65 mg/L	Golder Associates, 2013
									Electrical conductivity*	43 mS/m	DWAF, 2008
	III	Klipspruit (confluence with Olifants)	RU12	12	D			Salinity in the water which is associated with industries and mines is excessive. This salt is negatively impacting on ecosystem function and the suitability of water for domestic use by informal communities using the water for basic human needs and vegetable/livestock watering. Salt concentrations need to be improved to a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Electrical conductivity*	98 mS/m	DWAF, 2008
									Sulphates*	350 mg/L	Golder Associates, 2013
2	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31	C	Quality	Salts	Salts from upstream activities and in particular episodic spikes in sulphate concentrations are a	Sulphates*	140 mg/L	Golder Associates,

								threat to the river ecosystem and also to agricultural users. Overall salt and sulphate concentrations (mean or median but also maximum concentrations) need to be improved to C/D category levels that do not threaten the ecosystem. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			2013
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quality	Salts	Upstream mine activities are having a negative impact on the salt concentrations in the river which is in turn having a negative impact on salt-intolerant organisms in the river. Accordingly salts need to be improved to a C/D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Sulphates*	140 mg/L	Golder Associates, 2013
									Electrical conductivity*	70 mS/m	DWAF, 2008
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			Salts: Salts in the river water arising from upstream activities in particular mining are of concern for maintenance of the ecosystem and also for agricultural users. Concentrations and also maxima of salt in particular sulphate should be maintained in a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Sulphates*	350 mg/L	Golder Associates, 2013
									Electrical conductivity*	98 mS/m	DWAF, 2008
5	III	Olifants (releases from Flag Boshielo Dam) and Olifants (outlet of quaternary - outlet of IUA5)	RU52 and RU53	52 and 53	D	Quality	Salts	Salts: Salts from upstream activities including agriculture, Wastewater Treatment Works and mining are a threat to the river ecosystem and also to users. Overall salt and sulphate concentrations (mean or median but also maximum concentrations) need to be maintained at *D category* levels that do not threaten the ecosystem or users of the water. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Sulphates*	350 mg/L	Golder Associates, 2013
								Salts: Salts from upstream activities including agriculture, Wastewater Treatment Works and mining are a threat to the river ecosystem and also to users. Overall salt and sulphate concentrations (mean or median but also maximum concentrations) need to be maintained at D category levels that do not threaten the	Electrical conductivity*	98 mS/m	DWAF, 2008

								ecosystem or users of the water. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			
6	III	Upper reaches of Dwars (before mining impacts)	RU62	62	C	Quality	Salts	Salt loads associated with upstream mining activities are in an elevated state and should be improved to a C category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Electrical conductivity*	70 mS/m	DWAF, 2008
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	130	D	Quality	Salts	Excessive salinisation associated with mining and upstream activities are negatively impacting on this RU. Salt concentrations must be improved to a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Electrical conductivity*	98 mS/m	DWAF, 2008
		Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104				Excessive salinisation associated with mining and upstream activities are negatively impacting on this RU. Salt concentrations must be improved to a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Electrical conductivity*	98 mS/m	
									Sulphates*	350 mg/L	
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	System Variables	Current pH, alkalinity concentrations and associated acidity are important issues in this RU because of acid mine drainage which is negatively impacting on the ecosystem. The lack of alkalinity is potentially reaching a tipping point where there would be no buffering allowing pH to drop dramatically causing acidity to rise. Alkalinity must be maintained at concentrations which do not allow for a dramatic rise in acidity. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Alkalinity*	60 mg/L CaCO3	DWAF, 2008
									Turbidity*	10.0 NTU	
									Dissolved oxygen*	5 mg/L O2	
		Klipspruit (confluence with Olifants)	RU12	12	D			Reduced flows are negatively affecting temperatures and dissolved oxygen levels which in turn put stress on the ecosystem. Alkalinity associated with acid mine drainage is unnaturally low and poses a risk for future acidity of the river. Temperature and dissolved oxygen should be maintained in the river at a D category but the	Temperature*	3 deg C	
									Dissolved oxygen*	5 mg/L O2	
									Alkalinity*	60 mg/L CaCO3	

								alkalinity should be stabilised at present concentrations or ideally improved. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Quality	System Variables	Upstream mining activities have negatively impacted on the alkalinity levels in the river which renders the river vulnerable to rapid acidification. The alkalinity should thus be improved to a C/D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Alkalinity*	60 mg/L CaCO3	DWAF, 2008
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			Upstream activities including the presence of the dam are having an impact on instream oxygen concentrations as well as reducing alkalinity of the water which introduces the risk of future acidity. Negative impacts are already manifesting in the ecosystem as well as agriculture and for recreational users. Dissolved oxygen and alkalinity should be maintained in a C/D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Temperature*	3 deg C	
									Dissolved oxygen*	5 mg/L O2	
									Alkalinity*	60 mg/L CaCO3	
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Quality	System Variables	Insufficient river flows are leading to a rise in water temperature, compounded by nutrient levels which result in a drop in dissolved oxygen. Temperatures and dissolved oxygen are important to maintain the ecosystem and trout industry in particular and should be improved to a C category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Temperature*	≤ abs(dev from ambient) 1 deg C	DWAF, 2008
									Dissolved oxygen*	7 mg/L O2	
7	III	Olifants (outlet quaternary - outlet of IUA7)	RU72	72	D	Quality	System Variables	Excessive sediment is an issue in this RU. Sedimentation of riverine habitats and also the difficulties associated with the use of sediment-laden water needs to be managed. Sediment concentrations should thus not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on water institutions. Where available the 95%ile of observed or	Suspended solids*	38 mg/L	DWAF, 2008

								modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			
10	II	Olifants (confluence with Steelpoort)	RU95	95	D	Quality	System Variables	Excessive sediment is an issue in this RU. Sedimentation of riverine habitats and also the difficulties associated with the use of sediment-laden water needs to be managed. Sediment concentrations should thus not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on water institutions. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Turbidity (NTUs)*	10.0 NTU	DWAF, 2008
		Olifants (outlet - outlet of IUA10)	RU98	98	C				Suspended solids*	23 mg/L	
		Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D			Sedimentation of riverine habitats and also the difficulties associated with the use of sediment-laden water must be managed. Sediment concentrations should thus not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on fitness for use for water institutions. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Suspended solids*	38 mg/L	DWAF, 2008
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	103	D	Quality	System Variables	Sedimentation in the RU is impacting on ecosystem structure and function. Sedimentation must not excessively impact on habitat state. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Suspended solids*	38 mg/L	DWAF, 2008
		Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104				Sedimentation in the RU is impacting on ecosystem structure and function. Sedimentation must not excessively impact on habitat state. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Alkalinity*	60 mg/L CaCO3	DWAF, 2008
									Turbidity*	10.0 NTU	
									Temperatures*	≤ abs(dev from ambient) 3 deg C	
									Dissolved oxygen*	5 mg/L O2	
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Quality	System Variables	System variables: Sedimentation of riverine habitats and also the difficulties associated with	Suspended solids*	23 mg/L	DWAF, 2008

								the use of sediment-laden water must be managed. Sediment concentrations should thus not reach levels where instream sedimentation excessively impacts on the instream habitat or where suspended sediments negatively impact on fitness for use for water institutions. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.			
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C			Sedimentation is negatively driving the ecosystem processes and negatively impacting on all habitats. Sediment loads must be reduced so that sedimentation does not negatively impact on habitat state. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Suspended solids*	23 mg/L	DWAF, 2008
									Turbidity (NTUs)*	5.5 NTU	
13	I	Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Quality	System Variables	Turbidity associated with upstream forestry activities is a threat to the protected status of this system and should be minimised. The sediment situation should be improved to a B category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Turbidity (NTUs)*	1.0 NTU	DWAF, 2008
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Quality	Toxins	Evidence suggests that there are toxic chemicals emitted from agricultural activities and mines which are entering the river and which are untreatable by conventional water treatment processes. Toxicity levels must comply with the fitness for use which is acceptable for lifetime consumption (Class 1#) after treatment in the existing infrastructure. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	F*	2.8 mg/L	DWAF, 2008
									Al*	128 µg/L	
									As*	113 µg/L	
									Cd hard*	4.0 µg/L	
									Cr(VI)*	161 µg/L	
									Cu hard*	7.0 µg/L	
									Hg*	1.34 µg/L	
									Mn*	1145 µg/L	
									Pb hard*	11.25 µg/L	
									Se*	26 µg/L	
									Zn*	31 µg/L	
									Chorine*	4.1 µg/L free Cl	
									Endosulfan*	0.165 µg/L	
									Atrazine*	89 µg/L	
		Klipspruit (confluence with Olifants)	RU12	12	D	Quality	Toxins	It is suspected that there are toxics in this system linked to upstream industrial activities which may be having a negative impact on ecosystem functioning. Toxics should not be allowed to	F*	2.8 mg/L	DWAF, 2008
									Al*	128 µg/L	
									As *	113 µg/L	
									Cd hard*	4.0 µg/L	

								deteriorate and should be maintained in a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Cr(VI)*	161 µg/L	
									Cu hard*	7.0 µg/L	
									Hg**	1.34 µg/L	
									Mn*	1145 µg/L	
									Pb hard*	11.25 µg/L	
									Se*	26 µg/L	
									Zn*	31 µg/L	
									Chorine*	4.1 µg/L free Cl	
									Endosulfan*	0.165 µg/L	
									Atrazine*	89 µg/L	
2	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31	C	Quality	Toxins	Upstream activities including Wastewater Treatment Works and agriculture are suspected to be introducing toxins into the river which are negatively impacting on the ecosystem and agricultural users. Toxic concentrations should be minimised and should not exceed a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	F*	2.3 mg/L	DWAF, 2008
									Al*	84 µg/L	
									As*	76 µg/L	
									Cd hard*	2.3 µg/L	
									Cr(VI)*	94 µg/L	
									Cu hard*	5.4 µg/L	
									Hg*	0.75 µg/L	
									Mn*	835 µg/L	
									Pb hard*	7.63 µg/L	
									Se*	18 µg/L	
									Zn*	20 µg/L	
									Chorine*	2.4 µg/L free Cl	
									Endosulfan*	0.103 µg/L	
									Atrazine*	64 µg/L	
3	II	Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D	Quality	Toxins	Upstream activities related to mining, agricultural activities and the consequent eutrophication of Loskop Dam are creating water suspected of containing a variety of toxins. Loskop Dam acts as a sink for many of these toxins. The potential for toxics associated with agricultural activities (pesticides), eutrophication of Loskop Dam (blue-green algae) and toxics from upstream users particularly if assimilative capacity of Loskop reduces due to low alkalinity on river of great concern. The concentrations of toxic substances must be improved to a D category to minimise toxic effects on the ecosystem and other users of the system. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	F*	2.8 mg/L	DWAF, 2008
									Al*	128 µg/L	
									As*	113 µg/L	
									Cd hard*	4.0 µg/L	
									Cr(VI)*	161 µg/L	
									Cu hard*	7.0 µg/L	
									Hg*	1.34 µg/L	
									Mn*	1145 µg/L	
									Pb hard*	11.25 µg/L	
									Se*	26 µg/L	
									Zn*	31 µg/L	
									Chorine*	4.1 µg/L free Cl	
									Endosulfan*	0.165 µg/L	
									Atrazine*	89 µg/L	
5	III	One node at outlet of B32H, confluence with Olifants. Included: B32G	RU49	49	C	Quality	Toxins	Pesticides and toxics associated with mines and upstream agricultural activities may be excessive in this RU and should be improved to a C	F*	2.3 mg/L	DWAF, 2008
									Al*	84 µg/L	
									As*	76 µg/L	

		(Moses) and b32H (Mametse and Moses)						category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	Cd hard*	2.3 µg/L	
									Cr(VI)*	94 µg/L	
									Cu hard*	5.4 µg/L	
									Hg*	0.75 µg/L	
									Mn*	835 µg/L	
									Pb hard*	7.63 µg/L	
									Se*	18 µg/L	
									Zn*	20 µg/L	
									Chorine*	2.4 µg/L free Cl	
									Endosulfan*	0.103 µg/L	
									Atrazine*	64 µg/L	
6	III	Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D	Quality	Toxins	There are risks of unacceptable levels of toxins in this system associated with upstream activities. This may be due to contamination by metals, organic contaminants and endocrine-disrupters. Toxics should be minimised to reduce the risk of human health and ecosystem impairment and should be maintained in a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	F*	2.8 mg/L	DWAF, 2008
									Al*	128 µg/L	
									As*	113 µg/L	
									Cd hard*	4.0 µg/L	
									Cr(VI)*	161 µg/L	
									Cu hard*	7.0 µg/L	
									Hg*	1.34 µg/L	
									Mn*	1145 µg/L	
									Pb hard*	11.25 µg/L	
									Se*	26 µg/L	
									Zn*	31 µg/L	
									Chorine*	4.1 µg/L free Cl	
									Endosulfan*	0.165 µg/L	
									Atrazine*	89 µg/L	
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Quality	Toxins	There is a risk of toxic chemicals being present due to upstream agricultural activities. This poses a risk to communities who drink from the system and also for FEPA fish support plan. Toxicity levels must be minimised to levels in sympathy with a B category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	F*	1.8 mg/L	DWAF, 2008
									Al*	41 µg/L	
									As*	39 µg/L	
									Cd hard*	1.0 µg/L	
									Cr(VI)*	41 µg/L	
									Cu hard*	3.6 µg/L	
									Hg*	0.30 µg/L	
									Mn*	525 µg/L	
									Pb hard*	3.88 µg/L	
									Se*	9 µg/L	
									Zn*	9 µg/L	
									Chorine*	1.1 µg/L free Cl	
									Endosulfan*	0.048 µg/L	
									Atrazine*	34 µg/L	
11	III	Ga-Selati (EWR site - EWR14b) (existing) and Ga-Selati (outlet of quaternary -outlet of IUA11)	RU103 RU104	103 and 104	D	Quality	Toxins	Upstream mining poses a health risk to local users due to associated toxins. Toxicity must be maintained in a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard	F*	2.8 mg/L	DWAF, 2008
									Al*	128 µg/L	
									As*	113 µg/L	
									Cd hard*	4.0 µg/L	
									Cr(VI)*	161 µg/L	

								procedure which has been selected to remove the extreme values considered to represent outliers.	Cu hard*	7.0 µg/L	
									Hg*	1.34 µg/L	
									Mn*	1145 µg/L	
									Pb hard*	11.25 µg/L	
									Se*	26 µg/L	
									Zn*	31 µg/L	
									Chorine*	4.1 µg/L free Cl	
									Endosulfan*	0.165 µg/L	
									Atrazine*	89 µg/L	
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Quality	Toxins	Toxicity levels have a potential to impact on local biodiversity and health of the ecosystem. Toxicity levels must not exceed a D category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	F*	2.3 mg/L	DWAF, 2008
									Al*	84 µg/L	
									As*	76 µg/L	
									Cd hard*	2.3 µg/L	
									Cr(VI)*	94 µg/L	
									Cu hard*	5.4 µg/L	
									Hg*	0.75 µg/L	
									Mn*	835 µg/L	
									Pb hard*	7.63 µg/L	
									Se*	18 µg/L	
									Zn*	20 µg/L	
									Chorine*	2.4 µg/L free Cl	
									Endosulfan*	0.103 µg/L	
									Atrazine*	64 µg/L	
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Quality	Pathogens	The large numbers of un-served upstream communities are producing waste which is entering the river resource and is contaminating water resources being used by downstream communities. Concentrations of pathogens should be maintained at levels where downstream use is not compromised. A C/D category is necessary for this. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	*E.coli**	130 counts/100 ml	DWAF, 1996
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Quality	Pathogens	The large numbers of un-served upstream communities are producing waste which is entering the river resource and is contaminating water resources being used by downstream communities. Concentrations of pathogens should be maintained at levels where downstream use is not compromised. A C/D category is necessary for this. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme	*E.coli**	130 counts/100 ml	DWAF, 1996

								values considered to represent outliers.			
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Quality	Pathogens	The upstream Wastewater Treatment Works are a source of pathogens in this system and are the cause of a human health risk especially to downstream communities and those using the river for recreational activities. Pathogens numbers should be improved to a C category. Where available the 95%ile of observed or modelled data has been provided. The 95%ile threshold is a standard procedure which has been selected to remove the extreme values considered to represent outliers.	*E.coli**	130 counts/100 ml	
**as per standard methods of America Water Works Association (www.awwa.org)*											

Table 10: Supplementary information for RIVER HABITAT in priority RUs in the Olifants WMA.

RIVER HABITAT										
IUA	**Class**	**River**	**RU**	**Node**	**REC**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**	**Reference**
1	III	Olifants (releases from Witbank Dam) and Klipspruit (confluence with Olifants)	RU9 RU12	9 and 12	D	Habitat	Instream Habitat	RU 9 - Habitat is important in this RU for maintenance of the ecosystem structure and function. RU 12 - Multiple stressors associated with land-use activities, road and other infrastructure impacts, urban and peri-urban communities and water abstraction have caused excessive stress on the instream habitat. This habitat is important for on-going sustainable functioning of the ecosystem.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	DWA, 2009
		Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D			The overall instream river habitat is important for the wellbeing of the aquatic ecosystem and also for the users who consider it to be aesthetically pleasing; however this is under threat from reduced flows.	RHAM findings equate to ecosystem in a B/C category (equivalent to EcoClassification score of 70 - 80)	DWA, 2009
		Olifants	RU13	13	B					
2	II	Bronkhorstpruit (outlet from Nronkhorstspruit Dam)	RU24	24	C	Habitat	Instream Habitat	The instream habitat is under stress from upstream dams which are reducing the flow, as well as from urban informal settlements and agriculture related land use practices. It is an important component of the ecosystem template and supports local biodiversity used for ecotourism and recreation.	RHAM Score B/C category (equivalent to EcoClassification score of 70 - 80)	DWA, 2009
		Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31				The instream habitat is important in this RU. It is important as a template for the ecosystem which is the main focus here, and should be managed to maintain a condition which will be beneficial for other responder components including mammals, birds and amphibians/reptiles.	RHAM findings equate to ecosystem in a C category	
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Habitat	Instream Habitat	Instream habitat is very important for the well-being of the aquatic ecosystem and will also be important for the	RHAM findings equate to ecosystem in a B/C	DWA, 2009

								users who consider the habitat to be aesthetically pleasing.	category (equivalent to EcoClassification score of 70 - 80)	
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			Flow alteration is substantially impacting on the instream habitat which is important as it is the basis for the structure and functioning of the ecosystem.		
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Habitat	Instream Habitat	The instream habitat of this river is important for sustainable use of the river but is being negatively impacted by reduced flows from upstream as well as reduced water quality. This will require rehabilitation of the instream habitat to a level where the instream ecosystem processes can support the associated ecosystem.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	DWA, 2009
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Habitat	Instream Habitat	The instream habitat of this river is important for sustainable use of the river but is being negatively impacted by reduced flows from upstream as well as reduced water quality. This will require rehabilitation of the instream habitat to a level where the instream ecosystem processes can support the associated ecosystem.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	DWA, 2009
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C			The instream habitat is important for ecosystem functioning but impacts associated with land use, especially agriculture, are affecting the ability of users to sustainably use the aquatic resource.	RHAM findings equate to ecosystem in a C category	
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Habitat	Instream Habitat	Instream habitat is important for maintenance of the local aquatic biodiversity and the trout industry in particular.	RHAM findings equate to ecosystem in a B/C category (equivalent to EcoClassification score of 70 - 80)	DWA, 2009
		Steelpoort (inflow to De Hoop Dam)	RU57	57	C	Habitat	Instream Habitat	The instream habitat quality is important to maintain the overall ecosystem in suitable state however it is under stress.	RHAM findings equate to ecosystem in a B/C category (equivalent to EcoClassification score of 70 - 80)	
		Upper reaches of Dwars (before mining impacts)	RU62	62	C	Habitat	Instream Habitat	The instream habitat is important for the structure and function of the ecosystem but is presently in an inadequate state mainly due to inadequate flows.	RHAM findings equate to ecosystem in a B/C category (equivalent to EcoClassification score of 70 - 80)	
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D	Habitat	Instream Habitat	Instream habitat is an important component of the ecosystem template and in this RU the ecosystem sensitivity is considered to be high thus making it vulnerable.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	
7	III	Olifants (outlet quaternary - outlet of IUA7)	RU72	72	D	Habitat	Instream Habitat	The instream habitat is important for this RU as it forms the template for the ecosystem and is important for the associated biota. The instream habitat should thus be protected from excessive sedimentation.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score	DWA, 2009

									of 50 - 60)	
8	II	Spekboom (outlet of quaternary - outlet of IUA8)	RU82	82	B	Habitat	Instream Habitat	The instream habitat provides an important template for the rest of this ecosystem especially the NFEPA fish support area but is impacted by poor flows and land use practises associated with agriculture.	RHAM findings equate to ecosystem in a A/B category	DWA, 2009
9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary) and Ohrigstad (outlet of quaternary - outlet of IUA9)	RU83 RU86	83 and 86	D	Habitat	Instream Habitat	Instream flows are negatively impacted by low flows and other aspects of upstream activities.	RHAM findings equate to ecosystem in a C category	DWA, 2009
10	II	Olifants (confluence with Steelpoort) and Olifants (ERW11, confluence with Blyde) existing)	RU95 RU96	95 and 96	D	Habitat	Instream Habitat	The instream habitat is important for this RU as it forms the template for the ecosystem and is important for the associated biota. The instream habitat should thus be protected from excessive sedimentation.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	DWA, 2009
		Olifants (outlet - outlet of IUA10)	RU98	98	C					
	II	Makhutswi, including Moungwana and Malomanye	RU97	97	C	Habitat	Instream Habitat	The instream habitat is important for the ecosystem structure and function but sedimentation associated with upstream land use activities (peri-urban communities) is negatively affecting the system.	RHAM findings equate to ecosystem in a B/C category (equivalent to EcoClassification score of 70 - 80)	
11	III	Ga-Selati (EWR site - EWR14b) (existing) and Ga-Selati (outlet of quaternary - outlet of IUA11)	RU103 RU104	103 and 104	D	Habitat	Instream Habitat	Instream habitat is important to maintain ecosystem structure and function but is being compromised by excessive sedimentation and water quality modification issues.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	DWA, 2009
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Habitat	Instream Habitat	The instream habitat is important for this RU as it forms the template for the ecosystem and is important for the associated biota. The instream habitat should thus be protected from excessive sedimentation.	RHAM findings equate to ecosystem in a C/D category (equivalent to EcoClassification score of 50 - 60)	DWA, 2009
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				The instream habitat forms a crucial part of the overall KNP conservation effort.	RHAM findings equate to ecosystem in a C category	
13	I	Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Habitat	Instream Habitat	The instream habitat is essential for this ecosystem	RHAM findings equate to ecosystem in a A/B category	DWA, 2009
1	III	Olifants (EWR site 1 - EWR1) (existing)	RU11	11	D	Habitat	Riparian	The riparian habitat is aesthetically important for tourism and also provides important habitat for fauna. The riparian habitat should thus maintained in a *B/C category* condition suitable for this use. RU 34 - The riparian habitat is aesthetically important for tourism (game farms) and also provides habitat for charismatic fauna. The riparian zone should be maintained in a B/C category.	VEGRAI (Level III) in ≥A/B category	Kleynhans et al, 2007; DWAF, 2008
		Olifants	RU13	13	B					
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Habitat	Riparian	The riparian habitat is aesthetically important for tourism and also provides important habitat for fauna.	VEGRAI (Level III) in ≥A/B category	Kleynhans et al, 2007;

								The riparian habitat should thus maintained in a *B/C category*. condition suitable for this use. RU 34 - The riparian habitat is aesthetically important for tourism (game farms) and also provides habitat for charismatic fauna. The riparian zone should be maintained in a B/C category.		DWAF, 2008
1	III	Klipspruit (confluence with Olifants)	RU12	12	D	Habitat	Riparian	The riparian zone is negatively impacted by land-use and local communities as well as by low flows. This habitat forms an important buffer between various land uses and the aquatic ecosystem and is presently in a poor condition.	VEGRAI (Level III) in ≥C category	Kleynhans et al, 2007; DWAF, 2008
2	III	Bronkhorstpruit (outlet from Bronkhorstspruit Dam)	RU24	24	C	Habitat	Riparian	The riparian habitat is under stress from agriculture which has unacceptably reduced its quality. This is an important component of the ecosystem template and supports local biodiversity used for ecotourism and recreation. Thus the riparian habitat should be improved to a C*/D category*.	VEGRAI (Level III) in ≥B/C category (equivalent to EcoClassification score of 70 - 80)	Kleynhans et al, 2007; DWAF, 2008
	II	Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU31	31				The riparian habitat provides an important template for the ecosystem, so if this component is maintained it will be beneficial for other responder components including mammals, birds and amphibians/reptiles. The riparian habitat should be maintained in a *C category*.	VEGRAI (Level III) in ≥B category	
5	III	Olifants (releases from Flag Boshielo Dame) and Olifants (outlet of quaternary - outlet of IUA5)	RU 52, 53	52 and 53	D	Habitat	Riparian	The riparian habitat is important for the entire ecosystem, for fauna and for the stability of the river banks, and also as a resource of local communities. Exotic invasions, instream flow reductions and agriculture are a threat to this. The riparian habitat should be in a C/D category to support both ecosystem and downstream communities.	VEGRAI (Level III) in ≥B/C category (equivalent to EcoClassification score of 70 - 80)	Kleynhans et al, 2007; DWAF, 2008
6	III	Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU 66	66	D	Habitat	Riparian	The riparian zone is an important component of the aquatic ecosystem as it provides a buffering from the activities in the neighbouring terrestrial ecosystem and also provides cover for various aquatic species and contributes to assimilation of wastes. At present this is under stress and needs to be improved to a D category	VEGRAI (Level III) in ≥C category	Kleynhans et al, 2007; DWAF, 2008
7	III	Olifants (outlet of quaternary - outlet at IUA7)	RU72	72	D	Habitat	Riparian	The riparian habitat is an important template for the overall ecosystem and for associated biota. It is also important in preventing sediment loss from the adjacent terrestrial ecosystem, for stabilisation of the stream bank and for meeting user needs. The riparian habitat should thus be kept in a D category.	VEGRAI (Level III) in ≥C category	Kleynhans et al, 2007; DWAF, 2008
10	II	Olifants (confluence with Steelpoort) and Olifants (ERW11, confluence with Blyde) existing)	RU95 RU96	95 and 96	D	Habitat	Riparian	The riparian habitat is an important template for the overall ecosystem and for associated biota. It is also important in preventing sediment loss from the adjacent terrestrial ecosystem, for stabilisation of the stream bank and for meeting user needs. The riparian habitat should thus be kept in a D category.	VEGRAI (Level III) in ≥C category	Kleynhans et al, 2007; DWAF, 2008
		Olifants (outlet of quaternary	RU98	98	C			The riparian habitat is an important template for the		

		- outlet of IUA10)						overall ecosystem and for associated biota. It is also important in preventing sediment loss from the adjacent terrestrial ecosystem, for stabilisation of the stream bank and for meeting user needs. The riparian habitat should thus be kept in a D category.		
11	III	Ga-Selati (EWR site - EWR1b) (existing) and Ga-Selati (outlet of quaternary - outlet of IUA11)	RU 103, 104	103 and 104	D	Habitat	Riparian	Riparian vegetation contributes to bank stability and provides habitat for Instream and riparian biota. Current impacts include water quality, quantity and habitat alterations associated with mines and upstream users. Current state must be improved to a D category.	VEGRAI (Level III) in ≥C category	Kleynhans et al, 2007; DWAF, 2008
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Habitat	Riparian	The riparian habitat is an important template for the overall ecosystem and for associated biota. It is also important in preventing sediment loss from the adjacent terrestrial ecosystem, for stabilisation of the stream bank and for meeting user needs. The riparian habitat should thus be kept in a D category.	VEGRAI (Level III) in ≥C category	Kleynhans et al, 2007; DWAF, 2008
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				The riparian plants form an important component of KNP biodiversity and contribute to ecosystem wellbeing. They should be improved to an *A/B category* to contribute to the attainment of the recommended integrated C EcoStatus category as required by the WRC study.	VEGRAI (Level IV) in ≥A category	

Table 11: Supplementary information for RIVER BIOTA in priority RUs in the Olifants WMA.

RIVER BIOTA										
IUA	**Class**	**River**	**RU**	**Node**	**REC**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**	**Reference**
1	III	Olifants (releases from Witbank Dam)	RU9	9	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category).	Kleynhans, 2007
2	II	Bronkhorstpruit (outlet from Bronkhorstpruit Dam) and Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU24 RU31	24 31	C	Biota	Fish	Fish provide a local source of food for local communities and are an important part of recreation and ecosystem functioning. Ecologically important species which are representative of populations from the Olifants and Klein-Olifants Rivers occur within the Wilge River which provides a refuge.	FRAI Score between 60 and 65 (low C category). Critical habitat for indicator species according to RHAM findings equivalent to low C category.	Kleynhans, 2007
		Wilge (confluence with Bronkhorstpruit)	RU27	27						
3	II	Kranspoortspruit (EWR site - EWR3) (existing)	RU35	35	B	Biota	Fish	This resource unit provides an ecologically important refuge for species which are representative of populations from the Olifants and Klein-Olifants Rivers.	Critical habitat for indicator species according to RHAM findings equivalent to low C category.	Kleynhans, 2007
		Olifants (outlet of quaternary - outlet of	RU40	40	D			This resource acts as major barrier to the upstream movement of tropical species that	FRAI Score between 60 and 65 (low C category).	

		IUA3)						historically migrated into the upper reaches of the catchment predominantly during high flow periods. Because of this, this reach now acts as an important maintenance and spawning area for many migrating species. Provision of suitable flows, water quality, habitat and ecological cues to maintain species is required.		
4	III	Elands(outlet of quaternary - outlet of IUA4)	RU46	46	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category).	Kleynhans, 2007
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category).	Kleynhans, 2007
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 60 and 65 (low C category).	Kleynhans, 2007
		Olifants (releases from Flag Boshielo Dame)	RU52	52	D	Biota	Fish	Fish provide a local source of food for local communities and are an important part of recreation and ecosystem functioning. Ecologically important species which are representative of populations from the Olifants and Klein-Olifants Rivers occur within the Wilge River which provides a refuge.	FRAI Score between 60 and 65 (low C category). Critical habitat for indicator species according to RHAM equivalent to low C category.	Kleynhans, 2007
		Olifants (outlet of quaternary - outlet of IUA5)	RU53	53					Critical habitat for indicator species according to RHAM equivalent to low C category.	
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Biota	Fish	Fish provide a local source of food for local communities and are an important part of recreation and ecosystem functioning. Ecologically important species which are representative of populations from the Olifants and Klein-Olifants Rivers occur within the Wilge River which provides a refuge.	FRAI Score between 60 and 65 (low C category).	Kleynhans, 2007
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D			Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 60 and 65 (low C category).	
7	III	Olifants (outlet quaternary - outlet of IUA7)	RU72	72	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 60 and 65 (low C category).	Kleynhans, 2007
8	II	Spekboom (outlet of	RU82	82	B	Biota	Fish	Conditions need to be improved so that there is	FRAI Score between 80 and 85	Kleynhans,

		quaternary - outlet of IUA8)						re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	(low B category). Critical habitat for indicator species according to RHAM equivalent to low B category.	2007
9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary)	RU83	83	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category). Critical habitat for indicator species according to RHAM equivalent to low B category.	Kleynhans, 2007
	III	Ohrigstad (outlet of quaternary - outlet of IUA9)	RU86	86	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 60 and 65 (low C category). Critical habitat for indicator species according to RHAM equivalent to low B category.	Kleynhans, 2007
10	II	Blyde (EWR site - EWR12) (existing)	RU88	88	B	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 80 and 85 (low B category). Critical habitat for indicator species according to RHAM equivalent to low B category.	Kleynhans, 2007
		Mohlapitse (upper reaches)	RU93	93		Biota	Fish	Fish provide a local source of food for local communities and are an important part of recreation and ecosystem functioning. Ecologically important species which are representative of populations from the Olifants and Klein-Olifants Rivers.	FRAI Score between 80 and 85 (low B category). Critical habitat for indicator species according to RHAM equivalent to low B category.	Kleynhans, 2007
		Olifants (confluence with Steelpoort)	RU95 RU98	95 98	D	Biota	Fish	RU95 - Fish provide a local source of food for local communities and are an important part of recreation and ecosystem functioning. Ecologically important species which are representative of populations from the Olifants and Klein-Olifants Rivers. RU96 and RU98 - Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category).	Kleynhans, 2007
		Olifants (EWR11, confluence with Blyde) (existing)	RU96	96						
11	III	Ga-Selati (EWR site - EWR14b) (existing)	RU103	103	D	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category).	Kleynhans, 2007
		Ga-Selati (outlet of quaternary - outlet of IUA11)	RU104	104						
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Biota	Fish	Conditions need to be improved so that there is re-establishment of representative fish populations where tolerant species in particular should prevail, not only for the sake of the ecosystem but also for community use.	FRAI Score between 40 and 50 (low D category).	Kleynhans, 2007
		Olifants (outlet of	RU116	116				Fish are important components of KNP	FRAI Score between 40 and 50	Kleynhans,

		quaternary - outlet of IUA12)						biodiversity and contribute to ecosystem wellbeing. They should be improved to a C category to contribute to the attainment of the recommended integrated C EcoStatus category as required by the WRC study. In addition the population structure of the locally protected Tigerfish population (Hydrocynus vittatus) must be maintained in a viable state.	(low D category). Critical habitat for indicator species according to RHAM equivalent to low B category.	2007
13	I	Blyde (confluence with Lisbon)	RU117	117	C	Biota	Fish	Fish community structures are important to maintain the state of the overall water resource. Thus the local fish community structures should be maintained including stable population structures of the endemic Treur River barb (Barbus treurensis).	FRAI Score between 80 and 85 (low B category). Critical habitat for indicator species according to RHAM equivalent to low B category.	Kleynhans, 2007
		Blyde (inflow to Blyderivierpoort Dam - outlet of IUA13)	RU121	121	B	Biota	Fish	Fish community structures are important to maintain the state of the overall water resource which is classified as a FEPA conservation area. Thus the local fish community structures should be maintained including stable population structures of the endemic Treur River barb (Barbus treurensis) and Knerian spp.	FRAI Score between 80 and 85 (low B category). Critical habitat for indicator species according to RHAM equivalent to low B category.	Kleynhans, 2007
1	III	Olifants (EWR site 1 - EWR1) (existing) and Klipspruit (confluence with Olifants)	RU11 and RU12	11 and 12	D	Biota	Aquatic invertebrates	Invertebrates provide an indication of the ecosystem condition and are also an essential component of the aquatic ecosystem.	MIRAI Score C/D category (equivalent to EcoClassification score of 50 - 60)	Taylor et al, 2005; DWAF, 2008
		Olifants	RU13	13	B					
2	II	Bronkhorstpruit (outlet from Nronkhorstspruit Dam) and Wilge (EWR site - EWR4, outlet of IUA2) (existing)	RU24 RU31	24 and 31	C	Biota	Aquatic invertebrates	RU 24 - These form an important part of the ecosystem functioning and are used as indicators for the state of ecosystem health and give an indication of overall water quality impacts from upstream activities. RU 31 - The community of benthic macroinvertebrates is being stressed by water quality and quantity impacts yet this river also acts as a refuge for invertebrate species that may occur in the Olifants and Klein-Olifants Rivers.	MIRAI Score B/C category (equivalent to EcoClassification score of 70 - 80)	Taylor et al, 2005; DWAF, 2008
3	II	Klein Olifants (EWR site - EWR3) (existing)	RU34	34	C	Biota	Aquatic invertebrates	These form an important part of the ecosystem functioning and are used as indicators for the state of ecosystem health and give an indication of overall water quality impacts from upstream activities.	MIRAI Score C category	Taylor et al, 2005; DWAF, 2008
		Olifants (outlet of quaternary - outlet of IUA3)	RU40	40	D			These form an important part of the ecosystem functioning and are used as indicators for the state of ecosystem health and give an indication of overall water quality impacts from upstream activities.	MIRAI Score C/D category (equivalent to EcoClassification score of 50 - 60)	
4	III	Elands(outlet of	RU46	46	D	Biota	Aquatic	Invertebrates provide an important part of the	MIRAI Score C/D category	Taylor et al,

		quaternary - outlet of IUA4)					invertebrates	overall river ecosystem and when in good condition will support the fish populations. They also provide a useful indicator of the health of the overall ecosystem and also suitability of some users.	(equivalent to EcoClassification score of 50 - 60)	2005; DWAF, 2008
5	III	Elands (outlet of quaternary, confluence with Olifants)	RU47	47	D	Biota	Aquatic invertebrates	Invertebrates provide an important part of the overall river ecosystem and when in good condition will support the fish populations. They also provide a useful indicator of the health of the overall ecosystem and also suitability of some users.	MIRAI Score C/D category (equivalent to EcoClassification score of 50 - 60)	Taylor et al, 2005; DWAF, 2008
		One node at outlet of B32H, confluence with Olifants. Included: B32G (Moses) and b32H (Mametse and Moses)	RU49	49	C					
6	III	One node at outlet of B41A. Included: Grootspruit (outlet of quaternary) and Langspruit, including Lakenvleispruit and Kleinspruit	RU54	54	C	Biota	Aquatic invertebrates	Invertebrates are used as an integrated measure of water quality and also of the overall state of the ecosystem. Abundances of invertebrates must also be maintained to provide food for the trout industry.	MIRAI Score C category	Taylor et al, 2005; DWAF, 2008
		Steelpoort (inflow to De Hoop Dam) and Upper reaches of Dwars (before mining impacts)	RU57 RU62	57 and 62				Aquatic inverts are good indicators of water quality and overall habitat including flow conditions.	MIRAI Score C/D category (equivalent to EcoClassification score of 50 - 60)	
		Steelpoort (EWR site - EWR10) (existing) (confluence with Olifants - outlet of IUA6)	RU66	66	D			Invertebrates are and important component of the ecosystem and also provide a useful indication of water quality and quantity impacts.	MIRAI Score C/D category (equivalent to EcoClassification score of 50 - 60)	
11	II	Ga-Selati (EWR site - EWR14b) (existing) and Ga-Selati (outlet of quaternary -outlet of IUA11)	RU103 RU104	103 and 104	D	Biota	Aquatic invertebrates	Invertebrates are useful indicators of water quality and overall habitat condition.	MIRAI Score C/D category (equivalent to EcoClassification score of 50 - 60)	Taylor et al, 2005; DWAF, 2008
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Aquatic invertebrates	Aquatic invertebrates are important components of KNP biodiversity and contribute to ecosystem wellbeing.	MIRAI Score B/C category (equivalent to EcoClassification score of 70 - 80)	Taylor et al, 2005; DWAF, 2008
5	III	Olifants (releases from Flag Boshielo Dam) and Olifants (outlet of quaternary - outlet if IUA5)	RU52 RU53	52 and 53	D	Biota	Diatoms	Diatoms are useful indicators of overall ecosystem health and in particular of water quality.	SPI score C category	Taylor et al, 2005; DWAF, 2008
9	III	One node at outlet of B60F. Included: Kranskloofspruit, Mantshibi, Ohrigstad (outlet of quaternary) and Ohrigstad (outlet of quaternary - outlet of	RU83 RU86	83 and 86	D	Biota	Diatoms	Diatoms are useful indicators of overall ecosystem health and in particular of water quality.	SPI score C category	Taylor et al, 2005; DWAF, 2008

		IUA9)								
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Diatoms	Diatoms are useful indicators of overall ecosystem health and in particular of water quality.	SPI score B/C category (equivalent to EcoClassification score of 70 - 80)	Taylor et al, 2005; DWAF, 2008
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Periphyton	Periphyton is an important food source for instream biota and is an important component of KNP biodiversity. Periphyton also contributes to ecosystem wellbeing and affects the aesthetic appearance of the river for ecotourism.	SPI-Score C/D category (equivalent to EcoClassification score of 50 - 60)	Taylor et al, 2007a, b, c, d; Harding and Taylor, 2011
7	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Biota	Birds	Riparian and aquatic birds are an important part of the food chain and biodiversity of this ecologically important area which is a "transition" zone between ecoregions.	Presence of Riparian and aquatic birds: <35 species (listed at end of column) per summer count.	Avian Demography Unit, 2011
		Olifants (outlet of quaternary - outlet of IUA5)	RU53	53					Presence of Riparian and aquatic birds: 9 species (listed at end of column) per summer count.	
		Olifants (outlet of quaternary - outlet of IUA7)	RU72	72				The birds of the area form an important part of the food chain and need to be protected so that this use is sustainable.	Presence of Riparian and aquatic birds : <30species (listed at end of column) per summer count.	
10	II	Olifants (confluence with Steelpoort)	RU95	95	D	Biota	Birds	The birds of the area form an important part of the food chain and need to be protected so that this use is sustainable.	Presence of Riparian and aquatic birds: <10 species (listed at end of column) per summer count.	Avian Demography Unit, 2011
		Olifants (EWR11, confluence with Blyde) (existing)	RU96	96				The birds of the area form an important part of the food web. Aquatic indicator species should remain viable.	Presence of Riparian and aquatic birds: <25 species (listed at end of column) per summer count.	Avian Demography Unit, 2011
10	II	Olifants (outlet of quaternary - outlet of IUA10)	RU98	98	C	Biota	Birds	The birds of the area form an important part of the food web. Aquatic indicator species should remain viable.	Presence of Riparian and aquatic birds: <30 species (listed at end of column) per summer count.	Avian Demography Unit, 2011
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Biota	Birds	The birds of the area form an important part of the food web. Aquatic indicator species should remain viable.	Presence of Riparian and aquatic birds: <35 species (listed at end of column) per summer count.	Avian Demography Unit, 2011
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				Aquatic and riparian birds are important components of KNP biodiversity and contribute to ecosystem wellbeing.	Presence of Riparian and aquatic birds: <35 species (listed at end of column) per summer count.	
5	III	Olifants (releases from Flag Boshielo Dam)	RU52	52	D	Biota	Amphibians and Reptiles	Crocodiles are important large animals in this area, both for the ecosystem where they are top predators, and for ecotourism.	< 120 individual animals, but the absolute threshold should be no less than 7 individual animals	Lacy and Polak, 2014; Botha, 2005; Botha, 2010.
		Olifants (outlet of quaternary - outlet of IUA5)	RU53	53	D	Biota	Amphibians and Reptiles	Crocodiles are important large animals in this area, both for the ecosystem where they are top predators, and for ecotourism.	< 120 individual animals, but the absolute threshold should be no less than 7 individual	Botha, 2005; Botha; 2010

									animals	
12	II	Olifants (outlet of quaternary - outlet of IUA12)	RU116	116	C	Biota	Amphibians and Reptiles	Amphibians and reptiles are important components of KNP biodiversity and contribute to ecosystem wellbeing.	Hatchlings and yearlings 5-8% of the total population; pre-reproductive (2-5 year old) 30% of total population; reproductive (5-40 year old) 45-47% of total population; dominant animals (40- >90 year old) 8-10% of total population <160 individual animals	Lacy and Polak, 2014; Botha, 2005; Botha, 2010
7	III	Olifants (outlet at quaternary - outlet at IUA7)	RU72	72	D	Biota	Plants	This RU contains many rare endemic riparian plants which are contributing to biodiversity and supply of plants for food, medicinal values and mats etc. for people. The vegetation also provides an important corridor for bird movement.	VEGRAI (Level IV) in ≥D category	Macfarlane et al, 2007
10	II	Olifants (confluence at Steelpoort)	RU95	95						
10	II	Olifants (EWR11, confluence with Blyde) (existing)	RU96	96	D	Biota	Mammals	The local Hippopotamus population must remain in a viable state, as this species contributes to local ecosystem processes	Less than 5 hippos in this reach of the river. Fewer than 4 cows present. This TPC should be linked to flow-related causes and not other factors such as food shortages or persecution.	Mpumalanga Parks, 2005 and 2009 (census data)
		Olifants (outlet - outlet of IUA10)	RU98	98	C			The local Hippopotamus population must remain in a viable state, as this species contributes to local ecosystem processes	Less than 10 hippos in this reach of the river. Fewer than 80% cows present. This TPC should be linked to flow-related causes and not other factors such as food shortages or persecution.	Mpumalanga Parks, 2005 and 2009 (census data)
12	II	Olifants (EWR site - EWR13) (existing)	RU105	105	C	Biota	Mammals	The local Hippopotamus population must remain in a viable state, as this species contributes to local ecosystem processes	Less than 10 hippos in this reach of the river. Fewer than 80% cows present. This TPC should be linked to flow-related causes and not other factors such as food shortages or persecution.	Mpumalanga Parks, 2005 and 2009 (census data)
		Olifants (outlet of quaternary - outlet of IUA12)	RU116	116				Mammals are important components of KNP biodiversity and contribute to ecosystem wellbeing.	Less than 35 hippos in this reach of the river. Fewer than 80% cows present. This TPC should be linked to flow-related causes and not other factors such as the impact of the Massingir Dam, food shortages or persecution.	Kruger National Park, 2013 (census data)
*** Data obtained from bird clubs and conservation authorities and measured as per methods prescribed by Avian Demography Unit, Department of Statistical Sciences University of Cape Town or Birdlife SA.*										

4.2 WETLAND RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS FOR THE OLIFANTS WMA

The outcomes of the RQO and NL determination of the sub-components and indicators for the wetland component of the RQO determination study for the Olifants WMA, including a summary of additional supplementary information are provided as follows:

- RQOs for regional wetland in the Olifants WMA are presented in Table 12.
- RQOs for the wetland water quantity component are presented in Table 13
- RQOs for the wetland water quality component are presented in Table 14.
- RQOs for the wetland water habitat component are presented in Table 15.
- RQOs for the wetland water biota component are presented in Table 16.
- Supplementary information for the wetland water quantity component is presented in Table 17.
- Supplementary information for the wetland water quality component is presented in Table 18.
- Supplementary information for the wetland water habitat component is presented in Table 19.
- Supplementary information for the wetland water biota component is presented in Table 20.

4.2.1 WETLAND RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 12: RQOs for REGIONAL WETLANDS in the Olifants WMA

REGIONAL WETLANDS		
RQO	**Indicator/ measure**	**Numerical Limits**
There must be no net loss in wetland functioning within the IUA.	Condition of wetlands in the IUA, based on a desktop-level wetland assessment supplemented with a site-level assessment of a subset of indicator wetlands within the IUA. Every 5 years	Hectare equivalents of wetlands in the IUA have not been accurately determined*. Refined mapping and an assessment of the current state is required. The numerical criteria should equate to the hectare equivalents in the IUA based on the assessment of current state.
Validated wetland FEPAs in a good condition (equivalent to an A-B ecological category) must be maintained whilst wetland FEPAs that are not in a good condition must be improved to their best attainable ecological condition.	Condition of validated wetland FEPAs in the IUA, based on a desktop-level assessment of validated wetland FEPAs supplemented with a site-level assessment of a subset of these wetlands within the IUA. Every 5 years	Hectare equivalents of wetland FEPAs in the IUA have not been validated**. An assessment of the current condition of validated wetland FEPAs is required. The numerical criteria should equate to the hectare equivalents of wetland FEPAs in the IUA based on the assessment of current state.
Landuses associated with validated FEPA wetland clusters must be controlled to maintain hydrological linkages that maintain connectivity between wetlands.	Landuse associated with validated FEPA wetland clusters, using a desktop assessment of landuse compatibility within a 500m buffer of validated NFEPA wetland clusters. Every 5 years	Landuse associated with validated wetland clusters in the IUA is still to be determined**. An assessment of the landuse compatibility within buffer zones is required. The numerical criteria should equate to hectare equivalents of the buffer zones based on the current landuse compatibility scores.
Wetland FEPAs must be formally protected through appropriate protection mechanisms to secure key biodiversity values and meet wetland conservation targets.	Proportional of validated wetland FEPAs that are formally protected, using an IUA level assessment of protection status based on available protected area coverage's. Every 5 years	Validation of wetland FEPAs has not been undertaken. Once completed, the numerical criteria should equate to the hectare equivalents of the current condition of wetland FEPAs within formally protected areas.
* Confidence in the assessment used as part of the initial NFEPA wetland assessment is regarded as low. A baseline survey to verify and update the existing wetland coverage is therefore required in order to ensure that an up-to-date map is available for wetlands in the IUA. Critical information that should be improved includes (i) wetland boundaries; (ii) wetland types and (iii) present ecological state. This assessment can be largely undertaken at a desktop level, with selected ground-truthing and would ideally be undertaken as part of the NFEPA coverage update.		
** Confidence in the selection of wetland FEPAs as part of the initial assessment is regarded as low. A baseline survey to verify and update wetland FEPAs and FEPA wetland clusters is therefore required in order to focus monitoring activities. This should be based on desktop mapping and further engagement with stakeholders.		

Table 13: RQOs for WETLAND WATER QUANTITY in priority RUs in the Olifants WMA

WETLAND WATER QUANTITY							
IUA	**Wetland**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**
2, 6, 13	2.1 Elandsvlei pan system	RU23	Quantity	Water inputs	Existing levels of water inputs from the wetlands catchment must be maintained whilst no increase in direct abstraction from the wetlands are permitted.	Mapping of the extent of dams and SFR activities in the wetland & associated catchment. Mapping to be undertaken at a scale of 1:10 000. Every 5 years	Current extent of plantation forestry and dams in the catchment: To be determined.
	6.1 Lakenvlei wetland complex	RU54					
	6.2 Welgevonden wetland	RU57					
	6.3 Draaikraal wetland_1	RU58					
	6.4 Draaikraal wetland_2	RU59					
	13.1 Treur wetland	RU120					
1, 2, 3, 4, 6, 9	1.1 Blesbokspruit wetland	RU5	Quantity	Water distribution and retention patterns	Existing water distribution and retention patterns must be maintained to ensure no loss in functional value.	PES Score for water distribution & retention patterns based on a detailed (Level 2) assessment of water distribution and retention patterns using Wet-Health (Macfarlane et al. 2007). This should include detailed mapping of impact features together with mapping and rating of discrete disturbance units with similar impacts. Every 5 years	10% worse than initial PES Score for water distribution & retention patterns: To be determined
	1.2 Rietspruit wetland	RU6					
	1.3 Kriel wetland	RU3 and 4					
	1.5 Koringspruit wetland	RU1					
	1.6 Klipspruit wetland						
	1.7 Klein Olifants	RU15					

	1.8 Matla wetland tributary	RU15					
	1.9 Woes-Alleenspruit wetland	RU16					
	1.10 Bosmanspruit wetland	RU16					
	1.11 Kopermyn wetland	RU17					
	2.3 Delmas wetland	RU21					
	2.4 Bronkhorstspruit tributary	RU21					
	3.1 Klein Olifants Tributary	RU34					
	4.1 Elands tributary wetland	RU41					
	6.2 Welgevonden wetland	RU57					
	6.3 Draaikraal wetland_1	RU58					
	6.4 Draaikraal wetland_2	RU59					
	6.5 Draaikraal wetland_3						
	6.6 Belfast wetland_1	RU54					
	6.7 Belfast wetland_2						
	9.1 Krankloofspruit tributary	RU83					
	9.2 Ohrigstad wetland	RU85					
2, 6	2.6 Zaalklap wetland	RU28	Quantity	Water distribution and retention patterns	Water distribution and retention patterns must be improved to enhance existing functional values.	PES Score for water distribution & retention patterns based on a detailed (Level 2) assessment of water distribution and retention patterns using Wet-Health (Macfarlane et al. 2007). This should include detailed mapping of impact features together with mapping and rating of discrete disturbance units with similar impacts. Every 5 years	10% worse than realistic best attainable state: To be determined
	2.7 Saalboomspruit wetland						
	6.1 Lakenvlei wetland complex	RU54					

Table 14: RQOs for WETLAND WATER QUALITY in priority RUs in the Olifants WMA

WETLAND Water Quality								
IUA	**Wetland**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**	**95th Percentiles**
2	2.3 Delmas wetland	RU21	Quality	Pathogen	*E. ~~Coli levels~~Coli levels* must comply with fitness for use guidelines.	*E. Coli **	≤ 130 counts/100 ml	No data
**as per standard methods of America Water Works Association (www.awwa.org)*								

Table 15: RQOs for WETLAND HABITAT in priority RUs in the Olifants WMA

WETLAND HABITAT							
IUA	**Wetland**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**
2	2.1 Elandsvlei pan system	RU23	Habitat	Wetland Vegetation	The condition of wetland vegetation and associated buffer zone habitat must be maintained.	Vegetation structure and associated habitat suitability. Assessment of vegetation structure and associated habitat suitability within pans and associated mapped buffer zones (To be developed with EWT). Every 3 years	Should be maintained in current condition: To be determined
1, 2,	1.1 Blesbokspruit	RU 5	Habitat	Wetland	The condition of wetland	Detailed (Level 2) assessment of wetland vegetation using the	10% worse than initial

3, 4, 6, 9, 13	wetland			Vegetation	vegetation must be maintained in order to secure existing functions and values.	vegetation module of Wet-Health (Macfarlane et al. 2007). Vegetation assessment to be supported by vegetation sampling and calculation of Wetland Index Value & Floristic Quality Assessment Index (Cowden et al., 2013). Every 3-5 years	PES Score for water distribution & retention patterns: To be determined
	1.2 Rietspruit wetland	RU6					
	1.3 Kriel wetland	RU3 and 4					
	1.4 Klippoortjiespruit wetland	RU7					
	1.5 Koringspruit wetland	RU1					
	1.6 Klipspruit wetland	RU12					
	1.7 Klein Olifants	RU15					
	1.8 Matla wetland tributary	RU15					
	1.9 Woes-Alleenspruit wetland	RU16					
	1.10 Bosmanspruit wetland	RU16					
	1.11 Kopermyn wetland	RU17					
	2.2 Koffiespruit tributary	RU22					
	2.3 Delmas wetland	RU21					
	2.4 Bronkhorstspruit tributary	RU21					
	3.1 Klein Olifants Tributary	RU34					
	4.1 Elands tributary wetland	RU41					
	6.2 Welgevonden wetland	RU57					
	6.3 Draaikraal wetland_1	RU58					
	6.4 Draaikraal wetland_2	RU59					
	6.5 Draaikraal wetland_3	RU59					
	6.6 Belfast wetland_1	RU54					
	6.7 Belfast wetland_2	RU54					
	9.1 Krankloofspruit	RU83					

	tributary						
	9.2 Ohrigstad wetland	RU85					
	13.1 Treur wetland	RU120					
2,6	2.6 Zaalklap wetland	RU28	Habitat	Wetland Vegetation	The condition of wetland vegetation should be improved to a realistic best attainable state.	Detailed (Level 2) assessment of wetland vegetation using the vegetation module of Wet-Health (Macfarlane et al. 2007). Vegetation assessment to be supported by vegetation sampling and calculation of Wetland Index Value & Floristic Quality Assessment Index (Cowden et al., 2013). Every 3-5 years	10% worse than realistic best attainable state: To be determined
	2.7 Saalboomspruit wetland						
	6.1 Lakenvlei wetland complex	RU54					
	1.1 Blesbokspruit wetland	RU5	Habitat	Wetland Geomorphology	The geomorphic integrity of the wetland must be maintained to ensure no loss in functional value. Every 3 years	Magnitude of impacts for (i) erosional features & (ii) depositional features within the wetland. Use Geomorphology module of Wet-Health (Sub-component: Erosional features) as the framework for assessment (Macfarlane et al. 2007). Assessment will need to include desktop and field-based assessments to quantify the impact of drains and gullies on geomorphic conditions.	15% worse than initial PES Score for selected geomorphic criteria: To be determined.
	1.2 Rietspruit wetland	RU6					
	1.3 Kriel wetland	R3 and 4					
1	1.5 Koringspruit wetland	RU1					
	6.1 Lakenvlei wetland complex	RU54	Habitat	Wetland Geomorphology	The geomorphic integrity of the wetland must be maintained to ensure that the integrity of the peatland is not compromised. Every 3 years	Magnitude of impacts for (i) erosional features & (ii) depositional features within the wetland. Use Geomorphology module of Wet-Health (Sub-component: Erosional features) as the framework for assessment (Macfarlane et al. 2007). Assessment will need to include desktop and field-based assessments to quantify the impact of drains and gullies on geomorphic conditions. Every 3 years	15% worse than initial PES Score for selected geomorphic criteria: To be determined.
	6.2 Welgevonden wetland	RU57					
6	6.4 Draaikraal wetland_2	RU59					

Table 16: RQOs for WETLAND BIOTA in priority RUs in the Olifants WMA

WETLAND BIOTA							
IUA	**Wetland**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**
6	6.1 Lakenvlei wetland complex	RU54	Biota	Plants	The extent of *Typha capensis* must be maintained within acceptable levels so as to not undermine the process of peat formation.	Aerial extent of *Typha*-dominated plant communities within wetland system. Desktop mapping (using available aerial photography / Google earth imagery) supported by vegetation sampling to estimate the proportional aerial cover of *Typha* within each disturbance unit mapped as part of the Wet-Health assessment. A weighted score is then calculated to reflect the relative cover of *Typha* in the wetland as a whole. Every 3-5 years	10% increase in the extent *Typha* dominated plant communities: To be determined
2	2.1. Elandsvlei Pan	RU23	Biota	Birds	Maintenance of grass owl population numbers is desirable given the importance of this area.	African Grass-Owl *(Tyto capensis)* according to population numbers*	3 pairs of African Grass-Owls across the pan system (excludes fledglings).
6	6.1 Lakenvlei Wetland	RU54	Biota	Birds	Populations of Grey Crowned Cranes and Wattled Cranes must be maintained to meet conservation targets for these	Grey Crowned Cranes *(Balearica regulorum)*, Wattled Cranes *(Bugeranus carunculatus)* according to population numbers	Population of 65 Grey Crowned Cranes*. One breeding pair of

					important species.		Wattled Cranes**.
13	13.1 Treur wetland	RU120	Biota	Fish	A viable population of *Barbus treurensis* should be found here.	Suitable annual recruitment (young of year), using electrofishing and small mesh and large mesh seine netting. Every 3 years, during High and Low Flows	Should be maintained in a C category (equivalent to EcoClassification Score >60)
**as per standard methods of America Water Works Association (www.awwa.org)*							
*** Data obtained from bird clubs and conservation authorities and measured as per methods prescribed by Avian Demography Unit, Department of Statistical Sciences University of Cape Town or Birdlife SA.*							

4.2.2 SUPPLEMENTARY INFORMATION FOR THE WETLAND RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 17: Supplementary information for WETLAND WATER QUANTITY in priority RUs in the Olifants WMA.

WETLAND WATER QUANTITY							
IUA	**Wetland**	**RU**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**	**Reference**
2, 6, 13	2.1 Elandsvlei pan system	RU23	Quantity	Water inputs	Water inputs are important in shaping habitat characteristics of pan systems. Afforestation (and abstraction) poses a threat to natural hydrological functioning. No further increase in abstraction or stream flow reduction activities should be permitted to reduce potential hydrological impacts on these pan systems.	Any increase in the extent of SFR activities (Particularly dams & plantations).	N/A
	6.1 Lakenvlei wetland complex	RU54			Maintenance of water inputs is critical for peat formation and to prevent oxidation. Any increase in stream flow reduction or abstraction activities could threaten the integrity of these areas. Current water inputs must therefore be maintained.		
	6.2 Welgevonden wetland	RU57					
	6.3 Draaikraal wetland_1	RU58					
	6.4 Draaikraal wetland_2	RU59					
	13.1 Treur wetland	RU120			Maintaining water inputs are critical to prevent oxidation of peatland systems. Any further expansion in SFR activities would serve to exaggerate impacts on this important wetland system and must be avoided.		
1, 2, 3, 4, 6, 9	1.1 Blesbokspruit wetland	RU5	Quantity	Water distribution and retention patterns	Diffuse water distribution is required to optimise water quality enhancement functions. While an improvement in wetland distribution and retention patterns is desirable, this is likely to be unachievable in this particular wetland. Existing water distribution and retention patterns should therefore be maintained to ensure no loss in functional value.	10% better than the initial PES score for this criterion: To be determined	Macfarlane et al, 2007
	1.2 Rietspruit wetland	RU6					
	1.3 Kriel wetland	RU3 and 4					
	1.5 Koringspruit wetland	RU1			Diffuse water distribution is required to optimise water quality enhancement functions. Current erosion threatens to undermine wetland functioning. Rehabilitation is required in order to safeguard the water quality enhancement functions of this wetland.		
	1.6 Klipspruit wetland				Diffuse water distribution is required to optimise water quality enhancement functions. The wetland is however located in an urban context where drainage is a common threat. Elevated peak flows may also contribute to erosion and incision. Given the importance of water quality enhancement functions, existing water distribution and retention patterns must be maintained to ensure no loss in functional value.		
	1.7 Klein Olifants	RU15			Changes in landuse are likely to accelerate erosion which could alter water distribution and retention patterns in the wetland. This would result in a loss of wetland habitat, important for wetland-dependant plant & animal species. Maintenance of the existing geomorphic template is required to ensure that biodiversity maintenance functions are not undermined.		
	1.8 Matla wetland tributary	RU15					
	1.9 Woes-Alleenspruit wetland	RU16			Diffuse water distribution is required to optimise water quality enhancement functions. Existing water distribution and retention patterns should therefore be maintained to ensure no loss in functional value.		
	1.10 Bosmanspruit wetland	RU16					
	1.11 Kopermyn wetland	RU17					
	2.3 Delmas wetland	RU21			Maintaining diffuse flows is essential in order to maintain the water		

					quality enhancement functions of this wetland. Maintenance of flow patterns is required to ensure that there is not a reduction in the capacity of the wetland to provide this service.		
	2.4 Bronkhorstspruit tributary	RU21			Water distribution and retention patterns are important in defining the habitat template for wetland-dependant biota. Maintenance of diffuse flows is also important for maintaining water quality enhancement functions. Water and distribution and retention patterns must therefore be maintained to ensure that habitat structure and variability is not negatively affected and that water quality enhancement functions are not undermined.		
	3.1 Klein Olifants Tributary	RU34			Water distribution and retention patterns are important in defining the habitat template for wetland-dependant biota. Drainage / erosion would undermine habitat value and should be avoided. Maintenance of water and distribution and retention patterns is therefore required to ensure that habitat suitable for cranes and other wetland-dependant biota is maintained.		
	4.1 Elands tributary wetland	RU41			Water distribution and retention patterns are important in defining the habitat template for wetland-dependant biota. Drainage / erosion would undermine habitat value and should be avoided.		
	6.2 Welgevonden wetland	RU57			Any drainage or erosion would undermine conservation value. Current water distribution and retention patterns must therefore be maintained.		
	6.3 Draaikraal wetland_1	RU58					
	6.4 Draaikraal wetland_2	RU59					
	6.5 Draaikraal wetland_3				Water distribution & retention patterns are important in ensuring that peatland areas remain saturated and that appropriate foraging and breeding habitat is available for biota including threatened crane species. Maintenance of water distribution & retention patterns is therefore required to ensure that the existing peatland areas and habitat for crane species is not undermined.		
	6.6 Belfast wetland_1	RU54			Maintenance of diffuse flows is essential in order to maintain the water quality enhancement functions of this wetland. Maintenance of diffuse flow patterns (already improved through rehabilitation efforts) is required to ensure that water quality enhancement functions are not undermined.		
	6.7 Belfast wetland_2				Diffuse flows provide optimal conditions for water quality enhancement. Maintenance of flow patterns is therefore required to ensure that there is not a reduction in the capacity of the wetland to provide this service.		
	9.1 Krankloofspruit tributary	RU83			Diffuse water distribution is required to optimise water quality enhancement functions. Maintenance of water distribution & retention patterns is therefore required to ensure that water quality enhancement functions are not further undermined.		
	9.2 Ohrigstad wetland	RU85					
2, 6	2.6 Zaalklap wetland	RU28	Quantity	Water distribution and retention patterns	Diffuse flows are important for maintaining habitat diversity and water quality enhancement functions. Historic drainage has impacted negatively on the wetland. Rehabilitation is therefore required to improve habitat value and to enhance water quality enhancement functions provided by the wetland.	10% better than realistic best attainable state: To be determined	Macfarlane et al, 2007
	2.7 Saalboomspruit wetland				Diffuse flows are important for maintaining habitat diversity and water quality enhancement functions. Historic drainage has impacted		

					negatively on the wetland with headcut advancement threatening to cause further loss in functional values. Rehabilitation is therefore required to halt headcut advancement and improve both habitat and water quality enhancement values.		
	6.1 Lakenvlei wetland complex	RU54			Parts of the wetland remain affected by drainage which undermines conservation value. Rehabilitation of degraded areas is required to improve the existing conservation values of the site.		

Table 18: Supplementary information for WETLAND WATER QUALITY in priority RUs in the Olifants WMA.

WETLAND WATER QUALITY								
IUA	Wetland	RU	Component	Sub Component	Context of the RQO	TPC		Reference
2	2.3 Delmas wetland	RU21	Quality	Pathogen	Elevated pathogen levels associated with discharges from the waste water treatment works poses a health risk for local community members. A reduction in E. Coli levels to within an acceptable range is required to reduce the risk of water borne diseases associated with faecal contamination emanating from the upstream waste water treatment works.	*E. Coli **	130 counts/100 ml	DWAF, 1996

Table 19: Supplementary information for WETLAND HABITAT in priority RUs in the Olifants WMA.

WETLAND HABITAT								
IUA	Wetland	RU	Component	Sub Component	Context of the RQO	TPC		Reference
2	2.1 Elandsvlei pan system	RU23	Habitat	Wetland Vegetation	Wetland vegetation and associated buffer zone habitat provides habitat for grass owls and other wetland-dependant species. Maintenance of wetland vegetation and associated untransformed habitat is required to ensure that these pans continue to provide important refuge for biodiversity within this agricultural landscape.	10% better than the initial PES score for this criterion: To be determined		*Note: This method should be refined based on the initial method used to collect field data as part of an MSc study on owl populations associated with the Elandsvlei Pan System.* Pretorius, In prep
1, 2, 3, 4, 6, 9, 13	1.1 Blesbokspruit wetland	RU 5	Habitat	Wetland Vegetation	Wetland vegetation plays a key role in improving water quality. It also provides habitat for wetland-dependant biota. Maintenance of vegetation attributes is therefore required to prevent further loss in biodiversity maintenance and water quality enhancement functions.	10% better than the initial PES score for this criterion: To be determined		Macfarlane et al,2007; WRC, 2008; Cowden et al, 2013
	1.2 Rietspruit wetland	RU6			Wetland vegetation plays a key role in improving water quality. It also provides habitat for wetland-dependant biota. Maintenance is required to prevent further loss in wetland functioning.			
	1.3 Kriel wetland	RU3 and 4			Wetland vegetation plays a key role in improving water quality. Rehabilitation is required in order to prevent further loss in water quality enhancement functions.			
	1.4 Klippoortjiespruit wetland	RU7			Wetland vegetation plays a key role in improving water quality. It also provides habitat for wetland-dependant biota with extensive Leersia beds occurring in this wetland. Maintenance is required to ensure that existing biodiversity values are not undermined within this heavily transformed catchment.			
	1.5 Koringspruit wetland	RU1			Wetland vegetation plays a key role in improving water quality. Rehabilitation is required in order to secure and prevent further loss in water quality enhancement functions.			
	1.6 Klipspruit wetland	RU12			Wetland vegetation: Wetland vegetation plays a key role in improving water quality and buffering the impacts of mining and urban areas on downstream water resources. Maintenance is required to prevent further loss in wetland functioning			
	1.7 Klein Olifants	RU15			Wetland vegetation is a good indicator of the habitat and biodiversity value of a wetland and provides foraging & breeding			

					habitat for crane species. Maintenance is required to ensure that existing biodiversity values are not undermined.		
	1.8 Matla wetland tributary	RU15			Wetland vegetation is a good indicator of the habitat and biodiversity value of a wetland and provides foraging & breeding habitat for crane species. Maintenance is required to ensure that existing biodiversity values are not undermined.		
	1.9 Woes-Alleenspruit wetland	RU16			Wetland vegetation plays a key role in improving water quality and buffering the impacts of mining activities on downstream water resources. Maintenance is required to prevent further loss in wetland functioning.		
	1.10 Bosmanspruit wetland	RU16			Wetland vegetation plays a key role in improving water quality and buffering the impacts of mining activities on downstream water resources. Maintenance is required to prevent further loss in wetland functioning.		
	1.11 Kopermyn wetland	RU17			Wetland vegetation provides habitat for wetland-dependant biota and plays a key role in improving water quality. Maintenance is required to secure existing maintain habitat values and prevent further loss in wetland functioning.		
	2.2 Koffiespruit tributary	RU22			Wetland vegetation is a good indicator of the habitat and biodiversity value of a wetland. Maintenance of wetland vegetation is necessary to ensure that these values are not undermined		
	2.3 Delmas wetland	RU21			Assimilation of toxics and uptake of nutrients requires good vegetation cover. Maintenance of wetland vegetation is therefore required to ensure that optimal conditions for water quality enhancement are maintained.		
	2.4 Bronkhorstspruit tributary	RU21			Wetland vegetation (particularly areas of tall grass habitat) is important for African Grass Owls and plays a key role in water quality amelioration. Maintenance of wetland vegetation characteristics is therefore required to ensure that these functions are not undermined.		
	3.1 Klein Olifants Tributary	RU34			Wetland vegetation provides foraging & breeding habitat for cranes and other wetland-dependant species. Wetland vegetation characteristics must therefore be retained to support biota utilizing the wetland.		
	4.1 Elands tributary wetland	RU41			Wetland vegetation provides foraging & breeding habitat for cranes and other wetland-dependant species. Wetland vegetation characteristics must therefore be retained to support biota utilizing the wetland.		
	6.2 Welgevonden wetland	RU57			Wetland vegetation provides habitat which is critical to wetland-dependant biota including threatened bird species. Maintenance of vegetation is therefore required to maintain existing conservation values.		
	6.3 Draaikraal wetland_1	RU58			Wetland vegetation provides habitat which is critical to wetland-dependant biota including threatened bird species. Maintenance of vegetation is therefore required to maintain existing conservation values.		
	6.4 Draaikraal wetland_2	RU59			Wetland vegetation provides habitat which is critical to wetland-dependant biota including threatened bird species. Maintenance of		

					vegetation is therefore required to maintain existing conservation values.		
	6.5 Draaikraal wetland_3	RU59			Wetland vegetation provides the basic habitat template on which wetland-dependant biota including threatened crane species depend. Maintenance of vegetation characteristics is required to ensure that habitat is retained for cranes and other wetland-dependant biota.		
	6.6 Belfast wetland_1	RU54			Water quality enhancement functioning is dependent on good vegetation cover. Maintenance of wetland vegetation is therefore required to ensure that water quality enhancement functions are not undermined.		
	6.7 Belfast wetland_2	RU54			Assimilation of nutrients and other contaminants from the upstream waste water treatment works and mining activities requires good vegetation cover. Maintenance of wetland vegetation is therefore required to ensure that existing water quality enhancement functions are retained.		
	9.1 Krankloofspruit tributary	RU83			Wetland vegetation plays a key role in improving water quality. Maintenance of wetland vegetation is required to ensure that water quality enhancement functions are not further undermined.		
	9.2 Ohrigstad wetland	RU85			Wetland vegetation plays a key role in improving water quality. Maintenance of wetland vegetation is required to ensure that water quality enhancement functions are not further undermined.		
	13.1 Treur wetland	RU120			Vegetation condition provides a useful surrogate measure for habitat value. Maintenance of wetland vegetation is therefore required to ensure that biodiversity values are retained.		
2,6	2.6 Zaalklap wetland	RU28	Habitat	Wetland Vegetation	Wetland vegetation provides a useful surrogate for habitat value and is essential for water quality enhancement functions. An improvement in wetland vegetation structure and composition is important to ensure that plant species composition is enhanced together with associated habitat values. This is also necessary in order to enhance existing water quality enhancement functions.	10% better than realistic best attainable state: To be determined	Macfarlane et al,2007; WRC, 2008; Cowden et al, 2013
	2.7 Saalboomspruit wetland				Wetland vegetation provides a useful surrogate for habitat value and is essential for water quality enhancement functions. An improvement in wetland vegetation structure and composition is required to ensure that habitat values and water quality enhancement functions are improved.		
	6.1 Lakenvlei wetland complex	RU54			Wetland vegetation provides habitat which is critical to wetland-dependant biota including threatened bird species. Rehabilitation of areas affected by drainage is required to enhance existing habitat values.		
	1.1 Blesbokspruit wetland	RU5	Habitat	Wetland Geomorphology	Erosion & drainage can undermine the water quality enhancement functions of the wetland. Maintenance of the existing geomorphic template is required to prevent further loss in wetland functioning.	15% better than the initial PES score for this criterion: To be determined.	Macfarlane et al,2007
	1.2 Rietspruit wetland	RU6					
	1.3 Kriel wetland	R3 and 4			Erosion & drainage threaten to undermine the water quality enhancement functions of the wetland. Rehabilitation is required in order to prevent further loss in water quality enhancement functions.		
1	1.5 Koringspruit wetland	RU1					

	6.1 Lakenvlei wetland complex	RU54	Habitat	Wetland Geomorphology	Peat is susceptible to desiccation and erosion. No further impacts to wetland geomorphology should therefore be permitted to ensure that the integrity of the peatland is not compromised.	15% better than the initial PES score for this criterion: To be determined.	Macfarlane et al,2007
	6.2 Welgevonden wetland	RU57					
6	6.4 Draaikraal wetland_2	RU59					

Table 20: Supplementary information for WETLAND BIOTA in priority RUs in the Olifants WMA.

WETLAND BIOTA							
IUA	**Wetland**	**RU**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**	**Reference**
6	6.1 Lakenvlei wetland complex	RU54	Biota	Plants	Species such as *Carex* and *Phragmite*s are peat forming and desirable in this system. There are however indications that the extent of *Typha* is increasing which could affect peat creation. An increase in *Typha capensis* is regarded as undesirable for peat creation and needs to be carefully monitored.	5% increase in the extent *Typha*-dominated plant communities	Macfarlane et al, 2007
2	2.1. Elandsvlei Pan	RU23	Biota	Birds	This cluster of pans was identified as an area of exceptional biodiversity importance as part of the NFEPA process. They have also been highlighted as providing important habitat for grass owls within a largely transformed catchment. Grass owl population numbers have been monitored over a period of 6 years as part of an MSc study. This indicated that grass owls are typically be encountered around pans where grass growth is suitable and impacts (e.g. Alien plant encroachment) are limited. A maximum of 3 pairs were encountered although it is suggested that the pans could support 4 pairs if properly managed	2 pairs of African Grass-Owls across the pan system (excludes fledglings).	Pretorius, In prep
6	6.1 Lakenvlei Wetland	RU54	Biota	Birds	The wetland is home to a range of threatened bird species. This is one of a handful of wetlands where there is an opportunity to stabilise and improve the population status of threatened bird species. Populations of Grey Crowned Cranes and Wattled Cranes must therefore be maintained to meet conservation targets for these important species.	Any reduction in population numbers of Grey Crowned Cranes during an annual survey. No breeding pairs of Wattled Cranes sighted during an annual survey.	Franke (Pers. comm.), 2014
13	13.1 Treur wetland	RU120	Biota	Fish	*Barbus treurensis* occurs in this river. Alien fish predators, particularly small mouth bass (*Micropterus dolomieu*) poses a key threat to population viability. Appropriate control of alien invasive species and other land-based impacts is therefore required to ensure that the existing populations of *Barbus treurensis* are maintained.	C category	Kleynhans, 2007

4.3 DAM RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS FOR THE OLIFANTS WMA

The outcomes of the RQO and NL determination of the sub-components and indicators for the dam component of the RQO determination study for the Olifants WMA, including a summary of additional supplementary information are provided as follows:

- RQOs for the dam water quantity component are presented in Table 21.
- RQOs for the dam water quality component are presented in Table 22.
- RQOs for the dam water biota component are presented in Table 23.
- Supplementary information for the dam water quantity component is presented in Table 24.
- Supplementary information for the dam water quality component is presented in Table 25.
- Supplementary information for the dam water biota component is presented in Table 26.

4.3.1 DAM RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 21: RQOs for DAM WATER QUANTITY in priority RUs in the Olifants WMA

DAM WATER QUANTITY									
IUA	**Dams**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**		
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E)	RU9	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Olifants in B11G; VMAR = 164.05x10^6m□; PES=D category*. (Releases from Witbank Dam monitored by B1H010.)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.128 (60)	0.085 (99)
							Nov	0.245 (90)	0.197 (99)
							Dec	0.332 (90)	0.254 (99)
							Jan	0.415 (90)	0.291 (99)
							Feb	0.514 (80)	0.291 (99)
							Mar	0.401 (80)	0.244 (99)
							Apr	0.323 (80)	0.216 (90)
							May	0.218 (70)	0.094 (99)
							Jun	0.147 (90)	0.16 (90)
							Jul	0.108 (99)	0.141 (90)
							Aug	0.084 (99)	0.113 (99)
							Sep	0.073 (90)	0.085 (90)
	Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)				The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Olifants in B11J; VMAR = 169.46x10^6m□; PES=D category*. (Releases - no gauge close by)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.138 (80)	0.093 (99)
							Nov	0.261 (80)	0.158 (99)
							Dec	0.352 (80)	0.105 (99)
							Jan	0.439 (99)	0.439 (99)
							Feb	0.544 (99)	0.544 (99)
							Mar	0.427 (80)	0.164 (99)
							Apr	0.344 (70)	0.093 (99)
							May	0.234 (70)	0.067 (99)
							Jun	0.158 (70)	0.062 (99)
							Jul	0.117 (80)	0.086 (99)
							Aug	0.091 (90)	0.086 (99)
							Sep	0.079 (80)	0.031 (99)
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Klein Olifants in B12C; VMAR = 53.52x10^6m□; PES=D category*. (Releases from Middelburg Dam monitored by B1H015.)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.048 (90)	0.044 (99)
							Nov	0.078 (90)	0.062 (99)
							Dec	0.112 (90)	0.102 (99)
							Jan	0.148 (99)	0.134 (99)

							Feb	0.174 (9)	0.158 (99)	
							Mar	0.138 (90)	0.123 (99)	
							Apr	0.115 (90)	0.104 (99)	
							May	0.092 (90)	0.078 (99)	
							Jun	0.074 (90)	0.067 (99)	
							Jul	0.058 ()90	0.053 (99)	
							Aug	0.048 (80)	0.034 (99)	
							Sep	0.04 (70)	0.00	
2	Bronkhorstspruit Dam (25°53'14.1"S; 28°43'18.4"E)	RU23	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Bronkhorstspruit in B20C; VMAR = 56.4x10^{6}m□; PES=C category*. (Releases from Bronkhorstspruit Dam, monitored by B2R001)		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)	
							Oct	0.17 (60)	0.073 (99)	
							Nov	0.207 (70)	0.088 (99)	
							Dec	0.224 (70)	0.095 (99)	
							Jan	0.263 (70)	0.11 (99)	
							Feb	0.326 (70)	0.136 (9)	
							Mar	0.303 (70)	0.126 (99)	
							Apr	0.294 (60)	0.122 (99)	
							May	0.266 (60)	0.111 (99)	
							Jun	0.251 (60)	0.104 (99)	
							Jul	0.222 (60)	0.094 (99)	
							Aug	0.196 (60)	0.084 (99)	
							Sep	0.176 (60)	0.076 (99)	
	Wilge (Primier Mine) Dam (25°48'2.7"S; 28°51'46"E)	RU26			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Wilge in B20F; VMAR = 45.8x10^{6}m□; PES=C category*. (Releases - no gauge close by)		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)	
							Oct	0.133 (70)	0.065 (99)	
							Nov	0.165 (70)	0.079 (99)	
							Dec	0.187 (70)	0.089 (99)	
							Jan	0.231 (70)	0.108 (99)	
							Feb	0.295 (70)	0.137 (99)	
							Mar	0.279 (70)	0.129 (99)	
							Apr	0.252 (60)	0.069 (99)	
							May	0.205 (60)	0.082 (99)	
							Jun	0.181 (60)	0.086 (99)	
							Jul	0.156 (60)	0.049 (99)	
							Aug	0.138 (60)	0.041 (99)	
							Sep	0.124 (60)	0.054 (99)	
3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Olifants in B32A from EWR5; VMAR = 532.6x10^{6}m□; PES=C category*. (Releases from Loskop Dam, monitored by B3H017)		Maintenance low flows (m^3/s) (%ile)	Drought flows (m^3/s) (%ile)	Freshets (m^3/s) (%ile)
							Oct	0.985 (70)	0.451 (99)	0.493 (99)
							Nov	1.493 (70)	0.667 (99)	1.74 (60)
							Dec	1.818 (70)	0.804 (99)	2.85 (10)
							Jan	2.197 (70)	0.965 (99)	4.248 (10)
							Feb	2.725 (70)	1.192 (99)	0.968 (99)
							Mar	2.367 (70)	1.036 (99)	1.748 (80)
						Freshets are important for the		Apr	2.047 (60)	0.902 (99)	0.617 (99)

					downstream ecosystem and should be released.		May	1.626 (60)	0.723 (99)	0.00
							Jun	1.299 (70)	0.585 (99)	0.00
							Jul	1.088 (70)	0.494 (99)	0.00
							Aug	0.885 (70)	0.409 (99)	0.00
							Sep	0.765 (70)	0.359 (99)	0.00
	Roodepoort Dam (25°23'40"S, 29°29'10"E)	RU38			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases:Selons in B32B; VMAR = 26.19x10^{6}m□; PES=B category*. (Releases from Roodepoort Dam, monitored by B3H019)	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
							Oct		0.088 (60)	0.032 (99)
							Nov		0.128 (60)	0.044 (99)
							Dec		0.15 (60)	0.05 (99)
							Jan		0.188 (60)	0.062 (99)
							Feb		0.234 (60)	0.076 (99)
							Mar		0.199 (60)	0.065 (99)
							Apr		0.186 (50)	0.061 (99)
							May		0.147 (50)	0.049 (99)
							Jun		0.123 (60)	0.043 (99)
							Jul		0.105 (60)	0.037 (99)
							Aug		0.092 (50)	0.033 (99)
							Sep		0.083 (60)	0.031 (99)
4	Rust De Winter Dam (25°14'0"S; 28°31'5"E)	RU41	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Elands in B31C ; VMAR = 33.47x10^{6}m□; PES=C category*. (Releases from Rust de Winter Dam, monitored by B3H014)	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
							Oct		0.084 (70)	0.044 (99)
							Nov		0.126 (70)	0.064 (99)
							Dec		0.135 (70)	0.069 (99)
							Jan		0.178 (70)	0.09 (99)
							Feb		0.209 (70)	0.105 (99)
							Mar		0.192 (70)	0.096 (99)
							Apr		0.164 (70)	0.083 (99)
							May		0.126 (70)	0.065 (99)
							Jun		0.105 (70)	0.055 (99)
							Jul		0.093 (70)	0.049 (99)
							Aug		0.085 (70)	0.045 (99)
							Sep		0.078 (70)	0.041 (99)
	Mkhombo Dam (25°5'45"S; 28°55'0"E)	RU45			Release pattern is important and should be based on the natural flow pattern to ensure the protection of ecosystem function downstream.	Flow releases: Elands EWR6 in B31G; VMAR = 60.32x10^{6}m□; PES=D category*. (Releases from Mkhombo Dam, monitored by B3H020)	Maintenance low flows (m^3/s) (%ile)			Drought flows (m^3/s) (%ile)
							Oct		0.077 (99)	0.077 (99)
							Nov		0.117 (99)	0.109 (99)
							Dec		0.133 (99)	0.133 (99)
							Jan		0.173 (99)	0.173 (99)
							Feb		0.177 (99)	0.177 (99)
							Mar		0.176 (99)	0.176 (99)
							Apr		0.143 (90)	0.132 (99)
							May		0.114 (99)	0.114 (99)
							Jun		0.092 (99)	0.092 (99)

							Jul	0.084 (99)	0.084 (99)
							Aug	0.077 (99)	0.077 (99)
							Sep	0.068 (99)	0.068 (99)
5	Rooikraal Dam (25°17'34"S; 29°39'7"E)	RU48	Quantity	Low Flows	Releases of drought requirements are at least required to maintain ecosystem function downstream.	Flow releases: Bloed in B32F; VMAR = 17.15x10^{6}m□; PES=B category*. (Releases from Rooikraal Dam - no active gauge close by)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.03 (40)	0.007 (99)
							Nov	0.095 (40)	0.00
							Dec	0.115 (40)	0.024 (99)
							Jan	0.138 (40)	0.019 (99)
							Feb	0.178 (40)	0.021 (99)
							Mar	0.12 (40)	0.019 (99)
							Apr	0.081 (40)	0.012 (99)
							May	0.047 (40)	0.01 (99)
							Jun	0.035 (40)	0.008 (99)
							Jul	0.03 (40)	0.007 (99)
							Aug	0.024 (40)	0.006 (99)
							Sep	0.021 (40)	0.005 (99)
	Flag Boshielo Dam (24°46'50"S; 29°25'32"E)	RU52			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Olifants EWR7 in B51C; VMAR = 726.64x10^{6}m3; PES=D category*. (Releases from Flag Boshielo Dam, monitored by B5H004)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.556 (99)	0.556 (99)
							Nov	0.849 (99)	0.849 (99)
							Dec	1.007 (99)	1.007 (99)
							Jan	1.214 (99)	1.214 (99)
							Feb	1.499 (99)	1.499 (99)
							Mar	1.303 (99)	1.303 (99)
							Apr	1.140 (99)	1.140 (99)
							May	0.888 (99)	0.888 (99)
							Jun	0.726 (99)	0.726 (99)
							Jul	0.611 (99)	0.611 (99)
							Aug	0.514 (99)	0.514 (99)
							Sep	0.457 (99)	0.457 (99)
6	Belfast Dam (25°39'56.12"S; 30°0'44.62"E)	RU54	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Langspruit in B41A; VMAR = 41.97x10^{6}m3; PES=C category*. (Releases to Langspruit - no gauge close by)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.157 (70)	0.086 (99)
							Nov	0.242 (70)	0.058 (99)
							Dec	0.319 (70)	0.172 (99)
							Jan	0.418 (70)	0.224 (99)
							Feb	0.529 (70)	0.282 (99)
							Mar	0.446 (70)	0.224 (99)
							Apr	0.417 (70)	0.22 (99)
							May	0.322 (70)	0.146 (99)
							Jun	0.251 (70)	0.138 (99)
							Jul	0.189 (70)	0.105 (99)
							Aug	0.157 (70)	0.089 (99)

						Sep	0.143 (70)	0.082 (99)
Tonteldoos Dam (25°16'45"S; 29°56'30"E)	RU56	Quantity	Low Flows	The dam must be managed to provide sufficient releases together with the Vlugkraal Dam for the protection of ecosystem function downstream as well as for other users.	PES=C category Flow releases: Tonteldoos Dam at outlet of B41C; VMAR = 14.85x10^{6}m3*. (Releases from Tonteldoos Dam, monitored by B4R001)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
						Oct	0.057 (70)	0.026 (99)
						Nov	0.086 (70)	0.019 (99)
						Dec	0.111 (70)	0.062 (99)
						Jan	0.145 (70)	0.08 (99)
						Feb	0.184 (70)	0.1 (99)
						Mar	0.156 (70)	0.082 (99)
						Apr	0.146 (70)	0.073 (99)
						May	0.114 (70)	0.049 (99)
						Jun	0.09 (70)	0.051 (99)
						Jul	0.068 (70)	0.039 (99)
						Aug	0.057 (70)	0.033 (99)
						Sep	0.052 (70)	0.03 (99)
Vlugkraal Dam (25°13'45"S; 29°57'1"E)	RU56	Quantity	Low Flows	The dam must be managed to provide sufficient releases together with the Tonteldoos Dam for the protection of ecosystem function downstream as well as for other users.	Flow releases: Vlugkraal at outlet of B41C; VMAR = 14.85x10^{6}m□; PES=C category*. (Releases from Vlugkraal Dam, monitored by B4H017)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
						Oct	0.057 (70)	0.026 (99)
						Nov	0.086 (70)	0.019 (99)
						Dec	0.111 (70)	0.062 (99)
						Jan	0.145 (70)	0.08 (99)
						Feb	0.184 (70)	0.1 (99)
						Mar	0.156 (70)	0.082 (99)
						Apr	0.146 (70)	0.073 (99)
						May	0.114 (70)	0.049 (99)
						Jun	0.09 (70)	0.051 (99)
						Jul	0.068 (70)	0.039 (99)
						Aug	0.057 (70)	0.033 (99)
						Sep	0.052 (70)	0.03 (99)
Der Bruchen Dam (25°3'19"S 30°7'12"E)	RU62	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Groot Dwars in B41G; VMAR = 24.48x10^{6}m□; PES=C category*. (Releases from Der Bruchen Dam - no gauge close by)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
						Oct	0.062 (60)	0.034 (99)
						Nov	0.096 (70)	0.051 (99)
						Dec	0.122 (70)	0.064 (99)
						Jan	0.143 (70)	0.075 (99)
						Feb	0.18 (70)	0.093 (99)
						Mar	0.159 (70)	0.071 (99)
						Apr	0.146 (70)	0.076 (99)
						May	0.119 (70)	0.062 (99)
						Jun	0.095 (70)	0.05 (99)
						Jul	0.072 (70)	0.039 (99)
						Aug	0.061 (70)	0.034 (99)
						Sep	0.057 (70)	0.031 (99)
De Hoop Dam	RU64	Quantity	Low Flows	The dam must be managed to	Flow releases: Steelpoort EWR9 in	Maintenance low flows (m^3/s) (%ile)		Drought

	(24°57’30’’ S; 29°57’25 E)				provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	B41H; VMAR = 137.53x10⁶m□; PES=D category*. (Releases from De Hoop Dam, monitored by B4H023)			flows (m^3/s) (%ile)
							Oct	0.240 (99)	0.240 (99)
							Nov	0.357 (90)	0.183 (99)
							Dec	0.469 (99)	0.469 (99)
							Jan	0.607 (99)	0.607 (99)
							Feb	0.685 (99)	0.685 (99)
							Mar	0.638 (99)	0.638 (99)
							Apr	0.570 (99)	0.570 (99)
							May	0.464 (99)	0.464 (99)
							Jun	0.357 (99)	0.357 (99)
							Jul	0.283 (99)	0.283 (99)
							Aug	0.239 (99)	0.239 (99)
							Sep	0.213 (99)	0.213 (99)
8	Lydenburg Dam (25°8’1’’S; 30°31’1E)	RU74	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Sterk in B42B at dam; VMAR = 9.44x10⁶m□; PES=C category*. (Releases from Lydenburg - no gauge close by)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.026 (70)	0.014 (99)
							Nov	0.041 (70)	0.022 (99)
							Dec	0.052 (70)	0.027 (99)
							Jan	0.063 (70)	0.033 (99)
							Feb	0.074 (70)	0.038 (99)
							Mar	0.063 (70)	0.033 (99)
							Apr	0.058 (70)	0.03 (99)
							May	0.049 (70)	0.026 (99)
							Jun	0.04 (70)	0.021 (99)
							Jul	0.031 (70)	0.017 (99)
							Aug	0.026 (70)	0.014 (99)
							Sep	0.025 (70)	0.014 (99)
	Buffelskloof Dam (24°57’15’’S; 30°16’1E)	RU79	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Watervals in B42F;VMAR = 28.56x10⁶m□; PES=C category*. (Releases from Buffelskloof Dam, monitored by B4H021)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.088 (70)	0.048 (99)
							Nov	0.109 (70)	0.059 (99)
							Dec	0.126 (70)	0.067 (99)
							Jan	0.142 (70)	0.075 (99)
							Feb	0.173 (70)	0.091 (99)
							Mar	0.159 (70)	0.083 (99)
							Apr	0.155 (70)	0.082 (99)
							May	0.139 (70)	0.073 (99)
							Jun	0.126 (70)	0.067 (99)
							Jul	0.105 (70)	0.056 (99)
							Aug	0.092 (70)	0.05 (99)
							Sep	0.087 (70)	0.048 (99)
9	Ohrigstad Dam (24°55’1’’S; 30°37’1’’E)	RU83	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem	Flow releases: Ohrigstad in B60E; VMAR = 15.95x10⁶m□;PES=C	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)

					function downstream as well as for other users.	category*. (Releases from Ohrigstad Dam, monitored by B6H011 of B6H012)	Oct	0.053 (80)	0.029 (99)
							Nov	0.063 (80)	0.034 (99)
							Dec	0.076 (80)	0.04 (99)
							Jan	0.093 (80)	0.049 (99)
							Feb	0.126 (80)	0.065 (99)
							Mar	0.119 (80)	0.062 (99)
							Apr	0.107 (80)	0.056 (99)
							May	0.09 (80)	0.047 (99)
							Jun	0.082 (80)	0.044 (99)
							Jul	0.069 (80)	0.037 (99)
							Aug	0.06 (80)	0.033 (99)
							Sep	0.055 (80)	0.03 (99)
10	Blyderivierpoort Dam (24°32'57"S; 30°48'5"E)	RU88	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Blyde EWR12 in B60J;VMAR = 361.98x10^{6}m□; PES=B category*. (Releases from Blyderivierpoort Dam, monitored by B6H005)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	2.223 (60)	0.725 (99)
							Nov	2.394 (70)	0.769 (99)
							Dec	2.763 (60)	0.866 (99)
							Jan	3.387 (60)	1.030 (99)
							Feb	4.274 (70)	1.263 (99)
							Mar	4.446 (60)	1.308 (99)
							Apr	3.991 (70)	1.188 (99)
							May	3.529 (60)	1.067 (99)
							Jun	3.180 (70)	0.976 (99)
							Jul	2.844 (70)	0.887 (99)
							Aug	2.507 (60)	0.799 (99)
							Sep	2.289 (70)	0.742 (99)
11	Tours Dam (24°5'50"S; Logitude:30°15'13"E)	RU99	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Ngwabitsi in B72E; VMAR = 25.68x10^{6}m□; PES=D category*. (Releases from Tours Dam, monitored by B7H002 of B7H023)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.034 (70)	0.00
							Nov	0.038 (60)	0.00
							Dec	0.052 (60)	0.00
							Jan	0.09 (50)	0.001 (99)
							Feb	0.182 (60)	0.001 (99)
							Mar	0.157 (60)	0.001 (99)
							Apr	0.105 (70)	0.001 (99)
							May	0.059 (70)	0.00
							Jun	0.053 (70)	0.00
							Jul	0.045 (80)	0.00
							Aug	0.041 (70)	0.00
							Sep	0.037 (70)	0.00
12	Klaserie Dam (24°31'30"S; 31°4'15"E	RU106	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	Flow releases: Klaserie OLI_EWR7 in B73A; VMAR = 25.54x10^{6}m□; PES=B/C category*. (Releases from Klaserie Dam, monitored by B7R001)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	0.084 (70)	0.026 (99)
							Nov	0.102 (70)	0.031 (99)

							Dec	0.155 (60)	0.044 (99)
							Jan	0.238 (60)	0.067 (99)
							Feb	0.323 (70)	0.069 (99)
							Mar	0.339 (60)	0.060 (99)
							Apr	0.276 (70)	0.063 (99)
							May	0.184 (70)	0.053 (99)
							Jun	0.136 (70)	0.040 (99)
							Jul	0.108 (70)	0.032 (99)
							Aug	0.092 (70)	0.028 (99)
							Sep	0.081 (70)	0.025 (99)
	Phalaborwa Barrage (24°4'1"S: 31°10'1"E)	RU114			Releases from the weir are important to maintain and protect the ecosystem function downstream, especially in the KNP.	Flow releases: Olifants EWR13 in B72D; VMAR = 1762.2x10^6m□; PES=C category*. (Releases from Phalaborwa Barrage, monitored by B7R002)	Maintenance low flows (m^3/s) (%ile)		Drought flows (m^3/s) (%ile)
							Oct	3.940 (70)	2.149 (99)
							Nov	5.411 (80)	2.883 (99)
							Dec	6.802 (70)	3.576 (99)
							Jan	8.351 (70)	4.347 (99)
							Feb	10.019 (80)	5.178 (99)
							Mar	10.125 (70)	5.231 (99)
							Apr	8.812 (70)	4.577 (99)
							May	7.209 (70)	3.778 (99)
							Jun	5.671 (70)	3.012 (99)
							Jul	4.732 (70)	2.544 (99)
							Aug	3.998 (70)	2.179 (99)
							Sep	3.508 (70)	1.934 (99)

** Per Rule Table*

Table 22: RQOs for DAM WATER QUALITY in priority RUs in the Olifants WMA

DAM WATER QUALITY								
IUA	**Dams**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**	**95^{th} Percentiles**
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E)	RU9	Quality	Nutrients	The system must be maintained in a mesotrophic state to avoid cyanobacterial blooms and the associated algal toxins.	PO_4-P *	≤ 0.020 mg/L P	0.04
	Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)					TIN *	≤ 0.85 mg/L N	0.1665
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18				Chl-a: phytoplankton *	≤ 18 µg/L	No data
2	Bronkhorstspruit Dam (25°53'14.1"S; 28°43'18.4"E)	RU23	Quality	Nutrients	Nutrient concentrations in the dam must be maintained at mesotrophic levels.	PO_4-P *	≤ 0.020 mg/L P	0.07
						TIN *	≤ 0.85 mg/L N	0.5
						Chl-a: phytoplankton *	≤ 18 µg/L	No data

3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quality	Nutrients	The dam must be maintained in a mesotrophic state to avoid cyanobacterial blooms and the associated algal toxins.	PO_4-P *	≤ 0.020 mg/L P	0.033
						TIN *	≤ 0.85 mg/L N	0.9
						Chl-a: phytoplankton *	≤ 18 µg/L	No data
4	Rust De Winter Dam (25°14'0"S; 28°31'5"E) Mkhombo Dam (25°5'45"S; 28°55'0"E)	RU41; RU45	Quality	Nutrients	Nutrients must be maintained at mesotrophic levels.	PO_4-P *	≤ 0.020 mg/L P	0.039
						TIN *	≤ 0.85 mg/L N	0.2
						Chl-a: phytoplankton *	≤ 18 µg/L	No data
5	Flag Boshielo Dam (24°46'50"S; 29°25'32"E)	RU52	Quality	Nutrients	Nutrients must be maintained at mesotrophic levels.	PO_4-P *	≤ 0.020 mg/L P	0.047
						TIN *	≤ 0.85 mg/L N	0.3
						Chl-a: phytoplankton *	≤ 18 µg/L	No data
6	Tonteldoos Dam (25°16'45"S; 29°56'30"E) VlugkraalDam (25°13'45"S; 29°57'1"E)	RU56	Quality	Nutrients	Nutrient concentrations must be maintained such that the system is in a mesotrophic state or better.	PO_4-P *	≤ 0.020 mg/L P	0.048
						TIN *	≤ 0.85 mg/L N	0.3
						Chl-a: phytoplankton *	≤ 18 µg/L	No data
8	Buffelskloof Dam (24°57’15’’S; 30°16’1E)	RU79	Quality	Nutrients	Nutrients must be maintained at mesotrophic levels so as to retain the recreational value of the dam.	PO_4-P *	≤ 0.020 mg/L P	0.031
						TIN *	≤ 0.85 mg/L N	0.211
9	Ohrigstad Dam (24°55’1’’S; 30°37’1’’E)	RU83	Quality	Nutrients	Nutrients must be maintained at mesotrophic levels so as to avoid eutrophication.	PO_4-P *	≤ 0.020 mg/L P	0.075
						TIN *	≤ 0.85 mg/L N	0.145
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E)	RU9	Quality	Salts	Salt concentrations must be maintained at levels where they allow for a sustainable ecosystem in the dam and downstream and do not compromise users.	Sulphates *	≤ 140mg/L	210.7
						Electrical conductivity *	≤ 70 mS/m	68.38
	Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)				Salt and sulphate concentrations must be maintained at levels where they allow for a sustainable ecosystem in the dam and downstream and do not compromise users.	Sulphates *	≤ 140mg/L	210.7
						Electrical conductivity *	≤ 70 mS/m	68.38
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18			Salt concentrations must be maintained at levels where they allow for a sustainable ecosystem in the dam and downstream and do not compromise users.	Sulphates *	≤ 140mg/L	445
						Electrical conductivity *	≤ 70 mS/m	105
3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quality	Salts	Salt concentrations must be maintained at levels where they allow for a sustainable ecosystem in the dam and downstream and do not compromise users.	Sulphates *	≤ 140mg/L	148.9
						Electrical conductivity *	≤ 70 mS/m	51

5	Flag Boshielo Dam (24°46'50"S; 29°25'32"E)	RU52	Quality	Salts	Salt concentrations must be maintained at levels where they allow for a sustainable ecosystem in the dam and downstream and do not compromise users.	Sulphates *	≤ 140mg/L	116.5
						Electrical conductivity *	≤ 70 mS/m	59.1
8	Buffelskloof Dam (24o57'15''S; 30o16'1E)	RU79	Quality	Salts	Salt concentrations must be maintained at levels where they allow for a sustainable ecosystem in the dam and downstream and do not compromise users.	Sulphates *	≤ 140mg/L	7.5
						Electrical conductivity *	≤ 70 mS/m	22.1
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E); Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)	RU9	Quality	System Variables	The pH in the dam must be maintained at levels where it does not compromise the ecosystem or users.	pH_max *	≥ 8.4	8.3
						pH_min *	≤ 6.2	7.3
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18	Quality	System Variables	The pH in the dam must be maintained at levels where it does not compromise the ecosystem or users.	pH_max *	≥ 8.4	8.6
						pH_min *	≤ 6.2	7.5
4	Mkhombo Dam (25°5'45"S; 28°55'0"E)	RU45	Quality	System Variables	The pH in the dam must be improved and maintained at levels where it does not compromise the ecosystem or users.	pH_max *	≥ 8.4	8.4
						pH_min *	≤ 6.2	7.5
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E); Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)	RU9	Quality	Toxins	The system must be maintained in a mesotrophic state to avoid cyanobacterial blooms and the associated algal toxins. Metal concentrations in the dam must be maintained at levels which allow for a sustainable ecosystem.	F *	≤ 2.3 mg/L	0.7
						Al *	≤ 84 µg/L	No data
						As *	≤ 76 µg/L	No data
						Cd mhrd *	≤ 2.3 µg/L	No data
						Cr(VI) *	≤ 94 µg/L	No data
						Cu mhrd *	≤ 5.4 µg/L	No data
						Hg *	≤ 0.75 µg/L	No data
						Mn *	≤ 835 µg/L	No data
						Pb mhrd *	≤ 7.63 µg/L	No data
						Se *	≤ 18 µg/L	No data
						Zn *	≤ 20 µg/L	No data
						Chlorine *	≤ 2.4 µg/L free Cl	No data
						Chl-a: phytoplankton *	≤ 18 µg/L	No data
3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quality	Toxins	Toxicity of metals must be maintained at concentrations that would not pose a threat to human or ecosystem health. The dam must be maintained in a mesotrophic state to avoid cyanobacterial blooms and the associated algal toxins.	F *	≤ 2.3 mg/L	0.5
						Al *	≤ 84 µg/L	No data
						As *	≤ 76 µg/L	No data
						Cd mhrd *	≤ 2.3 µg/L	No data
						Cr(VI) *	≤ 94 µg/L	No data
						Cu mhrd *	≤ 5.4 µg/L	No data
						Hg *	≤ 0.75 µg/L	No data
						Mn *	≤ 835 µg/L	No data
						Pb mhrd *	≤ 7.63 µg/L	No data
						Se *	≤ 18 µg/L	No data
						Zn *	≤ 20 µg/L	No data
						Chlorine *	≤ 2.4 µg/L free Cl	No data
						Chl-a: phytoplankton *	≤ 18 µg/L	No data
**as per standard methods of America Water Works Association (www.awwa.org)*								

Table 23: RQOs for DAM BIOTA in priority RUs in the Olifants WMA

DAM BIOTA							
IUA	**Dams**	**RU**	**Component**	**Sub Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**
1	Witbank Dam (RU 9, 25°54'34.71"S; 29°18'52.31"E),Middleburg Dam (RU 18, 25°46'30"S; 29°32'46"E)	RU9 RU18	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
2	Bronkhorstspruit Dam (RU 23, 25°53'14.1"S; 28°43'18.4"E), Wilge (Primier Mine) Dam (RU 26, 25°48'2.7"S; 28°51'46"E)	RU23 RU26	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
3	Loskop Dam (RU 37, 25°25'1"S, 29°21'30"E)	RU37	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
4	Rust De Winter Dam (RU 41, 25°14'0"S; 28°31'5"E), Mkhombo Dam (RU 45, 25°5'45"S; 28°55'0"E)	RU41 RU45	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
5	Flag Boshielo Dam (RU 52, 24°46'50"S; 29°25'32"E)	RU52	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
6	De Hoop Dam (RU 64, 24o57'30'' S; 29o57'25 E)	RU64	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
9	Ohrigstad Dam (RU 83, 24o55'1''S; 30o37'1''E)	RU83	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.

10	Tours Dam (RU 99, 24°5'50"S; Logitude:30°15'13"E)	RU99	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.
11	Klaserie Lake (RU 106, 24°31'30"S; 31°4'15"E)	RU106	Biota	Fish	The wellbeing of the fish community of this artificial ecosystem must be maintained in a suitable condition to contribute to regional biodiversity and to support local recreational angling industry. Consumption of fish must not pose a health risk to local communities.	Implementation of the Index of Reservoir Habitat Impairment (IRHI) by Miranda and Hunt (2011).	Habitat suitability and fish wellbeing in a state which is equivalent to a D or better ecological category.

4.3.2 SUPPLEMENTARY INFORMATION FOR THE DAM RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 24: Supplementary information for DAM QUANTITY in priority RUs in the Olifants WMA.

DAM WATER QUANTITY								
IUA	**Dams**	**RU**	**Component**	**Sub Component**	**RQO**	**Context of the RQO**	**TPC**	**Reference**
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E)	RU9	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The purpose of the dam is to release water for domestic (urban) and industrial use.	Not Applicable	DWA, 2012
	Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)				The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam was built for recreational and domestic (urban) use.	Not Applicable	DWA, 2012

	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam was built to supply water for domestic and industrial use	Not Applicable	DWA, 2012
2	Bronkhorstspruit Dam (25°53'14.1"S; 28°43'18.4"E)	RU23	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The purpose of the dam is to supply water for domestic (urban) and industrial use.	Not Applicable	DWA, 2012
	Wilge (Primier Mine) Dam (25°48'2.7"S; 28°51'46"E)	RU26			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam supplies water for mining, industrial and domestic use.	Not Applicable	DWA, 2012
3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam was built for irrigation, domestic (rural), recreational use.	Not Applicable	DWAF, 2001

					Freshets are important for the downstream ecosystem and should be released.	Freshets are important for the downstream ecosystem and should be released.		
	Roodepoort Dam (25°23'40"S, 29°29'10"E)	RU38			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam was built mainly for irrigation releases.	Not Applicable	DWA, 2012
4	Rust De Winter Dam (25°14'0"S; 28°31'5"E)	RU41	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam is used to supply water for irrigation.	Not Applicable	DWA, 2012
	Mkhombo Dam (25°5'45"S; 28°55'0"E)	RU45			Release pattern is important and should be based on the natural flow pattern to ensure the protection of ecosystem function downstream.	The dam is used to supply water for domestic (urban and rural), industrial and irrigation users.	Not Applicable	DWAF, 2001

5	Rooikraal Dam (25°17'34"S; 29°39'7"E)	RU48	Quantity	Low Flows	Releases of drought requirements are at least required to maintain ecosystem function downstream.	The dam is used to supply water for irrigation.	Not Applicable	DWA, 2012
	Flag Boshielo Dam (24°46'50"S; 29°25'32"E)	RU52			The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam supplies water for irrigation, domestic and industrial use.	Not Applicable	DWAF, 2001
6	Belfast Dam (25°39'56.12"S; 30°0'44.62"E)	RU54	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam is used to domestic water supply.	Not Applicable	DWA, 2012
	Tonteldoos Dam (25°16'45"S; 29°56'30"E)	RU56	Quantity	Low Flows	The dam must be managed to provide sufficient releases together with the Vlugkraal Dam for the protection of ecosystem function downstream as well as for other users.	The dam is used to supply water for irrigation.	Not Applicable	DWA, 2012

	Vlugkraal Dam (25°13'45"S; 29°57'1"E)	RU56	Quantity	Low Flows	The dam must be managed to provide sufficient releases together with the Tonteldoos Dam for the protection of ecosystem function downstream as well as for other users.	The dam is used to supply water for irrigation.	Not Applicable	DWA, 2012
	Der Bruchen Dam (25°3'19"S 30°7'12"E)	RU62	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam supplies water for mining and irrigation use.	Not Applicable	DWA, 2012
	De Hoop Dam (24°57'30'' S; 29°57'25 E)	RU64	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The purpose of the dam is to supply water for domestic (urban & rural), mining and industrial use.	Not Applicable	DWAF, 2001
8	Lydenburg Dam (25°8'1''S;	RU74	Quantity	Low Flows	The dam must be managed to provide	The purpose of the dam is to supply	Not Applicable	DWA, 2012

	30°31’1E)				sufficient releases for the protection of ecosystem function downstream as well as for other users.	water for domestic (urban) and industrial use.		
	Buffelskloof Dam (24°57’15’’S; 30°16’1E)	RU79	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	This dam was constructed mainly for irrigation releases, but needs to release water for protection of ecosystem functioning downstream.	Not Applicable	DWA, 2012
9	Ohrigstad Dam (24°55’1’’S; 30°37’1’’E)	RU83	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	This dam was constructed mainly for irrigation releases, but needs to release water for protection of ecosystem functioning downstream.	Not Applicable	DWA, 2012
10	Blyderivierpoort Dam (24°32'57"S; 30°48'5"E)	RU88	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	This dam was constructed mainly for irrigation, domestic and recreational use, but also needs to release water for protection of ecosystem functioning downstream.	Not Applicable	DWAF, 2001

11	Tours Dam (24°5'50"S; Logitude:30°15'13"E)	RU99	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	The dam supplies water for domestic (rural) use	Not Applicable	DWA, 2012
12	Klaserie Dam (24°31'30"S; 31°4'15"E	RU106	Quantity	Low Flows	The dam must be managed to provide sufficient releases for the protection of ecosystem function downstream as well as for other users.	This dam was constructed mainly to supply water for irrigation, but it also needs to release water for protection of ecosystem functioning downstream.	Not Applicable	Rapid Reserve as part of WRC study, extrapolated from OLI-EWR7 in B73A
	Phalaborwa Barrage (24°4'1"S: 31°10'1"E)	RU114			Releases from the weir are important to maintain and protect the ecosystem function downstream, especially in the KNP.	The barrage supplies water for domestic and industrial use.	Not Applicable	DWAF, 2001

Table 25: Supplementary information for DAM QUALITY in priority RUs in the Olifants WMA.

DAM WATER QUALITY								
IUA	**Dams**	**RU**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**		**Reference**
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E)	RU9	Quality	Nutrients	There have been incidents of nutrient peaks and mean annual concentrations reaching eutrophic levels, probably as a result of the use of fertilisers and poor functioning of sewage treatment works upstream. Increasing nutrients may result in cyanobacterial blooms and associated toxins. There is also potential for cyanobacterial blooms.	PO_4-P *	0.015 mg/L P	DWAF, 2008
	Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)					TIN *	0.70 mg/L N	
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18				Chl-a: phytoplankton *	15 µg/L	
2	Bronkhorstspruit Dam (25°53'14.1"S; 28°43'18.4"E)	RU23	Quality	Nutrients	There have been incidents of nutrient peaks due to upstream activities. Increasing nutrients may result in cyanobacterial blooms and associated toxins	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
						Chl-a: phytoplankton *	15 µg/L	
3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quality	Nutrients	There have also been historical occurrences of cyanobacterial blooms.	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
						Chl-a: phytoplankton *	15 µg/L	
4	Rust De Winter Dam (25°14'0"S; 28°31'5"E) Mkhombo Dam (25°5'45"S; 28°55'0"E)	RU41; RU45	Quality	Nutrients	There have been incidents of nutrient peaks which could lead to eutrophication problems.	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
						Chl-a: phytoplankton *	15 µg/L	
5	Flag Boshielo Dam (24°46'50"S; 29°25'32"E)	RU52	Quality	Nutrients	There have been incidents of nutrient peak, which could lead to eutrophication problems.	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
						Chl-a: phytoplankton *	15 µg/L	
6	Tonteldoos Dam (25°16'45"S; 29°56'30"E) VlugkraalDam (25°13'45"S; 29°57'1"E)	RU56	Quality	Nutrients	There are incidents of peak nutrient concentrations in the dam.	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
						Chl-a: phytoplankton *	15 µg/L	
8	Buffelskloof Dam (24°57'15''S; 30°16'1E)	RU79	Quality	Nutrients	There are incidents of high nutrient concentrations.	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
9	Ohrigstad Dam (24°55'1''S; 30°37'1''E)	RU83	Quality	Nutrients	Nutrient concentrations are increasing.	PO_4-P *	0.015 mg/L P	DWAF, 2008
						TIN *	0.70 mg/L N	
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E)	RU9	Quality	Salts	There are fluctuations in salinity as a result of upstream mining activities.	Sulphates *	80 mg/L	Golder Associates, 2013
						Electrical conductivity *	55 mS/m	DWAF, 2008
	Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)				There is fluctuation in salinity, which may be a result of acid mine drainage in the dam.	Sulphates *	80 mg/L	Golder Associates, 2013
						Electrical conductivity *	55 mS/m	DWAF, 2008
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18			There are increasing sulphate concentrations indicating acid mine drainage impacts from upstream.	Sulphates *	80 mg/L	Golder Associates, 2013
						Electrical conductivity *	55 mS/m	DWAF, 2008
3	Loskop Dam (25°25'1"S,	RU37	Quality	Salts	Increased sulphate levels suggest acid mine drainage	Sulphates *	80 mg/L	Golder

	29°21'30"E)				impacts.			Associates, 2013
						Electrical conductivity *	55 mS/m	DWAF, 2008
5	Flag Boshielo Dam (24°46'50"S; 29°25'32"E)	RU52	Quality	Salts		Sulphates *	80 mg/L	Golder Associates, 2013
						Electrical conductivity *	55 mS/m	DWAF, 2008
8	Buffelskloof Dam (24o57'15''S; 30o16'1E)	RU79	Quality	Salts	Fluctuations in salinity reflected suggest acid mine drainage impacts from upstream.	Sulphates *	80 mg/L	Golder Associates, 2013
						Electrical conductivity *	55 mS/m	DWAF, 2008
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E); Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)	RU9	Quality	System Variables	Reflected fluctuations in pH in the dam suggest acid mine drainage impacts.	pH_max *	8.0	DWAF, 2008
						pH_min *	6.5	
	Middleburg Dam (25°46'30"S; 29°32'46"E)	RU18	Quality	System Variables	pH in the dam is increasing due to upstream mining activity.	pH_max *	8.0	DWAF, 2008
						pH_min *	6.5	
4	Mkhombo Dam (25°5'45"S; 28°55'0"E)	RU45	Quality	System Variables	The pH in the dam is increasing which could affect ecosystem function.	pH_max *	8.0	DWAF, 2008
						pH_min *	6.5	
1	Witbank Dam (25°54'34.71"S; 29°18'52.31"E); Doornpoort Dam (25°51'42.01"S; 29°18'19.92"E)	RU9	Quality	Toxins	There is potential for cyanobacterial blooms. There is the likelihood of heavy metals from acid mine drainage and industrial waste precipitating in the dam.	F *	2.0 mg/L	DWAF, 2008
						Al *	63 µg/L	
						As *	58 µg/L	
						Cd hard *	1.6 µg/L	
						Cr(VI) *	68 µg/L	
						Cu hard *	4.9 µg/L	
						Hg *	0.53 µg/L	
						Mn *	680 µg/L	
						Pb hard *	5.75 µg/L	
						Se *	13 µg/L	
						Zn *	14 µg/L	
						Chorine *	1.8 µg/L free Cl	
						Chl-a: phytoplankton *	15 µg/L	
3	Loskop Dam (25°25'1"S, 29°21'30"E)	RU37	Quality	Toxins	There is potential for heavy metal contamination associated with acid mine drainage from upstream mining activity. There have also been historical occurrences of cyanobacterial blooms.	F *	2.0 mg/L	DWAF, 2008
						Al *	63 µg/L	
						As *	58 µg/L	
						Cd hard *	1.6 µg/L	
						Cr(VI) *	68 µg/L	
						Cu hard *	4.9 µg/L	
						Hg *	0.53 µg/L	
						Mn *	680 µg/L	
						Pb hard *	5.75 µg/L	
						Se *	13 µg/L	
						Zn *	14 µg/L	
						Chorine *	1.8 µg/L free Cl	
						Chl-a: phytoplankton *	15 µg/L	

*as per standard methods of America Water Works Association (www.awwa.org)

Table 26: Supplementary information for DAM BIOTA in priority RUs in the Olifants WMA. .

DAM BIOTA							
IUA	**Dams**	**RU**	**Component**	**Sub Component**	**Context of the RQO**	**TPC**	**Reference**
1	Witbank Dam (RU 9, 25°54'34.71"S; 29°18'52.31"E),Middleburg Dam (RU 18, 25°46'30"S; 29°32'46"E)	RU9 RU18	Biota	Fish	These dams serve as an important refuge area for a variety of ecologically important indigenous fish species and maintain an economically important angling industry which targets alien fishes.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
2	Bronkhorstspruit Dam (RU 23, 25°53'14.1"S; 28°43'18.4"E), Wilge (Primier Mine) Dam (RU 26, 25°48'2.7"S; 28°51'46"E)	RU23 RU26	Biota	Fish	This dam is an important refuge area for indigenous fishes including a population of the indicator Smallscale yellowfish (*Labeobarbus polylepis*). Alien species occur in the dam and are targeted by local anglers. Although these aliens do not out-compete adult Smallscale yellowfish they may be affecting the recruitment of these yellowfishes and other indigenous species.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
3	Loskop Dam (RU 37, 25°25'1"S, 29°21'30"E)	RU37	Biota	Fish	This dam is an important refuge area for indigenous fish species including species of the family Cyprinidae and Cichlidae of which the Mozambique tilapia (*Oreochromis mossambicus*) is currently listed as near threatened. Other important species include the near threatened Papermouth barb (*Barbus rapax cf. B. matozzi*) viable population structures of these species needs to be maintained.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
4	Rust De Winter Dam (RU 41, 25°14'0"S; 28°31'5"E), Mkhombo Dam (RU 45, 25°5'45"S; 28°55'0"E)	RU41 RU45	Biota	Fish	This dam is an important refuge area for indigenous fish species including species of the family Cyprinidae and Cichlidae of which the Mozambique tilapia (*Oreochromis mossambicus*) is currently listed as near threatened. Other important species include the near threatened Papermouth barb (*Barbus rapax cf. B. matozzi*) viable population structures of these species needs to be maintained.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
5	Flag Boshielo Dam (RU 52, 24°46'50"S; 29°25'32"E)	RU52	Biota	Fish	This dam maintains abundant populations of indigenous Cyprinid, Mochokidae, Siluriforms and Cichlid families which take up refuge in the dam.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
6	De Hoop Dam (RU 64, 24o57'30'' S; 29o57'25 E)	RU64	Biota	Fish	This dam can maintain important populations of indigenous Cyprinid, Mochokidae, Siluriforms and Cichlid families and facilitate the establishment of an economically and socially important indigenous species angling industry through which the protected Mozambique tilapia (Oreochromis mossambicus) population can benefit.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
9	Ohrigstad Dam (RU 83, 24o55'1''S; 30o37'1''E)	RU83	Biota	Fish	This dam is an important refuge area for indigenous fishes and must be managed to ensure that the indigenous species diversity of the dam is maintained, the population structures of ecologically important species is suitable and that aliens do not pose a high level of risk to the viability of indigenous species.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example
10	Tours Dam (RU 99, 24°5'50"S; Logitude:30°15'13"E)	RU99	Biota	Fish	This dam is an important refuge area for indigenous fishes and must be managed to ensure that the indigenous species diversity of the dam is maintained, the population structures of ecologically important species is suitable and that aliens do not pose a high level of risk to	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example

					the viability of indigenous species.		
11	Klaserie Lake (RU 106, 24°31'30"S; 31°4'15"E)	RU106	Biota	Fish	This dam is an important refuge area for indigenous fishes and must be managed to ensure that the indigenous species diversity of the dam is maintained, the population structures of ecologically important species is suitable and that aliens do not pose a high level of risk to the viability of indigenous species.	Considerable (not significant change in fish community structure).	Miranda and Hunt, 2011; Wepener et al., 2011 for example

4.4 GROUNDWATER RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS FOR THE OLIFANTS WMA

The outcomes of the RQO and NL determination of the sub-components and indicators for the groundwater component of the RQO determination study for the Olifants WMA, including a summary of additional supplementary information are provided as follows:

- RQOs for groundwater presented in Table 27.
- Supplementary information for groundwater is presented in Table 28.

4.4.1 GROUNDWATER RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 27: RQOs for GROUNDWATER in priority RUs in the Olifants WMA

GROUNDWATER					
IUA	**RU**	**Component**	**RQO**	**Indicator/ measure**	**Numerical Limits**
All	All Prioritised RUs	Quantity	Where water use is higher than requirements for Reserve, Schedule 1 and General Authorizations, abstraction rates should not exceed the average recharge.	Abstraction Volume (Q) per hectare > Reserve, Schedule[1] and General Authorizations.	Q < Average recharge per hectare
All	RU1 RU2 RU3 RU4 RU6 RU7 RU8 RU9 RU10 RU11 RU12 RU14 RU15 RU17 RU18 RU19 RU24 RU27 RU28 RU31 RU33 RU34 RU56 RU59 RU62 RU73	Aquifer	Medium to long-term water trends should not show a negative deviation from the natural trend	Depth to Groundwater Level using Groundwater Monitoring Guidelines[2]	At least one NGwQI MP monitoring site that is representative of the aquifer. Water level fluctuations in Dolomitic aquifers[6] should not exceed 6m.
	RU22				Water level fluctuations around the average site water level should not exceed 18.2 m
	RU21				Water level fluctuations around the average site water level should not exceed 19.1 m
	RU53				Water level fluctuations around the average site water level should not exceed 20.9 m
	RU58				Water level fluctuations around the average site water level should not exceed 8.8 m
All	All Prioritised RUs	Quantity	The radius of influence should not intersect any other protection zone. In cases where infringements already exits, the infringements will be used as baseline measurement.	Radius of influence (r) □. r = 1.5*√(T*t/S), T=Transmissivity (m^2/d), t=Time (days), S=Storativity. Annual sampling via GIS algorithm or on introduction of new borehole	r should not overlap with any other radius of influence, cone of depression, protection zone or increase zone infringements
All	All Prioritised RUs	Ecological	A protection zone along a river/stream is required to protect the ecological reserve. In cases where infringements already exit, the infringements will be used as baseline measurement.	Distance from river (L) 4. L = (T*i)/R, T=Transmissivity (m2/d), i=Groundwater Gradient, R=Recharge (m/d). Annual sampling via GIS algorithm or on introduction of new borehole	L should not overlap with any other radius of influence, cone of depression, protection zone or increase zone infringements
All	All Prioritised RUs	Ecological	A protection zone along a wetland is required to protect the ecological reserve. In cases where infringements already exit, the infringements will be used as baseline measurement.	Distance from river (L)[4]. L = (T*i)/R, T=Transmissivity (m^2/d), i=Groundwater Gradient, R=Recharge (m/d) W=Wetland Perimeter. Annual sampling via GIS algorithm or on introduction of new borehole (perimeter is based on the Wetland Delineation Guidelines).	L should not overlap with any other radius of influence, cone of depression, protection zone or increase zone infringements
All	All Prioritised RUs	Quality	Boreholes require a protection zone from microbial pollution source within a minimum of 73m depending on the geohydrological conditions of the area.	Microbial radius (r)[4]. r = 2(0.28*T) + 53, T=Transmissivity (m^2/d). Annual sampling via GIS algorithm or on introduction of new borehole	Distance to pit latrine > r

All	All Prioritised RUs	Quality	Boreholes require a protection zone from microbial pollution source within a minimum of 73m depending on the geohydrological conditions of the area.	Background water quality per borehole using Groundwater Monitoring Guidelines2²	Water quality should not be allowed to deteriorate significantly form background water quality

[1] *General Authorization for the taking and storage of water, DWAF (2012)*

[2] *A Guideline for the Assessment, Planning and Management of Groundwater Resources in South Africa, DWAF (2008)*

[3] *The radius of influence is time dependent and the RU statistics is based on borehole pumping of 8 hours/day*

[4] *A protection zone is defined as a zone where the groundwater gradient is maintained*

[5] *South African Water Quality Guidelines, DWAF (1996)*

[6] *Groundwater Resource Directed Measures, WRC (2007)*

[7] *Groundwater Resource Directed Measures, WRC Project No K8/891 (2011)*

4.4.2 SUPPLEMENTARY INFORMATION FOR THE GROUNDWATER RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS TABLES

Table 28: Supplementary information for GROUNDWATER in priority RUs in the Olifants WMA.

GROUNDWATER						
IUA	**RU**	**Component**	**Indicator/ measure**	**Context of the RQO**	**TPC**	**Reference**
All	All Prioritised RUs	Quantity	Abstraction Rate (Q) per hectare > Reserve, Schedule¹ and General Authorizations.	In areas where the abstraction per unit area exceeds the recharge per unit area, aquifer failure is likely. Although it is not possible to abstract all recharge from groundwater, the abstraction compared to the recharge gives an indication of the current aquifer stress.	Stress Index = Abstraction / Recharge, Highly Stressed = 0.65 to 0.95, Critically Stressed > 0.95	WRC, 2007
All	RU1 RU2 RU3 RU4 RU6 RU7 RU8 RU9 RU10 RU11 RU12 RU14 RU15 RU17 RU18 RU19 RU24 RU27 RU28 RU31 RU33 RU34 RU56 RU59 RU62 RU73	Aquifer	Depth to Groundwater Level using Groundwater Monitoring Guidelines²	Recovery in groundwater levels over time is an indication that over abstraction is not taking place. Although groundwater levels can vary significantly across a resource unit, groundwater monitoring points should be identified which is representative of the overall aquifer response.	N/A	WRC, 2011
	RU22			Recovery in groundwater levels over time is an indication that over abstraction is not taking place. Although groundwater levels can vary significantly across a resource unit, groundwater monitoring points should be identified which is representative of the overall aquifer response.	Declining water level trend from average level after wet season	WRC, 2011
	RU21					
	RU53					
	RU58					
All	All Prioritised RUs	Quantity	Radius of influence (r) □. r = 1.5*√(T*t/S), T=Transmissivity (m²/d), t=Time (days), S=Storativity. Annual sampling via GIS	The radius of influence of a borehole gives an indication of how far the effect of the borehole drawdown will reach. It should be noted that this is a theoretical estimate and is not dependent on	N/A	WRC, 2007

			algorithm or on introduction of new borehole	the abstraction rate, but only on the aquifer parameters and the duration of abstraction. The borehole radius of influence should not intersect any other radius of influence or protection zone.		
All	All Prioritised RUs	Ecological	Distance from river (L) 4. L = (T*i)/R, T=Transmissivity (m2/d), i=Groundwater Gradient, R=Recharge (m/d). Annual sampling via GIS algorithm or on introduction of new borehole	The concept of a river protection zone is to ensure that the average groundwater gradient toward the river is not altered, as this is the driving force of the natural groundwater seepage toward the river. This gradient will stay intact as long as there are no other protection zones infringing on the river protection zone.	N/A	WRC, 2007
All	All Prioritised RUs	Ecological	Distance from river (L) [4]. L = (T*i)/R, T=Transmissivity (m^2/d), i=Groundwater Gradient, R=Recharge (m/d) W=Wetland Perimeter. Annual sampling via GIS algorithm or on introduction of new borehole (perimeter is based on the Wetland Delineation Guidelines).	The concept of a wetland protection zone is to ensure that the average groundwater gradient toward the wetland is not altered, as this is the driving force of the natural groundwater seepage toward the wetland. This gradient will stay intact as long as there are no other protection zones infringing on the wetland protection zone.	N/A	WRC, 2007
All	All Prioritised RUs	Quality	Microbial radius (r) [4]. r = 2(0.28*T) + 53, T=Transmissivity (m^2/d). Annual sampling via GIS algorithm or on introduction of new borehole	Communities dependent on groundwater often don't have sufficient infrastructure for sanitation purposes. The result of this is that houses and pit latrines are often constructed close to the water supply which leads to microbial pollution of the groundwater emanating from the pit latrines. High Nitrate values are a known cause of the "blue baby" syndrome and are fatal to young children. The microbial protection zone aims to protect groundwater from being exposed to high Nitrate values.	N/A	WRC, 2007
All	All Prioritised RUs	Quality	Background water quality per borehole using Groundwater Monitoring Guidelines2[2]	Groundwater should be fit for use e.g. human consumption, stock watering or irrigation purposes. Due to the fact that groundwater quality is related to the underlying geology it is often found that the background water quality exceeds the guideline associated with a particular use. For these cases the groundwater quality should be managed against the natural background values and all other cases should be managed against the specified guideline applicable to the specific use.	Continued declining water quality trend from established background	N/A

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6 APPENDICES

6.1 APPENDIX A: TECHNICAL BRIEF FOR THE JUSTIFICATION OF WATER QUALITY NUMERICAL LIMITS USED IN THE STUDY.

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SCOPE OF THE BRIEF

The brief was to determine water quality RQOs and Numerical Limits i.e. numerical estimates of the values of water quality variables ensuring a balance between ecological functioning and economic use of water resources for the Olifants River.

Variability and uncertainty in the data

The contributors to the indeterminacy of the value of a water quality variable characteristic of a desired state are divided into the two entities, *variability* and *uncertainty*:

- Uncertainty: in a system is partitioned into known elements, the behaviour of which are unknown, and elements interacting with and within systems, which are completely unknown. Known uncertainty is for example the direction and magnitude of climate change, of population migrations, of international commodity markets. Unknown uncertainty is that which is identified and reduced through the application of scientific research and management experience. Thus in order to account for uncertainty, RQOs may be regarded as “best estimates” in the light of current knowledge.
- Variability: in the system is the known or potentially known changing behaviour of elements within the system, such as annual fluctuations in temperature, rainfall, drought cycles and others.

In this assessment an attempt is made to quantify variability in water quality parameters by making the assumption that elements influencing immediate future behaviour of systems impacting on the water quality of a resource are relatively static in the short timeframe of the anticipated lifetime of the RQO. The variability in the water quality of the water resource is taken as the variance in the water quality parameters measured over a stipulated period. The variability embedded in the RQO is expressed as the 95th %ile of the projected range of the water quality variable. In other words, embedded in the philosophy underlying the endeavour of quantifying RQOs for water quality is the knowledge that the Numerical Limits must change in future as understanding of the ecosystem is improved.

Compliance with water quality RQOs and Numerical Limits

Compliance with RQOs and especially Numerical Limits may be confused with compliance with a license condition. The main difference between compliances is that RQOs are *objectives* conceivably unattainable at present. In the present application, the managers of the water resource would be required to demonstrate continual approach towards the RQO, as opposed to the situation of compliance with a license condition, which is strict adherence to an achievable range of water quality values.

Conceived future implementation of water quality RQOs

The expression of RQOs as numerical quantities, albeit with ranges to address variability and embedded uncertainty, is viewed by the author of this document as an interim strategy, pending a more sophisticated approach. It is conceived here that rather than documentation and Gazetting of numerical values of RQOs, a more favourable future approach would be documentation and Gazetting of an accepted, scientifically and technically defensible, *method* of deriving unambiguous RQOs, in the light of the complexity of each system examined. Within complex systems many factors are connected to each other as “trade-offs”, arising naturally and immutably, such that the behaviour of one entity is strongly negatively or positively impacted by another. In these situations the normal logic of fixed entities breaks down. An imperfect but simple example would be the definition of RQOs for Winter and Summer periods, when annual absolutes do not exist.

Bayesian logic handles fractional values of descriptors.
Since systems of interacting elements may be represented as networks of known or hypothesised relationships between known entities, the Bayesian Network Analysis approach is more subtle and dynamic than the approach assumed in the current endeavour. It is anticipated that this or similar instruments may be standardised, as opposed to the uncertain and changing numerical descriptors of a desired state of a water resource.

Sources of information for this study
Site Water Quality Monitoring Data

Water quality monitoring data informing the projected values of water quality parameters was obtained from the DWA WMS database.

Water Quality Standards
The sources of water quality standards were the:

- South African Water Quality Guidelines (second edition). Volume 1: Domestic Use (2006);

METHODS
Origin of the data
The Google Earth WMS templates were used to locate the most appropriate DWA water quality monitoring sites to adequately characterise the water quality status and trends in the resource under investigation. In the case of dams the choice of monitoring point is usually straightforward since for most dams there exists a water quality monitoring point at which samples are taken and analysed and the resultant water quality information is readily available on the WMS site. In the case of rivers the situation is much more complex as water quality monitoring points may fortuitously be located at the lowest point of the region (or Resource Unit) of interest, but often such DWA water quality monitoring points are located elsewhere on the water resource, or completely absent. Various strategies are implemented to estimate what the conditions might be in the water resource under investigation, including inspection of land use and assignment of data from similar water resources relatively close geographically.

Use of the data
Prior to the current determination of numerical values for characterising desired states of the water resources, analysis had been performed of the requirements of various entities within the ambit of the resource and the general RQO expressed in terms of DWA categories “A” to “E”. In deriving the current values, an adaptation of the methods for deriving site-specific water use license criteria was implemented. A reference monitoring point, supposedly representing data from a “pre-anthropogenic” impact, was chosen such that the water quality monitoring data represented a state several decades before the present. The “Present Ecological Status” monitoring location was chosen as described above.

Monitoring data points were examined for obvious spurious irregularities, such as those resulting from errors in input to the WMS database. These would typically be manifested as gross “outliers” from the range of the data representing the water quality parameter under investigation. Caution should be exercised, however, in excising these “outliers” from the dataset, as they may represent real occurrences which may be a feature of the system impacting the water resource, and thus should be retained in the analysis. There are methods of cross-checking such apparent anomalies. For instance, if a spike in electrical conductivity is observed in a water resource directly downstream of a coal-mining operation, the corresponding pH of the water sample would be expected to decrease significantly. If not, then traditional statistical outlier analyses may be implemented to test for advisability of deleting the value from the analysis. Water quality monitoring data is often sparse and there is a considerable temptation to use one of the “missing value interpolation” algorithms to yield a larger dataset for analysis. This practice was avoided in this endeavour, but may be considered in future implementations, particularly if a Bayesian analysis is used. The dataset representing the reference condition and the present ecological status were inputted into the Reserve Determination program TEACHA, the use and interpretation being provided in DWA (2008).

The distinct advantages of using this tool include

- Rigorous development of the algorithms
- Extensive implementation of the method for setting guidelines
- Similarity of purpose between the setting of guidelines and derivation of RQOs
- Embedded sophisticated methods for determining the 95^{th} %ile for the numerical limits.

Baseline adjustment of the “reference condition” data was implemented in order to project the output of the TEACHA program into the range of desirability of the water quality parameters. The latter implementation may seem at first glance to add an arbitrary modification to an exact procedure. The justification for this approach lies in the current high indeterminacy of the characteristics of the systems within the regions of interest, mindful of the objective of the exercise, that being to establish a range of values for the RQOs, expressed as a 95^{th} %ile. Workshops were convened and the required medium-term water quality objectives established based on current available information as described above. The outputs of the workshops as regarding water quality were the different levels of protection required for a water resource, including rivers, dams and wetlands. These levels of protection were translated into the well-known and widely implemented water resource classes. In some instances water quality classes have not been derived for water quality constituents of interest and of importance. Variables not currently analysed and graded in terms of the water resource class system include sulphate, uranium, biological oxygen demand (BOD) and Chemical Oxygen Demand (COD).

RQOs as indicators of water quality risk

The water quality RQOs and their associated Numerical Limits function as recommended upper concentrations for the resource to be managed. The RQOs and Numerical Limits thus function as target indicators for management, akin to the “Effects” values employed in an Ecological Risk Assessment (US EPA 1999). The observed concentrations of the water quality variables would function as “Exposure” parameters to be compared to the Effects values. The water quality variable in concern would be referred to as the “Stressor” and the measure of the water quality variable as the “Exposure”. These two measures fit into the Tier I Risk Assessment method which is simply a comparison of the two values, Exposure and Effects values, in a mathematical relationship. More specifically the Tier I Risk Quotient is the value obtained when Exposure concentrations are divided by Effects concentrations. Thus if the Tier I Risk Quotient is less than 1.0 then the Exposure concentrations are less than the Effects concentrations, and one assumes that all is well with respect to that water quality parameter. In the case of the analysis performed in the derivation of the RQOs in the current study, the Tier I Risk Quotient would be less than 1.0 if the concentrations of water quality parameter were below the RQO Numerical Limit for that parameter.

Use of DWA Classifications for water quality RQOs.

The target quality of the water resource under investigation is expressed in the familiar DWA resource classifications expressed in Table A2.1 below. Acceptable resource classes range from A to D and are directly associated with PES ratings which range from 1 to 4. In the case of many water quality variables, the concentrations relate to the classes in a linear fashion, as shown in Figure A2.1.

Table A2.1: DWA resource classifications

Resource ecosystem values	Natural	Good	Upper Fair	Lower Fair
Deviation from reference condition	No change	Small change	Moderate change	Large change
Water Quality category	A	B	C	D
PES Ratings	1	2	3	4

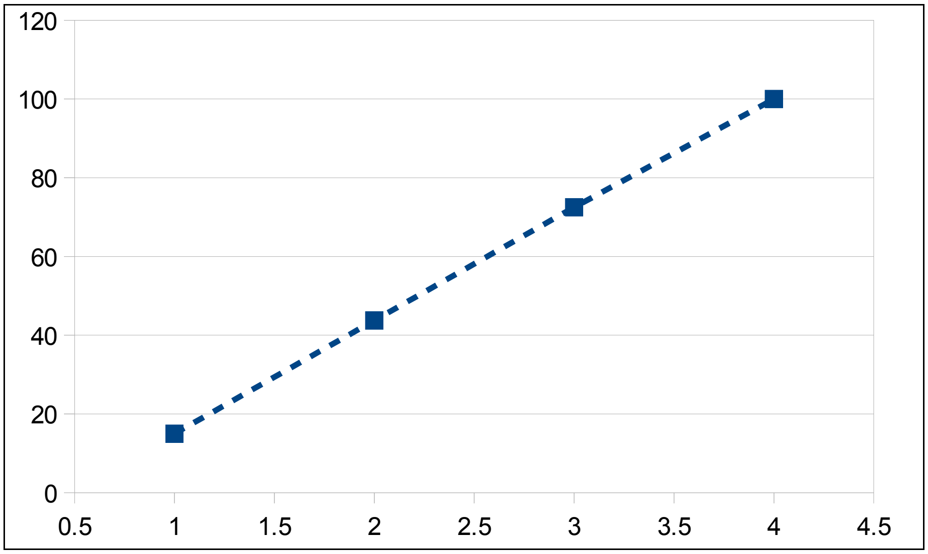

Figure A2:1 Concentrations (y-axis) of ammonia corresponding to DWA categories (x-axis).

The general method for establishing the concentration ratings is to establish the chronic effects concentration of a particular water quality variable on an indicator organism and to set the upper limit of the A category to this value. The acute effects value on the organism is set to the upper limit of the D category. The intervening categories are usually derived by interpolating a straight line through the A value and the D value, with the PES ratings acting as the numerical equivalent of the categories A to D. Fractional ratings are allowed for, given that some of the resource classes are broad in definition and some ecosystem requirements change within the classification. Thus if an ecosystem requirement falls between an A and a B category, the required value of the ecosystem category is designated AB. The numerical equivalent of the fractional ecosystem category is derived by interpolating between the categories on either side. Thus if a concentration value corresponding to an AB category is required, the concentration values of the water quality variable corresponding to A category (PES rating = 1.0) and B category (PES rating = 2.0) are interpolated to a PES rating of 1.5. E.g. for unionised ammonia the concentrations corresponding to the ecological categories are as presented in Table A2.2

Table A2.2 Ammonia (unionised) values at fractional levels of WQ category.

Water Quality category	A	AB	B	BC	C	CD	D
PES Ratings	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Ammonia (ug/L N)	15.0	29.4	43.8	57.8	72.5	86.2	100

Thresholds of potential concern (TPCs)

The threshold of potential concern (TPC) is the numerical value which serves as an alert that the ecological system is potentially threatened by approach of the relevant water quality variable to the RQO Numerical Limit value. The TPC is set to the concentration corresponding to the interpolated intermediate fractional value of the ecosystem category. Thus, for example, if the substance in question is ammonia and the Numerical Limit is the

AB category, corresponding to a PES rating of 1.5 (mapping onto a concentration of 29.4 ug/L N), the TPC will correspond to a PES rating of 1.0 (mapping onto a concentration of 15.0 ug/L N).

Relationship of RQO Numerical Limits and TPCs with Risk Quotients

If the RQO Numerical Limit is the upper limit of tolerable effects, corresponding to stressor concentrations, a Risk Quotient of a stressor at the RQO is 1.0. Since in the case of a linear relationship of DWA categories with stressor concentrations corresponding to chronic ill effects (upper limit of A category) to acute ill effects (upper limit of D category) the intercept of the extrapolated line is not guaranteed to be zero, there is no clear regularity between TPC and Risk Quotient.

Water Quality Criteria defining risk

Exposure parameters

Water quality exposure parameters as classified in DWAF (2008) are presented below (Table A2.3). This list is incomplete with respect to the study of the catchments in this study, for which local guidelines were derived.

Table A2.3: Water quality indicators for which SA Guidelines exist

Algae	Cyanide	Phenol
Alkalinity	Dissolved Organic Carbon	Phosphorus
Aluminium	Dissolved Oxygen	Potassium
Ammonia	Endosulfan	Protozoan Parasites
Arsenic	Enteric Viruses	Radionuclides
Asbestos	Faecal Streptococci	Selenium
Atrazine	Fluoride	Silica
Beryllium	Iron	Sodium
Boron	Lead	Sodium Absorption Rate
Cadmium	Lithium	Sulphate
Calcium	Magnesium	Sulphides
Carbon Dioxide CO	Manganese	Suspended Solids
Chemical Oxygen Demand	Mercury	Total Dissolved Solids
Chloride	Molybdenum	Total Hardness
Chromium(VI)	Nickel	Trihalomethanes
Cobalt	Nitrate/Nitrite	Turbidity
Coliforms	Nitrogen (Inorganic)	Uranium
Coliphages	Odour	Vanadium
Contents	Organic Carbon	Zinc
Copper	pH	

SUBSTANCES RELEVANT TO THIS STUDY

Consideration of inclusion of WQ variables

The workshops defining the water quality categories of the selected geographical units, water resources, and the water quality constituents of relevance yielded the following comprehensive list for the Olifants, Upper Vaal and Lower Vaal catchments. The water quality constituents easily represent as indicators or measures of water quality in the geographical units. The values corresponding to the indicators or measures are specified in published texts. These are referenced in Table A2.4.

Table A2.4: Present State Rating variables used for the Water Quality RQO components (DWAF (2008)

Target	Type	Indicator
Human & ecosystem	Metal	Al
Human & ecosystem	Metalloid	As
Human & ecosystem	Pesticide	Atrazine
Human & ecosystem	Metal	Cd hard
Human, ecosystem & agriculture	Halogen	Chlorine (free)
Human & ecosystem	Metal	Cr(VI)
Human & ecosystem	Metal	Cu hard
Human & ecosystem	Pesticide	Endosulfan
Human & ecosystem	Halogen	F
Human & ecosystem	Metal	Hg
Wetland biota	Electron donor	Ammonia (unionised)
River and wetland biota	Oxidant	Dissolved oxygen
Human & ecosystem	Metal	Cu hard

Table A2.5: Variables used for the Water Quality RQO components (This study)

Target	Type	Indicator
Human	Algal toxins	Chl-a: phytoplankton
Wetland biota	Reductant	COD
Human & ecosystem	Metal	Mn
Human & ecosystem	Metalloid	Se
Wetland biota	Electron donor & acceptor	TIN-N
River organisms	Electron donor	Total Ammonia
Human & ecosystem	Metal	Uranium
Human & ecosystem	Metal	Zn
River and wetland biota	Oxidant	Dissolved oxygen

Nutrients

Nutrients - general

Total inorganic nitrogen (TIN = $[NO_2^-] + [NO_3^-] + [NH_4^+]$: species specified as concentration of nitrogen) – Note that unionised ammonia is regarded as a toxicant and described under “Toxics”. At pH levels below 9.3 most ammonia is in the ionised ammonium (NH_4^+) form.
Phosphate (PO_4^{3-}) – also referred to as SRP (Soluble Reactive Phosphorous) or ortho-phosphate, as distinct from Total Phosphate, designated “TP”.

Ammonia (Total)

Total ammonia as a nutrient was used in the context of river water quality.
Within the context of river water quality the total ammonia was specified as a RQO Numerical Limit in order to limit the trophic state of the river to mesotrophic (“good”) state, and to prevent nuisance conditions for ecotourism. Ammonia is very readily detected as a smell and is noxious at concentrations below that of many other naturally emitted gases.

Chl-a: phytoplankton

Chl-a: phytoplankton is used as an indicator for the presence of nutrients in a water resource. The indicator is useful because chlorophyll-a is readily and inexpensively measured by spectrophotometry.

Care has to be used in using Chl-a as an indicator where there is additional turbidity not due to algal biomass. If significant turbidity is a result of inorganic particle suspension the particles may occlude the chlorophyll and result in a measurement lower than actual.

Nitrate (NO_3) & Nitrite (NO_2)

Nitrate (NO_3) & Nitrite (NO_2) is a direct measure of nutrient concentration, the NOx being utilised by algae, high levels of which nutrient result in high levels of problematic algal biomass.

Total Inorganic Nitrogen (TIN)

Total Inorganic Nitrogen (TIN) is a useful measure of nutrient concentration.

Care must be taken, however, in systems in which ammonia is in high concentration. Ammonia will report to TIN, whilst it is not directly used as a nutrient by macroscopic organisms.

The assumption that ammonia is a useful component of TIN as describing nutrient status may not be valid. The conversion of ammonia to the actual nutrients NOx is slow and in many systems may be regarded as a "spectator ion".

Phosphate (PO_4)

Phosphate (PO_4) is a nutrient, being readily absorbed by organisms and used to make DNA and cell-wall phospholipids. *The ratio of phosphate to NOx is an important factor in predicting the undesirable growth of algal biomass, being important to a number of algal species.*

Pathogens

E. coli

E. coli is an important indicator of pathogens in water resources. Whilst active as a pathogen on its own, it is usually present concomitant with other water-borne pathogens utilising or being emitted through the digestive tract. *Cholera vibrii* is one such pathogen. Whilst ingestion of any water containing *E. coli* and associated pathogens is discouraged, the water in the resources under study are deemed as being non-potable, the RQO of *E. coli* defaulting to the agricultural limit. Support for the RWQO set at the limit of 150 counts/100 mL comes also from a study commissioned by the Australian Government Department of Sustainability, Environment, Water, Population and Communities (ANZECC/ARMCANZ, 2000) (cit. in: Sinclair et al., 2011). This study quotes objectives relating to water quality as:

Good:	<=150 CFU /100mL
Fair:	>150 and <500 CFU /100mL
Poor:	>500 and <1000 CFU /100mL
Very poor:	>1000 CFU /100mL

Salts

"Salts" is a term describing dissolved solids. Dissolved solids impact biota by influencing the ionic strength of the environment in which aquatic biota function. Ionic strength is an important determinant of the natural extent of biochemical reactions. Aquatic organisms usually have the ability to "osmoregulate", being the capacity to pump ions into, or out of the local environment through membranes. These reactions are frustrated if the concentrations of ions are too high or too low.

Electrical conductivity (EC)

Electrical conductivity has long been known to be an indicator of bulk ionic strength of aqueous solutions. Electrical conductivity is readily measured on-site using relatively inexpensive equipment.

Care must be taken in applying blanket values for RQOs using EC. In naturally saline systems organisms are adapted to the ambient salinity and high EC readings may not indicate a problem for the ecosystems. Default trigger values for key water quality variables for ecosystems in Australia (ANZECC/ARMCANZ 2000) are presented in the following table:

Region	Upper riverine (uS/cm)	Lower riverine (uS/cm)	Dams and lakes
South-east Australia	30-350	125-2200	20-30
Tropical Australia	20-250	20-250	90-900
South-west Australia	120-300	120-300	300-1500
South central Australia	n/d	100-5000	300-1000

Thus there may be a great regional disparity in EC values to which local biota are conditioned and a more sensitive approach is required. Whilst studies on particular organisms form the basis of many water quality guidelines, broader concerns such as biodiversity have been studied. The relationship between stream macroinvertebrates and measures of conductivity in Queensland river systems was examined to assess if there were any broad patterns in community composition that were attributable to salinity. Family level presence/absence stream macroinvertebrate data from edge (2580 samples) and riffle (1367 samples) habitats collected throughout Queensland in spring and autumn from 1994 to 2002 was used in this analysis. Salinity Sensitivity Scores (SSS) wer e derived for individual macroinvertebrate families in Queensland. SSS were derived from the results of a sensitivity analysis using predictive Artificial Neural Network (ANN) models. After establishing the SSS for individual macroinvertebrates, A Salinity Index (SI) was proposed to reflect changes in macroinvertebrate communities caused by changes in conductivity. The SI was calculated using a formula including presence/absence of taxa and number of taxa in the samples. (Dunlop et al, 2005). The results show that as conductivity increases, sensitive taxa are being replaced by tolerant taxa, and this is reflected in decreasing values of SI with increasing conductivity (Figure A2.2). This trend is obvious in both habitats but appears to be more prominent in riffles. Figure 10 shows changes in the percentage of sensitive and very tolerant taxa with increasing conductivity (12 equal intervals). With reference to riffle data, sites having an EC in the range of 800 and 1500 µS cm -1 were observed to have a decrease in the mean percent of sensitive taxa from 33 to 16.7 relative to the low conductivity category (22-99 µS cm -1) and percent of very tolerant taxa increased accordingly from 9.4% to 32%. The following figures (Figure A2.2 and Figure A2.3) indicate a possible method of evaluating site-specific RWQOs in important catchments .

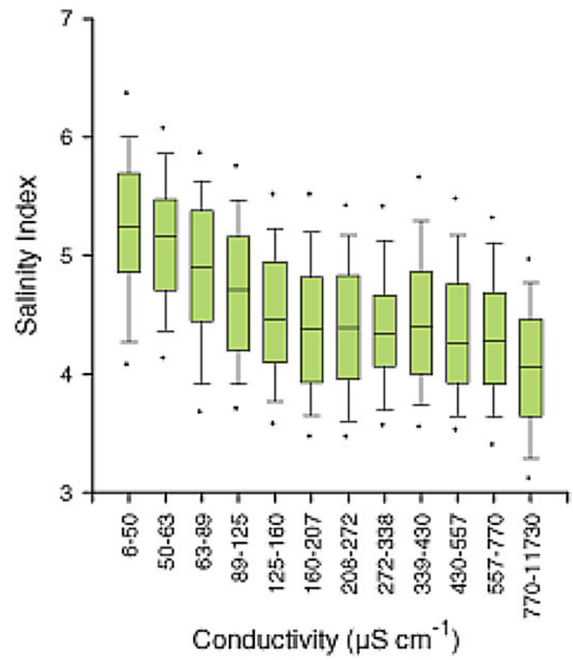

Figure A2.2: Salinity index along increasing conductivity gradient for edge habitats. Median values with boxes corresponding to 80th and 20th percentiles and horizontal bars to maximum and minimum.

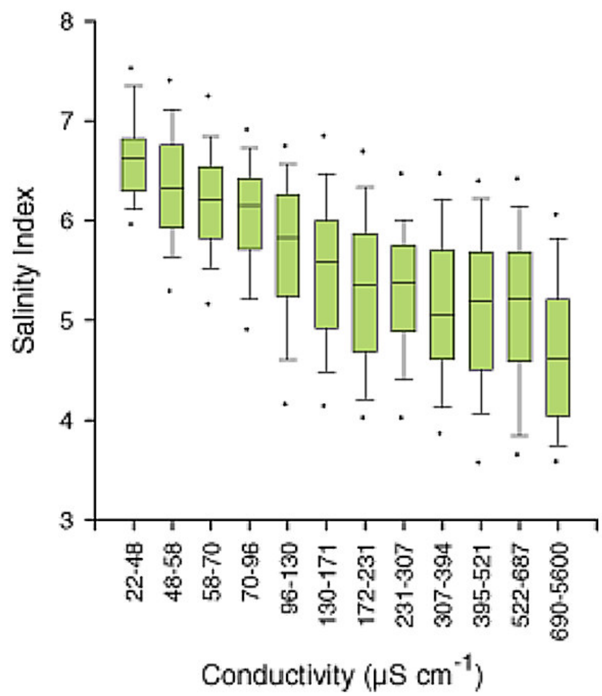

Figure A2.3. Salinity index along increasing conductivity gradient for riffle habitats. Median values with boxes corresponding to 80th and 20th percentiles and horizontal bars to maximum and minimum.

Sulphate (SO_4)

Sulphate is not usually considered a “Salt”. It is an anion, and usually a minor component of environmental water resources. In the regions of concern, however, acid mine drainage (AMD) is a significant concern downstream of large formal coal-mining operations, and intense informal coal-mining operations. Sulphate a good indicator, in combination with EC values, of the origin of water pollution contributing to adverse environmental conditions. Sulphate is also involved in problematic behaviour in anaerobic sediments. Sulphate is converted to sulphide, which interferes with the iron-phosphorous cycles. In addition, sulphate may competitively bind to anion-adsorption sites in sedimentary organic matter. By both mechanisms phosphate is expelled from sediments and becomes a problem in eutrophication (Smolders et al, 2006; E. Tamis & C.C. Karman, 2008).

System variables

pH

The concentration of the hydrogen ion (H^+) is particularly important in the regulation of various biochemical reactions, and is measured as pH = $-\log[H^+]$. All organisms operate within a range of pH values typical to their ability to regulate internal and external concentrations of hydrogen ion. This parameter is one of the most important parameters dictating limits on survival of species.

Alkalinity

Alkalinity is a “second-order” system variable, often correctly related to the capacity of the aqueous system to buffer bulk pH levels from small impacts by acidic or alkaline inputs. Usually carbonate anion, represented dominantly by bicarbonate anion at pH values about neutral (pH = 7), is the major factor in alkalinity of a system.

Dissolved oxygen

Dissolved oxygen is important for respiration of aquatic organisms. The levels of dissolved oxygen may be depleted by chemical reactions with organic matter, (reaction product being carbon dioxide). Dissolved oxygen may also be depleted by rapid, transient rise in temperature.

Temperature

Temperature is akin to pH in that all biochemical reactions are governed by temperature. Temperature governs the rate of reactions, and all organisms function within a range of temperature values, beyond which the different changes in rates of reactions leads to imbalances of biochemicals and ultimately to the collapse of the biochemical system that is an organism. Thermal impacts include outputs from power stations, outputs from dams which buffer temperature at levels that may differ from downstream rivers, and likewise changes in flow rates of rivers, impacting the rate of gain or loss of heat from the environment. Whilst it is recommended that water temperature be modelled from ambient air temperatures (DWAF, 2002; DWAF, 2008), it may be preferable to measure temperature directly to eliminate unaccounted confounding factors influencing model estimates. Temperature requirements of organisms are site-specific. Thus there is no universal baseline for temperature data as a measure of ecological impact. The expedient of using temperature *deviations* from optimal/natural conditions is effectively used.

Turbidity and/or water clarity

Turbidity/water clarity is the result of suspended particles in the river. The suspended particles may influence the river system by excluding light (implied by the "water clarity" description), or by directly occluding gill membranes of aquatic organisms. As with temperature and salinity, turbidity/water clarity is site-specific. Most aquatic scientists prefer to use clarity measures as opposed to turbidity measures. The advantage of this choice is that rapid measurements may be made under field conditions. The disadvantage is that measurements are related to individual observer optical functionality, and thus clarity is not a repeatable, fixed measure. Thus in this document turbidity is recommended as a measure, being reliably and accurately measurable in an analytical laboratory.

Toxic substances

Toxic Substances currently regulated by DWS. Toxic substances are chosen as those listed in the South African Water Quality Guidelines for Aquatic Ecosystems (DWAF, 1996) (Table A2.6). This category includes unionised ammonia, toxic metal ions and toxic organic substances. Toxic substances identified as relevant to the current study are listed in Table A2.7.

Table A2.6: Toxic Substances (ecological) regulated by DWAF (1996)

Aluminium	Lead
Ammonia	Manganese
Arsenic	Mercury
Atrazine	Nitrogen (Inorganic)
Cadmium	pH (Acidity and Alkalinity)
Chlorine	Phenol
Chromium	Phosphorus (Inorganic)
Copper	Selenium
Cyanide	Temperature
Dissolved Oxygen	Total Dissolved Salts/Solids
Endosulfan	Total Suspended Solids
Fluoride	Zinc
Iron	

Table A2.7: Toxic Substances relevant to this study

Target	Type	Indicator	Reference
Human & ecosystem	Metal	Al	DWAF (2008) (Tables below)
Human & ecosystem	Metalloid	As	
Human & ecosystem	Pesticide	Atrazine	
Human & ecosystem	Metal	Cd hard	
Human	Algal toxins	Chl-a: phytoplankton	
Human, ecosystem & agriculture	Halogen	Chlorine (free)	
Wetland biota	Reductant	COD	
Human & ecosystem	Metal	Cr(VI)	
Human & ecosystem	Metal	Cu hard	
Human & ecosystem	Pesticide	Endosulfan	
Human & ecosystem	Halogen	F	
Human & ecosystem	Metal	Hg	
Human & ecosystem	Metal	Mn	
Wetland biota	Electron donor	Ammonia (unionised)	
Human & ecosystem	Metal	Cu hard	
Human & ecosystem	Metalloid	Se	This study
Wetland biota	Electron donor & acceptor	TIN-N	This study
River organisms	Electron donor	Total Ammonia	This study
Human & ecosystem	Metal	Uranium	This study
Human & ecosystem	Metal	Zn	This study

Selected toxic substances will be discussed in this section.

Ammonia (unionised)

Unionised ammonia is toxic. It readily enters cells through lipid cell walls (hydrophobic) due to being neutrally charged, not excluded as would be hydrophilic charged ions. Once within the cell, ammonia may ionise and change internal pH values, or it may overwhelm the mechanisms of excretion of toxic metabolic by-products. Ammonia is the principle form of nitrogenous excretion by fishes. At 25 degrees C at pH values of above 9.3, ammonia exists predominantly in the unionised form. The pH at which ammonia exists in the unionised form is dependent on temperature. Lookup tables may be used to determine the concentration of unionised ammonia from the concentration of total ammonia. This process is laborious and it is here recommended that total ammonia be analysed for as a screening value.

Hardness-sensitive toxic transition metals

As regulated as toxins, the toxic transition metals Cu, Cd and Pb have differential effects on biota as a function of water hardness. In the current study the RQOs corresponding to these toxic metals refer to the levels in hard water. This assumption was initially motivated by hardness levels appropriate to systems in which dolomite was dissolved by AMD, as occurs in the gold-mining areas of the Western Basin. At low levels of ambient hardness, high-hardness RQOs for these metals will be somewhat under-protective of aquatic life. It is a topic for future discussion as to whether the RQO values for the metal ions be adapted for current levels of hardness in the resource waters, or for future levels of hardness extrapolated by chemical speciation calculation from all RQOs for the resource under investigation.

Toxic ions of Mn, Se and Zn

Categorical concentration criteria for the toxic ions of Mn, Se and Zn are absent from the DWAF (1999) and DWAF (2008) guideline documents. Thus the levels of concentrations of these entities corresponding to resource water classes were derived using the method of assigning chronic toxicity values to the upper limit of "natural" class A, and acute toxicity values to the upper limit of "natural" class D.

Cyanobacterial blooms; algal toxins

Cyanobacterial blooms and other algal toxins are extremely dangerous if ingested. The toxins emitted by these organisms are very expensive to measure directly. Thus a useful surrogate is used, being measurements of Chl-a: phytoplankton.

Uranium

≤ 10 µg/L (Irrigation),
≤ 15 µg/L (this study)

Canadian Council of Ministers of the Environment. 2011. Canadian water quality guidelines for the protection of aquatic life: Uranium. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg. Pp 1-9. Not much work has been done to establish uranium water quality guidelines for ecosystems. A notably consciencious study of this matter was conducted in British Columbia (CCME. 2011 in: CCME, 2011a). The method of determining Canadian Water Quality Guidelines for Uranium (Total recoverable, Unfiltered) for the Protection of Aquatic Life in ecological systems was the Species Sensitivity Distribution (SSD). The long-term water quality criteria were based on the SSD 5th percentile, as opposed to the SSD 5th percentile, 90% LFL (5%) = 9 µg/L, or the SSD 5th percentile, 90% UFL (95%) = 130 µg/L. Toxicity endpoints were lethality. Long-term exposure guidelines identify benchmarks in the aquatic ecosystem that are intended to protect all forms of aquatic life for *indefinite* exposure periods (≥ 7d exposures for fish and invertebrates, ≥ 24h for aquatic plants and algae). Long-term exposure levels toxic to a range of species was determined to be 15 µg/L uranium. "Long-term" exposure ranged from exposure periods of 7 days (*C. dubia*; reproduction) to 141d (*S. namaycush*; survival). The short-term water quality criteria were based on the SSD 5th percentile, as opposed to the SSD 5th percentile, 90% LFL (5%) = 8.5 µg/L, or the SSD 5th percentile, 90% UFL (95%) = 25 µg/L. Toxicity endpoints were non-viable embryos, survival and growth. "Short-term" exposure ranged from exposure periods of 24h (*C. latipinnis*) to 96h (*O. mykiss*). Short-term exposure levels toxic to species was determined to be 33 µg/L uranium. Toxicity endpoints were lethality. An example plot of long-term SSD is presented in Figure A2.4.

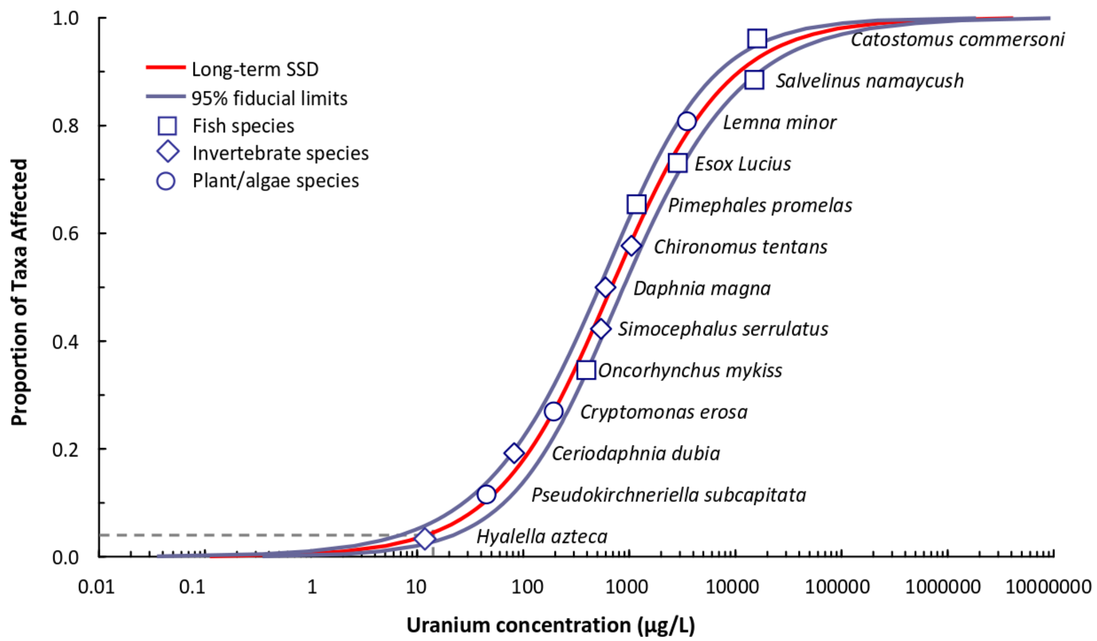

Figure A2.4: Long-term SSD for Uranium (Total recoverable, Unfiltered)

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SA RESERVE GUIDELINES

Water quality ranges corresponding to resource classifications are presented in Table A2.8 below:

Table A2.8: Water quality ranges corresponding to resource classifications

Natural – Poor categories		Natural	Good	Upper Fair	Lower Fair	Poor
PES rating		0	1	2	3	4
Deviation from reference condition		No change	Small change	Moderate change	Large change	Serious change
Water quality indicator	Units	Values				
EC	mS/m	0	30.1	55.1	85	-
pH	5th percentile Min	6.5	5.9	5.6	5	4
pH	95th percentile Max	6.5	6.5	5.9	5.6	5
pH	95th percentile Min	8	8	8.8	9.2	10
pH	5th percentile Max	8	8.8	9.2	10	11
Al	µg/L	20	62.5	105	150	192.5
Ammonia	µg/L	15	43.75	72.5	100	128.75
As	µg/L	20	57.5	95	130	167.5
Atrazine	µg/L	19	48.75	78.5	100	129.75
Cd soft	µg/L	0.2	0.7	1.2	1.8	2.3
Cd mod	µg/L	0.2	0.95	1.7	2.8	3.55
Cd hard	µg/L	0.3	1.63	2.95	5	6.33
Chorine (free)	µg/L	0.4	1.75	3.1	5	6.35
Cr(III)	µg/L	24	115	206	340	431
Cr(VI)	µg/L	14	67.5	121	200	253.5
Cu soft	µg/L	0.5	1.03	1.55	1.6	2.13
Cu mod	µg/L	1.5	3.03	4.55	4.6	6.13
Cu hard	µg/L	2.4	4.88	7.35	7.5	9.98
Cyanide	µg/L	4	32.5	61	110	138.5
Endosulfan	µg/L	0.02	0.08	0.13	0.2	0.26
Fluoride	µg/L	1500	2510	3520	2540	3550
Pb soft	µg/L	0.5	1.63	2.75	4	5.13
Pb mod	µg/L	1	3	5	7	9
Pb hard	µg/L	2	5.75	9.5	13	16.75
Hg	µg/L	0.08	0.53	0.97	1.7	2.15
Phenol	µg/L	60	200	340	500	640
DO	mg/L	8	8	6	6	4
PO4-P	mg/L P	0	0.01	0.02	0.03	0.13
TIN-N	mg/L N	0	0.25	0.7	1	4
Chl-a: periphyton (mg/m2)	mg/m^2	0	10	15	20	30
Chl-a: phytoplankton (µg/L)	µg/L	0	1.7	12	21	84

Data taken from DWAF (2008)

6.2 APPENDIX B: ADDITIONAL JUSTIFICATION OF SULPHATE SPECIFIC WATER QUALITY NUMERICAL LIMITS USED IN THE STUDY.

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There are a number of different guidelines or trigger values for sulphate concentration published by various regulatory agencies. Most of the guidelines and trigger values are based on species sensitivity distributions which are the "toxicology state-of-the-art" at the time of writing of this document. Many propose a guideline value for aquatic health in terms of sulphate concentration as around 500 mg/L sulphate. The current study assumes that the EC guideline values for aquatic health have been in use for a long period and are thus assumed to be provisionally non-contentious. Thus setting a sulphate guideline value as guided by EC relationships in a highly sulphate-polluted catchment would be appropriate until more site-specific methods were applied, such as whole effluent toxicity tests. Sulphate and EC values that were measured in tandem by DWA and published on WMS were downloaded and submitted to a rigorous data verification regime. The paired values were then plotted and a very large scatter was observed in the data. This scatter was enhanced when a log-log transformation was applied. Cluster analysis was applied to the dataset and three main clusters emerged. The most relevant cluster was fortunately the most linear. From this linear cluster of paired SO4 and EC values a direct least squares linear interpolation was performed, yielding a result with a high correlation coefficient. The interpolation of the least squares relationship to the EC value corresponding to a "D" class river water quality yielded a value of approximately 500 mg/L sulphate for a "D" class river. This value was set at the "D" level for sulphate concentrations and the "C", "B" and "A" values derived as were the values derived for use in the DWA Reserve Determination process.

INTRODUCTION

Sulphate is not usually considered a “Salt”. It is an anion, and usually a minor component of environmental water resources. In the regions of concern, however, acid mine drainage (AMD) is a significant concern downstream of large formal coal-mining operations, and intense informal coal-mining operations. In regions such as these, sulphate a good indicator, in combination with EC values, of the origin of water pollution contributing to adverse environmental conditions. In setting resource quality objectives for the Olifants and Upper Vaal catchments, the problem was encountered that there are no non-contentious guidelines available in South Africa for sulphate concentrations in highly impacted rivers. The problem reared its head in the above catchments in particular due to the great levels of sulphate loading emanating from coal- and gold-mining activities. There are no coherent internationally developed guidelines for sulphate concentrations in rivers, for the protection of aquatic communities. The procedure-based guidelines derived for sulphate utilised the techniques of Species Sensitivity Distributions, current "state of the art" for aquatic toxicology studies. In the absence of such studies in South Africa for sulphate and in particular for the catchments under study, in an explicitly site-specific undertaking such as resource quality objectives, an empirical approach was assumed. In the current study, guided by large values of internationally accepted guidelines, monitoring data were obtained from the DWA water quality monitoring programme database (WMS). This data was analysed with a view to establishing a provisional objective guideline based on sulphate/EC relationships. This current documentary is a summary of the above efforts.

Sulphate: Direct or indirect toxicity?

Sulphate toxicity as a direct phenomenon is somewhat contentious. The reason for the above is the fact that adverse health effects observed in organisms manifest at relatively high concentrations of sulphate. The contention is introduced at high sulphate concentrations due to concomitant high concentrations of the coupled cations, and of ionic strength, measured as electrical conductivity. Influences of these specific ions and system variables confound interpretation of laboratory toxicity tests, upon which most substance-specific guidelines are based.

Indirect toxicity: Chemically reducing environments.

Sulphate loading on a water resource containing a substantial reducing phase such as a wetland or a dam may exert indirect toxicity effects that are important to consider. Sulphate is also involved in problematic behaviour in anaerobic sediments. Sulphate is converted to sulphide, which interferes with the iron-phosphorous cycles. In addition, sulphate may competitively bind to anion-adsorption sites in sedimentary organic matter. By both mechanisms phosphate is expelled from sediments and becomes a problem in eutrophication. Indirect effects on these water resources originate from the conversion of sulphate to sulphide within sediments or other phases rich in organic matter. Sulphate reducing bacteria (SRBs) use the organic matter to reduce the sulphate. Sulphide is extremely toxic to oxygen-metabolising organisms. It binds to, and inactivates respiratory enzymes containing iron and copper several orders of magnitude stronger than does cyanide, a more charismatic toxin. The effect of concomitant increase of sulphate and organic matter has been observed to result in hyper-abundance of hydrogen sulphide in the sediments of the Loskop dam. Estimation of the loading of sulphate to create sulphide problems involves models more sophisticated than the ambit of the current study.

Confounding effects of other WQ variables

As mentioned above, specific coupled cations and system variables such as electrical conductivity may make assignation of toxicity to sulphate problematic. Some factors, e.g. hardness (concentrations of calcium and magnesium) and chloride concentrations confounding the establishment of direct sulphate toxicity have been recognised as persuasive enough to include in local water management legislation in the state of Iowa, USA.

Some sulphate guidelines implemented internationally

Many guideline values have been proposed and published and embedded as trigger values by various governing bodies. Much of the reasoning behind the derivation of the guidelines is opaque. Where the reasoning is not opaque, there is great discrepancy between values recommended. The following high guideline levels are presented in this light.

- USA: In the state of Wyoming, USA, the current level of permissible sulphate concentrations in fresh water resources is 3,000 mg/L SO4, and there is a petition underway to reduce this value to 500 mg/L. In the state of Iowa, based on toxicity test data and available toxicity data from a total of 11 species, to achieve aquatic life protection and livestock watering uses, concentrations for sulphate from 500 mg/L to 2,000 mg/L are not to be exceeded except in receiving waters for which mixing is allowed.
- Canada: In a Chronic Effects Benchmark study for the British Columbia (BC) government by Golder Canada (2013) based on toxicity test data, the hardness-level-adjusted sulphate environmental guideline for “moderately soft/hard to hard” water (76-180 mg/L $CaCO_3$) is between 309 mg/L sulphate and 743 mg/L sulphate. Meays and Nordin (2013) proposed a BC sulphate water quality guideline for moderately hard to hard water conditions, and recalculated benchmarks for hard water conditions, based on model-averaged sulphate toxicity endpoints from three direct investigations of sulphate toxicity in relation to water hardness. In a site-specific assessment for medium hard waters, sulphate concentrations were proposed to be set by TOTAL E&P Canada Ltd (2013) at alert levels of 309 to 430 mg/L.
- Australia: In a study involving actual site-specific toxicity testing and using the ANZECC guidelines “the concentrations of sulphate that would protect 95% of species would be 341 mg/L sulphate and the concentration predicted to be protective of 99% of species would be 123 mg/L” (Hydrobiology, 2012).

ESTIMATION OF SITE-SPECIFIC SULPHATE TARGET VALUES FOR THE OLIFANTS CATCHMENT

Method for estimating sulphate trigger values

The method for deriving interim target sulphate trigger values for the Olifants catchment and extrapolated to the Vaal catchments involves recognition of the high range of water quality standard values, and the operational assumption that electrical conductivity recommendations may guide estimations for a maximum value of sulphate recommended for various water quality classes.

Datamining: Clarifying EC-SO4 relationship

The main objective of analysing monitoring data for the Olifants River catchment is to derive a sulphate Resource Quality Indicator measurement. Sulphate was identified as an indicator of resource quality specific to sub-catchments of the Olifants River catchment. Managing operations such that sulphate concentrations fall below certain trigger values implies managing for sulphate toxicity, or managing for other environmental stressors for which sulphate may be a surrogate. Since EC is managed in the catchments, and SO4 is a contributor to EC, any “toxicity” of SO4 above the possible total contribution to EC by SO4 would be a useless endeavour.

Hazard Class risk method

The regions of the Olifants catchment under consideration are heavily impacted or soon to be heavily impacted by coal mining activities. When setting a RQO regulators are balancing long-term ecological health against short-term and necessary economic growth. Whilst in individual publications river classes are proposed correlated with percent species protected (as is the approach used in most first-world countries), this method has not as yet been comprehensively applied. In the current analysis it is estimated that a "D" class would represent a preservation of between 90% and 95% of the species in the ecosystem. The modifications are presented below (Table B1).

Table B1: Proposed hazard class values corresponding to water quality categories

HC_p	Water condition	Classification	Natural – Poor categories	Water Quality category	PES rating
$<HC_1$ (50)	Natural	Unmodified, or approximates natural condition.	Natural	A	0
HC_5 (5-25)	Good	Largely natural with few modifications.	Good	B	1
HC_5 (25-35)	Upper Fair	Moderately modified.	Upper Fair	C	2
HC_5 (36-50)	Lower Fair	Large change	Lower Fair	D	3
$>HC_5$ (50)	Poor	Largely modified.	Poor	E	4

In the absence of better information on the distribution of the sulphate concentrations and protection levels, an operational assumption was made in the current study that for a Level D ecosystem one may tolerate of the order of 10% of the data variance unassigned in the description of the HC5. This approximates to a sulphate concentration of 500 mg/L, as will be demonstrated below. It has been noted in many publications that the toxicity of sulphate to aquatic life is strongly dependent on water chemistry, not only hardness but chloride concentration and concentration of other constituents. It may well be that site-specific toxicity testing is required in the future.

ANALYSIS OF OLIFANTS WQ DATA

Considering the difficulty in finding coherent water quality guidelines from literature, the following operational approach was employed:

- The fundamental assumption was that sulphate may be acting in concert with other water quality constituents in a synergistic manner, possibly contributing to exhaustion of target organisms in their battles with metals or simple osmotic stress. Electrical conductivity (EC) was chosen as an indicator of osmotic shock for which there are already guideline values published (DWAF, 2008).
- Since EC values are not published for recommended limits to a D category water resource, the value of 110 mS/m was extrapolated to a PES of 3.0 from values published that corresponded to lower PES values and lower DWA classes.

UPPER LIMIT OF SULPHATE TRIGGER VALUE

Based on a limiting condition of 110 mS/m electrical conductivity, the maximum sulphate concentration recommended is calculated from limiting ionic conductivities. From CRC Handbook of Chemistry, and Physics, 91st Edition, Weast, R. C.,Ed., CRC Press, Boca Raton, FL, 1989 (Table B2).

Table B2: Electrical conductivity of sodium sulphate solutions

Mass % Sodium sulphate	0.5	1.0	2.0	5.0
EC (mS/m)	590	1120	1970	4270

Fitting curve of the form $-10\ x^3\ -105\ x2\ +1235\ x$

Thus for a pure sodium sulphate solution in water, interpolation yields the mass fraction of 0.09% (m/m) to effect an EC of 110 mS/m.

A mass fraction of 0.09% corresponds to a concentration of 900 mg/L of sodium sulphate, which equals 6.34 mmoles/L of sodium sulphate. This equates to 6.34 mmoles/L of sulphate ion which corresponds to 608 mg/L sulphate.

This therefore is the maximum concentration of sulphate as a trigger to be derived in this study.

Please note that the above analysis only works for sodium sulphate in a pure solution because the electrical conductivities were *measured* for this system.

DERIVATION OF SULPHATE TRIGGER VALUE FROM WQ MONITORING DATA

All water quality monitoring data for all stations in the Olifant River catchment (Region B) were retrieved from WMS. There were 69,388 records retrieved. Of these data, records where both EC and sulphate were present were extracted and the highest 20% of EC value data retained (13,898 records). Within this data set the highest 10% of sulphate concentrations were retained, yielding 2,360 records. If there were some regularity between EC and SO4 at elevated concentrations of both, it would mean that SO4 dominates the ionic composition of the water and that some value of SO4 trigger may be derived from the EC regulation value. The figure below (Figure B1) shows the relationships between SO4 and EC in the dataset as derived above. A direct plot shows a great deal of scatter in the relationship between SO4 and EC in the Olifants River catchment which is expected.

In order to reveal more of the detail in the scatter at lower SO4 and EC values a log-log plot is used (Figure B1).

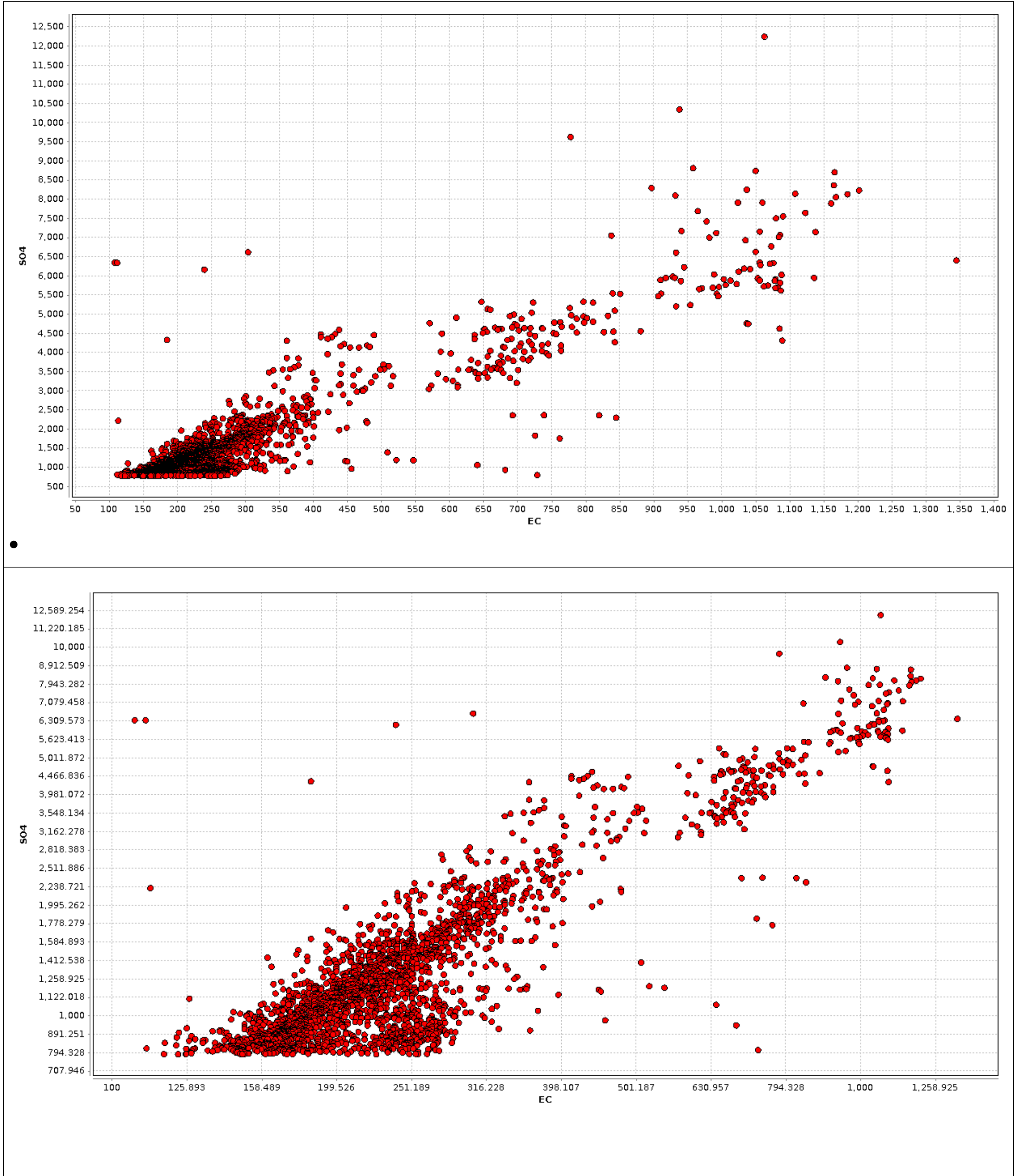

Figure B1 (a) Direct plot of SO4 vs EC; (b) log-log plot of SO4 vs EC

A direct linear regression on the EC and SO4 data produces the relationship:

[SO4 (mg/L)] = 6.4 x [EC (mS/m)] -190.

There is considerable scatter in the diagram. The intercept of the regression line is negative, implying that in the absence of sulphate the EC in general would be about 30 mS/m. This at least checks logically – were there to be a positive intercept it would imply that a non-zero concentration solution of sulphate could have zero EC.

When the SO4-EC relationship is explored in detail in the log-log plot (Figure (b)), three clusters appear. In order to find a useful relationship between EC and SO4 to base some limiting value on, a clearer picture needs to be formed describing the entire dataset. Simply stated, if one expects (or desires) a simple relationship between e.g. EC and SO4 and complexity arises in the projected relationship between the variables, it means that there is some additional factor or combination of factors that is causing the complexity. It is a useful assumption that the aforementioned factor(s) would be chemical in nature. Identifying the factor(s) would allow for their contribution to the complexity to be removed, yielding a clearer relationship between EC and SO4 in this case. The methods of data mining are used for this objective. Since the driving force of all chemical and biochemical reactions, the free energy, is directly proportional to the logarithms of concentrations, all water quality variables were represented as logarithms. The above statement is not strictly true, since it is the "activities" of the chemical constituents that are thus related to the free energy, and the activities vary with increasing concentration of salts in solution. There are in the system of interest considerably higher concentrations of salts than the "infinite dilution" that is required for use of concentrations as activities without transformation. Concentrations are presented as the molar form of the chemical constituent, as opposed to the mass per unit volume form most often used in water quality management. This transformation is performed in order to compare magnitudes of chemical constituents on the same level, the level at which the constituents would behave as molecular or atomic entities. It is noted that pH is already in a log form, being the negative logarithm of the concentration of free hydrogen ion. In order to compare pH with the other variables in the data mining exercise, it was used as the negative value of pH, denoted pH_neg. The reason to use data mining is to understand macro-dynamics in the higher salinity parts of the Olifants River system. Thus initially all water quality data are used in analysis.

Cluster analysis

To return to the original objective of the datamining activity, the monitoring data in the Olifants River catchment was analysed to establish workable relationships between the concentrations of sulphate and the physical water quality parameter Electrical Conductivity, the latter for which there exist trigger values for management of water quality to environmental and human health targets. The upper limit of EC characterising a water resource as a D-category resource in terms of water quality is 110 mS/m. A relationship between EC and the conductivity of a pure sodium sulphate solution was explored in a previous section. The work in this section aims to determine a relationship relating to the unique additional background salts of the region such that a water quality trigger value for sulphate may be provisionally established.

K-means clustering

The objective of cluster analysis is to establish similarities and difference between data points as viewed in groups. Thus clustering aims to group together points that are most similar, and to distinguish between groups so determined. K-means clustering is an *exclusive* method in that each point is assigned to one cluster only. The default analysis in Rapidminer was used, being clustering by squared Euclidean distances between points, and discrimination between clusters measured by this divergence parameter by the technique of Bregman Divergences.

Data integrity verification

Chemical analytical data is subject to the occasional mishap, such as entry into a database involving the misplacement of a decimal point, or in cases of high concentrations of a particular constituent, errors in dilution of the sample to levels acceptable to the analytical instruments. Whilst it is expected that the data used in the exercise of determining a convincing relationship between EC and SO4 will have significant scatter, modelling procedure of data verification is followed.

Mass balance calculations

The first test that should be applied to a chemical analysis is the mass-balance calculation. In the case of waters not heavily polluted and thus coming more under the heading of industrial water, an effective screen for bulk errors in chemical analyses takes the form of the mass balance. Mass balance involves adding up the individual concentrations per litre (usually expressed in milligrams per litre) and comparing the total to the "total dissolved solids" or TDS. The technique is relatively simple but has some minor problems associated with it. Carbonate and bicarbonate concentrations are not usually reported directly and need to be calculated from the Total Alkalinity and the pH values. There is the risk of making errors in calculating carbonate species concentrations in this way. In addition, TDS is often (usually) not determined directly, owing to the high costs of determining by dehydration. Usually TDS is derived from the EC measurement by multiplying by a scalar factor. This method may not be valid if the ionic composition of the samples deviates significantly from "natural", which would be the case in the Olifants and Vaal River catchments. In many cases, as appears to be the case with the WMS data, the TDS is actually derived as the sum of the analysed dissolved constituents. The WMS database explicitly quotes the DMS = "Dissolved mineral solids". A caution with respect to the concern of calculation of carbonate species mentioned above: The mass balance is much better effected after submitting the total analytical data to a chemical speciation calculation. This technique was used to verify the database of chemical analyses at the requisite coarse level.

Charge balance calculations

The program Phreeqci was used to calculate charge imbalances. A charge imbalance detected by a proper chemical speciation analysis refers to uncertainty in the concentrations of one or more of the water quality constituents analysed for, or in the worst case, a chemical species not analysed for. Chemical analyses featuring charge imbalances of less than 5% are acceptable for interpretation according to the ASTM "Standard Methods" (APHA), 1998). The dataset derived to represent resource waters of D-category or better was subjected to filtering by charge balance calculation.

DATA FILTERING

Sulphate data cleaning

All data points with sulphate concentrations less than 0.032 mmol/L SO4 were removed. The reason for this was that this is the maximum of the "instrumental detection limit" concentrations. Inclusion of these values in the analysis would skew the analysis towards unrealistically low concentrations of sulphate.

Sulphate data reduction

During exploratory clustering analysis the dataset clustered according to sulphate concentrations as seen in the figure below (Figure B2):

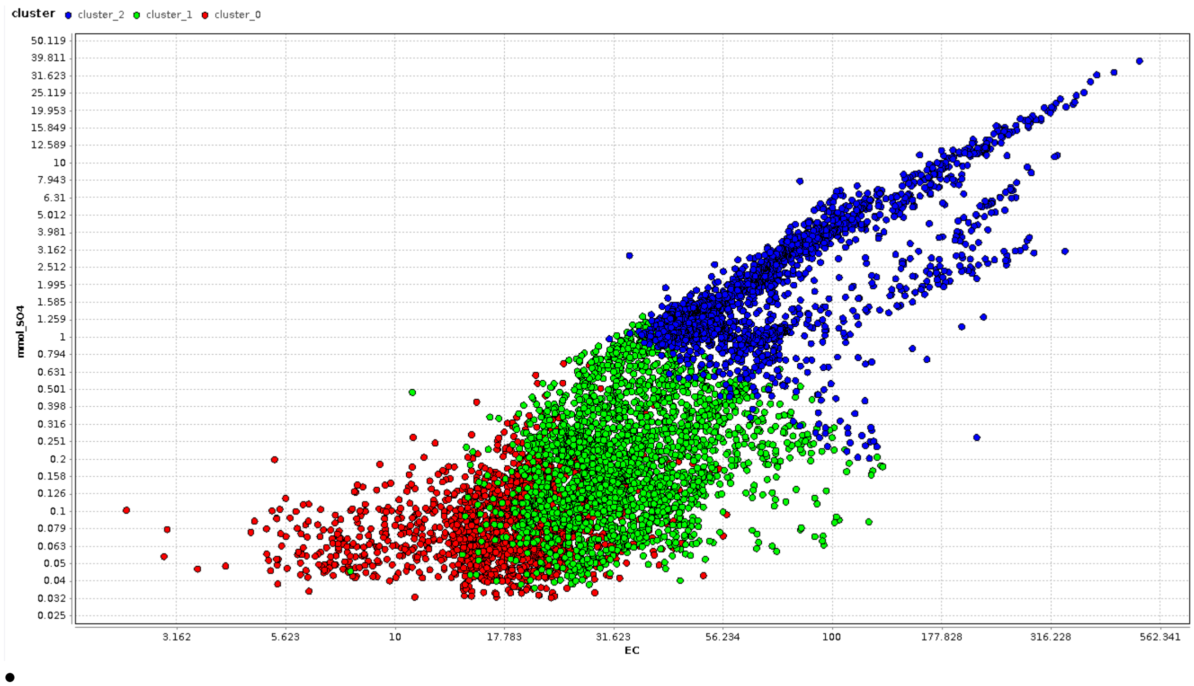

Figure B2 Preliminary cluster analysis of SO4-EC data for Olifants catchment

This was not a meaningful clustering as it did not achieve a linearity of a single cluster for analysis by linear regression. Thus all SO4 values below a concentration of 1 mmol/L were removed and the following clustering obtained (Figure B3).

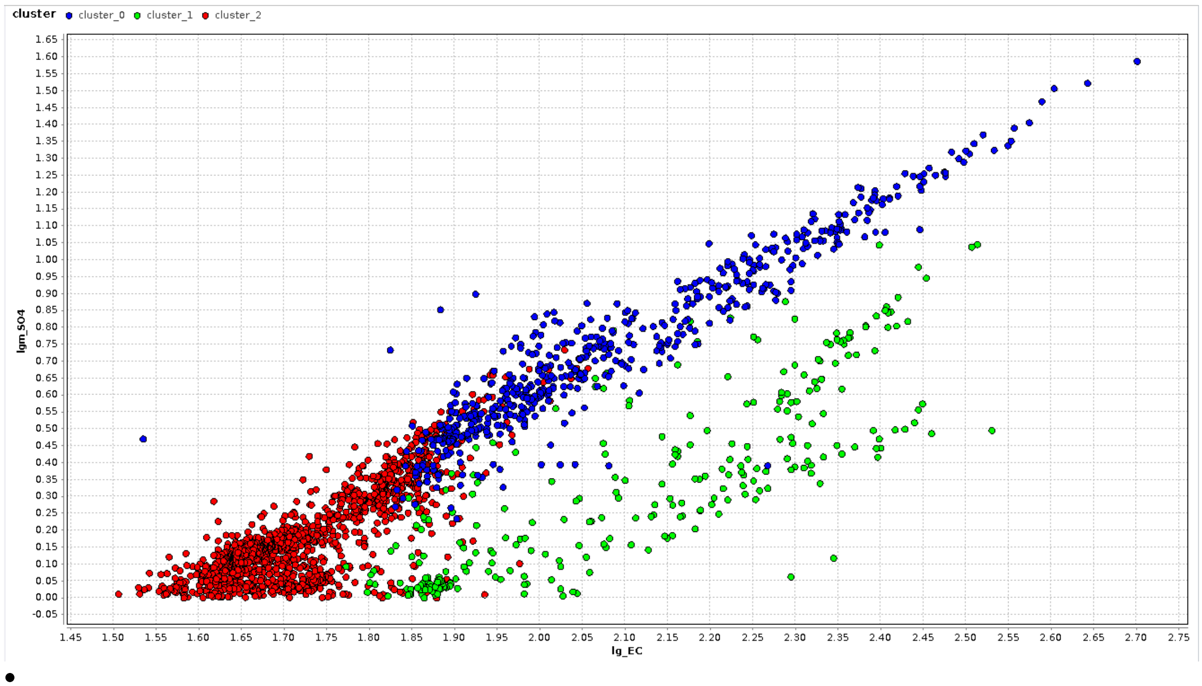

Figure B3: Cluster analysis of SO4-EC data with low values removed

The centroid plot of the clusters (Figure B4) shows the clustering driven mainly by the concentrations of chloride, sodium, phosphate, and then sulphate.

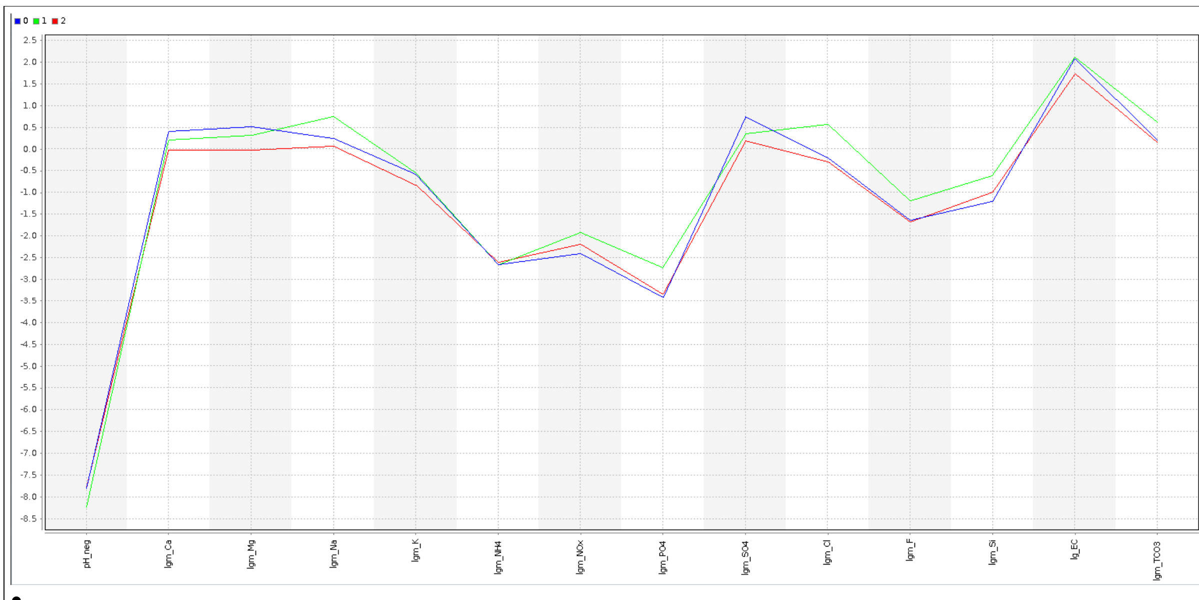

Figure B4: Centroid plot of clusters presented in Figure.

A parallel plot (Figure B5) demonstrates this separation.

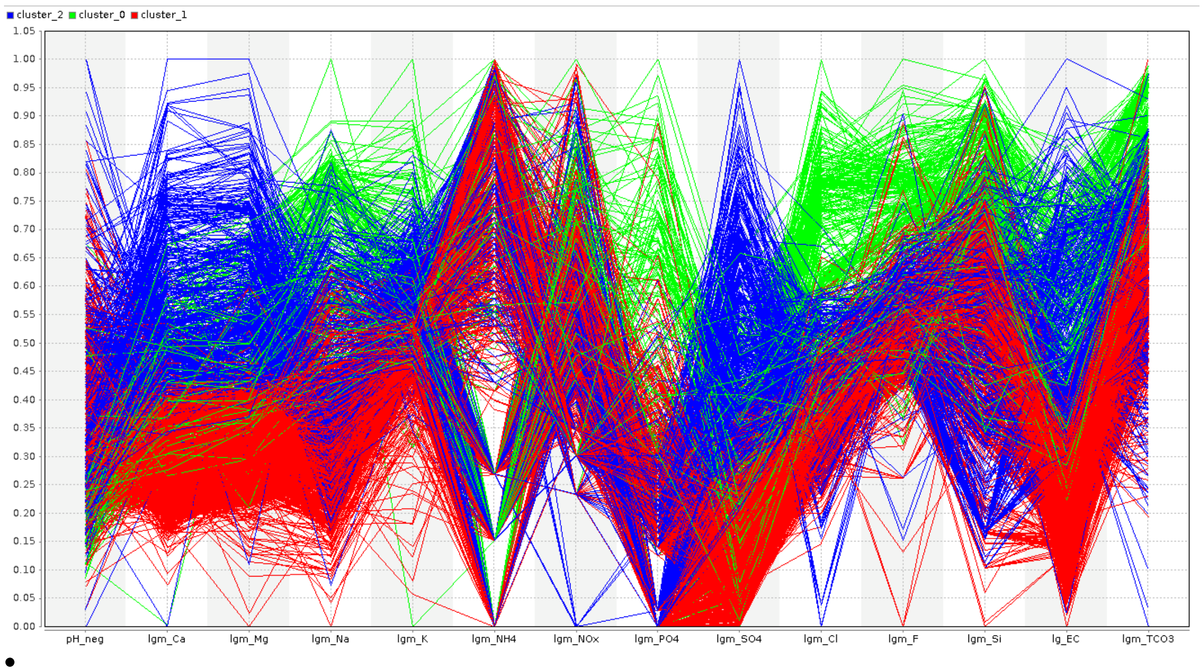

Figure B5: Parallel plot of clusters presented in Figure.

The separation of the clusters does reveal a relatively linear relationship between SO4 and EC in the combination of clusters 1 and 2. However the fact that clusters 1 and 2 still contain a sulphate-concentration component may be problematic. On the other hand, it may not. A further test was implemented in data exploration. The analysis was repeated with all data featuring SO4 concentrations less than 3 mmol/L removed (Figure B6).

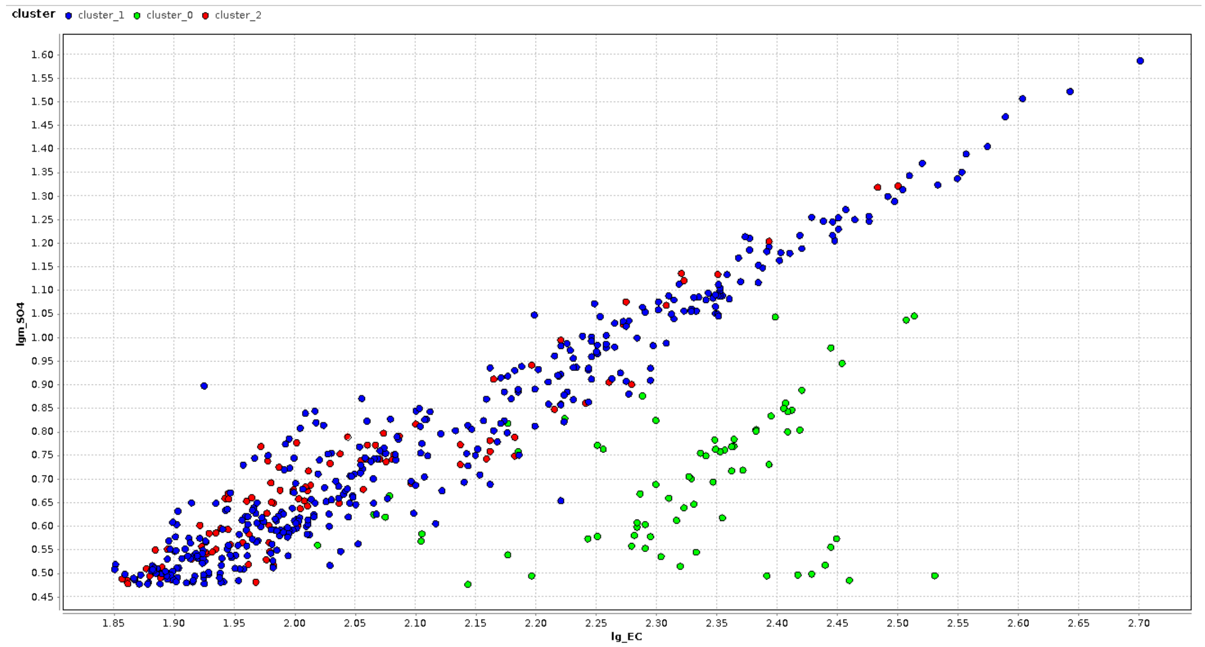

Figure B6: Cluster analysis of SO4-EC data above 3 mmol/L.

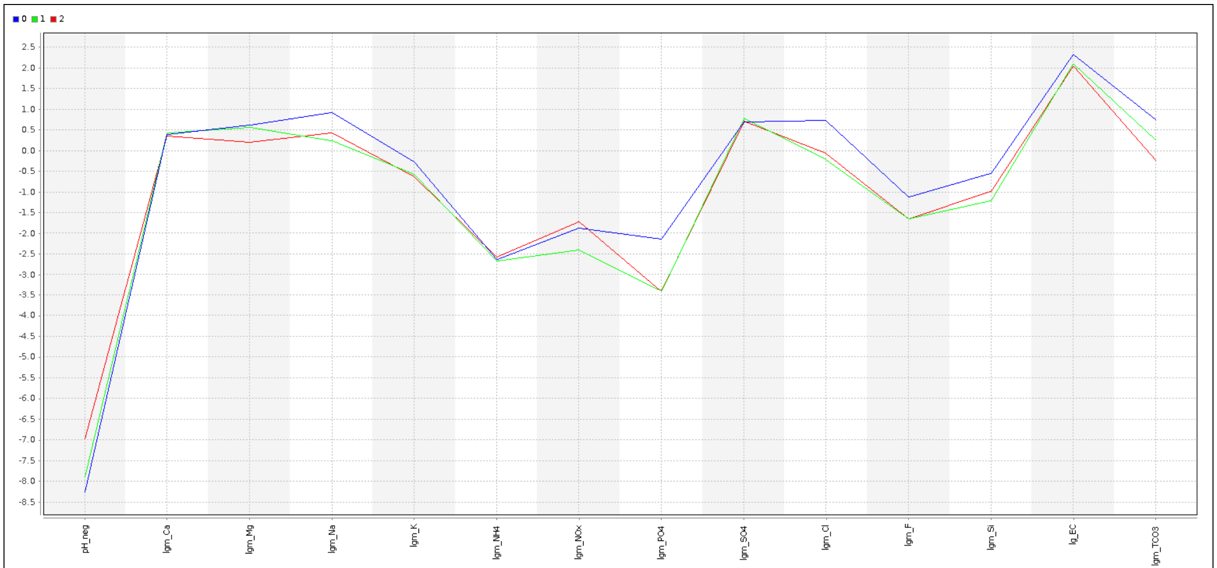

Figure B7 Centroid plot of SO4-EC data above 3 mmol/L.

The linear regression on the lgm_SO4 vs lg_EC set defined by the combination of Clusters 1 and 2 reveal the following statistics:

lgm_SO4 = 1.28 x lg_EC -1.93; r^2 = 97%.

Interpolation of the maximum limit of EC for a water resource of Class D yields the information in the following table (Linear correlation = 96.5%):

EC (mS/m)	lg_EC	lgm_SO4	m_SO4 (mmol/L)	SO4 (mg/L)
110	2.04	0.70	5.05	495

FINAL RECOMMENDATIONS OF TRIGGER VALUES FOR SULPHATE

The value of 500 ("rounded up" from 495 mg/L) was set at the "D" level for sulphate concentrations and the "C", "B" and "A" values derived as were the values derived for use in the DWA Reserve Determination process (Table B3).

Table B3: Sulphate trigger values recommended

Water Quality category	Natural – Poor categories	PES rating	SO4 (mg/L)
A	Natural	0	50
AB		0.5	65
B	Good	1	80
BC		1.5	140
C	Upper Fair	2	200
CD		2.5	350
D	Lower Fair	3	500

CONCLUSION

The current study assumes that the EC guideline values for aquatic health have been in use for a long period and are thus assumed to be provisionally non-contentious. Thus setting a sulphate guideline value as guided by EC relationships in a highly sulphate-polluted catchment would be appropriate until more site-specific methods were applied, such as whole effluent toxicity tests. Sulphate and EC values that were measured in tandem by DWA and published on WMS were downloaded and submitted to a rigorous data verification regime. The paired values were then plotted and a very large scatter was observed in the data. This scatter was enhanced when a log-log transformation was applied. Cluster analysis was applied to the dataset and three main clusters emerged. The most relevant cluster was fortunately the most linear. From this linear cluster of paired SO4 and EC values a direct least squares linear interpolation was performed, yielding a result with a high correlation coefficient. The interpolation of the least squares relationship to the EC value corresponding to a "D" class river water quality yielded a value of approximately 500 mg/L sulphate for a "D" class river. This value was set at the "D" level for sulphate concentrations and the "C", "B" and "A" values derived as were the values derived for use in the DWA Reserve Determination process.

REFERENCES

APHA (1998): American Public Health Association (APHA), 1998. Standard Methods for the Examination of Water and Wastewater, 20th ed. American Public Health Assoc., Washington, DC.

DWAF (2008): Department of Water Affairs and Forestry, South Africa. 2008. Methods for determining the Water Quality component of the Ecological Reserve. Prepared by Scherman Consulting.

Golder Canada (2013): Golder Canada (2013, Project Number: 13-1346-0001) Appendix 3.6: “Chronic Effects Benchmarks”.

Hydrobiology (2012): Hydrobiology Pty Ltd, 2012. “Sulphate Trigger Value for MRM mine”.

TOTAL E&P Canada Ltd (2013): Joslyn North Mine Project Modifications Amendment Application Appendix J: Water Quality Supporting Information. November 2013. TOTAL E&P Canada Ltd.

6.3 APPENDIX C: WATER QUANTITY RULE TABLES INCLUDING MONTHLY FLOW PERCENTILES FOR APPLICABLE RQOS.

Olifants RQOs (quantity)

Witbank Dam, Olifants River
IUA 1
RU 9

- Desktop Version 2, Printed on 2008/06/29
- Summary of IFR rule curves for : MU9B Generic Name
- Determination based on defined BBM Table with site specific assurance rules.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow
- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.509	0.505	0.496	0.478	0.445	0.389	0.310	0.220	0.143	0.107
Nov	1.474	1.465	1.446	1.409	1.339	1.218	1.025	0.757	0.397	0.243
Dec	2.323	2.308	2.278	2.218	2.106	1.910	1.598	1.164	0.682	0.299
Jan	3.807	3.406	3.061	2.752	2.452	1.950	1.646	1.223	0.753	0.456
Feb	1.634	1.547	1.467	1.385	1.287	1.122	0.961	0.736	0.486	0.329
Mar	1.902	1.751	1.617	1.492	1.360	1.139	0.970	0.735	0.472	0.164
Apr	0.868	0.862	0.848	0.820	0.767	0.680	0.557	0.416	0.295	0.120
May	0.404	0.401	0.394	0.380	0.354	0.312	0.252	0.183	0.123	0.096
Jun	0.273	0.272	0.269	0.264	0.255	0.239	0.217	0.192	0.171	0.058
Jul	0.201	0.200	0.199	0.196	0.191	0.183	0.171	0.158	0.147	0.134
Aug	0.156	0.156	0.155	0.153	0.149	0.143	0.135	0.125	0.117	0.113
Sep	0.135	0.135	0.134	0.132	0.127	0.120	0.111	0.099	0.090	0.042

- Reserve flows without High Flows

Oct	0.237	0.236	0.232	0.226	0.213	0.192	0.162	0.129	0.099	0.086
Nov	0.488	0.486	0.481	0.473	0.456	0.427	0.380	0.316	0.244	0.199
Dec	0.661	0.658	0.652	0.640	0.616	0.575	0.511	0.420	0.320	0.257
Jan	0.827	0.823	0.814	0.798	0.767	0.714	0.628	0.510	0.378	0.294
Feb	1.023	1.018	1.007	0.984	0.942	0.869	0.752	0.590	0.409	0.296
Mar	0.799	0.794	0.786	0.769	0.737	0.681	0.593	0.470	0.334	0.164
Apr	0.598	0.595	0.586	0.569	0.537	0.485	0.411	0.325	0.252	0.120
May	0.404	0.401	0.394	0.380	0.354	0.312	0.252	0.183	0.123	0.096
Jun	0.273	0.272	0.269	0.264	0.255	0.239	0.217	0.192	0.171	0.058
Jul	0.201	0.200	0.199	0.196	0.191	0.183	0.171	0.158	0.147	0.134
Aug	0.156	0.156	0.155	0.153	0.149	0.143	0.135	0.125	0.117	0.113
Sep	0.135	0.135	0.134	0.132	0.127	0.120	0.111	0.099	0.090	0.042

- Natural Duration curves

Oct	8.094	2.386	1.493	0.855	0.687	0.508	0.403	0.310	0.243	0.131
Nov	18.954	13.233	8.746	6.829	4.757	2.816	1.875	1.026	0.397	0.243
Dec	24.481	21.020	13.094	10.951	5.753	4.133	2.516	1.759	0.911	0.299
Jan	30.276	21.853	14.359	9.644	7.527	5.529	3.248	2.259	1.512	0.728
Feb	32.461	17.560	11.702	6.630	4.274	3.418	2.600	1.749	0.951	0.595
Mar	28.457	8.121	5.682	4.697	3.147	2.255	1.363	0.851	0.500	0.164
Apr	11.030	5.093	3.399	2.319	1.671	1.420	0.922	0.706	0.301	0.120
May	5.414	2.796	1.732	1.348	0.889	0.713	0.541	0.433	0.202	0.119
Jun	2.276	1.493	1.038	0.864	0.602	0.521	0.421	0.367	0.204	0.058
Jul	1.505	0.989	0.747	0.638	0.511	0.455	0.381	0.306	0.258	0.134
Aug	0.859	0.661	0.575	0.463	0.422	0.370	0.325	0.276	0.246	0.116
Sep	0.899	0.575	0.455	0.424	0.367	0.328	0.285	0.251	0.174	0.042

Doornpoort Dam, Olifants River
IUA 1
RU 9

- Desktop Version 2, Printed on 3/28/2014
- Summary of IFR rule curves for : MU28AB Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.535	0.531	0.521	0.503	0.467	0.409	0.328	0.234	0.153	0.116
Nov	1.523	1.513	1.493	1.453	1.379	1.249	1.042	0.755	0.413	0.234
Dec	2.391	2.374	2.341	2.274	2.150	1.932	1.586	1.105	0.569	0.231
Jan	3.897	3.491	3.143	2.833	2.535	2.037	1.746	1.341	0.890	0.606
Feb	1.705	1.618	1.540	1.462	1.375	1.228	1.096	0.913	0.709	0.581
Mar	1.971	1.817	1.679	1.548	1.408	1.170	0.979	0.713	0.416	0.187
Apr	0.908	0.900	0.883	0.848	0.781	0.672	0.517	0.339	0.187	0.117
May	0.432	0.429	0.421	0.404	0.374	0.324	0.253	0.172	0.102	0.069
Jun	0.292	0.289	0.284	0.274	0.255	0.223	0.179	0.127	0.084	0.063
Jul	0.216	0.215	0.212	0.206	0.196	0.178	0.152	0.123	0.098	0.087
Aug	0.168	0.168	0.166	0.162	0.155	0.144	0.128	0.109	0.094	0.086
Sep	0.147	0.146	0.143	0.138	0.128	0.112	0.090	0.064	0.042	0.032

Reserve flows without High Flows

Oct	0.256	0.254	0.251	0.243	0.230	0.208	0.176	0.140	0.109	0.094
Nov	0.520	0.518	0.512	0.501	0.480	0.444	0.386	0.306	0.217	0.160
Dec	0.701	0.696	0.687	0.669	0.635	0.575	0.480	0.348	0.201	0.108
Jan	0.876	0.873	0.866	0.852	0.827	0.784	0.714	0.617	0.510	0.442
Feb	1.085	1.080	1.072	1.056	1.025	0.970	0.884	0.765	0.631	0.547
Mar	0.850	0.845	0.835	0.814	0.774	0.706	0.596	0.444	0.275	0.169
Apr	0.637	0.632	0.620	0.596	0.550	0.476	0.370	0.248	0.144	0.096
May	0.432	0.429	0.421	0.404	0.374	0.324	0.253	0.172	0.102	0.069
Jun	0.292	0.289	0.284	0.274	0.255	0.223	0.179	0.127	0.084	0.063
Jul	0.216	0.215	0.212	0.206	0.196	0.178	0.152	0.123	0.098	0.087
Aug	0.168	0.168	0.166	0.162	0.155	0.144	0.128	0.109	0.094	0.086
Sep	0.147	0.146	0.143	0.138	0.128	0.112	0.090	0.064	0.042	0.032

Natural Duration curves

Oct	8.244	2.404	1.512	0.870	0.739	0.523	0.429	0.329	0.246	0.134
Nov	19.784	13.688	8.885	6.964	4.823	2.967	1.956	1.084	0.413	0.255
Dec	24.966	21.337	13.299	11.526	6.131	4.734	2.774	1.956	0.971	0.310
Jan	31.209	22.431	14.576	10.058	7.796	5.847	3.375	2.330	1.534	0.765
Feb	32.767	17.630	11.909	7.044	4.481	3.485	2.745	1.790	1.004	0.608
Mar	29.473	8.692	5.888	4.742	3.215	2.378	1.579	0.892	0.579	0.187
Apr	11.211	5.417	3.789	2.535	1.755	1.466	0.988	0.733	0.367	0.143
May	5.470	3.091	1.777	1.363	0.974	0.736	0.553	0.444	0.213	0.138
Jun	2.500	1.516	1.092	0.922	0.629	0.544	0.448	0.382	0.212	0.093
Jul	1.568	1.038	0.788	0.661	0.541	0.459	0.399	0.343	0.265	0.146
Aug	0.896	0.739	0.586	0.485	0.448	0.377	0.351	0.302	0.258	0.127
Sep	0.938	0.625	0.471	0.440	0.401	0.336	0.293	0.258	0.181	0.062

Olifants River
IUA 1
RU 11

Desktop Version 2, Printed on 9/2/2014
Summary of IFR rule curves for : Olifants_1 Generic Name
Determination based on site specific parameters from SPATSIM database.
Regional Type : Olifants ERC = D

Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.588	0.584	0.576	0.557	0.524	0.468	0.389	0.298	0.221	0.185
Nov	1.648	1.638	1.616	1.574	1.494	1.355	1.134	0.826	0.484	0.268
Dec	2.594	2.577	2.541	2.470	2.337	2.104	1.734	1.220	0.647	0.286
Jan	4.286	3.831	3.441	3.096	2.766	2.216	1.904	1.470	0.986	0.682
Feb	1.807	1.710	1.623	1.539	1.448	1.293	1.163	0.982	0.781	0.654
Mar	2.148	1.975	1.822	1.678	1.528	1.276	1.084	0.818	0.521	0.269
Apr	0.980	0.973	0.957	0.923	0.860	0.756	0.610	0.442	0.298	0.228
May	0.461	0.458	0.451	0.438	0.413	0.373	0.315	0.249	0.192	0.166
Jun	0.317	0.315	0.311	0.302	0.287	0.261	0.224	0.181	0.145	0.129
Jul	0.240	0.239	0.237	0.232	0.223	0.208	0.187	0.162	0.141	0.131
Aug	0.191	0.190	0.189	0.185	0.179	0.168	0.153	0.136	0.121	0.114
Sep	0.168	0.167	0.165	0.161	0.153	0.140	0.122	0.100	0.082	0.074

Reserve flows without High Flows

Oct	0.278	0.277	0.274	0.269	0.259	0.243	0.220	0.194	0.172	0.161
Nov	0.541	0.538	0.533	0.522	0.502	0.466	0.409	0.330	0.243	0.187
Dec	0.716	0.712	0.703	0.686	0.653	0.596	0.505	0.379	0.238	0.149
Jan	0.892	0.889	0.883	0.871	0.848	0.808	0.745	0.657	0.559	0.497
Feb	1.105	1.102	1.094	1.079	1.051	1.001	0.923	0.814	0.693	0.616
Mar	0.880	0.876	0.866	0.847	0.812	0.750	0.651	0.514	0.361	0.265
Apr	0.669	0.665	0.655	0.634	0.595	0.531	0.441	0.337	0.249	0.207
May	0.461	0.458	0.451	0.438	0.413	0.373	0.315	0.249	0.192	0.166
Jun	0.317	0.315	0.311	0.302	0.287	0.261	0.224	0.181	0.145	0.129
Jul	0.240	0.239	0.237	0.232	0.223	0.208	0.187	0.162	0.141	0.131
Aug	0.191	0.190	0.189	0.185	0.179	0.168	0.153	0.136	0.121	0.114
Sep	0.168	0.167	0.165	0.161	0.153	0.140	0.122	0.100	0.082	0.074

Natural Duration curves

Oct	8.673	2.546	1.665	1.060	0.877	0.650	0.500	0.392	0.295	0.187
Nov	21.177	14.267	9.236	7.373	5.189	3.468	2.126	1.215	0.525	0.305
Dec	27.356	21.871	14.068	12.063	7.687	5.313	3.293	2.352	1.139	0.392
Jan	36.178	23.738	15.476	10.902	8.419	6.635	3.610	2.528	1.684	0.918
Feb	33.767	18.155	13.079	7.841	5.076	3.952	3.146	2.079	1.224	0.711
Mar	30.358	9.827	6.291	5.100	3.648	2.729	1.781	1.135	0.687	0.269
Apr	12.369	6.107	4.109	2.840	2.068	1.682	1.211	0.880	0.467	0.228
May	6.033	3.510	2.065	1.520	1.072	0.911	0.709	0.575	0.396	0.190
Jun	2.928	1.674	1.292	1.061	0.756	0.629	0.579	0.471	0.309	0.177
Jul	1.885	1.176	0.956	0.777	0.638	0.571	0.493	0.444	0.336	0.205
Aug	1.150	0.933	0.698	0.594	0.549	0.463	0.429	0.392	0.302	0.190
Sep	1.111	0.752	0.583	0.529	0.490	0.409	0.367	0.313	0.216	0.147

Klipspruit
IUA 1
RU 12

- Desktop Version 2, Printed on 3/27/2014
- Summary of IFR rule curves for : MU18B Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.086	0.085	0.084	0.081	0.077	0.070	0.059	0.047	0.037	0.032
Nov	0.153	0.153	0.151	0.147	0.141	0.129	0.111	0.086	0.058	0.040
Dec	0.247	0.245	0.242	0.235	0.223	0.202	0.168	0.120	0.068	0.035
Jan	0.251	0.229	0.210	0.193	0.176	0.147	0.127	0.100	0.069	0.050
Feb	0.618	0.550	0.491	0.440	0.390	0.307	0.260	0.195	0.122	0.077
Mar	0.262	0.240	0.221	0.204	0.186	0.157	0.136	0.107	0.075	0.055
Apr	0.187	0.186	0.183	0.177	0.165	0.147	0.121	0.090	0.065	0.053
May	0.088	0.087	0.086	0.084	0.079	0.072	0.061	0.049	0.039	0.034
Jun	0.088	0.087	0.086	0.084	0.079	0.072	0.062	0.050	0.040	0.035
Jul	0.081	0.080	0.079	0.078	0.074	0.068	0.059	0.050	0.041	0.038
Aug	0.073	0.073	0.072	0.070	0.067	0.062	0.054	0.046	0.039	0.035
Sep	0.065	0.065	0.063	0.061	0.056	0.048	0.037	0.024	0.013	0.008

Reserve flows without High Flows

Oct	0.063	0.063	0.062	0.060	0.058	0.053	0.047	0.040	0.033	0.030
Nov	0.076	0.076	0.075	0.074	0.071	0.067	0.060	0.051	0.041	0.034
Dec	0.083	0.083	0.082	0.080	0.076	0.070	0.061	0.047	0.032	0.023
Jan	0.092	0.091	0.090	0.089	0.086	0.081	0.073	0.062	0.049	0.041
Feb	0.109	0.108	0.107	0.105	0.102	0.096	0.086	0.073	0.058	0.049
Mar	0.102	0.102	0.101	0.099	0.096	0.090	0.081	0.069	0.055	0.046
Apr	0.095	0.094	0.093	0.091	0.087	0.080	0.070	0.059	0.050	0.046
May	0.088	0.087	0.086	0.084	0.079	0.072	0.061	0.049	0.039	0.034
Jun	0.088	0.087	0.086	0.084	0.079	0.072	0.062	0.050	0.040	0.035
Jul	0.081	0.080	0.079	0.078	0.074	0.068	0.059	0.050	0.041	0.038
Aug	0.073	0.073	0.072	0.070	0.067	0.062	0.054	0.046	0.039	0.035
Sep	0.065	0.065	0.063	0.061	0.056	0.048	0.037	0.024	0.013	0.008

Natural Duration curves

Oct	0.814	0.650	0.467	0.388	0.310	0.254	0.209	0.172	0.138	0.090
Nov	1.366	1.161	0.876	0.694	0.509	0.432	0.324	0.274	0.204	0.096
Dec	2.184	1.785	1.154	0.948	0.724	0.534	0.455	0.396	0.269	0.112
Jan	2.718	1.635	1.333	1.098	0.948	0.717	0.609	0.463	0.355	0.202
Feb	3.563	2.025	1.451	1.219	0.876	0.703	0.599	0.504	0.322	0.203
Mar	2.259	1.878	1.501	1.101	0.941	0.694	0.519	0.474	0.321	0.093
Apr	1.821	1.331	1.092	0.930	0.768	0.702	0.505	0.394	0.266	0.073
May	1.325	0.989	0.859	0.743	0.642	0.553	0.426	0.325	0.231	0.041
Jun	1.065	0.887	0.721	0.637	0.529	0.459	0.409	0.293	0.201	0.081
Jul	0.889	0.758	0.609	0.508	0.455	0.396	0.347	0.265	0.198	0.071
Aug	0.736	0.605	0.508	0.437	0.355	0.321	0.273	0.205	0.175	0.075
Sep	0.829	0.525	0.448	0.390	0.285	0.239	0.204	0.162	0.093	0.039

Olifants River
IUA 1
RU 13

- Desktop Version 2, Printed on 3/27/2014
- Summary of IFR rule curves for : MU29 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow
- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.965	0.958	0.943	0.912	0.855	0.759	0.625	0.470	0.338	0.277
Nov	2.604	2.588	2.556	2.492	2.371	2.161	1.827	1.362	0.844	0.518
Dec	4.150	4.124	4.071	3.966	3.768	3.423	2.875	2.112	1.263	0.728
Jan	6.933	6.194	5.560	4.996	4.452	3.544	3.011	2.270	1.444	0.924
Feb	2.905	2.745	2.600	2.457	2.295	2.023	1.780	1.441	1.065	0.827
Mar	3.532	3.250	3.002	2.773	2.538	2.143	1.857	1.461	1.019	0.631
Apr	1.706	1.694	1.667	1.612	1.508	1.338	1.098	0.821	0.584	0.474
May	0.887	0.882	0.872	0.851	0.811	0.746	0.654	0.548	0.457	0.415
Jun	0.681	0.677	0.670	0.653	0.623	0.573	0.502	0.420	0.351	0.318
Jul	0.552	0.549	0.543	0.529	0.505	0.464	0.407	0.341	0.284	0.258
Aug	0.451	0.448	0.443	0.432	0.412	0.379	0.332	0.278	0.232	0.211
Sep	0.391	0.389	0.384	0.375	0.358	0.329	0.288	0.241	0.201	0.183

- Reserve flows without High Flows

Oct	0.519	0.516	0.510	0.498	0.475	0.436	0.382	0.320	0.267	0.243
Nov	0.906	0.902	0.894	0.878	0.849	0.797	0.715	0.601	0.474	0.394
Dec	1.175	1.170	1.159	1.139	1.101	1.034	0.927	0.780	0.615	0.511
Jan	1.437	1.431	1.419	1.393	1.347	1.265	1.135	0.954	0.752	0.626
Feb	1.758	1.750	1.735	1.704	1.647	1.547	1.388	1.167	0.920	0.765
Mar	1.459	1.453	1.440	1.414	1.367	1.283	1.150	0.965	0.758	0.629
Apr	1.169	1.162	1.146	1.112	1.051	0.949	0.805	0.640	0.499	0.433
May	0.887	0.882	0.872	0.851	0.811	0.746	0.654	0.548	0.457	0.415
Jun	0.681	0.677	0.670	0.653	0.623	0.573	0.502	0.420	0.351	0.318
Jul	0.552	0.549	0.543	0.529	0.505	0.464	0.407	0.341	0.284	0.258
Aug	0.451	0.448	0.443	0.432	0.412	0.379	0.332	0.278	0.232	0.211
Sep	0.391	0.389	0.384	0.375	0.358	0.329	0.288	0.241	0.201	0.183

- Natural Duration curves

Oct	14.176	5.488	3.177	2.289	1.706	1.430	1.098	0.933	0.676	0.433
Nov	32.778	20.675	14.032	12.060	9.267	6.304	4.093	2.508	1.285	0.625
Dec	39.501	33.583	22.499	19.456	13.325	9.502	5.529	3.861	2.752	0.926
Jan	54.566	34.939	24.220	19.142	12.459	11.399	7.094	4.652	3.763	1.964
Feb	60.251	30.014	19.916	15.274	8.639	7.081	5.630	4.282	2.989	1.728
Mar	42.910	19.616	10.715	8.841	7.680	5.317	4.021	2.535	1.796	0.631
Apr	17.870	10.872	8.021	5.733	4.653	3.762	2.758	1.929	1.447	0.733
May	9.741	6.687	4.783	3.468	2.819	2.296	1.919	1.396	1.064	0.556
Jun	5.664	3.943	2.986	2.488	2.037	1.755	1.431	1.192	0.965	0.436
Jul	4.454	2.946	2.322	2.039	1.699	1.464	1.202	1.113	0.814	0.418
Aug	2.726	2.274	1.893	1.650	1.422	1.154	0.974	0.825	0.765	0.635
Sep	3.137	1.929	1.478	1.300	1.123	0.992	0.756	0.679	0.548	0.316

Middelburg Dam, Klein Olifants River
IUA 1
RU 18

- Desktop Version 2, Printed on 2008/06/29
- Summary of IFR rule curves for : MU15 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.171	0.169	0.167	0.161	0.151	0.135	0.111	0.084	0.061	0.050
Nov	0.504	0.501	0.494	0.482	0.457	0.416	0.349	0.256	0.153	0.088
Dec	0.948	0.943	0.930	0.906	0.860	0.780	0.653	0.476	0.280	0.156
Jan	1.777	1.579	1.408	1.258	1.115	0.876	0.741	0.555	0.347	0.216
Feb	0.625	0.587	0.552	0.519	0.483	0.422	0.372	0.302	0.223	0.174
Mar	0.779	0.710	0.651	0.597	0.543	0.452	0.391	0.306	0.211	0.138
Apr	0.356	0.354	0.349	0.338	0.318	0.284	0.237	0.183	0.137	0.116
May	0.171	0.171	0.169	0.164	0.157	0.144	0.126	0.105	0.087	0.079
Jun	0.137	0.136	0.135	0.132	0.126	0.116	0.103	0.087	0.074	0.068
Jul	0.108	0.108	0.106	0.104	0.099	0.092	0.081	0.069	0.058	0.053
Aug	0.089	0.088	0.087	0.085	0.080	0.072	0.062	0.049	0.039	0.034
Sep	0.074	0.074	0.072	0.069	0.062	0.052	0.038	0.021	0.007	0.000

Reserve flows without High Flows

Oct	0.089	0.089	0.088	0.086	0.082	0.076	0.067	0.057	0.048	0.044
Nov	0.155	0.155	0.153	0.150	0.145	0.136	0.121	0.100	0.077	0.062
Dec	0.224	0.223	0.221	0.217	0.210	0.198	0.179	0.152	0.122	0.103
Jan	0.294	0.293	0.291	0.286	0.276	0.260	0.235	0.199	0.160	0.135
Feb	0.346	0.345	0.342	0.336	0.325	0.306	0.276	0.235	0.188	0.159
Mar	0.274	0.273	0.271	0.266	0.258	0.242	0.218	0.185	0.148	0.124
Apr	0.213	0.212	0.209	0.204	0.195	0.180	0.159	0.135	0.115	0.105
May	0.171	0.171	0.169	0.164	0.157	0.144	0.126	0.105	0.087	0.079
Jun	0.137	0.136	0.135	0.132	0.126	0.116	0.103	0.087	0.074	0.068
Jul	0.108	0.108	0.106	0.104	0.099	0.092	0.081	0.069	0.058	0.053
Aug	0.089	0.088	0.087	0.085	0.080	0.072	0.062	0.049	0.039	0.034
Sep	0.074	0.074	0.072	0.069	0.062	0.052	0.038	0.021	0.007	0.000

Natural Duration curves

Oct	1.647	0.732	0.437	0.306	0.209	0.172	0.153	0.134	0.101	0.075
Nov	4.931	3.133	2.311	1.555	1.115	0.814	0.583	0.386	0.220	0.089
Dec	7.732	5.470	3.913	3.121	2.445	1.546	0.926	0.736	0.485	0.269
Jan	10.062	6.564	3.681	3.323	2.203	1.673	1.299	1.072	0.586	0.377
Feb	14.199	4.741	3.067	2.059	1.542	1.190	0.988	0.831	0.645	0.281
Mar	4.667	3.293	1.561	1.172	0.915	0.814	0.568	0.497	0.351	0.138
Apr	2.195	1.609	1.065	0.868	0.756	0.621	0.498	0.305	0.247	0.147
May	1.337	0.945	0.799	0.702	0.534	0.467	0.362	0.276	0.213	0.082
Jun	0.980	0.702	0.625	0.521	0.386	0.343	0.278	0.193	0.139	0.081
Jul	0.672	0.474	0.414	0.381	0.329	0.273	0.209	0.172	0.097	0.078
Aug	0.482	0.388	0.291	0.269	0.246	0.217	0.175	0.149	0.112	0.060
Sep	0.502	0.316	0.231	0.201	0.189	0.166	0.135	0.120	0.085	0.027

Bronkhorstspruit Dam, Bronkhorstspruit
IUA 2
RU 23

- Desktop Version 2, Printed on 2008/06/30
- Summary of IFR rule curves for : MU23C Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
-
- Data are given in m^3/s mean monthly flow
-
- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.303	0.301	0.296	0.286	0.268	0.237	0.194	0.144	0.101	0.081
Nov	0.561	0.557	0.550	0.537	0.511	0.466	0.394	0.295	0.184	0.114
Dec	0.713	0.708	0.699	0.681	0.648	0.589	0.496	0.367	0.223	0.132
Jan	0.890	0.818	0.755	0.696	0.634	0.530	0.450	0.340	0.217	0.140
Feb	2.279	2.034	1.823	1.634	1.450	1.144	0.959	0.703	0.417	0.237
Mar	0.945	0.873	0.809	0.749	0.685	0.576	0.491	0.372	0.239	0.156
Apr	0.619	0.614	0.604	0.583	0.543	0.477	0.384	0.278	0.187	0.144
May	0.360	0.357	0.352	0.341	0.320	0.286	0.238	0.182	0.135	0.113
Jun	0.340	0.338	0.333	0.322	0.303	0.270	0.224	0.172	0.127	0.106
Jul	0.301	0.299	0.295	0.286	0.268	0.240	0.200	0.153	0.114	0.095
Aug	0.265	0.263	0.259	0.251	0.236	0.211	0.176	0.136	0.101	0.085
Sep	0.238	0.237	0.233	0.226	0.212	0.190	0.159	0.122	0.092	0.077

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.230	0.228	0.225	0.218	0.205	0.183	0.153	0.118	0.088	0.074
Nov	0.289	0.287	0.284	0.278	0.267	0.247	0.215	0.170	0.121	0.090
Dec	0.312	0.310	0.307	0.300	0.288	0.266	0.231	0.183	0.130	0.096
Jan	0.367	0.365	0.361	0.353	0.338	0.313	0.272	0.215	0.152	0.112
Feb	0.455	0.452	0.447	0.438	0.419	0.387	0.336	0.266	0.187	0.138
Mar	0.422	0.420	0.415	0.406	0.389	0.360	0.312	0.247	0.174	0.128
Apr	0.398	0.396	0.390	0.377	0.354	0.317	0.263	0.201	0.149	0.124
May	0.360	0.357	0.352	0.341	0.320	0.286	0.238	0.182	0.135	0.113
Jun	0.340	0.338	0.333	0.322	0.303	0.270	0.224	0.172	0.127	0.106
Jul	0.301	0.299	0.295	0.286	0.268	0.240	0.200	0.153	0.114	0.095
Aug	0.265	0.263	0.259	0.251	0.236	0.211	0.176	0.136	0.101	0.085
Sep	0.238	0.237	0.233	0.226	0.212	0.190	0.159	0.122	0.092	0.077

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.456	1.213	0.933	0.747	0.609	0.515	0.362	0.302	0.209	0.108
Nov	3.835	2.280	1.543	1.393	1.084	0.887	0.687	0.440	0.297	0.177
Dec	4.521	2.640	1.826	1.594	1.296	1.131	0.818	0.541	0.426	0.265
Jan	5.996	3.200	2.180	1.744	1.478	1.269	1.023	0.773	0.504	0.347
Feb	9.106	3.427	2.100	1.724	1.587	1.472	1.348	1.042	0.711	0.281
Mar	5.836	3.707	2.300	1.725	1.501	1.254	1.165	0.885	0.721	0.276
Apr	2.978	2.608	2.033	1.713	1.366	1.196	1.022	0.887	0.621	0.220
May	2.550	1.964	1.598	1.303	1.176	0.971	0.810	0.653	0.429	0.149
Jun	2.164	1.640	1.358	1.103	0.934	0.779	0.667	0.540	0.347	0.208
Jul	1.680	1.378	1.169	0.870	0.728	0.616	0.511	0.429	0.340	0.194
Aug	1.501	1.101	0.904	0.683	0.612	0.500	0.455	0.355	0.291	0.179
Sep	1.408	1.123	0.772	0.598	0.498	0.440	0.370	0.262	0.224	0.147

Wilge Dam (Premier Mine), Wilge River
IUA 2
RU 26

- Desktop Version 2, Printed on 2008/06/30
- Summary of IFR rule curves for : MU22B Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.250	0.249	0.245	0.237	0.222	0.197	0.162	0.122	0.088	0.072
Nov	0.422	0.419	0.414	0.404	0.385	0.353	0.301	0.228	0.148	0.097
Dec	0.599	0.595	0.588	0.573	0.545	0.497	0.420	0.314	0.195	0.120
Jan	0.762	0.702	0.649	0.599	0.547	0.460	0.393	0.301	0.198	0.133
Feb	1.915	1.713	1.538	1.382	1.231	0.977	0.823	0.609	0.371	0.221
Mar	0.828	0.767	0.714	0.663	0.608	0.516	0.442	0.340	0.226	0.155
Apr	0.497	0.493	0.484	0.465	0.431	0.374	0.294	0.201	0.122	0.085
May	0.277	0.275	0.271	0.262	0.246	0.219	0.181	0.138	0.101	0.083
Jun	0.245	0.244	0.240	0.233	0.220	0.198	0.167	0.132	0.101	0.087
Jul	0.212	0.210	0.207	0.199	0.186	0.163	0.132	0.095	0.064	0.050
Aug	0.187	0.186	0.183	0.176	0.164	0.144	0.115	0.083	0.055	0.042
Sep	0.167	0.166	0.164	0.159	0.149	0.134	0.112	0.086	0.065	0.054

Reserve flows without High Flows

Oct	0.180	0.179	0.176	0.171	0.162	0.146	0.123	0.098	0.075	0.065
Nov	0.229	0.228	0.226	0.221	0.213	0.198	0.174	0.140	0.103	0.080
Dec	0.261	0.260	0.257	0.252	0.242	0.225	0.197	0.159	0.117	0.090
Jan	0.323	0.321	0.318	0.311	0.299	0.277	0.243	0.196	0.143	0.110
Feb	0.412	0.410	0.405	0.397	0.381	0.354	0.310	0.249	0.181	0.139
Mar	0.388	0.387	0.383	0.375	0.360	0.334	0.292	0.235	0.171	0.131
Apr	0.342	0.339	0.333	0.321	0.298	0.261	0.208	0.147	0.095	0.071
May	0.277	0.275	0.271	0.262	0.246	0.219	0.181	0.138	0.101	0.083
Jun	0.245	0.244	0.240	0.233	0.220	0.198	0.167	0.132	0.101	0.087
Jul	0.212	0.210	0.207	0.199	0.186	0.163	0.132	0.095	0.064	0.050
Aug	0.187	0.186	0.183	0.176	0.164	0.144	0.115	0.083	0.055	0.042
Sep	0.167	0.166	0.164	0.159	0.149	0.134	0.112	0.086	0.065	0.054

Natural Duration curves

Oct	1.221	0.989	0.743	0.616	0.504	0.422	0.366	0.302	0.254	0.187
Nov	2.623	1.840	1.543	1.308	1.123	0.941	0.814	0.679	0.463	0.262
Dec	3.409	2.647	2.072	1.609	1.408	1.124	0.874	0.713	0.568	0.444
Jan	4.208	2.307	2.024	1.706	1.583	1.352	1.019	0.810	0.638	0.467
Feb	6.680	2.327	1.959	1.596	1.447	1.207	1.071	0.885	0.736	0.384
Mar	6.989	2.229	1.762	1.411	1.191	0.960	0.814	0.676	0.553	0.284
Apr	2.461	1.740	1.366	1.219	1.030	0.864	0.691	0.602	0.417	0.100
May	1.639	1.333	0.933	0.758	0.635	0.564	0.504	0.459	0.381	0.086
Jun	1.254	0.934	0.822	0.594	0.509	0.463	0.397	0.367	0.270	0.112
Jul	0.978	0.724	0.642	0.515	0.463	0.414	0.377	0.347	0.280	0.101
Aug	0.881	0.605	0.545	0.459	0.411	0.377	0.332	0.314	0.220	0.078
Sep	0.802	0.556	0.459	0.413	0.347	0.332	0.305	0.258	0.147	0.054

Wilge River
IUA 2
RU 31

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_4 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = B
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.393	1.383	1.358	1.306	1.211	1.053	0.830	0.574	0.354	0.253
Nov	2.684	2.667	2.632	2.562	2.430	2.201	1.836	1.330	0.765	0.409
Dec	3.536	3.514	3.466	3.373	3.198	2.892	2.407	1.732	0.979	0.506
Jan	3.954	3.651	3.382	3.123	2.844	2.373	1.987	1.451	0.854	0.478
Feb	9.833	8.808	7.742	5.469	4.191	3.840	3.418	2.993	1.686	0.864
Mar	4.261	3.957	3.683	3.417	3.123	2.627	2.201	1.609	0.950	0.535
Apr	2.474	2.454	2.410	2.318	2.147	1.865	1.467	1.008	0.617	0.434
May	1.525	1.514	1.487	1.433	1.331	1.164	0.927	0.655	0.423	0.315
Jun	1.338	1.328	1.305	1.258	1.169	1.023	0.816	0.579	0.376	0.281
Jul	1.148	1.139	1.119	1.079	1.003	0.878	0.702	0.499	0.326	0.245
Aug	0.958	0.951	0.935	0.901	0.838	0.735	0.589	0.420	0.277	0.210
Sep	0.831	0.825	0.811	0.782	0.728	0.639	0.513	0.369	0.245	0.187

Reserve flows without High Flows

Oct	0.963	0.955	0.939	0.905	0.842	0.738	0.591	0.422	0.278	0.211
Nov	1.306	1.299	1.282	1.251	1.191	1.087	0.922	0.692	0.436	0.275
Dec	1.475	1.466	1.448	1.412	1.344	1.226	1.039	0.778	0.488	0.305
Jan	1.762	1.752	1.730	1.687	1.606	1.464	1.239	0.926	0.578	0.359
Feb	2.243	2.229	2.201	2.146	2.043	1.862	1.575	1.176	0.731	0.451
Mar	2.069	2.057	2.031	1.980	1.885	1.718	1.453	1.084	0.674	0.415
Apr	1.825	1.811	1.779	1.714	1.592	1.391	1.107	0.780	0.501	0.371
May	1.525	1.514	1.487	1.433	1.331	1.164	0.927	0.655	0.423	0.315
Jun	1.338	1.328	1.305	1.258	1.169	1.023	0.816	0.579	0.376	0.281
Jul	1.148	1.139	1.119	1.079	1.003	0.878	0.702	0.499	0.326	0.245
Aug	0.958	0.951	0.935	0.901	0.838	0.735	0.589	0.420	0.277	0.210
Sep	0.831	0.825	0.811	0.782	0.728	0.639	0.513	0.369	0.245	0.187

Natural Duration curves

Oct	5.048	3.110	2.509	2.009	1.561	1.329	1.068	0.930	0.594	0.448
Nov	13.499	11.254	7.450	5.305	3.947	3.094	2.180	1.721	1.080	0.814
Dec	19.590	12.052	9.420	7.407	5.208	3.946	2.953	2.375	1.538	1.053
Jan	23.932	11.873	9.252	6.444	5.205	4.081	3.510	2.778	1.956	1.217
Feb	28.927	13.290	7.742	5.469	4.191	3.840	3.418	3.018	2.302	1.500
Mar	22.398	11.402	8.206	6.004	4.025	3.203	2.666	2.378	1.770	0.862
Apr	11.370	7.377	4.919	4.163	3.573	2.782	2.269	1.894	1.563	0.567
May	7.687	4.148	3.233	2.998	2.326	2.046	1.669	1.460	1.049	0.538
Jun	4.826	3.360	2.816	2.492	2.045	1.732	1.323	1.100	0.945	0.513
Jul	4.129	2.912	2.263	1.983	1.777	1.464	1.240	1.012	0.851	0.411
Aug	2.796	2.457	1.941	1.691	1.359	1.191	1.012	0.874	0.713	0.441
Sep	3.029	2.230	1.551	1.335	1.173	1.015	0.833	0.656	0.602	0.394

Klein Olifants River

IUA 3

RU 34

- Desktop Version 2, Printed on 3/27/2014
- Summary of IFR rule curves for : Olifants_3 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C/D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.357	0.354	0.348	0.336	0.313	0.275	0.222	0.160	0.108	0.084
Nov	1.012	1.006	0.993	0.966	0.917	0.830	0.693	0.501	0.288	0.154
Dec	1.704	1.693	1.671	1.626	1.543	1.397	1.165	0.843	0.485	0.259
Jan	3.215	2.869	2.572	2.306	2.048	1.617	1.358	0.997	0.595	0.342
Feb	1.287	1.214	1.147	1.080	1.002	0.871	0.748	0.578	0.388	0.268
Mar	1.569	1.441	1.327	1.221	1.109	0.921	0.777	0.577	0.355	0.215
Apr	0.754	0.748	0.736	0.710	0.662	0.584	0.473	0.345	0.236	0.185
May	0.402	0.400	0.393	0.381	0.357	0.318	0.263	0.200	0.146	0.121
Jun	0.313	0.311	0.306	0.297	0.279	0.250	0.210	0.163	0.123	0.104
Jul	0.262	0.260	0.256	0.248	0.234	0.210	0.176	0.137	0.103	0.088
Aug	0.210	0.208	0.205	0.199	0.187	0.168	0.141	0.110	0.083	0.071
Sep	0.175	0.174	0.171	0.166	0.155	0.137	0.112	0.083	0.059	0.047

Reserve flows without High Flows

Oct	0.212	0.210	0.207	0.201	0.189	0.170	0.142	0.111	0.084	0.071
Nov	0.372	0.370	0.366	0.358	0.342	0.315	0.272	0.211	0.144	0.102
Dec	0.515	0.512	0.507	0.496	0.475	0.440	0.383	0.305	0.217	0.162
Jan	0.647	0.643	0.636	0.623	0.597	0.552	0.481	0.382	0.272	0.202
Feb	0.767	0.764	0.755	0.739	0.709	0.655	0.571	0.453	0.322	0.240
Mar	0.631	0.627	0.620	0.606	0.579	0.531	0.457	0.352	0.236	0.163
Apr	0.506	0.503	0.495	0.480	0.451	0.404	0.337	0.260	0.195	0.164
May	0.402	0.400	0.393	0.381	0.357	0.318	0.263	0.200	0.146	0.121
Jun	0.313	0.311	0.306	0.297	0.279	0.250	0.210	0.163	0.123	0.104
Jul	0.262	0.260	0.256	0.248	0.234	0.210	0.176	0.137	0.103	0.088
Aug	0.210	0.208	0.205	0.199	0.187	0.168	0.141	0.110	0.083	0.071
Sep	0.175	0.174	0.171	0.166	0.155	0.137	0.112	0.083	0.059	0.047

Natural Duration curves

Oct	2.225	1.135	0.821	0.564	0.396	0.306	0.261	0.209	0.175	0.116
Nov	9.024	5.745	3.866	2.558	1.744	1.219	0.899	0.629	0.367	0.162
Dec	11.372	8.628	6.276	5.283	3.558	2.102	1.292	1.094	0.612	0.403
Jan	13.411	8.333	5.570	4.309	3.147	2.360	1.841	1.464	0.862	0.560
Feb	17.295	6.717	4.043	3.129	2.059	1.740	1.372	1.149	0.864	0.438
Mar	8.882	5.178	2.916	1.889	1.396	1.157	0.900	0.743	0.500	0.243
Apr	3.947	2.670	2.110	1.497	1.107	0.949	0.733	0.563	0.405	0.301
May	2.098	1.303	1.184	0.952	0.803	0.668	0.579	0.426	0.306	0.187
Jun	1.532	1.046	0.818	0.718	0.629	0.502	0.417	0.305	0.208	0.135
Jul	1.165	0.896	0.676	0.582	0.452	0.422	0.343	0.265	0.190	0.116
Aug	0.773	0.653	0.511	0.418	0.362	0.317	0.265	0.224	0.172	0.108
Sep	0.664	0.548	0.428	0.309	0.278	0.247	0.216	0.177	0.131	0.058

Loskop Dam, Olifants River
IUA 3
RU 37

- Desktop Version 2, Printed on 3/28/2014
- Summary of IFR rule curves for : MU30A Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.912	1.898	1.868	1.805	1.687	1.493	1.219	0.904	0.634	0.509
Nov	4.158	4.133	4.082	3.980	3.790	3.458	2.929	2.195	1.377	0.862
Dec	5.934	5.898	5.823	5.675	5.397	4.911	4.139	3.067	1.871	1.119
Jan	11.313	10.198	9.232	8.359	7.492	6.042	5.102	3.797	2.342	1.426
Feb	5.678	5.408	5.155	4.891	4.571	4.028	3.475	2.706	1.849	1.310
Mar	6.694	6.225	5.806	5.404	4.967	4.230	3.620	2.773	1.829	1.235
Apr	3.495	3.471	3.417	3.303	3.092	2.744	2.253	1.688	1.204	0.979
May	2.203	2.189	2.157	2.090	1.967	1.763	1.476	1.146	0.863	0.732
Jun	1.760	1.748	1.723	1.670	1.572	1.411	1.183	0.921	0.697	0.592
Jul	1.473	1.464	1.442	1.399	1.317	1.182	0.993	0.774	0.587	0.500
Aug	1.199	1.192	1.175	1.139	1.073	0.965	0.811	0.635	0.484	0.414
Sep	1.036	1.030	1.015	0.985	0.928	0.835	0.704	0.552	0.423	0.363

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.334	1.325	1.306	1.267	1.193	1.072	0.900	0.703	0.535	0.456
Nov	2.081	2.071	2.049	2.005	1.924	1.783	1.557	1.244	0.896	0.676
Dec	2.534	2.521	2.495	2.442	2.342	2.169	1.893	1.510	1.083	0.815
Jan	3.063	3.048	3.015	2.951	2.830	2.620	2.286	1.821	1.304	0.978
Feb	3.798	3.779	3.739	3.659	3.509	3.248	2.833	2.256	1.613	1.208
Mar	3.299	3.282	3.247	3.178	3.048	2.821	2.461	1.960	1.402	1.051
Apr	2.772	2.754	2.714	2.630	2.474	2.217	1.854	1.437	1.080	0.914
May	2.203	2.189	2.157	2.090	1.967	1.763	1.476	1.146	0.863	0.732
Jun	1.760	1.748	1.723	1.670	1.572	1.411	1.183	0.921	0.697	0.592
Jul	1.473	1.464	1.442	1.399	1.317	1.182	0.993	0.774	0.587	0.500
Aug	1.199	1.192	1.175	1.139	1.073	0.965	0.811	0.635	0.484	0.414
Sep	1.036	1.030	1.015	0.985	0.928	0.835	0.704	0.552	0.423	0.363

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	17.697	9.270	5.948	4.764	3.524	2.867	2.393	2.080	1.426	1.034
Nov	51.119	39.498	24.819	20.120	14.861	10.949	7.133	5.448	2.650	1.728
Dec	70.516	49.944	35.995	30.798	23.749	15.995	9.823	6.896	4.768	2.419
Jan	88.396	60.895	38.385	28.808	21.020	16.006	11.966	9.274	6.776	3.857
Feb	76.228	44.672	31.453	23.057	13.765	11.872	10.375	8.300	6.324	3.729
Mar	67.089	41.327	21.774	16.596	12.534	10.036	7.575	5.974	3.999	1.747
Apr	29.803	20.737	13.981	11.211	9.479	8.044	5.768	4.417	3.322	1.682
May	19.239	11.451	9.125	6.627	5.612	4.839	4.118	3.099	2.337	1.352
Jun	11.262	8.453	6.393	5.289	4.475	3.569	3.059	2.353	1.863	1.134
Jul	9.446	6.582	4.869	4.503	3.711	3.371	2.528	2.207	1.766	1.116
Aug	5.507	5.081	4.118	3.707	2.994	2.490	2.121	1.837	1.561	1.292
Sep	6.277	4.055	3.287	2.801	2.454	1.925	1.736	1.466	1.265	0.930

Roodepoort Dam, Selons River
IUA 3
RU 38

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : B32B Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = B
- Data are given in m^3/s mean monthly flow

	% Points									
Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.132	0.131	0.129	0.124	0.116	0.103	0.084	0.062	0.043	0.035
Nov	0.317	0.315	0.311	0.303	0.288	0.263	0.222	0.164	0.101	0.061
Dec	0.421	0.418	0.413	0.402	0.382	0.347	0.292	0.215	0.129	0.075
Jan	0.468	0.434	0.404	0.375	0.344	0.291	0.247	0.186	0.119	0.076
Feb	1.185	1.063	0.957	0.862	0.769	0.612	0.513	0.376	0.223	0.127
Mar	0.480	0.447	0.417	0.388	0.356	0.302	0.257	0.194	0.123	0.079
Apr	0.311	0.308	0.303	0.292	0.272	0.239	0.192	0.138	0.092	0.071
May	0.175	0.174	0.171	0.165	0.155	0.138	0.113	0.085	0.061	0.050
Jun	0.148	0.147	0.144	0.140	0.131	0.116	0.096	0.073	0.053	0.043
Jul	0.125	0.124	0.122	0.119	0.111	0.099	0.082	0.062	0.045	0.037
Aug	0.110	0.109	0.107	0.104	0.097	0.087	0.072	0.055	0.040	0.033
Sep	0.099	0.099	0.097	0.094	0.088	0.079	0.066	0.050	0.037	0.031

Reserve flows without High Flows

Oct	0.105	0.104	0.102	0.099	0.093	0.083	0.069	0.053	0.039	0.032
Nov	0.153	0.153	0.151	0.147	0.141	0.130	0.113	0.089	0.062	0.045
Dec	0.180	0.179	0.177	0.173	0.165	0.152	0.132	0.103	0.071	0.051
Jan	0.225	0.224	0.221	0.216	0.207	0.190	0.164	0.128	0.088	0.063
Feb	0.280	0.278	0.275	0.269	0.257	0.237	0.204	0.159	0.109	0.077
Mar	0.238	0.236	0.234	0.228	0.218	0.201	0.174	0.135	0.093	0.066
Apr	0.222	0.220	0.217	0.210	0.196	0.174	0.143	0.107	0.077	0.062
May	0.175	0.174	0.171	0.165	0.155	0.138	0.113	0.085	0.061	0.050
Jun	0.148	0.147	0.144	0.140	0.131	0.116	0.096	0.073	0.053	0.043
Jul	0.125	0.124	0.122	0.119	0.111	0.099	0.082	0.062	0.045	0.037
Aug	0.110	0.109	0.107	0.104	0.097	0.087	0.072	0.055	0.040	0.033
Sep	0.099	0.099	0.097	0.094	0.088	0.079	0.066	0.050	0.037	0.031

Natural Duration curves

Oct	0.624	0.426	0.358	0.280	0.261	0.209	0.183	0.157	0.127	0.097
Nov	1.860	1.173	0.860	0.687	0.559	0.432	0.386	0.282	0.204	0.131
Dec	2.681	1.490	1.180	0.945	0.825	0.736	0.538	0.418	0.250	0.153
Jan	4.783	1.829	1.385	1.101	0.896	0.765	0.624	0.448	0.370	0.179
Feb	5.080	3.088	1.546	1.190	0.955	0.732	0.616	0.492	0.393	0.293
Mar	2.882	1.464	1.131	0.948	0.792	0.683	0.526	0.414	0.332	0.183
Apr	1.427	1.057	0.876	0.799	0.660	0.556	0.417	0.343	0.262	0.154
May	0.848	0.665	0.556	0.504	0.396	0.343	0.276	0.243	0.194	0.142
Jun	0.590	0.486	0.397	0.328	0.289	0.262	0.239	0.212	0.170	0.127
Jul	0.470	0.358	0.317	0.280	0.250	0.235	0.205	0.190	0.164	0.116
Aug	0.403	0.314	0.261	0.231	0.220	0.209	0.190	0.168	0.142	0.108
Sep	0.359	0.270	0.239	0.224	0.216	0.185	0.166	0.143	0.123	0.104

Olifants River
IUA 3
RU 40

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_5 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C

- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.374	2.358	2.322	2.248	2.109	1.880	1.558	1.186	0.868	0.720
Nov	5.558	5.526	5.458	5.325	5.076	4.640	3.947	2.985	1.912	1.237
Dec	8.078	8.030	7.929	7.729	7.356	6.704	5.666	4.225	2.619	1.608
Jan	16.296	14.568	13.082	11.758	10.476	8.335	7.059	5.287	3.311	2.068
Feb	7.205	6.796	6.425	6.058	5.645	4.944	4.315	3.441	2.467	1.854
Mar	9.001	8.280	7.648	7.060	6.453	5.433	4.685	3.647	2.490	1.761
Apr	4.290	4.261	4.196	4.060	3.807	3.391	2.803	2.126	1.547	1.278
May	2.496	2.482	2.450	2.384	2.261	2.059	1.773	1.445	1.163	1.033
Jun	1.996	1.985	1.960	1.907	1.810	1.650	1.424	1.163	0.941	0.837
Jul	1.670	1.661	1.640	1.597	1.516	1.383	1.195	0.978	0.793	0.707
Aug	1.367	1.360	1.343	1.308	1.242	1.134	0.982	0.807	0.657	0.587
Sep	1.187	1.180	1.166	1.136	1.079	0.987	0.856	0.706	0.577	0.518

Reserve flows without High Flows

Oct	1.504	1.496	1.477	1.438	1.366	1.246	1.078	0.884	0.718	0.641
Nov	2.347	2.336	2.315	2.271	2.191	2.050	1.826	1.515	1.168	0.949
Dec	2.846	2.833	2.807	2.754	2.655	2.483	2.210	1.830	1.406	1.139
Jan	3.446	3.431	3.399	3.335	3.215	3.005	2.672	2.210	1.694	1.370
Feb	4.281	4.261	4.221	4.141	3.992	3.731	3.317	2.741	2.099	1.695
Mar	3.719	3.702	3.667	3.598	3.468	3.242	2.882	2.382	1.825	1.474
Apr	3.146	3.127	3.084	2.996	2.830	2.557	2.172	1.729	1.350	1.174
May	2.496	2.482	2.450	2.384	2.261	2.059	1.773	1.445	1.163	1.033
Jun	1.996	1.985	1.960	1.907	1.810	1.650	1.424	1.163	0.941	0.837
Jul	1.670	1.661	1.640	1.597	1.516	1.383	1.195	0.978	0.793	0.707
Aug	1.367	1.360	1.343	1.308	1.242	1.134	0.982	0.807	0.657	0.587
Sep	1.187	1.180	1.166	1.136	1.079	0.987	0.856	0.706	0.577	0.518

Natural Duration curves

Oct	18.134	9.614	6.425	5.025	3.995	3.230	2.666	2.397	1.594	1.187
Nov	55.475	39.954	26.258	21.146	15.733	11.481	7.851	5.799	2.867	2.002
Dec	76.538	51.359	38.471	34.076	25.616	17.380	11.630	8.023	5.238	2.733
Jan	101.747	62.862	39.546	30.645	22.189	17.103	13.852	10.230	7.463	4.342
Feb	83.201	48.636	33.296	23.752	15.960	13.000	11.442	9.082	7.031	4.233
Mar	74.843	42.880	23.055	18.164	14.322	10.723	8.658	6.575	4.376	2.057
Apr	31.254	23.927	14.834	12.137	10.779	8.603	6.539	4.938	3.835	1.917
May	19.971	13.030	9.954	7.575	6.037	5.570	4.465	3.476	2.584	1.553
Jun	12.353	9.209	6.813	5.752	4.807	4.113	3.526	2.596	2.157	1.300
Jul	10.122	7.206	5.335	4.981	4.002	3.741	2.856	2.464	1.983	1.228
Aug	6.209	5.570	4.465	3.969	3.274	2.759	2.382	2.102	1.781	1.561
Sep	6.933	4.390	3.704	3.094	2.704	2.230	1.983	1.671	1.451	1.073

Rust de Winter Dam,, Elands River
IUA 4
RU 41

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : B31C Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow
- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.173	0.172	0.169	0.164	0.153	0.136	0.112	0.085	0.061	0.050
Nov	0.491	0.488	0.481	0.469	0.446	0.406	0.343	0.254	0.155	0.093
Dec	0.558	0.554	0.547	0.533	0.507	0.461	0.388	0.287	0.174	0.103
Jan	1.646	1.458	1.105	0.960	0.810	0.661	0.538	0.474	0.291	0.167
Feb	0.608	0.565	0.526	0.489	0.450	0.383	0.330	0.257	0.175	0.123
Mar	0.840	0.762	0.695	0.634	0.572	0.469	0.400	0.303	0.196	0.129
Apr	0.392	0.389	0.383	0.370	0.345	0.305	0.248	0.182	0.125	0.099
May	0.171	0.170	0.168	0.163	0.154	0.139	0.119	0.095	0.075	0.065
Jun	0.142	0.141	0.139	0.136	0.128	0.116	0.099	0.080	0.063	0.055
Jul	0.126	0.125	0.123	0.120	0.113	0.103	0.088	0.071	0.056	0.049
Aug	0.115	0.114	0.112	0.109	0.103	0.094	0.080	0.065	0.051	0.045
Sep	0.105	0.105	0.103	0.101	0.095	0.086	0.074	0.060	0.048	0.042

- Reserve flows without High Flows

Oct	0.114	0.113	0.112	0.109	0.103	0.093	0.080	0.064	0.051	0.045
Nov	0.175	0.174	0.173	0.169	0.163	0.152	0.134	0.110	0.082	0.065
Dec	0.188	0.187	0.185	0.182	0.175	0.163	0.144	0.118	0.088	0.070
Jan	0.249	0.247	0.245	0.240	0.231	0.215	0.190	0.155	0.115	0.091
Feb	0.291	0.290	0.287	0.281	0.271	0.252	0.222	0.181	0.135	0.106
Mar	0.268	0.267	0.264	0.259	0.249	0.232	0.204	0.166	0.124	0.097
Apr	0.222	0.220	0.217	0.211	0.200	0.181	0.154	0.123	0.096	0.084
May	0.171	0.170	0.168	0.163	0.154	0.139	0.119	0.095	0.075	0.065
Jun	0.142	0.141	0.139	0.136	0.128	0.116	0.099	0.080	0.063	0.055
Jul	0.126	0.125	0.123	0.120	0.113	0.103	0.088	0.071	0.056	0.049
Aug	0.115	0.114	0.112	0.109	0.103	0.094	0.080	0.065	0.051	0.045
Sep	0.105	0.105	0.103	0.101	0.095	0.086	0.074	0.060	0.048	0.042

- Natural Duration curves

Oct	0.889	0.616	0.497	0.444	0.317	0.261	0.209	0.179	0.138	0.086
Nov	2.272	1.505	1.123	0.910	0.691	0.583	0.494	0.374	0.216	0.139
Dec	2.983	1.531	1.202	1.086	0.952	0.792	0.590	0.388	0.258	0.190
Jan	4.200	2.337	1.105	0.960	0.810	0.661	0.538	0.474	0.370	0.217
Feb	6.329	2.827	1.356	1.000	0.785	0.637	0.525	0.417	0.314	0.227
Mar	3.834	2.095	1.172	0.892	0.750	0.657	0.500	0.340	0.269	0.146
Apr	1.998	1.281	0.856	0.683	0.598	0.552	0.417	0.355	0.274	0.181
May	1.023	0.762	0.568	0.463	0.385	0.329	0.291	0.254	0.209	0.146
Jun	0.764	0.544	0.424	0.367	0.285	0.270	0.235	0.224	0.189	0.143
Jul	0.612	0.418	0.358	0.314	0.276	0.250	0.224	0.209	0.172	0.138
Aug	0.441	0.343	0.299	0.280	0.261	0.243	0.209	0.187	0.172	0.131
Sep	0.463	0.320	0.266	0.247	0.228	0.208	0.170	0.158	0.135	0.120

Mkhombo Dam, Elands River
IUA 4
RU 45

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_6 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.233	0.232	0.229	0.222	0.210	0.189	0.160	0.126	0.098	0.084
Nov	0.827	0.822	0.811	0.791	0.752	0.684	0.577	0.427	0.261	0.156
Dec	1.000	0.993	0.981	0.956	0.909	0.827	0.697	0.516	0.314	0.187
Jan	2.200	1.952	1.739	1.552	1.374	1.078	0.915	0.687	0.434	0.275
Feb	0.779	0.726	0.679	0.635	0.589	0.511	0.451	0.369	0.277	0.219
Mar	1.050	0.955	0.874	0.800	0.726	0.604	0.525	0.415	0.292	0.215
Apr	0.502	0.499	0.491	0.475	0.446	0.398	0.330	0.252	0.185	0.154
May	0.210	0.209	0.207	0.203	0.195	0.182	0.163	0.141	0.123	0.114
Jun	0.177	0.176	0.174	0.171	0.164	0.153	0.137	0.119	0.103	0.096
Jul	0.156	0.156	0.154	0.151	0.145	0.135	0.121	0.105	0.091	0.085
Aug	0.142	0.141	0.140	0.137	0.131	0.122	0.110	0.095	0.083	0.077
Sep	0.130	0.129	0.128	0.125	0.120	0.112	0.101	0.087	0.076	0.070

Reserve flows without High Flows

Oct	0.143	0.142	0.141	0.138	0.133	0.124	0.111	0.096	0.083	0.078
Nov	0.241	0.241	0.239	0.235	0.227	0.214	0.194	0.165	0.133	0.113
Dec	0.265	0.264	0.262	0.258	0.251	0.237	0.216	0.187	0.154	0.134
Jan	0.344	0.343	0.341	0.335	0.325	0.308	0.281	0.243	0.201	0.174
Feb	0.392	0.390	0.387	0.381	0.370	0.350	0.319	0.276	0.228	0.198
Mar	0.351	0.349	0.347	0.341	0.331	0.314	0.286	0.247	0.204	0.177
Apr	0.274	0.272	0.269	0.263	0.252	0.233	0.206	0.176	0.149	0.137
May	0.210	0.209	0.207	0.203	0.195	0.182	0.163	0.141	0.123	0.114
Jun	0.177	0.176	0.174	0.171	0.164	0.153	0.137	0.119	0.103	0.096
Jul	0.156	0.156	0.154	0.151	0.145	0.135	0.121	0.105	0.091	0.085
Aug	0.142	0.141	0.140	0.137	0.131	0.122	0.110	0.095	0.083	0.077
Sep	0.130	0.129	0.128	0.125	0.120	0.112	0.101	0.087	0.076	0.070

Natural Duration curves

Oct	1.533	0.985	0.718	0.660	0.499	0.402	0.318	0.270	0.195	0.128
Nov	6.100	3.484	2.513	1.703	1.409	0.991	0.839	0.623	0.340	0.209
Dec	6.909	4.015	2.897	2.319	1.944	1.595	1.219	0.696	0.450	0.306
Jan	7.831	4.409	2.914	2.167	1.669	1.259	0.968	0.775	0.611	0.345
Feb	11.435	5.039	2.815	1.781	1.360	1.220	0.851	0.692	0.544	0.367
Mar	6.626	3.734	2.536	1.342	1.228	1.071	0.787	0.590	0.418	0.240
Apr	3.076	2.147	1.321	1.131	1.034	0.873	0.699	0.557	0.419	0.280
May	1.538	1.271	0.918	0.748	0.631	0.562	0.473	0.398	0.336	0.206
Jun	1.204	0.889	0.716	0.611	0.520	0.431	0.391	0.339	0.303	0.198
Jul	0.923	0.705	0.616	0.530	0.458	0.414	0.361	0.335	0.274	0.184
Aug	0.735	0.573	0.497	0.467	0.444	0.388	0.331	0.301	0.259	0.170
Sep	0.685	0.493	0.434	0.404	0.369	0.327	0.280	0.238	0.210	0.179

Elands River
IUA 4
RU 46

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_6 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D

- Data are given in m^3/s mean monthly flow

- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.233	0.232	0.229	0.222	0.210	0.189	0.160	0.126	0.098	0.084
Nov	0.827	0.822	0.811	0.791	0.752	0.684	0.577	0.427	0.261	0.156
Dec	1.000	0.993	0.981	0.956	0.909	0.827	0.697	0.516	0.314	0.187
Jan	2.200	1.952	1.739	1.552	1.374	1.078	0.915	0.687	0.434	0.275
Feb	0.779	0.726	0.679	0.635	0.589	0.511	0.451	0.369	0.277	0.219
Mar	1.050	0.955	0.874	0.800	0.726	0.604	0.525	0.415	0.292	0.215
Apr	0.502	0.499	0.491	0.475	0.446	0.398	0.330	0.252	0.185	0.154
May	0.210	0.209	0.207	0.203	0.195	0.182	0.163	0.141	0.123	0.114
Jun	0.177	0.176	0.174	0.171	0.164	0.153	0.137	0.119	0.103	0.096
Jul	0.156	0.156	0.154	0.151	0.145	0.135	0.121	0.105	0.091	0.085
Aug	0.142	0.141	0.140	0.137	0.131	0.122	0.110	0.095	0.083	0.077
Sep	0.130	0.129	0.128	0.125	0.120	0.112	0.101	0.087	0.076	0.070

- Reserve flows without High Flows

Oct	0.143	0.142	0.141	0.138	0.133	0.124	0.111	0.096	0.083	0.078
Nov	0.241	0.241	0.239	0.235	0.227	0.214	0.194	0.165	0.133	0.113
Dec	0.265	0.264	0.262	0.258	0.251	0.237	0.216	0.187	0.154	0.134
Jan	0.344	0.343	0.341	0.335	0.325	0.308	0.281	0.243	0.201	0.174
Feb	0.392	0.390	0.387	0.381	0.370	0.350	0.319	0.276	0.228	0.198
Mar	0.351	0.349	0.347	0.341	0.331	0.314	0.286	0.247	0.204	0.177
Apr	0.274	0.272	0.269	0.263	0.252	0.233	0.206	0.176	0.149	0.137
May	0.210	0.209	0.207	0.203	0.195	0.182	0.163	0.141	0.123	0.114
Jun	0.177	0.176	0.174	0.171	0.164	0.153	0.137	0.119	0.103	0.096
Jul	0.156	0.156	0.154	0.151	0.145	0.135	0.121	0.105	0.091	0.085
Aug	0.142	0.141	0.140	0.137	0.131	0.122	0.110	0.095	0.083	0.077
Sep	0.130	0.129	0.128	0.125	0.120	0.112	0.101	0.087	0.076	0.070

- Natural Duration curves

Oct	1.533	0.985	0.718	0.660	0.499	0.402	0.318	0.270	0.195	0.128
Nov	6.100	3.484	2.513	1.703	1.409	0.991	0.839	0.623	0.340	0.209
Dec	6.909	4.015	2.897	2.319	1.944	1.595	1.219	0.696	0.450	0.306
Jan	7.831	4.409	2.914	2.167	1.669	1.259	0.968	0.775	0.611	0.345
Feb	11.435	5.039	2.815	1.781	1.360	1.220	0.851	0.692	0.544	0.367
Mar	6.626	3.734	2.536	1.342	1.228	1.071	0.787	0.590	0.418	0.240
Apr	3.076	2.147	1.321	1.131	1.034	0.873	0.699	0.557	0.419	0.280
May	1.538	1.271	0.918	0.748	0.631	0.562	0.473	0.398	0.336	0.206
Jun	1.204	0.889	0.716	0.611	0.520	0.431	0.391	0.339	0.303	0.198
Jul	0.923	0.705	0.616	0.530	0.458	0.414	0.361	0.335	0.274	0.184
Aug	0.735	0.573	0.497	0.467	0.444	0.388	0.331	0.301	0.259	0.170
Sep	0.685	0.493	0.434	0.404	0.369	0.327	0.280	0.238	0.210	0.179

Elands River
IUA 5
RU 47

- Desktop Version 2, Printed on 2008/06/30
- Summary of IFR rule curves for : B31J Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow
- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.319	0.317	0.313	0.304	0.287	0.259	0.219	0.174	0.135	0.117
Nov	1.093	1.086	1.072	1.045	0.994	0.905	0.764	0.567	0.348	0.210
Dec	1.309	1.301	1.285	1.252	1.191	1.085	0.916	0.682	0.420	0.255
Jan	2.789	2.479	2.214	1.979	1.756	1.385	1.177	0.889	0.568	0.366
Feb	1.064	0.994	0.931	0.873	0.811	0.706	0.625	0.512	0.386	0.306
Mar	1.417	1.292	1.184	1.086	0.988	0.824	0.717	0.569	0.403	0.287
Apr	0.661	0.656	0.647	0.627	0.589	0.528	0.441	0.341	0.255	0.215
May	0.288	0.286	0.283	0.278	0.267	0.248	0.223	0.193	0.168	0.156
Jun	0.241	0.240	0.237	0.232	0.223	0.208	0.186	0.162	0.140	0.130
Jul	0.212	0.211	0.209	0.205	0.197	0.183	0.164	0.143	0.124	0.115
Aug	0.192	0.191	0.189	0.185	0.178	0.166	0.149	0.129	0.112	0.104
Sep	0.175	0.174	0.172	0.169	0.162	0.151	0.135	0.117	0.102	0.095

- Reserve flows without High Flows

Oct	0.199	0.199	0.197	0.192	0.185	0.172	0.154	0.134	0.116	0.108
Nov	0.341	0.339	0.336	0.331	0.320	0.301	0.272	0.230	0.184	0.155
Dec	0.370	0.369	0.366	0.360	0.350	0.331	0.302	0.261	0.216	0.187
Jan	0.475	0.473	0.470	0.462	0.449	0.425	0.387	0.335	0.277	0.240
Feb	0.552	0.550	0.546	0.537	0.521	0.494	0.450	0.389	0.321	0.279
Mar	0.493	0.491	0.487	0.479	0.465	0.441	0.402	0.347	0.287	0.249
Apr	0.380	0.379	0.375	0.366	0.351	0.325	0.288	0.247	0.211	0.194
May	0.288	0.286	0.283	0.278	0.267	0.248	0.223	0.193	0.168	0.156
Jun	0.241	0.240	0.237	0.232	0.223	0.208	0.186	0.162	0.140	0.130
Jul	0.212	0.211	0.209	0.205	0.197	0.183	0.164	0.143	0.124	0.115
Aug	0.192	0.191	0.189	0.185	0.178	0.166	0.149	0.129	0.112	0.104
Sep	0.175	0.174	0.172	0.169	0.162	0.151	0.135	0.117	0.102	0.095

- Natural Duration curves

Oct	1.919	1.475	1.083	0.907	0.653	0.541	0.441	0.373	0.284	0.190
Nov	9.190	4.726	3.295	2.361	1.871	1.462	1.184	0.849	0.494	0.262
Dec	9.494	5.671	3.689	3.162	2.647	2.147	1.632	0.967	0.661	0.463
Jan	10.290	6.313	3.913	2.976	2.106	1.732	1.247	1.086	0.892	0.418
Feb	18.122	6.998	3.737	2.559	1.852	1.534	1.195	0.947	0.719	0.475
Mar	10.932	5.462	3.121	1.934	1.706	1.437	1.139	0.792	0.586	0.287
Apr	4.464	2.855	1.894	1.586	1.400	1.208	0.980	0.806	0.556	0.343
May	2.117	1.747	1.277	1.086	0.874	0.769	0.642	0.538	0.444	0.246
Jun	1.620	1.211	0.961	0.891	0.675	0.617	0.517	0.475	0.382	0.258
Jul	1.180	0.986	0.833	0.721	0.631	0.564	0.485	0.455	0.351	0.258
Aug	0.922	0.799	0.694	0.635	0.586	0.530	0.452	0.411	0.336	0.250
Sep	0.895	0.664	0.563	0.540	0.490	0.440	0.394	0.324	0.289	0.247

Rooikraal Dam, Bloed River
IUA 5
RU 48

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : B32F Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Lowveld ERC = B
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.062	0.059	0.052	0.042	0.030	0.019	0.013	0.010	0.009	0.009
Nov	0.305	0.290	0.259	0.206	0.141	0.081	0.040	0.021	0.016	0.016
Dec	0.555	0.454	0.359	0.263	0.145	0.090	0.057	0.043	0.041	0.041
Jan	0.376	0.328	0.275	0.212	0.128	0.075	0.041	0.028	0.028	0.028
Feb	1.306	1.043	0.806	0.577	0.294	0.172	0.100	0.071	0.067	0.066
Mar	0.331	0.315	0.283	0.229	0.163	0.101	0.059	0.039	0.034	0.030
Apr	0.169	0.160	0.141	0.112	0.077	0.048	0.029	0.020	0.017	0.015
May	0.071	0.067	0.059	0.046	0.033	0.022	0.015	0.012	0.011	0.011
Jun	0.054	0.051	0.045	0.037	0.027	0.018	0.013	0.010	0.008	0.008
Jul	0.046	0.044	0.038	0.031	0.022	0.015	0.011	0.008	0.007	0.007
Aug	0.037	0.035	0.030	0.025	0.019	0.013	0.009	0.007	0.006	0.006
Sep	0.032	0.030	0.027	0.019	0.015	0.010	0.007	0.006	0.005	0.005

Reserve flows without High Flows

Oct	0.043	0.041	0.037	0.030	0.021	0.014	0.010	0.008	0.007	0.007
Nov	0.136	0.129	0.115	0.090	0.060	0.031	0.012	0.003	0.001	0.001
Dec	0.160	0.153	0.136	0.109	0.076	0.049	0.032	0.026	0.025	0.025
Jan	0.189	0.181	0.163	0.131	0.091	0.053	0.029	0.020	0.020	0.020
Feb	0.249	0.236	0.208	0.162	0.108	0.062	0.035	0.024	0.022	0.022
Mar	0.172	0.164	0.148	0.120	0.086	0.054	0.033	0.022	0.020	0.020
Apr	0.119	0.113	0.100	0.079	0.055	0.034	0.021	0.014	0.012	0.012
May	0.071	0.067	0.059	0.046	0.033	0.022	0.015	0.012	0.011	0.011
Jun	0.054	0.051	0.045	0.037	0.027	0.018	0.013	0.010	0.008	0.008
Jul	0.046	0.044	0.038	0.031	0.022	0.015	0.011	0.008	0.007	0.007
Aug	0.037	0.035	0.030	0.025	0.019	0.013	0.009	0.007	0.006	0.006
Sep	0.032	0.030	0.027	0.019	0.015	0.010	0.007	0.006	0.005	0.005

Natural Duration curves

Oct	0.299	0.172	0.097	0.075	0.049	0.030	0.022	0.019	0.011	0.011
Nov	1.682	1.181	0.748	0.583	0.451	0.313	0.162	0.104	0.050	0.019
Dec	1.766	1.254	0.941	0.821	0.631	0.568	0.467	0.321	0.172	0.067
Jan	2.188	1.572	0.948	0.713	0.556	0.482	0.392	0.317	0.205	0.063
Feb	4.501	1.534	1.087	0.769	0.446	0.389	0.256	0.186	0.099	0.066
Mar	2.113	0.885	0.609	0.403	0.321	0.239	0.153	0.097	0.060	0.030
Apr	0.598	0.417	0.328	0.189	0.147	0.112	0.069	0.062	0.039	0.015
May	0.190	0.123	0.093	0.078	0.063	0.045	0.037	0.034	0.019	0.011
Jun	0.096	0.069	0.058	0.050	0.039	0.039	0.031	0.023	0.019	0.012
Jul	0.067	0.049	0.049	0.037	0.034	0.030	0.030	0.022	0.019	0.011
Aug	0.056	0.037	0.030	0.030	0.030	0.022	0.019	0.019	0.019	0.011
Sep	0.054	0.039	0.031	0.019	0.019	0.019	0.019	0.019	0.012	0.012

Moses River
IUA 5
RU 49

- Desktop Version 2, Printed on 2008/06/30
- Summary of IFR rule curves for : B32H Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.145	0.144	0.142	0.137	0.129	0.115	0.096	0.074	0.055	0.047
Nov	0.357	0.355	0.350	0.342	0.326	0.298	0.253	0.191	0.122	0.079
Dec	0.477	0.474	0.468	0.456	0.434	0.396	0.335	0.250	0.155	0.096
Jan	0.418	0.384	0.355	0.328	0.300	0.253	0.219	0.171	0.117	0.083
Feb	1.098	0.981	0.880	0.790	0.704	0.559	0.473	0.354	0.221	0.137
Mar	0.460	0.427	0.397	0.369	0.340	0.290	0.251	0.197	0.137	0.099
Apr	0.316	0.314	0.309	0.299	0.280	0.249	0.205	0.154	0.111	0.091
May	0.159	0.158	0.156	0.152	0.144	0.131	0.113	0.092	0.074	0.066
Jun	0.140	0.139	0.137	0.133	0.126	0.115	0.099	0.081	0.065	0.058
Jul	0.120	0.119	0.118	0.115	0.109	0.099	0.086	0.070	0.057	0.050
Aug	0.105	0.104	0.103	0.100	0.095	0.087	0.075	0.061	0.050	0.044
Sep	0.093	0.092	0.091	0.089	0.084	0.077	0.067	0.055	0.045	0.040

Reserve flows without High Flows

Oct	0.100	0.099	0.098	0.095	0.090	0.083	0.071	0.059	0.048	0.042
Nov	0.149	0.148	0.147	0.144	0.139	0.130	0.116	0.096	0.074	0.060
Dec	0.171	0.170	0.168	0.165	0.159	0.149	0.133	0.110	0.084	0.068
Jan	0.175	0.175	0.173	0.170	0.164	0.153	0.136	0.113	0.087	0.070
Feb	0.227	0.226	0.224	0.220	0.212	0.198	0.176	0.145	0.111	0.090
Mar	0.218	0.217	0.215	0.211	0.203	0.190	0.169	0.139	0.107	0.086
Apr	0.196	0.195	0.192	0.187	0.177	0.161	0.139	0.113	0.090	0.080
May	0.159	0.158	0.156	0.152	0.144	0.131	0.113	0.092	0.074	0.066
Jun	0.140	0.139	0.137	0.133	0.126	0.115	0.099	0.081	0.065	0.058
Jul	0.120	0.119	0.118	0.115	0.109	0.099	0.086	0.070	0.057	0.050
Aug	0.105	0.104	0.103	0.100	0.095	0.087	0.075	0.061	0.050	0.044
Sep	0.093	0.092	0.091	0.089	0.084	0.077	0.067	0.055	0.045	0.040

Natural Duration curves

Oct	0.997	0.773	0.594	0.463	0.340	0.280	0.224	0.194	0.146	0.101
Nov	2.816	1.917	1.462	1.150	0.992	0.818	0.563	0.378	0.266	0.120
Dec	2.860	2.158	1.673	1.579	1.161	0.997	0.862	0.747	0.448	0.213
Jan	2.688	2.016	1.523	1.281	1.142	0.937	0.750	0.661	0.470	0.325
Feb	4.158	2.836	1.682	1.306	1.145	0.930	0.777	0.628	0.471	0.339
Mar	3.655	2.457	1.609	1.236	0.993	0.855	0.650	0.482	0.343	0.149
Apr	2.450	1.705	1.312	1.192	0.806	0.679	0.559	0.478	0.274	0.170
May	1.647	1.116	0.870	0.642	0.523	0.437	0.392	0.317	0.246	0.153
Jun	0.988	0.772	0.617	0.529	0.436	0.363	0.332	0.285	0.204	0.143
Jul	0.687	0.538	0.485	0.426	0.388	0.336	0.291	0.261	0.217	0.134
Aug	0.597	0.429	0.373	0.343	0.321	0.295	0.258	0.243	0.209	0.153
Sep	0.590	0.432	0.313	0.285	0.258	0.235	0.204	0.193	0.177	0.139

Flag Boshielo Dam and Olifants River
IUA 5
RU 52

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_7 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.231	2.216	2.181	2.110	1.976	1.757	1.446	1.089	0.784	0.642
Nov	6.840	6.798	6.710	6.537	6.212	5.645	4.744	3.491	2.094	1.215
Dec	10.026	9.963	9.831	9.571	9.083	8.232	6.878	4.997	2.900	1.580
Jan	18.334	16.197	14.374	12.772	11.261	8.742	7.383	5.494	3.389	2.064
Feb	6.581	6.083	5.648	5.245	4.831	4.136	3.635	2.940	2.165	1.677
Mar	9.150	8.261	7.496	6.810	6.141	5.021	4.335	3.380	2.317	1.648
Apr	3.810	3.786	3.730	3.615	3.401	3.049	2.551	1.978	1.488	1.260
May	1.625	1.618	1.601	1.568	1.505	1.403	1.257	1.090	0.947	0.881
Jun	1.327	1.322	1.308	1.281	1.230	1.146	1.027	0.891	0.774	0.720
Jul	1.116	1.112	1.100	1.077	1.034	0.964	0.864	0.749	0.651	0.605
Aug	0.938	0.934	0.925	0.905	0.869	0.810	0.726	0.629	0.547	0.509
Sep	0.832	0.828	0.820	0.803	0.771	0.718	0.644	0.558	0.485	0.451

Reserve flows without High Flows

Oct	1.013	1.009	0.999	0.978	0.939	0.875	0.784	0.680	0.591	0.549
Nov	1.660	1.654	1.641	1.616	1.568	1.485	1.353	1.170	0.966	0.838
Dec	1.968	1.960	1.945	1.915	1.859	1.760	1.604	1.387	1.145	0.993
Jan	2.370	2.361	2.343	2.307	2.239	2.121	1.933	1.671	1.380	1.196
Feb	2.930	2.919	2.896	2.852	2.768	2.622	2.389	2.066	1.705	1.479
Mar	2.554	2.545	2.525	2.486	2.413	2.286	2.083	1.801	1.487	1.289
Apr	2.082	2.073	2.052	2.010	1.929	1.798	1.611	1.397	1.214	1.129
May	1.625	1.618	1.601	1.568	1.505	1.403	1.257	1.090	0.947	0.881
Jun	1.327	1.322	1.308	1.281	1.230	1.146	1.027	0.891	0.774	0.720
Jul	1.116	1.112	1.100	1.077	1.034	0.964	0.864	0.749	0.651	0.605
Aug	0.938	0.934	0.925	0.905	0.869	0.810	0.726	0.629	0.547	0.509
Sep	0.832	0.828	0.820	0.803	0.771	0.718	0.644	0.558	0.485	0.451

Natural Duration curves

Oct	21.961	12.664	8.617	6.657	5.354	4.316	3.666	3.039	2.177	1.460
Nov	72.307	46.273	35.529	28.110	20.154	16.350	10.343	8.113	4.479	2.654
Dec	88.105	59.080	52.595	43.720	29.839	25.030	15.016	12.272	7.400	3.905
Jan	135.387	73.925	46.479	35.868	27.012	21.950	16.719	14.453	10.383	5.559
Feb	121.300	62.260	42.138	33.565	20.242	17.076	13.988	12.719	10.545	6.552
Mar	100.463	45.049	30.563	25.209	20.718	14.344	10.771	7.960	5.481	3.129
Apr	43.931	29.090	19.383	16.829	13.877	10.895	8.225	5.992	4.738	3.021
May	25.635	17.189	11.626	8.979	8.016	6.993	6.033	4.656	3.412	2.389
Jun	15.764	11.231	8.546	7.392	6.076	5.336	4.390	3.573	2.971	1.998
Jul	12.974	9.043	6.829	6.183	4.954	4.697	3.775	3.371	2.759	1.635
Aug	8.180	6.739	5.709	5.066	4.096	3.726	3.233	2.789	2.475	2.053
Sep	8.769	5.768	4.645	3.951	3.607	3.102	2.789	2.303	1.998	1.520

Olifants River
IUA 5
RU 53

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_7 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.231	2.216	2.181	2.110	1.976	1.757	1.446	1.089	0.784	0.642
Nov	6.840	6.798	6.710	6.537	6.212	5.645	4.744	3.491	2.094	1.215
Dec	10.026	9.963	9.831	9.571	9.083	8.232	6.878	4.997	2.900	1.580
Jan	18.334	16.197	14.374	12.772	11.261	8.742	7.383	5.494	3.389	2.064
Feb	6.581	6.083	5.648	5.245	4.831	4.136	3.635	2.940	2.165	1.677
Mar	9.150	8.261	7.496	6.810	6.141	5.021	4.335	3.380	2.317	1.648
Apr	3.810	3.786	3.730	3.615	3.401	3.049	2.551	1.978	1.488	1.260
May	1.625	1.618	1.601	1.568	1.505	1.403	1.257	1.090	0.947	0.881
Jun	1.327	1.322	1.308	1.281	1.230	1.146	1.027	0.891	0.774	0.720
Jul	1.116	1.112	1.100	1.077	1.034	0.964	0.864	0.749	0.651	0.605
Aug	0.938	0.934	0.925	0.905	0.869	0.810	0.726	0.629	0.547	0.509
Sep	0.832	0.828	0.820	0.803	0.771	0.718	0.644	0.558	0.485	0.451

Reserve flows without High Flows

Oct	1.013	1.009	0.999	0.978	0.939	0.875	0.784	0.680	0.591	0.549
Nov	1.660	1.654	1.641	1.616	1.568	1.485	1.353	1.170	0.966	0.838
Dec	1.968	1.960	1.945	1.915	1.859	1.760	1.604	1.387	1.145	0.993
Jan	2.370	2.361	2.343	2.307	2.239	2.121	1.933	1.671	1.380	1.196
Feb	2.930	2.919	2.896	2.852	2.768	2.622	2.389	2.066	1.705	1.479
Mar	2.554	2.545	2.525	2.486	2.413	2.286	2.083	1.801	1.487	1.289
Apr	2.082	2.073	2.052	2.010	1.929	1.798	1.611	1.397	1.214	1.129
May	1.625	1.618	1.601	1.568	1.505	1.403	1.257	1.090	0.947	0.881
Jun	1.327	1.322	1.308	1.281	1.230	1.146	1.027	0.891	0.774	0.720
Jul	1.116	1.112	1.100	1.077	1.034	0.964	0.864	0.749	0.651	0.605
Aug	0.938	0.934	0.925	0.905	0.869	0.810	0.726	0.629	0.547	0.509
Sep	0.832	0.828	0.820	0.803	0.771	0.718	0.644	0.558	0.485	0.451

Natural Duration curves

Oct	21.961	12.664	8.617	6.657	5.354	4.316	3.666	3.039	2.177	1.460
Nov	72.307	46.273	35.529	28.110	20.154	16.350	10.343	8.113	4.479	2.654
Dec	88.105	59.080	52.595	43.720	29.839	25.030	15.016	12.272	7.400	3.905
Jan	135.387	73.925	46.479	35.868	27.012	21.950	16.719	14.453	10.383	5.559
Feb	121.300	62.260	42.138	33.565	20.242	17.076	13.988	12.719	10.545	6.552
Mar	100.463	45.049	30.563	25.209	20.718	14.344	10.771	7.960	5.481	3.129
Apr	43.931	29.090	19.383	16.829	13.877	10.895	8.225	5.992	4.738	3.021
May	25.635	17.189	11.626	8.979	8.016	6.993	6.033	4.656	3.412	2.389
Jun	15.764	11.231	8.546	7.392	6.076	5.336	4.390	3.573	2.971	1.998
Jul	12.974	9.043	6.829	6.183	4.954	4.697	3.775	3.371	2.759	1.635
Aug	8.180	6.739	5.709	5.066	4.096	3.726	3.233	2.789	2.475	2.053
Sep	8.769	5.768	4.645	3.951	3.607	3.102	2.789	2.303	1.998	1.520

Belfast Dam and Grootspruit
IUA 6
RU 54

- Desktop Version 2, Printed on 2008/07/03
- Summary of IFR rule curves for : B41A Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.260	0.258	0.255	0.247	0.233	0.209	0.176	0.138	0.106	0.090
Nov	0.565	0.561	0.554	0.539	0.511	0.462	0.384	0.276	0.156	0.080
Dec	0.866	0.861	0.851	0.831	0.793	0.727	0.622	0.477	0.314	0.212
Jan	1.839	1.669	1.521	1.387	1.253	1.028	0.879	0.671	0.440	0.294
Feb	1.011	0.971	0.933	0.893	0.842	0.755	0.662	0.534	0.390	0.300
Mar	1.114	1.046	0.984	0.923	0.856	0.742	0.642	0.504	0.350	0.253
Apr	0.709	0.705	0.694	0.673	0.633	0.568	0.475	0.369	0.278	0.220
May	0.436	0.433	0.427	0.414	0.390	0.350	0.293	0.229	0.173	0.147
Jun	0.341	0.339	0.334	0.325	0.308	0.280	0.241	0.196	0.157	0.139
Jul	0.256	0.254	0.251	0.244	0.232	0.211	0.182	0.148	0.119	0.106
Aug	0.212	0.211	0.209	0.203	0.193	0.176	0.152	0.124	0.100	0.089
Sep	0.193	0.192	0.190	0.185	0.176	0.160	0.139	0.114	0.092	0.082

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.213	0.212	0.209	0.203	0.193	0.175	0.151	0.122	0.098	0.087
Nov	0.337	0.335	0.331	0.322	0.306	0.278	0.234	0.172	0.103	0.060
Dec	0.444	0.442	0.438	0.430	0.414	0.387	0.343	0.283	0.216	0.174
Jan	0.583	0.581	0.575	0.564	0.543	0.507	0.450	0.371	0.282	0.226
Feb	0.738	0.735	0.728	0.714	0.688	0.642	0.569	0.468	0.356	0.285
Mar	0.621	0.619	0.612	0.600	0.577	0.538	0.474	0.386	0.288	0.227
Apr	0.565	0.561	0.554	0.539	0.510	0.462	0.395	0.319	0.253	0.220
May	0.436	0.433	0.427	0.414	0.390	0.350	0.293	0.229	0.173	0.147
Jun	0.341	0.339	0.334	0.325	0.308	0.280	0.241	0.196	0.157	0.139
Jul	0.256	0.254	0.251	0.244	0.232	0.211	0.182	0.148	0.119	0.106
Aug	0.212	0.211	0.209	0.203	0.193	0.176	0.152	0.124	0.100	0.089
Sep	0.193	0.192	0.190	0.185	0.176	0.160	0.139	0.114	0.092	0.082

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.008	0.743	0.508	0.407	0.340	0.295	0.250	0.179	0.149	0.090
Nov	2.843	1.721	1.358	1.231	1.088	0.876	0.698	0.563	0.436	0.174
Dec	4.615	3.114	2.024	1.598	1.378	1.288	1.098	0.859	0.586	0.340
Jan	7.430	4.365	2.763	2.035	1.747	1.337	1.180	1.064	0.743	0.429
Feb	7.614	4.208	2.443	2.042	1.596	1.319	1.162	1.029	0.843	0.484
Mar	4.092	2.240	1.777	1.643	1.366	1.232	0.941	0.702	0.568	0.422
Apr	2.458	1.809	1.404	1.231	1.003	0.922	0.752	0.640	0.428	0.220
May	1.408	1.128	0.874	0.799	0.635	0.508	0.441	0.385	0.295	0.179
Jun	1.003	0.702	0.563	0.482	0.382	0.320	0.285	0.258	0.201	0.154
Jul	0.556	0.478	0.351	0.317	0.306	0.258	0.228	0.194	0.161	0.146
Aug	0.478	0.336	0.273	0.250	0.228	0.202	0.183	0.168	0.146	0.134
Sep	0.478	0.363	0.266	0.231	0.201	0.185	0.162	0.143	0.123	0.108

Tonteldoos and Vlugkraal Dams, Tonteldoos and Vlugkraal Rivers
IUA 6
RU 56

- Desktop Version 2, Printed on 2008/07/03
- Summary of IFR rule curves for : B41C Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.094	0.093	0.092	0.089	0.083	0.074	0.061	0.046	0.034	0.026
Nov	0.199	0.198	0.195	0.190	0.180	0.163	0.135	0.097	0.054	0.027
Dec	0.304	0.302	0.298	0.291	0.278	0.255	0.219	0.168	0.111	0.075
Jan	0.650	0.589	0.537	0.489	0.442	0.362	0.310	0.237	0.156	0.105
Feb	0.355	0.341	0.327	0.313	0.295	0.265	0.232	0.188	0.138	0.107
Mar	0.395	0.370	0.348	0.327	0.303	0.263	0.228	0.180	0.126	0.093
Apr	0.250	0.249	0.245	0.237	0.223	0.199	0.166	0.127	0.094	0.079
May	0.154	0.153	0.151	0.146	0.138	0.123	0.102	0.079	0.059	0.049
Jun	0.123	0.122	0.120	0.117	0.111	0.101	0.087	0.071	0.057	0.051
Jul	0.092	0.092	0.091	0.088	0.084	0.076	0.066	0.054	0.044	0.039
Aug	0.078	0.077	0.076	0.074	0.071	0.065	0.056	0.046	0.037	0.033
Sep	0.071	0.070	0.069	0.067	0.064	0.059	0.051	0.042	0.034	0.031

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.077	0.076	0.075	0.073	0.069	0.062	0.052	0.041	0.031	0.026
Nov	0.119	0.118	0.117	0.114	0.108	0.098	0.082	0.060	0.035	0.020
Dec	0.155	0.155	0.153	0.150	0.145	0.135	0.121	0.100	0.077	0.062
Jan	0.203	0.202	0.200	0.196	0.189	0.177	0.157	0.130	0.099	0.080
Feb	0.257	0.256	0.253	0.249	0.240	0.224	0.199	0.164	0.126	0.101
Mar	0.218	0.217	0.214	0.210	0.203	0.189	0.167	0.137	0.104	0.083
Apr	0.198	0.197	0.194	0.188	0.178	0.161	0.137	0.109	0.085	0.074
May	0.154	0.153	0.151	0.146	0.138	0.123	0.102	0.079	0.059	0.049
Jun	0.123	0.122	0.120	0.117	0.111	0.101	0.087	0.071	0.057	0.051
Jul	0.092	0.092	0.091	0.088	0.084	0.076	0.066	0.054	0.044	0.039
Aug	0.078	0.077	0.076	0.074	0.071	0.065	0.056	0.046	0.037	0.033
Sep	0.071	0.070	0.069	0.067	0.064	0.059	0.051	0.042	0.034	0.031

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.370	0.269	0.183	0.146	0.127	0.105	0.090	0.063	0.056	0.026
Nov	0.864	0.625	0.490	0.448	0.394	0.316	0.251	0.208	0.154	0.062
Dec	1.508	0.971	0.732	0.579	0.500	0.463	0.396	0.310	0.209	0.123
Jan	2.591	1.408	0.855	0.728	0.624	0.478	0.422	0.377	0.269	0.153
Feb	2.658	1.339	0.880	0.736	0.570	0.475	0.413	0.368	0.302	0.169
Mar	1.333	0.769	0.642	0.601	0.485	0.441	0.336	0.250	0.202	0.149
Apr	0.799	0.656	0.517	0.448	0.359	0.332	0.270	0.231	0.154	0.081
May	0.504	0.407	0.314	0.287	0.231	0.183	0.161	0.142	0.108	0.067
Jun	0.378	0.255	0.208	0.177	0.147	0.127	0.104	0.096	0.073	0.058
Jul	0.202	0.179	0.131	0.119	0.108	0.097	0.082	0.067	0.060	0.056
Aug	0.172	0.131	0.101	0.093	0.086	0.078	0.071	0.063	0.056	0.049
Sep	0.170	0.135	0.100	0.081	0.077	0.069	0.062	0.058	0.046	0.042

Steelpoort River
IUA 6
RU 57

- Desktop Version 2, Printed on 2008/07/03
- Summary of IFR rule curves for : B41E Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.731	0.727	0.716	0.694	0.654	0.587	0.493	0.385	0.293	0.239
Nov	1.604	1.594	1.572	1.529	1.449	1.310	1.087	0.779	0.435	0.218
Dec	2.425	2.412	2.383	2.327	2.221	2.037	1.744	1.337	0.883	0.597
Jan	5.143	4.666	4.252	3.876	3.500	2.871	2.455	1.877	1.233	0.827
Feb	2.805	2.694	2.588	2.475	2.334	2.094	1.839	1.484	1.089	0.840
Mar	3.096	2.904	2.732	2.563	2.375	2.058	1.782	1.398	0.971	0.702
Apr	1.950	1.938	1.909	1.850	1.741	1.560	1.305	1.012	0.761	0.610
May	1.207	1.199	1.181	1.145	1.077	0.966	0.809	0.628	0.473	0.401
Jun	0.949	0.944	0.932	0.907	0.860	0.783	0.675	0.549	0.443	0.393
Jul	0.715	0.711	0.702	0.683	0.649	0.591	0.510	0.417	0.338	0.301
Aug	0.597	0.594	0.587	0.571	0.542	0.495	0.428	0.351	0.285	0.255
Sep	0.543	0.540	0.533	0.519	0.494	0.451	0.391	0.321	0.262	0.234

Reserve flows without High Flows

Oct	0.598	0.595	0.587	0.571	0.540	0.491	0.420	0.339	0.270	0.237
Nov	0.947	0.941	0.929	0.905	0.859	0.780	0.654	0.478	0.282	0.159
Dec	1.237	1.232	1.220	1.197	1.154	1.079	0.959	0.793	0.608	0.491
Jan	1.618	1.611	1.596	1.565	1.509	1.410	1.252	1.033	0.789	0.635
Feb	2.042	2.033	2.014	1.975	1.904	1.778	1.579	1.302	0.993	0.799
Mar	1.719	1.711	1.694	1.660	1.597	1.487	1.312	1.068	0.797	0.627
Apr	1.554	1.545	1.524	1.482	1.402	1.271	1.087	0.874	0.692	0.608
May	1.207	1.199	1.181	1.145	1.077	0.966	0.809	0.628	0.473	0.401
Jun	0.949	0.944	0.932	0.907	0.860	0.783	0.675	0.549	0.443	0.393
Jul	0.715	0.711	0.702	0.683	0.649	0.591	0.510	0.417	0.338	0.301
Aug	0.597	0.594	0.587	0.571	0.542	0.495	0.428	0.351	0.285	0.255
Sep	0.543	0.540	0.533	0.519	0.494	0.451	0.391	0.321	0.262	0.234

Natural Duration curves

Oct	2.834	2.057	1.411	1.128	0.971	0.833	0.713	0.493	0.414	0.239
Nov	7.874	5.255	4.001	3.569	3.164	2.704	2.006	1.651	1.265	0.505
Dec	12.832	8.199	5.847	4.540	4.047	3.782	3.289	2.539	1.617	0.956
Jan	20.479	11.563	7.340	5.895	4.887	3.909	3.390	2.938	2.139	1.296
Feb	20.556	10.557	7.015	5.936	4.530	3.671	3.212	2.848	2.319	1.335
Mar	10.652	6.011	5.063	4.615	4.036	3.439	2.640	1.956	1.572	1.180
Apr	6.609	5.058	3.993	3.422	2.770	2.569	2.087	1.771	1.192	0.610
May	3.853	3.118	2.431	2.203	1.755	1.396	1.236	1.083	0.833	0.508
Jun	2.886	1.960	1.593	1.366	1.088	0.938	0.795	0.737	0.567	0.432
Jul	1.572	1.363	1.001	0.889	0.844	0.739	0.638	0.538	0.463	0.418
Aug	1.333	0.971	0.754	0.721	0.650	0.586	0.534	0.470	0.418	0.381
Sep	1.323	1.022	0.760	0.640	0.579	0.525	0.459	0.417	0.351	0.320

Der Bruchen Dam and Dwars River

IUA 6

RU 62

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : B41G Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants   ERC = C

- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.102	0.101	0.100	0.097	0.091	0.082	0.069	0.054	0.042	0.036
Nov	0.227	0.226	0.223	0.218	0.208	0.191	0.165	0.127	0.086	0.060
Dec	0.329	0.327	0.323	0.316	0.301	0.276	0.236	0.180	0.118	0.079
Jan	0.322	0.305	0.289	0.273	0.255	0.224	0.195	0.155	0.110	0.082
Feb	0.682	0.624	0.572	0.525	0.477	0.396	0.340	0.261	0.173	0.118
Mar	0.344	0.327	0.311	0.294	0.274	0.241	0.208	0.162	0.111	0.079
Apr	0.248	0.247	0.243	0.235	0.221	0.198	0.166	0.128	0.096	0.081
May	0.161	0.160	0.158	0.154	0.145	0.132	0.113	0.091	0.072	0.063
Jun	0.128	0.128	0.126	0.122	0.116	0.105	0.090	0.073	0.058	0.051
Jul	0.098	0.097	0.096	0.094	0.089	0.081	0.069	0.056	0.045	0.039
Aug	0.083	0.083	0.082	0.079	0.075	0.069	0.059	0.048	0.038	0.034
Sep	0.077	0.076	0.075	0.073	0.070	0.063	0.054	0.044	0.036	0.032

Reserve flows without High Flows

Oct	0.083	0.083	0.082	0.080	0.075	0.069	0.059	0.048	0.038	0.034
Nov	0.134	0.133	0.132	0.129	0.124	0.116	0.103	0.085	0.064	0.051
Dec	0.170	0.170	0.168	0.165	0.159	0.148	0.131	0.107	0.081	0.065
Jan	0.200	0.199	0.197	0.193	0.186	0.173	0.154	0.126	0.095	0.075
Feb	0.251	0.250	0.247	0.242	0.233	0.218	0.192	0.157	0.119	0.094
Mar	0.222	0.221	0.219	0.214	0.205	0.190	0.166	0.133	0.095	0.072
Apr	0.198	0.197	0.194	0.189	0.179	0.162	0.138	0.111	0.088	0.077
May	0.161	0.160	0.158	0.154	0.145	0.132	0.113	0.091	0.072	0.063
Jun	0.128	0.128	0.126	0.122	0.116	0.105	0.090	0.073	0.058	0.051
Jul	0.098	0.097	0.096	0.094	0.089	0.081	0.069	0.056	0.045	0.039
Aug	0.083	0.083	0.082	0.079	0.075	0.069	0.059	0.048	0.038	0.034
Sep	0.077	0.076	0.075	0.073	0.070	0.063	0.054	0.044	0.036	0.032

Natural Duration curves

Oct	0.549	0.426	0.343	0.295	0.250	0.209	0.157	0.127	0.086	0.063
Nov	2.326	1.231	0.976	0.764	0.656	0.594	0.478	0.320	0.231	0.066
Dec	2.964	1.755	1.486	1.284	0.963	0.799	0.638	0.523	0.302	0.187
Jan	2.785	1.833	1.419	1.165	1.004	0.896	0.773	0.609	0.388	0.239
Feb	3.803	2.017	1.509	1.195	0.959	0.798	0.699	0.570	0.434	0.314
Mar	2.192	1.393	1.217	1.064	0.795	0.672	0.586	0.489	0.385	0.261
Apr	1.524	1.157	0.976	0.829	0.691	0.563	0.463	0.397	0.278	0.147
May	0.933	0.724	0.601	0.482	0.414	0.325	0.269	0.239	0.198	0.123
Jun	0.563	0.436	0.390	0.316	0.243	0.201	0.181	0.158	0.131	0.100
Jul	0.414	0.280	0.224	0.198	0.183	0.168	0.153	0.127	0.112	0.086
Aug	0.284	0.231	0.194	0.157	0.153	0.142	0.131	0.112	0.105	0.082
Sep	0.359	0.235	0.174	0.162	0.131	0.116	0.108	0.096	0.089	0.081

De Hoop Dam, Steelpoort River
IUA 6
RU 64

- Desktop Version 2, Printed on 9/3/2014
- Summary of IFR rule curves for : Olifants_9 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.597	0.593	0.586	0.570	0.542	0.494	0.427	0.350	0.284	0.253
Nov	1.564	1.554	1.534	1.493	1.418	1.286	1.075	0.783	0.458	0.253
Dec	2.355	2.342	2.314	2.260	2.157	1.977	1.692	1.295	0.853	0.575
Jan	4.542	4.094	3.708	3.363	3.027	2.465	2.125	1.652	1.124	0.792
Feb	2.217	2.118	2.026	1.934	1.827	1.645	1.474	1.235	0.969	0.801
Mar	2.546	2.372	2.218	2.074	1.922	1.667	1.472	1.202	0.901	0.711
Apr	1.527	1.518	1.498	1.458	1.382	1.258	1.082	0.879	0.706	0.626
May	0.860	0.856	0.847	0.830	0.797	0.742	0.665	0.577	0.501	0.466
Jun	0.684	0.681	0.674	0.660	0.634	0.591	0.529	0.459	0.399	0.371
Jul	0.525	0.523	0.517	0.507	0.486	0.453	0.406	0.352	0.306	0.285
Aug	0.443	0.441	0.436	0.427	0.410	0.382	0.343	0.297	0.258	0.240
Sep	0.409	0.407	0.403	0.394	0.379	0.353	0.316	0.274	0.238	0.221

Reserve flows without High Flows

Oct	0.445	0.443	0.439	0.430	0.413	0.384	0.345	0.299	0.260	0.241
Nov	0.735	0.731	0.722	0.706	0.674	0.620	0.533	0.412	0.277	0.192
Dec	0.934	0.931	0.924	0.909	0.883	0.836	0.762	0.659	0.544	0.472
Jan	1.211	1.206	1.197	1.179	1.144	1.084	0.987	0.854	0.705	0.611
Feb	1.512	1.506	1.495	1.472	1.428	1.353	1.233	1.066	0.880	0.763
Mar	1.272	1.268	1.258	1.238	1.202	1.138	1.037	0.897	0.741	0.642
Apr	1.093	1.089	1.078	1.055	1.013	0.944	0.846	0.734	0.637	0.593
May	0.860	0.856	0.847	0.830	0.797	0.742	0.665	0.577	0.501	0.466
Jun	0.684	0.681	0.674	0.660	0.634	0.591	0.529	0.459	0.399	0.371
Jul	0.525	0.523	0.517	0.507	0.486	0.453	0.406	0.352	0.306	0.285
Aug	0.443	0.441	0.436	0.427	0.410	0.382	0.343	0.297	0.258	0.240
Sep	0.409	0.407	0.403	0.394	0.379	0.353	0.316	0.274	0.238	0.221

Natural Duration curves

Oct	3.259	2.319	1.706	1.355	1.184	0.997	0.810	0.620	0.511	0.287
Nov	11.987	6.736	4.873	4.348	3.607	3.075	2.357	2.002	1.435	0.571
Dec	17.944	9.681	7.463	5.873	4.921	4.484	3.771	2.879	1.844	1.128
Jan	21.490	14.031	9.158	6.780	5.518	4.887	3.969	3.297	2.453	1.781
Feb	25.190	13.839	8.995	6.775	5.452	4.258	3.824	3.315	2.910	1.625
Mar	11.656	7.728	6.291	5.313	4.652	3.846	3.088	2.274	1.852	1.426
Apr	7.512	5.806	4.703	4.008	3.160	3.005	2.504	2.025	1.385	0.752
May	4.387	3.510	2.796	2.509	1.997	1.632	1.404	1.202	0.993	0.683
Jun	3.167	2.218	1.860	1.582	1.308	1.092	0.926	0.849	0.644	0.540
Jul	1.960	1.561	1.169	1.027	0.960	0.877	0.758	0.631	0.538	0.504
Aug	1.501	1.116	0.881	0.818	0.762	0.680	0.620	0.541	0.482	0.448
Sep	1.528	1.138	0.914	0.756	0.648	0.610	0.532	0.494	0.417	0.374

Steelpoort River
IUA 6
RU 66

- Desktop Version 2, Printed on 2008/07/03
- Summary of IFR rule curves for : B41K Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.210	1.204	1.190	1.160	1.105	1.014	0.885	0.738	0.611	0.552
Nov	3.126	3.109	3.075	3.009	2.883	2.664	2.316	1.832	1.293	0.953
Dec	4.586	4.561	4.509	4.406	4.214	3.879	3.345	2.604	1.778	1.258
Jan	7.629	6.954	6.370	5.840	5.314	4.432	3.856	3.056	2.165	1.604
Feb	4.378	4.222	4.076	3.920	3.728	3.402	3.061	2.587	2.058	1.726
Mar	4.740	4.471	4.230	3.997	3.742	3.310	2.946	2.439	1.874	1.519
Apr	2.871	2.856	2.822	2.751	2.619	2.402	2.095	1.742	1.440	1.300
May	1.859	1.850	1.832	1.794	1.722	1.604	1.438	1.247	1.084	1.008
Jun	1.486	1.480	1.465	1.434	1.377	1.283	1.150	0.997	0.867	0.806
Jul	1.151	1.145	1.134	1.110	1.066	0.993	0.890	0.772	0.671	0.624
Aug	0.981	0.976	0.966	0.946	0.909	0.846	0.759	0.658	0.572	0.532
Sep	0.919	0.914	0.905	0.886	0.851	0.793	0.711	0.616	0.535	0.498

Reserve flows without High Flows

Oct	0.988	0.983	0.973	0.953	0.915	0.853	0.764	0.663	0.576	0.535
Nov	1.680	1.674	1.661	1.635	1.587	1.503	1.370	1.185	0.978	0.848
Dec	2.139	2.131	2.115	2.082	2.021	1.914	1.744	1.508	1.245	1.080
Jan	2.641	2.631	2.610	2.570	2.495	2.363	2.153	1.862	1.537	1.333
Feb	3.304	3.292	3.266	3.216	3.121	2.956	2.694	2.329	1.923	1.667
Mar	2.800	2.790	2.768	2.726	2.646	2.506	2.283	1.974	1.630	1.413
Apr	2.320	2.310	2.286	2.239	2.149	2.003	1.795	1.557	1.352	1.258
May	1.859	1.850	1.832	1.794	1.722	1.604	1.438	1.247	1.084	1.008
Jun	1.486	1.480	1.465	1.434	1.377	1.283	1.150	0.997	0.867	0.806
Jul	1.151	1.145	1.134	1.110	1.066	0.993	0.890	0.772	0.671	0.624
Aug	0.981	0.976	0.966	0.946	0.909	0.846	0.759	0.658	0.572	0.532
Sep	0.919	0.914	0.905	0.886	0.851	0.793	0.711	0.616	0.535	0.498

Natural Duration curves

Oct	6.515	5.339	4.096	3.468	2.942	2.681	2.117	1.785	1.430	0.978
Nov	34.452	18.530	13.241	11.844	8.692	7.230	5.853	4.819	3.160	1.709
Dec	38.702	30.320	22.652	18.440	14.296	11.380	9.207	6.892	5.070	3.737
Jan	47.540	34.558	23.559	19.941	15.248	13.213	10.532	8.673	6.355	4.413
Feb	75.694	32.755	20.449	17.861	13.533	10.437	8.602	7.928	6.585	4.960
Mar	34.644	18.828	16.163	13.183	10.510	8.714	7.605	6.358	4.988	3.506
Apr	16.593	14.421	12.342	9.236	7.566	6.539	5.760	4.861	4.059	2.253
May	10.850	7.538	6.545	5.731	5.059	4.025	3.554	3.121	2.614	1.688
Jun	7.006	5.316	4.321	3.738	3.210	2.778	2.523	2.245	1.902	1.350
Jul	5.003	3.633	2.890	2.617	2.393	2.244	1.983	1.699	1.557	1.284
Aug	3.558	2.860	2.371	2.053	1.938	1.773	1.680	1.501	1.337	1.240
Sep	3.704	2.770	2.207	2.002	1.732	1.555	1.443	1.354	1.231	1.065

Olifants River
IUA 7
RU 72

- Desktop Version 2, Printed on 2008/07/15
- Summary of IFR rule curves for : B52J Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.358	2.342	2.306	2.231	2.092	1.861	1.537	1.163	0.843	0.695
Nov	7.747	7.700	7.601	7.404	7.037	6.395	5.375	3.957	2.376	1.381
Dec	11.178	11.108	10.962	10.672	10.130	9.183	7.678	5.587	3.255	1.788
Jan	20.191	17.854	15.859	14.105	12.448	9.686	8.189	6.107	3.788	2.328
Feb	7.292	6.758	6.290	5.855	5.404	4.648	4.092	3.320	2.460	1.919
Mar	9.968	9.016	8.195	7.457	6.736	5.528	4.780	3.739	2.579	1.850
Apr	4.042	4.016	3.959	3.839	3.616	3.249	2.731	2.135	1.625	1.388
May	1.770	1.762	1.745	1.708	1.640	1.528	1.370	1.188	1.032	0.960
Jun	1.438	1.432	1.418	1.388	1.333	1.242	1.113	0.965	0.839	0.780
Jul	1.204	1.199	1.187	1.162	1.116	1.040	0.932	0.808	0.702	0.653
Aug	1.014	1.009	0.999	0.978	0.939	0.875	0.785	0.680	0.591	0.550
Sep	0.903	0.899	0.890	0.871	0.836	0.779	0.699	0.606	0.526	0.489

Reserve flows without High Flows

Oct	1.105	1.100	1.089	1.067	1.024	0.954	0.855	0.742	0.644	0.599
Nov	1.891	1.884	1.870	1.841	1.787	1.692	1.542	1.333	1.101	0.955
Dec	2.254	2.246	2.228	2.194	2.130	2.017	1.838	1.589	1.312	1.138
Jan	2.732	2.722	2.701	2.659	2.581	2.445	2.228	1.926	1.590	1.379
Feb	3.381	3.369	3.343	3.291	3.194	3.025	2.757	2.384	1.968	1.706
Mar	2.904	2.893	2.871	2.826	2.743	2.598	2.368	2.047	1.690	1.465
Apr	2.318	2.308	2.284	2.237	2.148	2.001	1.794	1.555	1.351	1.256
May	1.770	1.762	1.745	1.708	1.640	1.528	1.370	1.188	1.032	0.960
Jun	1.438	1.432	1.418	1.388	1.333	1.242	1.113	0.965	0.839	0.780
Jul	1.204	1.199	1.187	1.162	1.116	1.040	0.932	0.808	0.702	0.653
Aug	1.014	1.009	0.999	0.978	0.939	0.875	0.785	0.680	0.591	0.550
Sep	0.903	0.899	0.890	0.871	0.836	0.779	0.699	0.606	0.526	0.489

Natural Duration curves

Oct	23.174	12.799	9.054	7.198	5.813	4.454	3.857	3.207	2.375	1.549
Nov	83.148	65.802	40.930	30.914	23.368	18.106	11.713	9.383	5.000	2.762
Dec	98.301	67.917	58.199	48.861	33.695	28.073	17.955	13.486	8.311	4.406
Jan	145.453	77.901	55.623	42.563	33.382	27.438	19.392	16.685	11.399	6.328
Feb	146.722	68.874	47.520	38.273	24.339	18.725	15.650	14.050	11.033	7.800
Mar	107.811	53.013	35.450	28.401	21.397	15.371	11.033	8.852	6.306	3.506
Apr	45.459	31.169	20.579	17.955	14.603	11.269	8.530	6.296	5.351	3.171
May	26.090	17.988	11.970	9.203	8.348	7.183	6.209	4.757	3.584	2.501
Jun	16.130	11.416	8.897	7.631	6.308	5.621	4.560	3.642	3.056	2.099
Jul	13.176	9.308	6.974	6.500	5.052	4.842	3.917	3.446	2.800	1.699
Aug	8.524	6.855	5.918	5.246	4.245	3.872	3.368	2.916	2.531	2.095
Sep	8.827	6.431	4.830	4.290	3.677	3.283	2.878	2.384	2.037	1.586

Lydenburg Dam, Sterkspruit

IUA 8

RU 74

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : Lyd_Dam Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.043	0.043	0.042	0.041	0.038	0.035	0.029	0.023	0.018	0.015
Nov	0.110	0.109	0.108	0.105	0.100	0.092	0.079	0.060	0.040	0.027
Dec	0.156	0.155	0.153	0.149	0.142	0.130	0.111	0.084	0.054	0.035
Jan	0.284	0.257	0.234	0.213	0.192	0.157	0.134	0.102	0.066	0.044
Feb	0.140	0.135	0.129	0.124	0.117	0.105	0.092	0.074	0.053	0.041
Mar	0.155	0.146	0.138	0.129	0.120	0.104	0.091	0.072	0.050	0.037
Apr	0.096	0.096	0.094	0.092	0.086	0.077	0.065	0.050	0.038	0.032
May	0.066	0.065	0.064	0.063	0.059	0.054	0.046	0.037	0.029	0.026
Jun	0.054	0.054	0.053	0.052	0.049	0.045	0.038	0.031	0.025	0.022
Jul	0.042	0.042	0.042	0.040	0.038	0.035	0.030	0.024	0.019	0.017
Aug	0.036	0.035	0.035	0.034	0.032	0.029	0.025	0.020	0.016	0.015
Sep	0.034	0.033	0.033	0.032	0.030	0.028	0.024	0.019	0.016	0.014

Reserve flows without High Flows

Oct	0.035	0.035	0.035	0.034	0.032	0.029	0.025	0.020	0.016	0.014
Nov	0.058	0.057	0.057	0.056	0.054	0.050	0.044	0.037	0.028	0.022
Dec	0.072	0.072	0.071	0.070	0.067	0.062	0.055	0.045	0.034	0.027
Jan	0.087	0.087	0.086	0.084	0.081	0.076	0.067	0.055	0.041	0.033
Feb	0.103	0.102	0.101	0.099	0.096	0.089	0.079	0.065	0.049	0.039
Mar	0.088	0.088	0.087	0.085	0.082	0.076	0.068	0.055	0.042	0.033
Apr	0.079	0.078	0.077	0.075	0.071	0.064	0.055	0.044	0.035	0.031
May	0.066	0.065	0.064	0.063	0.059	0.054	0.046	0.037	0.029	0.026
Jun	0.054	0.054	0.053	0.052	0.049	0.045	0.038	0.031	0.025	0.022
Jul	0.042	0.042	0.042	0.040	0.038	0.035	0.030	0.024	0.019	0.017
Aug	0.036	0.035	0.035	0.034	0.032	0.029	0.025	0.020	0.016	0.015
Sep	0.034	0.033	0.033	0.032	0.030	0.028	0.024	0.019	0.016	0.014

Natural Duration curves

Oct	0.185	0.149	0.122	0.110	0.097	0.084	0.069	0.063	0.042	0.035
Nov	1.356	0.659	0.337	0.246	0.203	0.184	0.152	0.132	0.094	0.057
Dec	1.101	0.894	0.739	0.484	0.324	0.271	0.209	0.177	0.143	0.102
Jan	1.682	1.122	0.669	0.491	0.401	0.339	0.257	0.210	0.175	0.114
Feb	1.261	0.873	0.623	0.455	0.346	0.286	0.242	0.216	0.174	0.139
Mar	0.871	0.548	0.391	0.364	0.287	0.264	0.214	0.189	0.152	0.123
Apr	0.489	0.419	0.327	0.247	0.227	0.194	0.181	0.159	0.137	0.081
May	0.311	0.228	0.185	0.160	0.147	0.140	0.125	0.111	0.090	0.057
Jun	0.194	0.149	0.131	0.118	0.107	0.096	0.090	0.080	0.068	0.049
Jul	0.143	0.109	0.094	0.083	0.079	0.077	0.066	0.061	0.055	0.044
Aug	0.111	0.098	0.078	0.067	0.063	0.059	0.055	0.052	0.048	0.043
Sep	0.127	0.107	0.068	0.062	0.058	0.053	0.048	0.047	0.042	0.037

Buffelskloof Dam, Watervals River
IUA 8
RU 79

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : B42F Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.140	0.139	0.137	0.133	0.126	0.113	0.096	0.076	0.058	0.050
Nov	0.233	0.231	0.229	0.224	0.214	0.197	0.171	0.134	0.092	0.066
Dec	0.327	0.325	0.321	0.313	0.299	0.274	0.235	0.180	0.119	0.081
Jan	0.332	0.313	0.296	0.279	0.260	0.227	0.198	0.157	0.111	0.083
Feb	0.709	0.645	0.590	0.540	0.489	0.403	0.345	0.264	0.174	0.117
Mar	0.356	0.337	0.320	0.302	0.282	0.248	0.216	0.172	0.122	0.091
Apr	0.268	0.266	0.263	0.254	0.239	0.214	0.179	0.139	0.104	0.088
May	0.188	0.187	0.185	0.179	0.170	0.154	0.132	0.106	0.084	0.074
Jun	0.171	0.170	0.168	0.163	0.154	0.140	0.120	0.097	0.077	0.068
Jul	0.142	0.141	0.139	0.135	0.128	0.117	0.100	0.081	0.065	0.057
Aug	0.125	0.124	0.122	0.119	0.113	0.103	0.088	0.071	0.057	0.051
Sep	0.118	0.117	0.116	0.113	0.107	0.097	0.084	0.068	0.054	0.048

Reserve flows without High Flows

Oct	0.119	0.119	0.117	0.114	0.108	0.098	0.084	0.069	0.055	0.049
Nov	0.152	0.151	0.150	0.147	0.141	0.132	0.117	0.097	0.074	0.059
Dec	0.175	0.174	0.173	0.169	0.163	0.152	0.135	0.111	0.084	0.067
Jan	0.197	0.196	0.195	0.191	0.184	0.171	0.152	0.125	0.094	0.075
Feb	0.241	0.240	0.238	0.233	0.224	0.209	0.185	0.152	0.115	0.092
Mar	0.221	0.220	0.218	0.214	0.206	0.192	0.170	0.140	0.105	0.084
Apr	0.211	0.209	0.207	0.201	0.190	0.172	0.147	0.119	0.094	0.082
May	0.188	0.187	0.185	0.179	0.170	0.154	0.132	0.106	0.084	0.074
Jun	0.171	0.170	0.168	0.163	0.154	0.140	0.120	0.097	0.077	0.068
Jul	0.142	0.141	0.139	0.135	0.128	0.117	0.100	0.081	0.065	0.057
Aug	0.125	0.124	0.122	0.119	0.113	0.103	0.088	0.071	0.057	0.051
Sep	0.118	0.117	0.116	0.113	0.107	0.097	0.084	0.068	0.054	0.048

Natural Duration curves

Oct	0.769	0.635	0.530	0.474	0.422	0.370	0.314	0.284	0.209	0.175
Nov	1.775	1.273	1.011	0.926	0.806	0.729	0.633	0.532	0.370	0.247
Dec	2.468	1.721	1.404	1.314	1.105	0.963	0.777	0.676	0.549	0.399
Jan	3.192	1.841	1.534	1.337	1.180	1.090	0.982	0.795	0.683	0.448
Feb	3.786	2.116	1.629	1.397	1.257	1.104	0.963	0.785	0.694	0.612
Mar	1.994	1.460	1.389	1.228	1.083	0.974	0.870	0.780	0.624	0.500
Apr	1.617	1.412	1.184	1.061	0.968	0.841	0.752	0.671	0.544	0.343
May	1.202	1.034	0.818	0.728	0.657	0.612	0.549	0.482	0.403	0.243
Jun	0.829	0.752	0.617	0.525	0.475	0.448	0.421	0.370	0.313	0.228
Jul	0.661	0.538	0.448	0.396	0.370	0.358	0.321	0.291	0.265	0.209
Aug	0.523	0.455	0.370	0.336	0.317	0.302	0.280	0.258	0.231	0.213
Sep	0.579	0.478	0.351	0.313	0.282	0.266	0.251	0.235	0.220	0.204

Spekboom River
IUA 8
RU 82

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : B42H Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = B
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.841	0.836	0.825	0.802	0.759	0.688	0.589	0.474	0.376	0.330
Nov	1.991	1.980	1.958	1.914	1.832	1.688	1.459	1.140	0.786	0.562
Dec	2.973	2.956	2.922	2.853	2.725	2.501	2.144	1.649	1.098	0.750
Jan	5.714	5.188	4.731	4.315	3.900	3.205	2.744	2.103	1.390	0.940
Feb	3.057	2.938	2.825	2.704	2.552	2.293	2.017	1.632	1.204	0.934
Mar	3.375	3.170	2.986	2.806	2.607	2.271	1.979	1.574	1.123	0.839
Apr	2.018	2.006	1.977	1.919	1.809	1.629	1.374	1.081	0.831	0.714
May	1.394	1.386	1.368	1.331	1.261	1.148	0.987	0.802	0.643	0.570
Jun	1.135	1.129	1.115	1.085	1.030	0.938	0.810	0.661	0.535	0.476
Jul	0.872	0.867	0.856	0.834	0.792	0.724	0.627	0.516	0.421	0.377
Aug	0.729	0.725	0.716	0.698	0.664	0.608	0.529	0.438	0.360	0.324
Sep	0.676	0.672	0.664	0.647	0.616	0.565	0.493	0.410	0.339	0.306

Reserve flows without High Flows

Oct	0.713	0.709	0.701	0.683	0.650	0.595	0.518	0.429	0.353	0.318
Nov	1.148	1.143	1.133	1.112	1.074	1.006	0.899	0.751	0.585	0.481
Dec	1.493	1.487	1.473	1.446	1.394	1.305	1.163	0.965	0.745	0.607
Jan	1.823	1.815	1.798	1.764	1.701	1.591	1.415	1.172	0.900	0.729
Feb	2.243	2.233	2.212	2.170	2.092	1.955	1.739	1.437	1.101	0.890
Mar	1.904	1.895	1.877	1.842	1.776	1.661	1.477	1.222	0.938	0.759
Apr	1.694	1.684	1.662	1.617	1.532	1.392	1.195	0.967	0.773	0.683
May	1.394	1.386	1.368	1.331	1.261	1.148	0.987	0.802	0.643	0.570
Jun	1.135	1.129	1.115	1.085	1.030	0.938	0.810	0.661	0.535	0.476
Jul	0.872	0.867	0.856	0.834	0.792	0.724	0.627	0.516	0.421	0.377
Aug	0.729	0.725	0.716	0.698	0.664	0.608	0.529	0.438	0.360	0.324
Sep	0.676	0.672	0.664	0.647	0.616	0.565	0.493	0.410	0.339	0.306

Natural Duration curves

Oct	2.826	2.307	1.844	1.620	1.404	1.210	1.038	0.896	0.627	0.526
Nov	17.932	8.098	5.999	3.978	3.356	2.913	2.311	2.049	1.254	0.829
Dec	16.286	12.496	10.125	8.412	6.019	4.813	3.480	2.808	2.154	1.408
Jan	22.581	14.960	9.957	8.214	6.866	6.022	3.909	3.196	2.729	1.583
Feb	22.280	15.013	9.702	7.577	6.052	4.729	3.716	2.984	2.534	2.129
Mar	13.262	8.087	6.616	5.873	4.607	4.010	3.095	2.759	2.195	1.732
Apr	8.113	7.369	4.996	4.113	3.218	3.002	2.585	2.353	1.898	1.150
May	5.081	3.771	2.714	2.363	2.244	2.016	1.844	1.598	1.325	0.803
Jun	2.847	2.334	2.002	1.744	1.620	1.466	1.343	1.188	1.022	0.721
Jul	2.162	1.710	1.437	1.281	1.221	1.154	1.027	0.926	0.844	0.665
Aug	1.710	1.460	1.213	1.038	0.978	0.926	0.848	0.795	0.724	0.646
Sep	1.914	1.547	1.084	0.972	0.880	0.818	0.760	0.718	0.648	0.586

Ohrigstad Dam and Ohrigstad River
IUA 9
RU 83

- Desktop Version 2, Printed on 4/1/2014
- Summary of IFR rule curves for : B60E Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Escarp ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.078	0.078	0.077	0.076	0.074	0.070	0.063	0.052	0.040	0.031
Nov	0.111	0.111	0.110	0.108	0.104	0.097	0.086	0.071	0.052	0.038
Dec	0.160	0.159	0.158	0.155	0.149	0.139	0.122	0.097	0.069	0.048
Jan	0.224	0.211	0.199	0.188	0.175	0.154	0.135	0.109	0.079	0.057
Feb	0.519	0.473	0.433	0.397	0.361	0.301	0.262	0.206	0.139	0.090
Mar	0.261	0.248	0.236	0.224	0.211	0.188	0.166	0.135	0.098	0.070
Apr	0.190	0.189	0.188	0.185	0.178	0.167	0.149	0.121	0.088	0.063
May	0.125	0.125	0.124	0.123	0.119	0.113	0.102	0.085	0.065	0.049
Jun	0.115	0.115	0.114	0.113	0.110	0.104	0.094	0.079	0.060	0.045
Jul	0.096	0.096	0.096	0.095	0.092	0.088	0.080	0.067	0.051	0.039
Aug	0.084	0.084	0.083	0.082	0.080	0.076	0.069	0.058	0.044	0.034
Sep	0.077	0.077	0.077	0.076	0.074	0.070	0.063	0.053	0.041	0.032

Reserve flows without High Flows

Oct	0.074	0.074	0.074	0.073	0.071	0.067	0.060	0.051	0.039	0.030
Nov	0.088	0.088	0.087	0.086	0.083	0.078	0.070	0.059	0.046	0.035
Dec	0.106	0.105	0.105	0.103	0.099	0.094	0.084	0.070	0.054	0.042
Jan	0.130	0.129	0.128	0.126	0.121	0.114	0.102	0.085	0.065	0.051
Feb	0.176	0.175	0.174	0.171	0.165	0.155	0.139	0.116	0.088	0.068
Mar	0.166	0.166	0.164	0.162	0.157	0.147	0.132	0.110	0.084	0.064
Apr	0.150	0.149	0.148	0.146	0.142	0.134	0.120	0.100	0.076	0.058
May	0.125	0.125	0.124	0.123	0.119	0.113	0.102	0.085	0.065	0.049
Jun	0.115	0.115	0.114	0.113	0.110	0.104	0.094	0.079	0.060	0.045
Jul	0.096	0.096	0.096	0.095	0.092	0.088	0.080	0.067	0.051	0.039
Aug	0.084	0.084	0.083	0.082	0.080	0.076	0.069	0.058	0.044	0.034
Sep	0.077	0.077	0.077	0.076	0.074	0.070	0.063	0.053	0.041	0.032

Natural Duration curves

Oct	0.243	0.205	0.187	0.161	0.142	0.123	0.116	0.105	0.090	0.078
Nov	0.644	0.517	0.378	0.328	0.289	0.258	0.212	0.181	0.123	0.096
Dec	1.135	0.773	0.627	0.519	0.455	0.392	0.347	0.317	0.209	0.149
Jan	2.001	1.288	0.814	0.668	0.568	0.508	0.437	0.392	0.299	0.202
Feb	3.509	2.199	1.224	0.732	0.612	0.517	0.459	0.401	0.322	0.248
Mar	2.539	1.729	0.821	0.556	0.489	0.444	0.399	0.329	0.291	0.209
Apr	1.034	0.590	0.521	0.478	0.417	0.367	0.340	0.305	0.258	0.185
May	0.470	0.399	0.362	0.340	0.314	0.291	0.254	0.231	0.205	0.146
Jun	0.343	0.320	0.293	0.270	0.251	0.228	0.204	0.189	0.166	0.127
Jul	0.254	0.235	0.224	0.205	0.190	0.175	0.161	0.142	0.131	0.108
Aug	0.220	0.194	0.175	0.161	0.149	0.142	0.134	0.123	0.108	0.093
Sep	0.220	0.185	0.154	0.139	0.127	0.123	0.112	0.108	0.093	0.085

Ohrigstad River
IUA 9
RU 86

- Desktop Version 2, Printed on 8/31/2011
- Summary of IFR rule curves for : OLI-EWR8 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Foothill ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.261	0.258	0.253	0.242	0.223	0.194	0.156	0.114	0.080	0.066
Nov	0.508	0.500	0.482	0.448	0.394	0.319	0.236	0.163	0.117	0.104
Dec	0.800	0.786	0.756	0.701	0.612	0.491	0.357	0.241	0.169	0.148
Jan	1.253	1.093	0.946	0.795	0.580	0.445	0.320	0.232	0.187	0.177
Feb	3.714	3.177	2.718	2.291	1.619	1.292	0.928	0.613	0.418	0.360
Mar	1.456	1.322	1.196	1.060	0.845	0.688	0.511	0.358	0.263	0.234
Apr	0.821	0.812	0.794	0.759	0.697	0.601	0.474	0.336	0.225	0.180
May	0.477	0.472	0.463	0.445	0.412	0.360	0.290	0.212	0.148	0.123
Jun	0.398	0.395	0.388	0.373	0.346	0.304	0.245	0.179	0.125	0.104
Jul	0.333	0.331	0.327	0.320	0.305	0.280	0.241	0.185	0.124	0.085
Aug	0.268	0.266	0.261	0.251	0.233	0.205	0.166	0.122	0.086	0.072
Sep	0.240	0.238	0.234	0.225	0.208	0.183	0.148	0.109	0.078	0.065

Reserve flows without High Flows

Oct	0.238	0.236	0.231	0.221	0.204	0.178	0.144	0.107	0.077	0.064
Nov	0.324	0.319	0.309	0.289	0.257	0.213	0.164	0.121	0.095	0.087
Dec	0.432	0.425	0.411	0.383	0.340	0.281	0.216	0.159	0.124	0.114
Jan	0.547	0.534	0.507	0.459	0.389	0.308	0.232	0.178	0.151	0.145
Feb	0.879	0.865	0.835	0.779	0.690	0.570	0.436	0.320	0.247	0.226
Mar	0.790	0.778	0.752	0.703	0.624	0.516	0.394	0.288	0.222	0.203
Apr	0.639	0.632	0.619	0.593	0.547	0.476	0.382	0.279	0.197	0.163
May	0.477	0.472	0.463	0.445	0.412	0.360	0.290	0.212	0.148	0.123
Jun	0.398	0.395	0.388	0.373	0.346	0.304	0.245	0.179	0.125	0.104
Jul	0.333	0.331	0.327	0.320	0.305	0.280	0.241	0.185	0.124	0.085
Aug	0.268	0.266	0.261	0.251	0.233	0.205	0.166	0.122	0.086	0.072
Sep	0.240	0.238	0.234	0.225	0.208	0.183	0.148	0.109	0.078	0.065

Natural Duration curves

Oct	0.877	0.709	0.556	0.474	0.388	0.317	0.287	0.239	0.213	0.164
Nov	3.488	2.558	1.744	1.339	1.100	0.826	0.648	0.502	0.316	0.208
Dec	5.100	3.006	2.513	2.072	1.725	1.381	1.228	1.060	0.601	0.347
Jan	9.073	4.350	3.256	2.498	1.983	1.714	1.344	1.172	0.859	0.523
Feb	15.191	9.751	3.580	2.555	2.050	1.653	1.368	1.112	0.794	0.529
Mar	9.468	4.969	2.505	2.031	1.549	1.333	1.154	0.892	0.732	0.444
Apr	3.140	2.311	1.744	1.512	1.254	0.992	0.849	0.756	0.583	0.370
May	1.680	1.281	1.042	0.967	0.848	0.739	0.597	0.545	0.452	0.287
Jun	0.995	0.891	0.768	0.706	0.656	0.610	0.490	0.436	0.374	0.262
Jul	0.762	0.661	0.605	0.534	0.485	0.470	0.422	0.358	0.295	0.239
Aug	0.653	0.500	0.474	0.422	0.385	0.362	0.343	0.302	0.243	0.205
Sep	0.590	0.471	0.397	0.359	0.328	0.301	0.285	0.247	0.208	0.181

Blyderivierpoort Dam, Blyde River
IUA 10
RU 88

- Desktop Version 2, Printed on 9/3/2014
- Summary of IFR rule curves for : Olifants_12 updated monthly fl
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Escarp ERC = B
- Data are given in m^3/s mean monthly flow
- % Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	2.714	2.708	2.685	2.637	2.545	2.375	2.089	1.669	1.162	0.780
Nov	3.324	3.312	3.280	3.216	3.092	2.871	2.507	1.981	1.357	0.891
Dec	4.222	4.204	4.160	4.072	3.906	3.611	3.132	2.444	1.634	1.031
Jan	6.405	6.069	5.758	5.442	5.071	4.444	3.837	2.981	1.987	1.252
Feb	14.941	13.688	12.589	11.580	10.552	8.814	7.564	5.771	3.659	2.087
Mar	7.669	7.339	7.024	6.694	6.291	5.594	4.853	3.780	2.507	1.556
Apr	5.847	5.833	5.781	5.673	5.461	5.072	4.420	3.458	2.299	1.427
May	4.215	4.210	4.177	4.108	3.970	3.710	3.264	2.594	1.771	1.148
Jun	3.925	3.922	3.894	3.833	3.708	3.472	3.063	2.440	1.670	1.084
Jul	3.397	3.397	3.375	3.328	3.228	3.033	2.688	2.150	1.473	0.953
Aug	2.995	2.993	2.972	2.926	2.832	2.654	2.346	1.877	1.298	0.856
Sep	2.825	2.821	2.800	2.755	2.665	2.495	2.203	1.765	1.227	0.819

- Reserve flows without High Flows

Oct	2.655	2.649	2.627	2.581	2.491	2.325	2.048	1.638	1.145	0.773
Nov	2.955	2.945	2.917	2.862	2.755	2.563	2.248	1.793	1.253	0.849
Dec	3.300	3.287	3.254	3.189	3.065	2.845	2.489	1.977	1.375	0.926
Jan	4.046	4.024	3.980	3.893	3.731	3.451	3.004	2.375	1.644	1.104
Feb	5.651	5.628	5.571	5.457	5.240	4.857	4.234	3.340	2.287	1.503
Mar	5.310	5.292	5.240	5.137	4.939	4.584	4.001	3.157	2.155	1.407
Apr	4.926	4.914	4.871	4.783	4.610	4.293	3.762	2.978	2.033	1.322
May	4.215	4.210	4.177	4.108	3.970	3.710	3.264	2.594	1.771	1.148
Jun	3.925	3.922	3.894	3.833	3.708	3.472	3.063	2.440	1.670	1.084
Jul	3.397	3.397	3.375	3.328	3.228	3.033	2.688	2.150	1.473	0.953
Aug	2.995	2.993	2.972	2.926	2.832	2.654	2.346	1.877	1.298	0.856
Sep	2.825	2.821	2.800	2.755	2.665	2.495	2.203	1.765	1.227	0.819

- Natural Duration curves

Oct	5.974	5.391	4.742	4.234	3.827	3.610	3.517	3.282	3.013	2.666
Nov	11.370	8.831	7.249	6.690	5.706	5.424	4.823	4.213	3.484	3.094
Dec	16.805	12.530	10.223	9.114	7.859	7.359	6.597	5.742	5.290	3.905
Jan	50.127	20.751	14.034	10.704	9.562	8.565	7.669	7.150	6.213	4.801
Feb	87.153	56.295	22.855	17.506	11.570	9.867	8.623	7.763	7.168	5.944
Mar	54.230	35.376	26.452	13.560	9.438	8.740	8.076	7.534	6.724	5.160
Apr	25.999	15.274	11.146	10.421	9.599	8.129	7.612	7.207	6.721	5.397
May	10.544	9.035	8.610	7.997	7.336	6.735	6.198	5.921	5.675	4.529
Jun	7.924	7.265	7.006	6.539	6.215	5.772	5.517	5.069	4.780	4.090
Jul	6.668	5.948	5.746	5.429	5.111	4.816	4.633	4.085	4.032	3.450
Aug	6.392	5.257	4.854	4.589	4.409	4.185	4.010	3.741	3.439	3.009
Sep	5.772	5.139	4.660	4.213	4.012	3.850	3.657	3.395	3.225	2.704

Olifants River
IUA 10
RU 95

- Desktop Version 2, Printed on 3/27/2014
- Summary of IFR rule curves for : B71F Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	3.056	3.036	2.989	2.892	2.712	2.415	1.996	1.514	1.102	0.910
Nov	10.069	10.006	9.877	9.620	9.139	8.300	6.965	5.109	3.041	1.740
Dec	14.918	14.824	14.627	14.237	13.507	12.233	10.206	7.390	4.251	2.276
Jan	11.527	10.423	9.471	8.617	7.781	6.383	5.518	4.315	2.974	2.130
Feb	33.359	29.465	26.141	23.223	20.469	15.881	13.409	9.972	6.142	3.732
Mar	11.988	10.882	9.927	9.066	8.217	6.796	5.894	4.640	3.242	2.363
Apr	5.958	5.919	5.830	5.647	5.305	4.742	3.947	3.033	2.250	1.887
May	2.414	2.404	2.380	2.330	2.237	2.084	1.868	1.620	1.408	1.309
Jun	1.990	1.981	1.961	1.920	1.844	1.718	1.540	1.335	1.160	1.079
Jul	1.666	1.659	1.642	1.608	1.544	1.438	1.289	1.118	0.971	0.903
Aug	1.412	1.406	1.392	1.363	1.308	1.219	1.093	0.947	0.823	0.765
Sep	1.262	1.256	1.243	1.217	1.169	1.089	0.976	0.846	0.735	0.684

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.453	1.447	1.432	1.402	1.346	1.254	1.124	0.975	0.847	0.788
Nov	2.331	2.322	2.304	2.269	2.202	2.086	1.900	1.643	1.357	1.176
Dec	2.752	2.742	2.721	2.679	2.600	2.463	2.244	1.940	1.602	1.389
Jan	3.338	3.326	3.300	3.249	3.154	2.987	2.722	2.354	1.943	1.685
Feb	4.261	4.245	4.212	4.147	4.025	3.812	3.474	3.004	2.480	2.150
Mar	3.799	3.785	3.756	3.698	3.589	3.400	3.098	2.679	2.211	1.917
Apr	3.075	3.062	3.031	2.968	2.849	2.655	2.380	2.063	1.793	1.667
May	2.414	2.404	2.380	2.330	2.237	2.084	1.868	1.620	1.408	1.309
Jun	1.990	1.981	1.961	1.920	1.844	1.718	1.540	1.335	1.160	1.079
Jul	1.666	1.659	1.642	1.608	1.544	1.438	1.289	1.118	0.971	0.903
Aug	1.412	1.406	1.392	1.363	1.308	1.219	1.093	0.947	0.823	0.765
Sep	1.262	1.256	1.243	1.217	1.169	1.089	0.976	0.846	0.735	0.684

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	25.194	14.833	10.107	8.341	7.363	5.600	4.820	4.230	3.293	2.487
Nov	88.993	67.110	43.040	32.095	25.386	19.850	13.966	10.390	6.412	3.816
Dec	110.618	77.752	62.601	53.786	37.698	31.261	20.072	15.394	9.872	5.589
Jan	153.222	95.314	65.457	48.529	37.130	29.327	22.637	18.989	13.676	8.460
Feb	171.991	96.887	57.569	44.155	30.266	23.123	19.701	17.774	13.091	8.755
Mar	130.597	76.381	48.025	37.705	27.289	18.586	14.613	12.041	9.058	5.518
Apr	63.484	39.923	27.195	23.210	18.488	16.493	11.644	8.596	7.226	4.178
May	31.108	22.009	16.368	12.720	11.055	10.208	7.956	6.620	5.253	3.424
Jun	19.201	13.920	11.979	10.282	8.488	7.809	6.717	5.702	4.414	3.191
Jul	15.304	11.533	9.203	8.639	7.008	6.377	5.776	5.040	3.909	2.621
Aug	10.517	8.531	7.956	6.918	5.824	5.317	4.801	4.331	3.558	3.118
Sep	10.421	7.569	6.466	5.687	5.058	4.417	4.101	3.453	2.994	2.431

Olifants River
IUA 10
RU 96

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_11 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	5.963	5.921	5.827	5.632	5.269	4.671	3.827	2.854	2.023	1.637
Nov	11.353	11.288	11.151	10.881	10.374	9.490	8.083	6.129	3.951	2.580
Dec	14.783	14.696	14.516	14.159	13.490	12.323	10.466	7.887	5.011	3.202
Jan	15.647	15.207	14.748	14.188	13.396	12.034	10.329	7.958	5.316	3.654
Feb	26.483	25.063	23.748	22.399	20.803	18.091	15.433	11.740	7.623	5.033
Mar	17.392	16.943	16.464	15.865	15.000	13.510	11.601	8.947	5.989	4.129
Apr	12.940	12.850	12.646	12.223	11.436	10.140	8.310	6.203	4.401	3.564
May	9.435	9.371	9.225	8.924	8.364	7.440	6.136	4.635	3.352	2.755
Jun	7.664	7.612	7.494	7.250	6.794	6.044	4.985	3.765	2.723	2.238
Jul	6.288	6.245	6.148	5.947	5.574	4.958	4.089	3.089	2.234	1.836
Aug	5.344	5.307	5.225	5.054	4.737	4.214	3.475	2.625	1.898	1.560
Sep	4.857	4.824	4.749	4.594	4.305	3.830	3.159	2.386	1.725	1.418

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	5.479	5.442	5.358	5.183	4.857	4.321	3.564	2.692	1.947	1.600
Nov	8.800	8.752	8.652	8.454	8.085	7.439	6.412	4.985	3.395	2.394
Dec	10.667	10.609	10.488	10.249	9.801	9.018	7.773	6.043	4.115	2.902
Jan	12.877	12.807	12.661	12.372	11.831	10.886	9.383	7.295	4.967	3.503
Feb	16.506	16.416	16.229	15.858	15.165	13.953	12.027	9.351	6.367	4.490
Mar	14.622	14.543	14.377	14.049	13.434	12.361	10.655	8.284	5.641	3.978
Apr	11.944	11.862	11.678	11.297	10.588	9.418	7.768	5.868	4.243	3.488
May	9.435	9.371	9.225	8.924	8.364	7.440	6.136	4.635	3.352	2.755
Jun	7.664	7.612	7.494	7.250	6.794	6.044	4.985	3.765	2.723	2.238
Jul	6.288	6.245	6.148	5.947	5.574	4.958	4.089	3.089	2.234	1.836
Aug	5.344	5.307	5.225	5.054	4.737	4.214	3.475	2.625	1.898	1.560
Sep	4.857	4.824	4.749	4.594	4.305	3.830	3.159	2.386	1.725	1.418

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	34.155	21.024	14.527	12.407	11.003	8.535	6.978	6.411	5.462	3.741
Nov	129.340	89.815	59.460	42.091	35.104	27.207	20.629	15.845	10.096	5.972
Dec	133.404	108.580	88.153	77.106	54.126	43.078	32.658	24.335	16.540	8.737
Jan	201.803	147.711	94.915	69.601	56.041	46.195	36.376	30.514	22.364	14.303
Feb	309.020	154.398	82.866	64.922	48.582	35.884	33.027	27.468	21.615	14.563
Mar	150.653	100.455	73.167	55.417	38.564	30.208	23.600	20.228	15.901	9.229
Apr	81.944	55.328	40.517	33.546	29.398	24.205	18.839	14.039	12.014	7.045
May	42.496	32.919	22.849	20.023	16.551	14.863	12.616	10.697	8.550	5.305
Jun	26.759	20.752	17.400	14.653	12.168	11.389	9.846	8.299	6.647	4.591
Jul	18.911	15.722	12.634	12.018	10.088	8.972	8.147	7.527	5.903	4.114
Aug	14.598	12.582	10.335	9.685	8.266	7.374	6.859	6.392	5.175	4.555
Sep	15.968	10.509	8.912	7.870	7.311	6.701	6.057	5.351	4.441	3.947

Makhutswi River
IUA 10
RU 97

- Desktop Version 2, Printed on 3/27/2014
- Summary of IFR rule curves for : B72A Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Foothill ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.180	0.178	0.173	0.163	0.146	0.119	0.084	0.045	0.014	0.002
Nov	0.227	0.223	0.213	0.195	0.165	0.125	0.080	0.040	0.016	0.008
Dec	0.352	0.345	0.329	0.301	0.255	0.193	0.124	0.065	0.028	0.007
Jan	0.874	0.751	0.637	0.519	0.351	0.244	0.144	0.074	0.038	0.004
Feb	2.658	2.261	1.919	1.598	1.050	0.802	0.549	0.301	0.148	0.004
Mar	1.059	0.954	0.854	0.742	0.564	0.426	0.271	0.136	0.052	0.007
Apr	0.622	0.614	0.596	0.563	0.505	0.416	0.296	0.166	0.062	0.004
May	0.318	0.314	0.306	0.290	0.261	0.214	0.151	0.082	0.025	0.000
Jun	0.278	0.275	0.268	0.254	0.229	0.189	0.134	0.072	0.022	0.000
Jul	0.249	0.247	0.243	0.235	0.221	0.196	0.156	0.101	0.040	0.000
Aug	0.215	0.212	0.207	0.196	0.177	0.146	0.103	0.056	0.017	0.000
Sep	0.192	0.189	0.185	0.175	0.157	0.129	0.091	0.049	0.015	0.000

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.175	0.173	0.168	0.158	0.141	0.116	0.081	0.044	0.013	0.001
Nov	0.190	0.186	0.178	0.163	0.138	0.104	0.065	0.032	0.011	0.005
Dec	0.229	0.224	0.214	0.195	0.164	0.123	0.077	0.037	0.012	0.005
Jan	0.334	0.324	0.301	0.262	0.205	0.139	0.077	0.033	0.011	0.004
Feb	0.575	0.562	0.536	0.487	0.409	0.304	0.187	0.085	0.022	0.004
Mar	0.549	0.538	0.514	0.469	0.395	0.294	0.181	0.083	0.022	0.003
Apr	0.444	0.438	0.426	0.401	0.359	0.293	0.206	0.111	0.034	0.003
May	0.318	0.314	0.306	0.290	0.261	0.214	0.151	0.082	0.025	0.000
Jun	0.278	0.275	0.268	0.254	0.229	0.189	0.134	0.072	0.022	0.000
Jul	0.249	0.247	0.243	0.235	0.221	0.196	0.156	0.101	0.040	0.000
Aug	0.215	0.212	0.207	0.196	0.177	0.146	0.103	0.056	0.017	0.000
Sep	0.192	0.189	0.185	0.175	0.157	0.129	0.091	0.049	0.015	0.000

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.422	0.362	0.317	0.284	0.239	0.209	0.187	0.164	0.146	0.004
Nov	0.702	0.532	0.467	0.394	0.355	0.324	0.266	0.235	0.147	0.012
Dec	1.710	0.993	0.833	0.665	0.541	0.455	0.377	0.317	0.246	0.007
Jan	6.004	2.460	1.385	1.072	0.821	0.676	0.504	0.411	0.291	0.004
Feb	14.071	7.771	3.534	2.335	1.050	0.802	0.678	0.500	0.335	0.004
Mar	11.025	6.549	3.420	1.191	0.840	0.717	0.594	0.414	0.314	0.007
Apr	3.086	1.813	1.049	0.899	0.733	0.610	0.494	0.417	0.343	0.004
May	1.023	0.814	0.721	0.590	0.523	0.459	0.399	0.329	0.258	0.000
Jun	0.729	0.598	0.559	0.490	0.405	0.378	0.347	0.293	0.231	0.000
Jul	0.553	0.485	0.429	0.396	0.336	0.317	0.299	0.250	0.205	0.000
Aug	0.459	0.411	0.370	0.329	0.291	0.261	0.243	0.220	0.179	0.000
Sep	0.421	0.359	0.316	0.293	0.243	0.228	0.212	0.193	0.154	0.000

Olifants River
IUA 10
RU 98

- Desktop Version 2, Printed on 3/27/2014
- Summary of IFR rule curves for : B72C Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	8.410	8.351	8.217	7.939	7.422	6.571	5.369	3.985	2.802	2.252
Nov	15.207	15.119	14.935	14.570	13.888	12.697	10.803	8.170	5.237	3.391
Dec	20.510	20.388	20.135	19.634	18.695	17.057	14.451	10.831	6.795	4.256
Jan	23.313	22.334	21.392	20.362	19.053	16.819	14.369	10.963	7.168	4.780
Feb	46.588	43.201	40.176	37.272	34.116	28.792	24.387	18.265	11.441	7.148
Mar	26.834	25.837	24.853	23.742	22.282	19.783	16.911	12.921	8.473	5.674
Apr	19.792	19.650	19.327	18.661	17.419	15.374	12.487	9.163	6.321	4.999
May	13.988	13.891	13.670	13.213	12.361	10.958	8.977	6.697	4.747	3.841
Jun	11.373	11.294	11.116	10.746	10.057	8.921	7.319	5.474	3.897	3.163
Jul	9.183	9.119	8.976	8.678	8.125	7.212	5.924	4.442	3.174	2.585
Aug	7.756	7.703	7.582	7.332	6.867	6.100	5.018	3.772	2.707	2.212
Sep	7.032	6.984	6.875	6.649	6.229	5.537	4.561	3.437	2.476	2.029

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	7.643	7.590	7.471	7.225	6.767	6.012	4.946	3.719	2.670	2.182
Nov	11.170	11.109	10.982	10.732	10.262	9.441	8.136	6.322	4.301	3.029
Dec	13.582	13.508	13.353	13.046	12.472	11.469	9.875	7.659	5.190	3.636
Jan	16.661	16.569	16.379	16.001	15.295	14.060	12.098	9.370	6.331	4.418
Feb	22.085	21.963	21.709	21.208	20.269	18.629	16.021	12.397	8.357	5.816
Mar	20.183	20.072	19.840	19.382	18.523	17.024	14.640	11.328	7.636	5.313
Apr	17.652	17.529	17.249	16.670	15.592	13.815	11.308	8.421	5.952	4.804
May	13.988	13.891	13.670	13.213	12.361	10.958	8.977	6.697	4.747	3.841
Jun	11.373	11.294	11.116	10.746	10.057	8.921	7.319	5.474	3.897	3.163
Jul	9.183	9.119	8.976	8.678	8.125	7.212	5.924	4.442	3.174	2.585
Aug	7.756	7.703	7.582	7.332	6.867	6.100	5.018	3.772	2.707	2.212
Sep	7.032	6.984	6.875	6.649	6.229	5.537	4.561	3.437	2.476	2.029

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	38.900	26.979	20.949	17.548	15.569	12.657	10.323	9.674	8.158	6.769
Nov	135.467	100.660	69.579	52.106	43.935	35.293	27.616	20.995	14.371	9.128
Dec	158.722	121.307	103.039	94.060	73.955	51.983	42.496	32.042	25.220	14.038
Jan	246.864	172.637	119.616	89.094	74.795	61.294	49.533	42.298	31.052	23.088
Feb	341.493	221.284	109.404	83.164	69.147	59.110	48.210	42.580	35.408	25.723
Mar	205.869	161.574	109.050	82.706	55.040	44.146	37.354	32.493	26.142	18.007
Apr	109.340	75.698	57.554	51.775	42.157	36.400	31.296	23.245	20.934	14.387
May	53.857	42.570	35.517	30.246	25.665	23.447	19.975	17.070	15.072	9.901
Jun	36.262	28.349	24.869	21.813	19.348	17.948	15.556	14.005	11.840	8.762
Jul	27.815	21.868	18.888	17.342	14.628	13.885	12.862	11.574	9.890	7.676
Aug	20.184	17.469	15.211	13.993	12.250	11.432	10.775	10.275	8.602	7.049
Sep	22.006	16.103	13.939	12.176	11.022	10.139	9.398	8.441	7.218	6.466

Tours Dam, Ngwabitsi River
IUA 11
RU 99

- Desktop Version 2, Printed on 2008/07/09
- Summary of IFR rule curves for : B72E Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Foothill ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.066	0.065	0.063	0.059	0.053	0.044	0.031	0.017	0.005	0.001
Nov	0.091	0.089	0.085	0.078	0.066	0.050	0.031	0.015	0.005	0.003
Dec	0.186	0.182	0.174	0.159	0.135	0.102	0.065	0.034	0.014	0.008
Jan	0.500	0.422	0.353	0.284	0.186	0.130	0.077	0.040	0.021	0.017
Feb	1.873	1.579	1.166	0.723	0.463	0.331	0.207	0.153	0.107	0.077
Mar	0.605	0.538	0.477	0.411	0.307	0.233	0.149	0.077	0.031	0.018
Apr	0.282	0.279	0.271	0.256	0.229	0.189	0.134	0.076	0.028	0.009
May	0.110	0.108	0.106	0.100	0.090	0.074	0.052	0.028	0.009	0.001
Jun	0.097	0.096	0.094	0.089	0.080	0.066	0.047	0.025	0.008	0.001
Jul	0.090	0.090	0.088	0.085	0.080	0.071	0.057	0.037	0.015	0.001
Aug	0.075	0.074	0.072	0.069	0.062	0.051	0.036	0.020	0.006	0.000
Sep	0.068	0.067	0.065	0.062	0.056	0.046	0.032	0.017	0.005	0.000

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.062	0.061	0.060	0.056	0.050	0.041	0.029	0.015	0.005	0.000
Nov	0.067	0.065	0.062	0.057	0.048	0.036	0.022	0.010	0.003	0.000
Dec	0.090	0.088	0.084	0.076	0.064	0.048	0.029	0.013	0.004	0.001
Jan	0.151	0.146	0.136	0.118	0.092	0.062	0.034	0.014	0.004	0.001
Feb	0.317	0.310	0.296	0.269	0.226	0.168	0.104	0.048	0.013	0.003
Mar	0.275	0.269	0.257	0.235	0.198	0.148	0.091	0.042	0.012	0.003
Apr	0.193	0.191	0.185	0.175	0.156	0.128	0.090	0.049	0.015	0.002
May	0.110	0.108	0.106	0.100	0.090	0.074	0.052	0.028	0.009	0.001
Jun	0.097	0.096	0.094	0.089	0.080	0.066	0.047	0.025	0.008	0.001
Jul	0.090	0.090	0.088	0.085	0.080	0.071	0.057	0.037	0.015	0.001
Aug	0.075	0.074	0.072	0.069	0.062	0.051	0.036	0.020	0.006	0.000
Sep	0.068	0.067	0.065	0.062	0.056	0.046	0.032	0.017	0.005	0.000

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.175	0.149	0.131	0.116	0.093	0.086	0.071	0.060	0.049	0.034
Nov	0.448	0.251	0.204	0.166	0.139	0.123	0.108	0.081	0.062	0.039
Dec	1.180	0.717	0.474	0.366	0.258	0.202	0.149	0.108	0.078	0.060
Jan	3.898	1.385	0.896	0.579	0.411	0.314	0.202	0.149	0.116	0.071
Feb	13.856	2.910	1.166	0.723	0.463	0.331	0.207	0.153	0.116	0.079
Mar	8.247	3.390	1.247	0.526	0.332	0.258	0.205	0.149	0.105	0.063
Apr	1.883	0.660	0.432	0.336	0.285	0.220	0.181	0.162	0.093	0.073
May	0.381	0.325	0.302	0.231	0.205	0.179	0.146	0.127	0.082	0.067
Jun	0.282	0.258	0.224	0.189	0.162	0.147	0.127	0.104	0.073	0.069
Jul	0.231	0.198	0.179	0.153	0.134	0.123	0.108	0.090	0.071	0.056
Aug	0.190	0.168	0.149	0.131	0.112	0.105	0.097	0.075	0.063	0.045
Sep	0.170	0.154	0.131	0.116	0.100	0.089	0.081	0.069	0.058	0.039

Ga-Selati River
IUA 11
RU 103

- Desktop Version 2, Printed on 2008/07/09
- Summary of IFR rule curves for : B72K Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Foothill ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.228	0.225	0.219	0.206	0.184	0.151	0.106	0.057	0.018	0.002
Nov	0.263	0.258	0.247	0.225	0.190	0.142	0.088	0.042	0.012	0.004
Dec	0.432	0.423	0.403	0.367	0.310	0.232	0.146	0.071	0.024	0.011
Jan	0.943	0.849	0.749	0.628	0.454	0.310	0.175	0.080	0.032	0.021
Feb	3.042	2.694	2.372	1.575	1.038	0.748	0.500	0.355	0.158	0.093
Mar	1.400	1.317	1.219	1.086	0.680	0.519	0.412	0.198	0.065	0.025
Apr	0.776	0.765	0.744	0.694	0.625	0.486	0.363	0.199	0.066	0.012
May	0.370	0.365	0.356	0.337	0.303	0.249	0.176	0.095	0.030	0.003
Jun	0.329	0.325	0.317	0.301	0.271	0.224	0.159	0.086	0.027	0.003
Jul	0.309	0.307	0.302	0.293	0.275	0.244	0.195	0.127	0.051	0.003
Aug	0.260	0.257	0.251	0.238	0.215	0.177	0.126	0.068	0.021	0.002
Sep	0.242	0.240	0.233	0.221	0.199	0.163	0.115	0.063	0.020	0.002

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.225	0.222	0.216	0.204	0.182	0.149	0.105	0.057	0.018	0.002
Nov	0.241	0.236	0.226	0.206	0.174	0.130	0.080	0.037	0.010	0.002
Dec	0.334	0.327	0.312	0.284	0.239	0.177	0.109	0.050	0.014	0.003
Jan	0.584	0.566	0.526	0.457	0.357	0.240	0.131	0.053	0.014	0.005
Feb	1.310	1.282	1.223	1.112	0.935	0.695	0.428	0.197	0.054	0.012
Mar	1.062	1.041	0.994	0.907	0.680	0.519	0.352	0.162	0.044	0.009
Apr	0.696	0.686	0.667	0.629	0.562	0.460	0.323	0.175	0.055	0.006
May	0.370	0.365	0.356	0.337	0.303	0.249	0.176	0.095	0.030	0.003
Jun	0.329	0.325	0.317	0.301	0.271	0.224	0.159	0.086	0.027	0.003
Jul	0.309	0.307	0.302	0.293	0.275	0.244	0.195	0.127	0.051	0.003
Aug	0.260	0.257	0.251	0.238	0.215	0.177	0.126	0.068	0.021	0.002
Sep	0.242	0.240	0.233	0.221	0.199	0.163	0.115	0.063	0.020	0.002

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.519	0.396	0.343	0.287	0.228	0.190	0.164	0.138	0.112	0.086
Nov	1.103	0.621	0.440	0.405	0.336	0.289	0.239	0.189	0.139	0.089
Dec	2.946	1.837	1.157	0.870	0.601	0.429	0.347	0.265	0.183	0.112
Jan	8.751	3.704	2.307	1.437	1.030	0.754	0.538	0.332	0.261	0.172
Feb	43.043	9.449	3.373	1.575	1.038	0.748	0.500	0.355	0.273	0.182
Mar	23.574	9.995	3.857	1.086	0.680	0.519	0.444	0.336	0.246	0.149
Apr	5.096	1.786	1.022	0.694	0.625	0.486	0.401	0.336	0.224	0.162
May	0.821	0.758	0.635	0.515	0.474	0.399	0.325	0.276	0.183	0.146
Jun	0.648	0.575	0.490	0.451	0.390	0.332	0.297	0.220	0.177	0.143
Jul	0.545	0.474	0.418	0.370	0.314	0.287	0.239	0.198	0.161	0.123
Aug	0.478	0.418	0.370	0.321	0.269	0.239	0.205	0.175	0.146	0.105
Sep	0.463	0.378	0.332	0.297	0.247	0.201	0.181	0.162	0.127	0.093

Ga-Selati River
IUA 11
RU 104

- Desktop Version 2, Printed on 2008/07/09
- Summary of IFR rule curves for : B72K Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Foothill   ERC = D
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.228	0.225	0.219	0.206	0.184	0.151	0.106	0.057	0.018	0.002
Nov	0.263	0.258	0.247	0.225	0.190	0.142	0.088	0.042	0.012	0.004
Dec	0.432	0.423	0.403	0.367	0.310	0.232	0.146	0.071	0.024	0.011
Jan	0.943	0.849	0.749	0.628	0.454	0.310	0.175	0.080	0.032	0.021
Feb	3.042	2.694	2.372	1.575	1.038	0.748	0.500	0.355	0.158	0.093
Mar	1.400	1.317	1.219	1.086	0.680	0.519	0.412	0.198	0.065	0.025
Apr	0.776	0.765	0.744	0.694	0.625	0.486	0.363	0.199	0.066	0.012
May	0.370	0.365	0.356	0.337	0.303	0.249	0.176	0.095	0.030	0.003
Jun	0.329	0.325	0.317	0.301	0.271	0.224	0.159	0.086	0.027	0.003
Jul	0.309	0.307	0.302	0.293	0.275	0.244	0.195	0.127	0.051	0.003
Aug	0.260	0.257	0.251	0.238	0.215	0.177	0.126	0.068	0.021	0.002
Sep	0.242	0.240	0.233	0.221	0.199	0.163	0.115	0.063	0.020	0.002

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.225	0.222	0.216	0.204	0.182	0.149	0.105	0.057	0.018	0.002
Nov	0.241	0.236	0.226	0.206	0.174	0.130	0.080	0.037	0.010	0.002
Dec	0.334	0.327	0.312	0.284	0.239	0.177	0.109	0.050	0.014	0.003
Jan	0.584	0.566	0.526	0.457	0.357	0.240	0.131	0.053	0.014	0.005
Feb	1.310	1.282	1.223	1.112	0.935	0.695	0.428	0.197	0.054	0.012
Mar	1.062	1.041	0.994	0.907	0.680	0.519	0.352	0.162	0.044	0.009
Apr	0.696	0.686	0.667	0.629	0.562	0.460	0.323	0.175	0.055	0.006
May	0.370	0.365	0.356	0.337	0.303	0.249	0.176	0.095	0.030	0.003
Jun	0.329	0.325	0.317	0.301	0.271	0.224	0.159	0.086	0.027	0.003
Jul	0.309	0.307	0.302	0.293	0.275	0.244	0.195	0.127	0.051	0.003
Aug	0.260	0.257	0.251	0.238	0.215	0.177	0.126	0.068	0.021	0.002
Sep	0.242	0.240	0.233	0.221	0.199	0.163	0.115	0.063	0.020	0.002

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.519	0.396	0.343	0.287	0.228	0.190	0.164	0.138	0.112	0.086
Nov	1.103	0.621	0.440	0.405	0.336	0.289	0.239	0.189	0.139	0.089
Dec	2.946	1.837	1.157	0.870	0.601	0.429	0.347	0.265	0.183	0.112
Jan	8.751	3.704	2.307	1.437	1.030	0.754	0.538	0.332	0.261	0.172
Feb	43.043	9.449	3.373	1.575	1.038	0.748	0.500	0.355	0.273	0.182
Mar	23.574	9.995	3.857	1.086	0.680	0.519	0.444	0.336	0.246	0.149
Apr	5.096	1.786	1.022	0.694	0.625	0.486	0.401	0.336	0.224	0.162
May	0.821	0.758	0.635	0.515	0.474	0.399	0.325	0.276	0.183	0.146
Jun	0.648	0.575	0.490	0.451	0.390	0.332	0.297	0.220	0.177	0.143
Jul	0.545	0.474	0.418	0.370	0.314	0.287	0.239	0.198	0.161	0.123
Aug	0.478	0.418	0.370	0.321	0.269	0.239	0.205	0.175	0.146	0.105
Sep	0.463	0.378	0.332	0.297	0.247	0.201	0.181	0.162	0.127	0.093

Olifants River

IUA 12

RU 105

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_13 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	6.039	6.003	5.920	5.749	5.429	4.903	4.160	3.305	2.573	2.233
Nov	11.488	11.427	11.300	11.049	10.579	9.757	8.451	6.636	4.612	3.339
Dec	15.829	15.742	15.560	15.201	14.529	13.354	11.487	8.892	6.000	4.181
Jan	17.747	16.879	16.076	15.254	14.284	12.635	11.025	8.788	6.294	4.725
Feb	38.032	34.952	32.250	29.739	27.140	22.772	19.566	15.111	10.145	7.021
Mar	20.220	19.340	18.513	17.642	16.581	14.773	12.910	10.320	7.434	5.618
Apr	14.289	14.199	13.996	13.575	12.792	11.501	9.679	7.582	5.788	4.955
May	9.766	9.709	9.579	9.311	8.812	7.989	6.827	5.490	4.347	3.816
Jun	7.939	7.893	7.788	7.572	7.170	6.507	5.570	4.493	3.571	3.142
Jul	6.412	6.375	6.291	6.118	5.795	5.264	4.514	3.650	2.912	2.568
Aug	5.417	5.386	5.316	5.171	4.901	4.456	3.828	3.104	2.486	2.199
Sep	4.912	4.884	4.821	4.691	4.448	4.048	3.482	2.832	2.276	2.017

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	5.338	5.308	5.239	5.096	4.830	4.392	3.773	3.061	2.453	2.169
Nov	7.798	7.762	7.688	7.540	7.263	6.781	6.013	4.946	3.757	3.009
Dec	9.486	9.442	9.350	9.169	8.830	8.238	7.297	5.988	4.530	3.612
Jan	11.645	11.591	11.478	11.255	10.836	10.105	8.942	7.327	5.526	4.393
Feb	15.468	15.396	15.245	14.947	14.389	13.413	11.862	9.707	7.305	5.794
Mar	14.118	14.052	13.915	13.643	13.133	12.242	10.827	8.859	6.666	5.287
Apr	12.335	12.263	12.098	11.758	11.123	10.078	8.603	6.904	5.452	4.777
May	9.766	9.709	9.579	9.311	8.812	7.989	6.827	5.490	4.347	3.816
Jun	7.939	7.893	7.788	7.572	7.170	6.507	5.570	4.493	3.571	3.142
Jul	6.412	6.375	6.291	6.118	5.795	5.264	4.514	3.650	2.912	2.568
Aug	5.417	5.386	5.316	5.171	4.901	4.456	3.828	3.104	2.486	2.199
Sep	4.912	4.884	4.821	4.691	4.448	4.048	3.482	2.832	2.276	2.017

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	38.986	26.997	20.968	17.600	15.576	12.698	10.353	9.681	8.180	6.776
Nov	135.664	100.667	69.591	52.118	43.958	35.305	27.643	21.053	14.379	9.140
Dec	159.226	121.393	103.136	94.105	74.395	52.628	42.552	32.583	25.243	14.049
Jan	250.168	172.678	119.762	89.169	74.817	61.302	49.884	42.716	31.075	23.111
Feb	342.101	221.970	109.433	83.180	69.887	59.131	48.223	42.617	35.417	25.781
Mar	206.541	161.772	109.711	82.855	55.052	44.153	37.392	32.919	26.154	18.022
Apr	109.815	75.741	57.785	51.786	42.215	36.412	31.308	23.322	20.988	14.394
May	53.913	42.593	35.559	30.279	25.680	23.581	20.046	17.089	15.095	9.909
Jun	36.292	28.360	24.880	21.825	19.383	17.963	15.567	14.016	11.863	8.765
Jul	27.845	21.935	18.922	17.398	14.639	13.908	12.907	11.604	9.901	7.680
Aug	20.214	17.507	15.222	14.027	12.287	11.481	10.794	10.338	8.610	7.056
Sep	22.029	16.150	13.962	12.191	11.038	10.177	9.425	8.461	7.230	6.478

Klaserie Dam, Klaserie River
IUA 12
RU 106

- Desktop Version 2, Printed on 9/3/2014
- Summary of IFR rule curves for : OLI-EWR7 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Escarp ERC = B/C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.110	0.110	0.109	0.107	0.103	0.096	0.084	0.066	0.045	0.029
Nov	0.167	0.166	0.165	0.161	0.155	0.143	0.124	0.096	0.063	0.038
Dec	0.312	0.310	0.307	0.300	0.287	0.264	0.226	0.172	0.109	0.061
Jan	0.559	0.522	0.489	0.456	0.420	0.360	0.309	0.236	0.151	0.089
Feb	1.430	1.297	1.181	1.076	0.837	0.743	0.556	0.427	0.278	0.101
Mar	0.683	0.646	0.612	0.577	0.536	0.466	0.396	0.295	0.175	0.085
Apr	0.448	0.447	0.443	0.434	0.416	0.384	0.330	0.251	0.155	0.071
May	0.227	0.226	0.224	0.221	0.213	0.199	0.174	0.137	0.092	0.053
Jun	0.172	0.172	0.171	0.168	0.163	0.152	0.134	0.106	0.071	0.044
Jul	0.132	0.132	0.131	0.130	0.126	0.118	0.104	0.083	0.056	0.035
Aug	0.113	0.113	0.112	0.110	0.107	0.100	0.088	0.070	0.047	0.030
Sep	0.102	0.102	0.101	0.100	0.096	0.090	0.079	0.063	0.043	0.028

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.103	0.102	0.102	0.100	0.096	0.090	0.079	0.062	0.043	0.028
Nov	0.129	0.128	0.127	0.124	0.120	0.111	0.097	0.076	0.052	0.034
Dec	0.191	0.190	0.188	0.184	0.177	0.163	0.142	0.111	0.075	0.048
Jan	0.292	0.290	0.287	0.280	0.268	0.247	0.214	0.167	0.113	0.072
Feb	0.439	0.437	0.432	0.423	0.404	0.372	0.318	0.242	0.152	0.085
Mar	0.416	0.414	0.409	0.400	0.383	0.351	0.299	0.224	0.135	0.069
Apr	0.350	0.349	0.346	0.339	0.326	0.301	0.260	0.200	0.127	0.071
May	0.227	0.226	0.224	0.221	0.213	0.199	0.174	0.137	0.092	0.053
Jun	0.172	0.172	0.171	0.168	0.163	0.152	0.134	0.106	0.071	0.044
Jul	0.132	0.132	0.131	0.130	0.126	0.118	0.104	0.083	0.056	0.035
Aug	0.113	0.113	0.112	0.110	0.107	0.100	0.088	0.070	0.047	0.030
Sep	0.102	0.102	0.101	0.100	0.096	0.090	0.079	0.063	0.043	0.028

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	0.267	0.204	0.163	0.141	0.125	0.103	0.091	0.081	0.072	0.041
Nov	0.687	0.528	0.370	0.305	0.224	0.191	0.169	0.127	0.084	0.052
Dec	2.622	1.518	0.859	0.681	0.511	0.383	0.307	0.260	0.147	0.066
Jan	4.911	2.622	1.515	1.095	0.737	0.593	0.492	0.392	0.235	0.119
Feb	8.420	4.927	2.726	1.271	0.837	0.743	0.556	0.427	0.278	0.101
Mar	5.686	3.434	2.236	1.559	0.759	0.674	0.414	0.342	0.238	0.094
Apr	2.602	1.704	0.697	0.632	0.512	0.441	0.366	0.298	0.240	0.071
May	0.587	0.486	0.414	0.358	0.320	0.304	0.232	0.185	0.150	0.053
Jun	0.350	0.311	0.256	0.224	0.214	0.188	0.162	0.136	0.110	0.052
Jul	0.235	0.198	0.170	0.160	0.154	0.138	0.125	0.110	0.094	0.053
Aug	0.220	0.163	0.135	0.128	0.122	0.116	0.100	0.091	0.078	0.047
Sep	0.204	0.165	0.139	0.110	0.104	0.100	0.088	0.081	0.065	0.049

Phalaborwa Barrage, Olifants River
IUA 12
RU 114

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_13 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	6.039	6.003	5.920	5.749	5.429	4.903	4.160	3.305	2.573	2.233
Nov	11.488	11.427	11.300	11.049	10.579	9.757	8.451	6.636	4.612	3.339
Dec	15.829	15.742	15.560	15.201	14.529	13.354	11.487	8.892	6.000	4.181
Jan	17.747	16.879	16.076	15.254	14.284	12.635	11.025	8.788	6.294	4.725
Feb	38.032	34.952	32.250	29.739	27.140	22.772	19.566	15.111	10.145	7.021
Mar	20.220	19.340	18.513	17.642	16.581	14.773	12.910	10.320	7.434	5.618
Apr	14.289	14.199	13.996	13.575	12.792	11.501	9.679	7.582	5.788	4.955
May	9.766	9.709	9.579	9.311	8.812	7.989	6.827	5.490	4.347	3.816
Jun	7.939	7.893	7.788	7.572	7.170	6.507	5.570	4.493	3.571	3.142
Jul	6.412	6.375	6.291	6.118	5.795	5.264	4.514	3.650	2.912	2.568
Aug	5.417	5.386	5.316	5.171	4.901	4.456	3.828	3.104	2.486	2.199
Sep	4.912	4.884	4.821	4.691	4.448	4.048	3.482	2.832	2.276	2.017

Reserve flows without High Flows

Oct	5.338	5.308	5.239	5.096	4.830	4.392	3.773	3.061	2.453	2.169
Nov	7.798	7.762	7.688	7.540	7.263	6.781	6.013	4.946	3.757	3.009
Dec	9.486	9.442	9.350	9.169	8.830	8.238	7.297	5.988	4.530	3.612
Jan	11.645	11.591	11.478	11.255	10.836	10.105	8.942	7.327	5.526	4.393
Feb	15.468	15.396	15.245	14.947	14.389	13.413	11.862	9.707	7.305	5.794
Mar	14.118	14.052	13.915	13.643	13.133	12.242	10.827	8.859	6.666	5.287
Apr	12.335	12.263	12.098	11.758	11.123	10.078	8.603	6.904	5.452	4.777
May	9.766	9.709	9.579	9.311	8.812	7.989	6.827	5.490	4.347	3.816
Jun	7.939	7.893	7.788	7.572	7.170	6.507	5.570	4.493	3.571	3.142
Jul	6.412	6.375	6.291	6.118	5.795	5.264	4.514	3.650	2.912	2.568
Aug	5.417	5.386	5.316	5.171	4.901	4.456	3.828	3.104	2.486	2.199
Sep	4.912	4.884	4.821	4.691	4.448	4.048	3.482	2.832	2.276	2.017

Natural Duration curves

Oct	38.986	26.997	20.968	17.600	15.576	12.698	10.353	9.681	8.180	6.776
Nov	135.664	100.667	69.591	52.118	43.958	35.305	27.643	21.053	14.379	9.140
Dec	159.226	121.393	103.136	94.105	74.395	52.628	42.552	32.583	25.243	14.049
Jan	250.168	172.678	119.762	89.169	74.817	61.302	49.884	42.716	31.075	23.111
Feb	342.101	221.970	109.433	83.180	69.887	59.131	48.223	42.617	35.417	25.781
Mar	206.541	161.772	109.711	82.855	55.052	44.153	37.392	32.919	26.154	18.022
Apr	109.815	75.741	57.785	51.786	42.215	36.412	31.308	23.322	20.988	14.394
May	53.913	42.593	35.559	30.279	25.680	23.581	20.046	17.089	15.095	9.909
Jun	36.292	28.360	24.880	21.825	19.383	17.963	15.567	14.016	11.863	8.765
Jul	27.845	21.935	18.922	17.398	14.639	13.908	12.907	11.604	9.901	7.680
Aug	20.214	17.507	15.222	14.027	12.287	11.481	10.794	10.338	8.610	7.056
Sep	22.029	16.150	13.962	12.191	11.038	10.177	9.425	8.461	7.230	6.478

Olifants River
IUA 12
RU 116

- Desktop Version 2, Printed on 9/2/2014
- Summary of IFR rule curves for : Olifants_16 Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : Olifants ERC = C
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	5.687	5.650	5.566	5.393	5.069	4.537	3.785	2.919	2.179	1.834
Nov	10.423	10.366	10.246	10.008	9.564	8.788	7.554	5.839	3.928	2.725
Dec	14.411	14.329	14.158	13.820	13.187	12.082	10.324	7.882	5.160	3.447
Jan	16.772	15.998	15.271	14.506	13.575	11.989	10.357	8.089	5.561	3.970
Feb	36.487	33.633	31.114	28.744	26.246	22.043	18.807	14.312	9.300	6.148
Mar	19.520	18.732	17.975	17.152	16.110	14.333	12.397	9.706	6.707	4.820
Apr	13.746	13.654	13.445	13.013	12.208	10.883	9.012	6.858	5.016	4.160
May	9.401	9.341	9.205	8.923	8.398	7.532	6.311	4.905	3.702	3.143
Jun	7.603	7.555	7.446	7.219	6.797	6.102	5.121	3.991	3.026	2.576
Jul	6.155	6.116	6.028	5.846	5.507	4.947	4.158	3.249	2.472	2.111
Aug	5.216	5.183	5.109	4.956	4.670	4.199	3.535	2.770	2.116	1.812
Sep	4.740	4.711	4.644	4.505	4.247	3.822	3.222	2.531	1.940	1.665

Reserve flows without High Flows

Oct	5.126	5.094	5.022	4.871	4.590	4.128	3.476	2.724	2.082	1.783
Nov	7.438	7.400	7.323	7.169	6.882	6.380	5.581	4.472	3.236	2.458
Dec	9.123	9.077	8.981	8.791	8.436	7.816	6.831	5.461	3.934	2.974
Jan	11.402	11.344	11.224	10.986	10.540	9.761	8.523	6.803	4.885	3.679
Feb	15.674	15.594	15.428	15.100	14.484	13.410	11.701	9.327	6.681	5.016
Mar	14.150	14.078	13.928	13.631	13.076	12.106	10.564	8.420	6.031	4.528
Apr	12.113	12.036	11.859	11.494	10.814	9.694	8.112	6.292	4.735	4.011
May	9.401	9.341	9.205	8.923	8.398	7.532	6.311	4.905	3.702	3.143
Jun	7.603	7.555	7.446	7.219	6.797	6.102	5.121	3.991	3.026	2.576
Jul	6.155	6.116	6.028	5.846	5.507	4.947	4.158	3.249	2.472	2.111
Aug	5.216	5.183	5.109	4.956	4.670	4.199	3.535	2.770	2.116	1.812
Sep	4.740	4.711	4.644	4.505	4.247	3.822	3.222	2.531	1.940	1.665

Natural Duration curves

Oct	40.005	27.834	21.569	18.257	16.110	13.269	10.745	10.226	8.509	7.030
Nov	139.209	101.204	70.351	53.329	44.518	35.745	28.318	21.852	14.649	9.549
Dec	169.310	127.901	108.094	95.654	77.292	58.744	46.464	33.281	26.355	14.423
Jan	301.721	185.447	123.536	95.520	76.079	66.906	53.211	44.751	33.610	24.108
Feb	403.100	261.698	120.304	94.808	77.402	61.996	50.128	45.176	35.962	26.608
Mar	241.614	177.102	122.950	86.081	56.369	49.776	39.083	34.636	27.684	18.690
Apr	116.346	83.009	63.522	53.160	44.066	38.449	32.639	24.649	21.601	15.154
May	55.526	44.702	36.820	31.119	27.233	25.034	21.158	17.790	15.834	10.353
Jun	37.901	29.383	26.308	22.411	20.482	18.858	16.138	14.637	12.508	9.140
Jul	29.245	23.656	19.866	18.272	15.539	14.636	13.964	12.093	10.323	7.997
Aug	21.382	18.720	15.681	14.729	13.071	12.130	11.473	10.898	8.931	7.273
Sep	22.928	17.226	14.703	12.731	11.952	10.787	9.950	9.093	7.585	6.725

Blyde River
IUA 13
RU 121

- Desktop Version 2, Printed on 3/28/2014
- Summary of IFR rule curves for : B60D Generic Name
- Determination based on site specific parameters from SPATSIM database.
- Regional Type : E.Escarp ERC = B
- Data are given in m^3/s mean monthly flow

% Points

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.962	1.957	1.941	1.906	1.839	1.715	1.508	1.203	0.834	0.557
Nov	2.598	2.589	2.564	2.512	2.414	2.238	1.950	1.532	1.036	0.666
Dec	3.521	3.506	3.469	3.394	3.252	3.001	2.593	2.008	1.319	0.806
Jan	5.745	5.369	5.031	4.703	4.342	3.734	3.214	2.480	1.628	0.998
Feb	14.172	12.837	11.679	10.635	9.603	7.866	6.730	5.099	3.178	1.749
Mar	6.770	6.399	6.058	5.720	5.334	4.669	4.041	3.132	2.053	1.247
Apr	5.103	5.090	5.044	4.948	4.759	4.414	3.834	2.979	1.948	1.172
May	3.336	3.331	3.305	3.251	3.141	2.935	2.581	2.049	1.397	0.902
Jun	3.041	3.039	3.017	2.970	2.873	2.690	2.372	1.888	1.290	0.835
Jul	2.480	2.480	2.464	2.429	2.357	2.215	1.962	1.570	1.076	0.697
Aug	2.122	2.120	2.105	2.073	2.006	1.881	1.663	1.331	0.921	0.609
Sep	1.949	1.947	1.932	1.901	1.839	1.722	1.522	1.220	0.851	0.571

Reserve flows without High Flows

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	1.862	1.858	1.842	1.810	1.747	1.631	1.437	1.151	0.806	0.546
Nov	2.122	2.114	2.095	2.055	1.978	1.840	1.615	1.288	0.901	0.611
Dec	2.432	2.423	2.398	2.350	2.259	2.097	1.834	1.457	1.013	0.682
Jan	3.046	3.030	2.996	2.930	2.809	2.598	2.261	1.787	1.236	0.829
Feb	4.221	4.203	4.161	4.075	3.914	3.627	3.162	2.494	1.708	1.123
Mar	4.070	4.056	4.017	3.938	3.786	3.513	3.066	2.419	1.651	1.077
Apr	3.857	3.848	3.815	3.746	3.610	3.361	2.944	2.329	1.588	1.030
May	3.336	3.331	3.305	3.251	3.141	2.935	2.581	2.049	1.397	0.902
Jun	3.041	3.039	3.017	2.970	2.873	2.690	2.372	1.888	1.290	0.835
Jul	2.480	2.480	2.464	2.429	2.357	2.215	1.962	1.570	1.076	0.697
Aug	2.122	2.120	2.105	2.073	2.006	1.881	1.663	1.331	0.921	0.609
Sep	1.949	1.947	1.932	1.901	1.839	1.722	1.522	1.220	0.851	0.571

Natural Duration curves

Month	10%	20%	30%	40%	50%	60%	70%	80%	90%	99%
Oct	5.014	4.241	3.435	3.009	2.737	2.490	2.375	2.195	1.915	1.613
Nov	8.870	7.330	6.154	5.521	4.687	4.259	3.916	3.275	2.581	2.010
Dec	17.066	12.425	10.260	8.572	7.628	6.440	5.526	5.096	3.909	2.763
Jan	29.365	19.000	14.897	11.070	10.144	9.151	8.554	6.694	5.119	3.644
Feb	57.734	38.104	22.553	15.117	13.070	11.868	9.764	8.474	6.800	3.952
Mar	39.441	28.431	22.999	14.288	11.839	9.830	8.434	7.105	6.216	3.875
Apr	21.728	15.799	11.215	10.367	9.124	8.499	7.512	7.041	5.598	3.133
May	9.282	8.464	7.945	7.333	6.631	6.257	5.462	4.984	4.480	2.431
Jun	6.802	6.235	5.691	5.390	5.019	4.657	4.198	3.835	3.430	2.377
Jul	5.178	4.615	4.204	3.902	3.741	3.558	3.200	2.976	2.632	2.277
Aug	4.409	3.595	3.330	3.170	3.013	2.879	2.628	2.431	2.143	1.852
Sep	4.205	3.395	3.144	2.770	2.585	2.423	2.377	2.191	1.995	1.628

6.4 APPENDIX D: TECHNICAL BRIEF FOR THE JUSTIFICATION OF CROCODILE (NILE CRO NUMERICAL LIMITS USED IN THE STUDY.

Introduction:

The Department of Water Affairs is determining the Resource Quality Objectives for the Olifants Water Management Area. Resource Quality Objectives aim to establish clear goals relating to the quality of water resources as a means of providing management goals to sustain a balance between their use and protection. Resource Quality Objectives comprise a descriptive statement which is underpinned by numerical criteria or values. This report contain my opinion with regards to recommendations in terms of the numerical limits for Nile crocodile populations in selected Resource Units in the Olifants Water Management Area.

In terms of suggesting and setting numerical limits for Nile crocodile populations in selected Resource Units in the Olifants Water Management Area the following had to be considered:

The number of crocodiles needed to indicate that the ecosystem is functioning at a sustainable level (Numerical Criteria).
Compliance
The number of crocodiles needed to warn that there is a danger that the population is decreasing and therefore that the Resource Quality Objectives may not be met (TPC: Threshold of Potential).
Sampling frequency and methods
References to support the numerical limit
Comments.

The only meaningful way to determine the numerical limits mentioned above is to run a population viability analysis to determine the minimum viable population size on the numbers of crocodiles that occur in selected resource units. Broadly defined, the term “population viability analysis” refer to the use of quantitative methods to predict the likely future status of a population (or collection of populations) of conservation concern (Morris *et al.* 1999). Simply put, population viability analyses are *quantitative* efforts to assess population health and the factors influencing it.

The minimum viable population size is an estimate of the number of individuals required for a high probability of survival of a population over a given period of time and since crocodiles are very longlived animals that period of time need to be very long too. We should be interested in determining the 95% probability of persistence of 100 years. The minimum viable population size is determined through the use of mathematical techniques and simulation models (population viability analysis) which project changes in initial population abundance over a set time period and account for processes such as inbreeding, depression, natural catastrophes, density dependence and environmental and demographic stochasticity.

However, because population viability analyses are typically based upon limited data, they must be viewed as tentative assessments of current population risk based upon what we now know rather than as iron-clad predictions of population fate.

Annexure A: **It is important to remember that the opinions and recommendations given in this work is based current data gathered using currently used methods and that therefore the population viability analysis should be reviewed after each new sampling and / or further aerial surveys to accommodate and reflect changes in the population.**

Methods:

The population of Nile crocodiles in the selected resource units of the Olifants Water Management Area wat simulated was simulated by using VORTEX 10.0 software. Population data used in these simulations were collected during two aerial surveys of the Nile crocodile population in the Olifants River completed in 2005 and 2009 (Botha, 2010). These particular surveys were used because they represent the population at its most vulnerable i.e. during and just after the population crashes of 2005 and 2008.
VORTEX is an individual-based simulation model for population viability analysis that simulates the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on the dynamics of wildlife populations. Because the growth or decline of a simulated population is strongly influenced by random events, separate model iterations using the exact same input parameters will produce different results. Consequently, the model was repeated 100 times for each resource unit to reveal the distribution of fates that the population might experience under a given set of input conditions. The population was projected 100 years into the future with an extinction definition of 1 single animal left in the population.

Other input conditions taken into account included dispersal, dispersal rates, reproductive system, reproductive rates, mortality rates, catastrophes, initial population size and genetics. VORTEX was originally developed to model mammalian and avian populations, but its capabilities have improved so that it can now be also be used for modeling reptiles (Miller and Lacy, 2003).

Results from the simulation is given as a series of statistics that report among other things on mean population size, probability of extinction, final population size, population growth rate

Results:

Results of the population simulation is given in table 1 below:

Table 1: Results of Vortex population viability analysis for resource units 52, 53 and 116 in the Olifants River.

Resource Unit	Mean number of crocs	Mean density crocs/km river	Numerical Criteria	Compliance	Threshold of Potential	Sampling Frequency
52, 53 (downstream of FBD)	148	2.50	> 150	120 - 150	< 120	Annual
116 (Olifants Gorge in KNP)	212	21.20	> 200	160 - 200	< 160	Annual

Discussion and Recommendations:

Based on the results of the Vortex population viability analysis we can make the following conclusions regarding the Nile crocodile population in selected areas of the Olifants River.

Resource units 52 and 53:

These resource units are located downstream of the Loskop Dam and should include the Olifants River downstream of Loskop dam, the Flag Boshielo Dam and the Olifants downstream of the Flag Boshielo Dam as one combined area. It is my opinion that the minimum number of crocodiles required to maintain the population and therefore indicate that the ecosystem is functioning at a sustainable level should be more than 150 individual crocodiles (Numerical Criteria) in this entire area. The population should not fall below 120 individual crocodiles which is the number of crocodiles needed to warn that there is a danger that the population is decreasing and therefore that the Resource Quality Objectives may not be met (TPC: Threshold of Potential).

To set a limit for compliance is made somewhat difficult by the complicated seasonal migration pattern of Nile crocodiles where dominant animals move between breeding and nesting areas and smaller crocodiles move into areas vacated by dominant animals. I suggest that the compliance figure be set at between the Numerical Criteria figure and the Threshold of Potential figure, therefore at between 120 and 150 individual crocodiles.

This area (resource units 52 and 53) includes some very important refuge areas for Nile crocodiles in the Olifants River. The area downstream of Loskop Dam is clearly a very important refuge area for crocodiles and include important nesting areas especially in terms of the loss of nesting areas in the Flag Boshielo Dam after the increase of the wall. The Nile crocodile population in the Flag Boshielo Dam is historically the only other population of consequence in the Olifants River outside the Kruger National Park. Seen against the backdrop of the 82% population decline in Loskop Dam between 2007 and 2011, it is extremely important the Flag Boshielo Dam Nile crocodile population is sampled regularly to be sure that resource quality objectives are met and that the ecosystem remain functioning. Although the population of Nile crocodiles downstream of the Flag Boshielo Dam is relatively small with a low density, it is still worth sampling annually. The reason for this is that if we assume that this area should have a crocodile density (number of crocodiles/km of river) similar to the area of the river from below Loskop Dam to just upstream of Flag Boshielo Dam and we base that assumption on the occurrence of similar situation (areas downstream from a major impoundment) and similar human pressures (agriculture and residential developments) then this area is likely a very important refuge and nesting area downstream of (below) the Flag Boshielo Dam.

Resource unit 116:

This resource unit is located in the Olifants Gorge in the Kruger National Park. It is my opinion that the minimum number of crocodiles required to maintain the population and therefore indicate that the ecosystem is functioning at a sustainable level should be more than 200 individual crocodiles (Numerical criteria). The population should not fall below 160 individual crocodiles which is the number of crocodiles needed to warn that there is a danger that the population is decreasing and therefore that the Resource Quality Objectives may not be met (TPC: Threshold of Potential). To set a limit for compliance is made somewhat difficult by the complicated seasonal migration pattern of Nile crocodiles where dominant animals move between breeding and nesting areas and smaller crocodiles move into areas vacated by dominant animals. I would set the compliance figure at between the numerical criteria and the TPC, therefore at between 160 and 200 individual crocodiles. This area is unique in terms of the high density of crocodiles (table 1) occurring over a very short distance of river and therefore it is important that this area be sampled on an annual basis.

Crocodile population structure in the Olifants River:
The population structure for Nile crocodiles in the Olifants River based on current data gathered with currently used methods (aerial surveys from a helicopter) can be decribed as follows:

Hatchlings and yearlings 5 - 8% of the total population;
Pre-reproductive animals (approximately 2 to 5 year old) 30% of total population;
Reproductive animals (approximately 5 to 40 year old) 45-47% of total population;
Dominant animals (approximately 40 to >90 year old) 8-10% of total population;
Unsized animals (includes animals not spotted or difficult to spot) approximately 7% of the total population

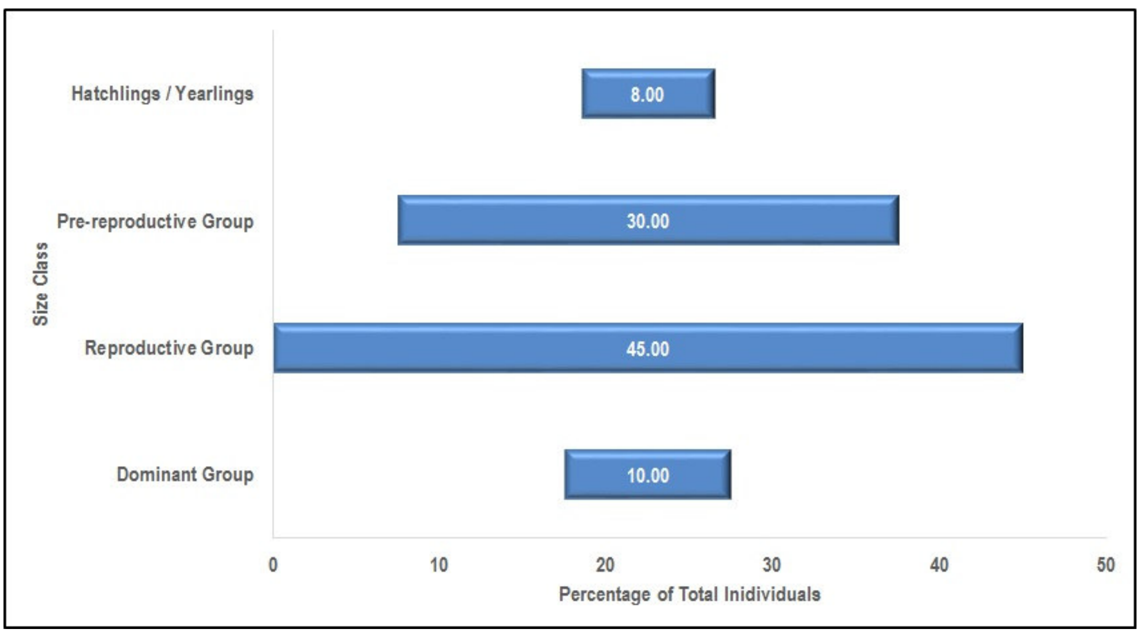

Figure 1: Population structure of the Olifants River Nile crocodile population based on the 2005 and 2009 aerial surveys. The graph does not include 7% animals that were not spotted or were difficult to spot during the surveys.

References:

Botha, P.J. 2010. *The distribution, conservation status and blood biochemistry of Nile crocodiles in the Olifants River System, Mpumalanga, South Africa*. PhD Thesis. University of Pretoria.

Miller, P.S., and Lacy, R.C. 2003. *VORTEX: A Stochastic Simulation of the Extinction Process. Version 9.21 User's Manual*. Conservation Breeding Specialist Group (SSC/IUCN).

Morris, W., Doak, D., Groom, M., Kareiva, P., Fieberg, J., Gerber, L., Murphy, P. and Thomson, D. 1999. *A practical handbook for population viability analysis*. The Nature Conservancy.