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Determination of Resource Quality Objectives for the Olifants-Doorn Water Management Area

Report No. 3
RQO Determination Report

Final
February 2014

Prepared by:

UMVOTO AFRICA (PTY) LTD

In association with

SOUTHERN WATERS ECOLOGICAL RESEARCH & CONSULTING CC

Umvoto Africa (Pty) Ltd. Earth . Water . Science . Life
P.O. Box 61 Muizenberg 7950. Telephone: (021) 788 8031. Fax: (086) 524 0001.
E-mail: amanzi@umvoto.com Internet: www.umvoto.com
Reg. No.: 2001\013609\07
Directors: E R Hay CJH Hartnady Associate: K Riemann

Department of Water Affairs
Directorate: Reserve Requirements

DETERMINATION OF RESOURCE QUALITY OBJECTIVES
FOR THE OLIFANTS DOORN WATER MANAGEMENT AREA

Report No. 3 - RQO Determination Report

APPROVAL

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CONSULTANTS : Umvoto Africa (Pty) Ltd in association with
Southern Waters Ecological Research and Consulting cc

AUTHORS : Dr Kornelius Riemann
Dr Alison Joubert
Dr Cate Brown

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STUDY TEAM: Approved for Umvoto

…… ……
E.R HAY K RIEMANN
Project Director Project Leader

DEPARTMENT OF WATER AFFAIRS
Directorate: RDM Compliance
Approved for Department of Water Affairs

…… ……
S MANAMELA NN
Project Manager D: RDM Compliance

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Authors' Contributions

Dr Kornelius Riemann	Study Leader, Groundwater RQOs
Dr Alison Joubert	Deputy Study Leader, Surface water RQOs
Dr Cate Brown	Advisor, Surface water RQOs
Ms Rowena Hay	Advisor
Mr Dylan Blake	Characterisation of groundwater
Dr Bruce Paxton	Fish RQOs
Mr Mark Rountree	Wetland RQOs
Mr Masibulele Fubesi	Groundwater RQOs
Mr Sinawo Jack	Groundwater RQOs

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List of Acronyms and Abbreviations

CAGE	Citrusdal Artesian Groundwater Exploration
C.A.P.E.	Cape Action for People and the Environment
CD: RDM	Chief Directorate: Resource Directed Measures
DANIDA	Danish International Development Agency
DEAT	Department of Environmental Affairs and Tourism
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
D: NWRP	Directorate: National Water Resource Planning
D: WRPS	Directorate: Water Resource Planning System
EIA	Environmental Impact Assessment
EGSA	Ecosystem Goods, Services and Attributes
EIS	Ecological Importance and Sensitivity
ESBC	Ecological Sustainable Base Configuration
EWR	Ecological or Environmental Water Requirements
FEPA	Freshwater Ecosystem Protected Areas
GRDM	Groundwater Reserve Directed Measures
ISP	Internal Strategic Perspective
IUA	Integrated Unit of Analysis
IWRM	Integrated Water Resources Management
IWRP	Integrated Water Resources Planning
MLF	Maintenance Low Flow
NEC	Accepted Gazetted Category
PES	Present Ecological Status
PGWC	Provincial Government of the Western Cape
PMC	Project Management Committee
PS	Present Status (used explicitly for groundwater)
RAMSAR	Convention on Wetlands
RC	Recommended Category (for rivers, usually expressed as Recommended Ecological Category, but the more general RC has been used here for river, estuaries, wetlands, and groundwater)
RQO	Resource Quality Objective
RU	Resource Unit
SANBI	South African National Biodiversity Institute
SASS	South African Scoring System
TMG	Table Mountain Group
TMGA	Table Mountain Group Aquifer
ToR	Terms of Reference
TPCs	Threshholds of Potential Concern
WARMS	Water Registration Management System
WMA	Water Management Area
WMS	Water Management System
WODRIS	Western Cape Olifants-Doring River Irrigation Study
WRC	Water Research Commission
WRCS	Water-Resource Classification System
WRYM	Water Resources Yield Model
WUA	Water Users Association

Part I: Introduction and Preparation

1 INTRODUCTION

1.1 BACKGROUND TO THE STUDY

The Department of Water Affairs (DWA), Chief-Directorate: Resource Directed Measures (CD:RDM) appointed Umvoto Africa (Pty) Ltd to undertake the "Determination of Resource Quality Objectives in the Olifants-Doorn Water Management Area (WMA)", based on the Proposal by Umvoto Africa and Southern Waters for the Project WP10537, submitted in June 2011.

The project was meant to run in parallel with the recent Water Resource Classification Study, undertaken by the DWA for the Olifants-Doorn WMA. However, due to delays beyond the control of this study, the Water Resource Classification Study was completed by beginning April 2012 and this study needed to develop RQOs based on the completed classification.

This study is seen as a Pilot Study, as the Olifants-Doorn WMA would then be the first WMA in which the Water Resource Classification process and the determination of RQOs have been completed according to the recently developed guidelines.

1.2 TERMS OF REFERENCE

The Terms of Reference for the study, as provided by the DWA, stipulates the aim and objectives as follows:

"The main aim of the project is to determine Resource Quality Objectives (RQOs) for all significant water resources in the above-mentioned Water Management Area. The RQOs are to be determined in accordance with the Department of Water Affairs' Procedures to Determine and Implement Resource Quality Objectives."

"The RQO determination process must not be limited to Surface Water Resource Quality Objectives, but must be extended to all forms of water resources that exist in the water management area (wetlands, lakes, river, groundwater, etc.)."

The Procedure to Determine and Implement Resource Quality Objectives (DWA 2011) describes a seven-step process for the determination of RQOs. However, these steps partly overlap with the steps for the Water Resource Classification System (WRCS), which was completed by beginning April 2012. Hence, the RQO procedures have been rationalised to avoid duplication of effort and contradiction of results.

1.3 PURPOSE OF THIS REPORT

The report:

- summarises the prioritisation of the Resource Units (RUs) in the Olifants-Doorn Water Management Area (WMA) (PART II: Section 6);
- summarises the evaluation of the priority Resource Units and the identification of the RQOs developed per selected RU (PART II: Section 7); and
- presents the draft RQOs developed for each of the priority Resource Units (PART III: Sections 9 to 28) providing RQOs that are considered pragmatic and implementable for rivers, estuaries, groundwater and wetland clusers in the priority RUs.

2 APPROACH ADOPTED FOR RQOS

RQO are both descriptive statements and attendant numerical values for a range of RQOs throughout the WMA (DWA 2011).

- The RQOs themselves are narrative and qualitative statements that describe the overall objectives for the RU (DWA 2011). They should be meaningful to stakeholders and responsible managers, and give direction for whatever action is necessary to achieve the vision for the resource. These RQOs are gazetted and are thus supported by law (DWA 2011).
- The numerical limits give a quantitative measure of the RQOs that can be used for monitoring, such as an upper limit for slat concentrations or a lower population size limit for fish. Typically there is a paucity of scientific information on which to base such numerical limits, and so these numerical limits are not gazetted and thus may be more easily adjusted if found to be inaccurate.

2.1 SEVEN STEP PROCESS

The seven-step procedure adopted by DWA for the determination of RQOs (DWA 2011) is:

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

There is considerable overlap between these seven activities and the seven-step procedure for the Water-Resource Classification System (WRCS; Dollar *et al.* 2006) that is used in the Classification Process. The Classification activities in the Olifants-Doorn WMA provided significant input to the RQO development process:

- The delineation of the catchment into IUAs and the description of delineated Resource Units (RQO Step 1) have been completed by the Classification.
- The vision for the catchment and the key elements of the IUAs (RQO Step 2) have been established.
- The hydrological RQOs and associated numerical limits (RQO Step 5) have been established for the RUs.

This means that the RQO process need only to start at Step 3, and can derive some of the RQOs and numerical values needed directly from the outcome of the Classification Process.

The approach adopted in this study was to:

1. provide RQOs at different levels of detail depending on available information and the particular needs of the ecosystem and/or users;
2. provide hydrological RQOs for every quaternary catchment/node;
3. ensure that pragmatic and implementable RQOs were provided for priority RUs.

The approaches to specific issues are detailed below.

2.2 RIVERS

2.2.1 Incorporation of available EWR data at a finer spatial scale

The Classification Project concentrated on the data produced as part of the development of the WRCS, and did not incoporate some of the data that had subsequently become available at a finer scale. These data have subsequently been incoprotaated into the RQOs. These are, in particular:

Jan Dissels: A rapid EWR determination was done for the Jan Dissels River as part of the compulsory Licesning procedures in that catchment (DWAF 2008). This resulted in a new node (Q7) at the confluence of the Jan Dissels with the Olifants (within E10J) in addition to R24 (for E10H) at the gauge (E1H006).

Kouebokkeveld: The rapid EWR determination was done for the Kouebokkeveld rivers as part of the C.A.P.E projects (CAPE 2009). This resulted in disaggregated hydrological information and EWRs in E21G and E21H:

- An existing node (R41 on the Leeu) for E21G was augmented with three additional nodes (A6-Waterkloof, A7-Skoongezicht and A8-Meul) (eight sites rather than two); and
- Three nodes (A1-Twee, A2-Heks, A3-Middeldeur) were added on tributaries in E21H.

E10J: Formal stipulations for lowflows are not appropriate at E10J because the Olifants River in this quaternary is used as a conduit for irrigation releases from Clanwilliam Dam (and to maintain levels at Bulshoek Barrage). The Raising Clanwilliam Dam study (Southern Waters 2007; Brown 2010) evaluated the extent to which proposed changes to the height of Clanwilliam Dam and releases from the dam would affect the Olifants River downstream of the dam wall to Bulshoek Barrage, and made recommendations for maintaining PES in the Olifants River between Clanwilliam Dam and Bulshoek Weir, i.e., R24: E10J.

2.2.2 Addition of nodes to account for all quaternaries

Nodes were added at the outlets of five quaternary catchments, to ensure that all quaternaries were included in this study, viz:

- Q1 – at the outlet of E33F at the confluence of the Droe and Troe-Troe rivers (part of the Olifants-Doring dryland farming Integrated Unit of Analysis (IUA);
- Q2 – in E31A (an endorheic catchment in the Knersvlakte IUA);
- Q3 – at the outlet (coast) of F60A on the Brak (in the Knervlakte IUA);
- Q4 – at the “outlet” of F60E; and
- Q5 – at the outlet of G30H on the Sandlaagte (in the Sandveld IUA).

2.2.3 Verification of Classification outputs

The basic Classification outputs (Section 3) were checked, and where applicable, updated to ensure that:

- information from the Comprehensive Reserve determination for the Olifants and Doring Basin was used in preference to other data, where applicable.
- information from the Rapid III Reserve determination for the Sandveld basins was used in preference to other data where applicable.
- the hydrological region used in Desktop matched more detailed information from reserve-related studies.
- the PES designations matched those from the recent national PES studies (DWA 2012d);

2.2.4 Floods (over and above node Reserve allocation)

The Reserve allocations at each reach were sufficient to maintain the condition of that reach and sufficient to meet that reach's contribution to the allocations in the downstream reaches (see also Section 2.2.10). In some cases, this resulted in additional flood requirements for unimpacted river reaches. These floods form an essential part of the Reserve requirements for river reaches downstream and for the estuary. In theory, the allocation of these additional floods limits large in-channel structures in those rivers. In practice, however, in-channel structures are impractical in those rivers for a wide variety of reasons, mainly related to a paucity of dam sites and/or remoteness. In all cases, according to the available data, the floods allocated still occurred naturally in 2007, i.e., the requirements should not affect existing infrastructure. The rivers affected by this flood allocation are:

- Tributaries and mainstem Olifants (upper reaches to gorge (E10A to E10D)), 60–80%;

- Kruis, Sand, Welgemoed and Driedam se (E21A, E21B, E21C), 60%;
- Houdenbeks (E21D), 40%;
- Tributaries of Riet (E21E and F), 80%;

- Tributaries and mainstem Leeu (E21G), 60%;
- Twee, 80%; other tributaries and mainstem Leeu (E21H), 60%;
- Mainstem Groot (E21J), 80%;
- Matjies (E21K), 80%;
- Matjies, other tributaries and mainstem Groot (E21L), 80%;

- Patats, Groot (b) and other rivers (E22A), 80%;
- Mainstem Groot (b) (E22B), 80%;
- Rivers in E22C (tributaries to Kolkies/Doring), 80%;
- Mainstem Doring (E22E), 80%;
- Tributaries and mainstem Doring (E22F), 80%;
- Mainstem Doring (E22G), 80%;

- Pakhuislaagte and other tributaries (Tankwa) (E23K), 80%;
- Eselbank, Dassieboskloof, other tributaries, and mainstem Tra-tra, (E24A), 80%;
- Matjiesfontein, other tributaries, and mainstem Tra-tra (E24B), 60%;

- Avontuur, Putslaagte, Biedou, and other tributaries (E24J), 80%;
- Kransgat, Brak, Paalkraal, and other tributaries (E24K), 80%;

- Brandewyn, Klipmekaar, and mainstem Doring (E24L), 80%;
- Olienhouts, Gifberg, other tributaries, and mainstem Doring (E24M), 80%;

- Droe, Varkfontein, other tributaries, and mainstem Oorlogskloof (E40A), 60%;
- Karee, Agterplaas, and mainstem Oorlogskloof (E40B), 60%;
- Tributatires and mainstem Oorlogskloof (E40C), 80%;
- Klein-Koebee, de Hoop, other tributaries, and mainstem Koebee (E40D), 80%;

- Huis, Soutkloof, other tributaries, and Kruismans (G30B), 60%;
- Kleinvlei, Jansekraal, and Bergvallei (G30C), 60%;
- Krom Antonies, Hol, other tributaries and mainstem Verlorevlei (G30D and G30E), 60%.

2.2.5 Focus on minimum dry season lowflows

The hydrological RQOs for the Olifants-Doorn WMA focus on minimum dry season lowflows. The dry summer months are without doubt the most critical period for implementation of the Reserve in the WMA because:

1) the growing season (when abstraction is highest) coincides with the period of lowest flow;
2) there are currently very few guaging stations in the Olifants-Doorn WMA, which means that it is not possible to monitor the full range of Reserve flows, however, mínimum fllow flows CAN be measured relatively easily either with a flow meter, or by establishing a rated section;
3) there are relatively few dams in the area that are large enough to appreciably affect wet season flows; and

4) only Clanwilliam Dam has outlet that can release floods, so Reserve flood requirements cannot be managed other than by limiting the number of in channel storages (see Section 2.2.4).

Thus, the single most important aspect of the hydrological regime in terms of implementing the Ecological Reserve is to ensure that the minimum dry season lowflows are met.

2.2.6 Calculation of incremental inflow and FEPAs

In order to provide a Reserve water balance for the Olifants and Sandveld catchments, the Classification study accommodated FEPAs as follows:

1. calculating the percentage of each quaternary that had been identified as FEPAs;
2. assigning an A/B category to the areas that had been identified as FEPAs;
3. setting the Reserve for a FEPA A/B category at 60% of the proportional nMAR in each quaternary.
4. calculating the proportional nMAR by multiplying the incremental nMAR by the percentage of each quaternary that had been identified as FEPAs, i.e., if 90% of the quaternary is FEPA then the incremental inflow from the FEPAs would be 60% of 90% of the nMAR.

This approach is difficult to implement because there is an underlying, and untested, assumption that in order to protect an FEPA tributary, 60% of the natural flow of that tributary must reach the mainstem. In fact many of the tributaries in the Olifants-Doorn WMA are in reasonably good condition upstream of the agricultural areas but, once they enter the agricultural areas, they are heavily abstracted and highly impacted. Examples of this on the Olifants River include: E10D-08034 (Tee River) and E10F-07605 (Heks River). Indeed, many of these rivers have numerous farm dams on them, E10F-07566 (Palmietfontein River) being a case in point. In most instances water from these rivers does not flow into the mainstem Olifants River at all in the dry season (C. Brown, pers. obs.). Thus, while it is possible to set 60% of the MAR as a requirement on paper, it will mean clawing back 40-60% of the dry season flows from farmers' allocations. Furthermore, because the section of river where 60% is 'required' is situated upstream of where the farmers' abstract, it will be difficult to justify the claw-back. In our opinion, trying to implement such a requirement in the context of the Olifants Basin will possibly undermine implementation of the ecological Reserve elsewhere in the catchment.

Thus, in the interests of implementability, the approach taken for the Reserve requirements stipulated as part of the RQOs was:

1. For each quaternary, use the sub-quaternaries (as defined in DWA 2012d) as these represent the most significant tributaries, and thus the major contributors to imcremental inflow in a quaternary;
2. Identify which of these quaternaries have been identified as FEPAs;
3. Identify the coordinates of the point upstream of which the FEPA tributaries could conceivable either have a PES of A/B category or could be restored to such.
4. Set the requirement upstream of this point as 60% of MAR[1].
5. For the incremental inflow to the mainstem rivers, focus on the dry season, and ensure that the Reserve stipulations for the month with lowest flow balance from upstream to downstream.
6. For each sub-quaternary, identify an absolute minimum lowflow below which the river should not drop at anytime.

1 Note, there is usually no hydrological information available for the sub-quaternaries, so this is 60% of an unknown MAR.

Note: It is likely that in many instances, the absolute minimum lowflow does not occur currently. Thus, implementation will require some claw-back from farmers, but this will be considerably less severe than would be the case if the WRCS approach was gazetted.

2.2.7 E10K (R33) – Reserve allocations

The Present Ecostatus (PES) at EWR Site 2 is an E-category. The main reason for the low PES is the presence of Bulshoek Barrage and Clanwilliam Dam upstream. These structures trap sediment and middle-range floods vital for the maintenance of the channel. This means that the site is supply-limited and has adjusted to the imposed change. The current channel has narrowed since the 1940s, and significant riparian vegetation encroachment has occurred. Additional impacts include cultivation of flood terraces. The current channel type represents pool-like conditions, although it is likely to have been an anabranching channel type prior to the construction of Bulshoek Barrage and Clanwilliam Dam. These changes have resulted in a geomorphology ecostatus (relative to natural/reference conditions) of an E-category.

The channel changes described above also represent a reduction in the habitat available for fish and macroinvertebrates, which together with the altered hydrology and barrier effects of the Bulshoek Barrage and Clanwilliam Dam have caused a significant change in these communities relative to reference conditions and hence a reduction in the ecostatus for these components.

There is little or no certainty that the ecostatus of EWR Reach 2 can be improved to a D-category solely by implementing flow releases from Bulshoek Barrage. During the EWR Workshop there was unanimous agreement from the scientists that the risk of even relatively high (40% natural Mean Annual Runoff (nMAR)) flow releases not supporting a D-category was extremely high as many of the impacts were related to the dam/barrage and, as such, improvement would probably require removal of (at least) Bulshoek Barrage. Furthermore, system analysis suggested that the estuary downstream of EWR Site 2 could be maintained in its present condition through reinstatement of some summer flows past EWR Site 2, and the winter contributions from primarily the Doring River, thereby relieving the pressure on the upper Olifants River to support the lower Olifants River and estuary. It was also acknowledged that a reduced EWR (10-17% nMAR), which was primarily aimed at maintenance of the water quality in EWR Reach 2, would result in an improvement in PES, albeit not to a D-category.

Thus, the Preliminary Ecological Reserve signed off for this location was for an E-category, and was c. 10% of the nMAR, excluding the floods with a return period greater than one year. After consideration of the above, and of aforegoing descision with respect to E10K, the signed off Preliminary Reserve was therefore used in the Classification balance sheet.

2.2.8 Estuary flow requirements

The estuary flow requirements provided in Section 9.2 are based on the deliberations by the estuarine team in 2004-2006 during the Comprehenisve Reserve Determination (DWAF 2006b). The process used to decide on the estuary flow requirements is different from that used for rivers in that it produces a recommended flow regime (as a time-series .mrv file) that has been evaluated using a hydrodynamic model of the estuary, which is calibrated with observed flows from Lutzville bridge. Thus, unless the records at Lutzville bridge are shown to be grossly incorrect, the estuarine requirements SHOULD be fairly robust with respect to changes in the synthesised hydrology. For this reason, we have opted not to adjust the estuarine requirements on the basis of changes made to the hydrology during the Classification project, and the estuary flow requirements provided in Section 9.2 are taken directly from DWAF (2006b).

2.2.9 Temporal scale of the "balance sheet" tool

The "balance sheet" tool was updated on the basis of activities explained in Sections 2.2.1 to 2.2.6. It was also extended to allow for "balancing" at a monthly time-step. This enabled a more refined level of balancing, but more importantly meant that minimum lowflow requirements could be set (e.g., see Section 2.2.6).

2.2.10 Balancing the "balance sheet" tool

The Reserve requirements for different reaches of river are set, in the first instance, to maintain a target ecological category in that section. Thus, the volumetric and distribution requirements tend to differ from reach to reach. This is particularly evident in a frequent mis-match between the estuary and the river reach immediately upstream thereof.

The Classification Process requires that the Reserve allocations that are gazetted are sufficient to meet the river reach to which the reserve is allocated as well as sufficient to meet that reach's contribution to the allocations in the downstream reaches.

This means that, in some areas, such as the Kouebokkeveld where the rivers are impacted by development at the top of the catchment, the Reserve alllocations will be higher than those required to maintain the condition of those river reaches.

In an effort to reduce the off-stream impacts of elevated Reserve allocations, and in recognition of the fact that many of the downstream reaches are in good ecological condition under their current (2011) flow conditions, any additional water required to meet downstream Reseve allocations was first sourced by increasing the Reserve requirements in undeveloped tributaries, and by limiting increases in more developed areas to the winter months.

Where winter allocations were increased to approximate 2006 flows, July, August and September were targeted, as farms dams tend to delay the onset of first winter flows (June) and reduce the duration of the winter (October). So higher Reserve requirements in July, August and September should not reduce the existing yield from farm dams. Also, the total Reserve allocations are lower than the 2006 flows.

2.2.11 Management Class

In terms of the WRCS, Management Classes apply only to Intergrated Units of Analysis (Dollar *et al*. 2010). There are no Management Classes for quaternaries.

2.2.12 .tab, .rul and .mrv files

The hydrological RQOs in this report only present the .tab files. The associated .rul and .mrv files are available electronically but are not particularly useful in the context of the WMA. The reasons for this are:

1. The synthesised hydrology for the Olifants-Doorn WMA has been adjusted approximately six times in the last 10 years. All the files for river nodes are calculated proportional to the naturalised hydrological input data. Thus, if the estimated naturalised flows at a node are higher, then the hydrological RQOs will be higher. Conversely, if the estimated flows are lower, then the hydrological RQOs will be lower tan those given.
2. The percentage nMAR represented by the .rul and .mrv files is highly dependent on the parameters chosen in the Desktop Model. For instance, the assurance values used to create the .rul and .mrv files from the .tab data, can greatly influence the longterm average of the Reserve requirement. The Western Cape recommended (default) assurance value for the

maintenance lowflows is 145, whereas that for the Drakensberg is 120. The 145 returns a higher longterm percentage MAR than does the 120. In some cases, as much as 75% higher than the recommended value in the .tab file.

3. There are currently very few guaging stations in the Olifants-Doorn WMA, which means that it is not possible to monitor the full range of Reserve flows. Nor is it possible to find a gauge with an unimpacted flow regime that can be used as a reference for naturalised flow.[2] Furthermore, if such a gauge was found or constructed, new .rul curves would need to be constructed for every quaternary that used it as a reference.
4. There is only one dam in the Olifants-Doorn WMA, Clanwilliam Dam, which can make flood releases, and the releases from Clanwilliam have been specifically designed to facilitate its role as an irrigation dam (see Section 11.2). Thus, Reserve flood requirements cannot be managed other than by limiting the number of small farm dams, and as such there is little or no need for .rul or .mrv files.

2.2.13 Monitoring of RQOs

The detailed RQOs for the priority RUs provide possible monitoring locations for monitoring the RQOs in individual RUs. These are only suggestions and the locations may be adjusted according to the requirements of ongoing or forthcoming monitoring programmes. Although there are several ongoing monitoring activities in the WMA, details about locations and frequency of sampling are often unclear. Where possible, these have been taken into account in setting the RQOs and recommending the monitoring locations. A review of these monitoring initiatives, and rationalisation of some activities and expansion of others, would greatly benefit water-resource management in the WMA, but is beyond the scope of this project.

2.3 WETLANDS

There are many wetlands of a variety of types in the Olifants-Doorn WMA; several clusters of which (approximately 25 000 ha) have been identified as National Freshwater Ecosystem Priority Areas (NFEPAs) (Nel *et al. 2*011). However, given the current level of information available for these wetlands, it is unrealistic to try to define RQOs for each individual wetland. It is also probably not feasible to monitor or impose such RQOs. Thus, this study followed the DWA recommendations for identifying appropriate levels of RQO determination for wetlands (DWA 2012c).

In terms of DWA (2012c) specific RQOs should be set for 'priority' wetlands, where data are available and where the level of threat is very high, and/or high risk water-uses are in place or proposed. Desktop data were used to idenitfy priority wetland areas and to develop RQO's for monitoring their condition.

Existing data on wetlands in the WMA that were used to develop specific RQOs included:

NFEPA data on wetlands: Nel et al (2011) attempted an automated classification and prioritisation of South African wetlands. These date provide the NFEPA location and priority status of the wetlands within the WMA. The location of wetlands fairly accurate but the size (extent) and type (HGM wetland type) of wetlands is not. This is due the the limitations of the underlying wetland map and automation and modelling limitations for determining wetland types.

C.A.P.E. fine scale planning: This study provided higher resolution and more accurate mapping of the priority wetland areas within the study area. This initial mapping was updated and

[2] The comprehensive Reserve studies had to use a gauge in the Twenty-fours River catchment (Berg WMA) to disaggregate the monthly modelled flows in the Olifants River (DWAF 2006).

refined in the subsequent Mondi Wetland Project assessments (Job et al, 2011), described below.

Mondi Wetlands Project (2010): A combination of desktop and field-based assessments of the extent of intact wetlands and PES was done by wetland experts from the Mondi Wetlands Programme in 2010 (Job et al. 2011). These data provided information relating to the extent and condition of priority wetlands and were used to generate RQO's for priority wetlands in the WMA.

2.3.1 Prioirity wetland clusters

Two priority wetland clusters were identified based on their NFEPA conservation value, the threats on the extent and condition of the wetlands posed by adjacent landuse activities and the availability of baseline data to develop and enable monitoring of RQOs. These are:

- Sandlaagte (G30H quaternary catchment), and;
- Nieuwoudtville (E32E and E40C quaternary catchments).

2.4 GROUNDWATER

Two separate sets of groundwater RQOs are developed; i.e. catchment specific RQOs to maintain the required groundwater contribution to the Ecological Reserve, which is assumed to equal the required maintenance low flow, and aquifer specific RQOs for selected RUs to ensure the minimum requirements for groundwater contribution to the surface water bodies are met. The latter will be either qualitative and or quantitative and cover both the required groundwater discharge and groundwater quality.

1. Infiltration from aquifers into surface water bodies is crucial for their hydrological integrity. Therefore a possible RQO might be to stipulate a hydraulic gradient to be maintained, or a minimum water level at a specified distance from the surface water body.
2. The Present State of selected indicators is based on existing monitoring data, where available. If sufficient data is not available, extrapolation from other areas and or geological reasoning is used.
3. In terms of the priority set of groundwater relevant RUs, availability of or suitability for groundwater measurements is deemed to be an over-riding consideration in the selection of sites. This is because, even though Reserve data may be available for a site, if it cannot be monitored at that site then implementation of the Reserve cannot be assessed.
4. The applicable scale of the RQOs depends upon the number of aquifers contributing significantly to the river flow.
5. The RQOs and appropriate nunmerical limits are based on what information is available, various specialist reports and estimations using geological reasoning.

The focus of the groundwater RQOs is twofold; i.e.

- to support the ecological requirements of the receiving surface water bodies, as determined by the surface water RQOs, and
- to ensure adequate water quality for the direct and indirect users of the groundwater resource.

The most important aspect of the hydrogeological regime in terms of implementing the Reserve is to ensure that the contribution from groundwater supports the minimum dry season lowflows.

The present status (PS) for groundwater as given in the Classification project (DWA 2012a) was updated for each quaternary catchment during an expert workshop held on 4 and 5 October 2012. It

was further agreed that no recommended categories (RC) for groundwater resources will be specified, as there is no guideline and current recommendations are not aimed at maintaining the ecological requirements in the receiving surface water bodies. The updated PSs are documented in Appendix B.

The detailed RQOs for the priority groundwater RUs provide generic recommendations for a possible monitoring network to enable the monitoring of RQOs in individual RUs. These are only suggestions and the locations may be adjusted according to the requirements of ongoing or forthcoming monitoring programmes. Where possible, existing monitoring networks have been taken into account in setting the RQOs and recommending additional monitoring locations.

2.5 INTEGRATED UNITS OF ANALYSIS

The IUAs remained the same as the Classification project (Figure 2.1).

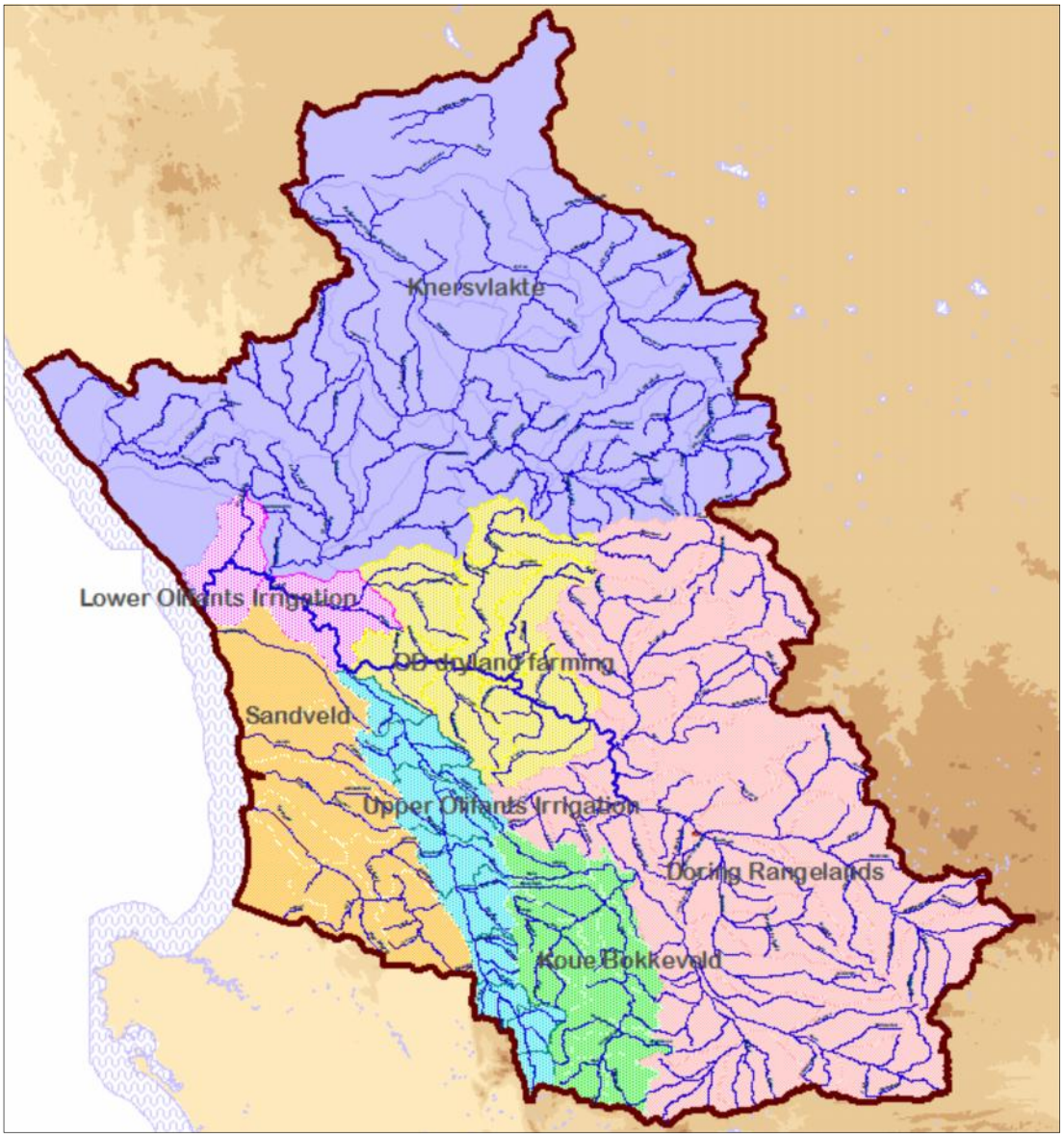

Figure 2.1 Integrated Units of Analysis for the Olifants-Doorn WMA.

3 OUTCOME OF THE CLASSIFICATION PROCESS

The categories for the quaternary catchments and associated management Classes for the IUAs in the Olifants-Doorn WMA recommended by the Classification project (DWA 2012a) are provided in Table 3.1. The Olifants-Doorn IUAs are shown in Figure 2.1. The requirements for ecological condition for the three Management Classes are given in Table 3.2. The adjustments required are discussed in the next section.

Table 3.1 Summary of river and estuary Categories (EC) and IUA Management Classes (MC) from the Classification project (DWA 2012a).

IUA	MC for IUA	Quat	River name	Mainstem EC	Tributary EC* (% of Incremental quat area)	Wetland area (WA) and EC*
Upper Olifants Irrigation	III	E10A	Olifants	C	C	-
		E10B	Olifants	C	C (80%); AB (20%)	-
		E10C	Olifants	C	AB (100%)	WA 1.2% of quat, 85% in AB
		E10D	Olifants	C	C (70%); AB (30%)	WA 5.4% of quat, 16% in AB
		E10E	Olifants	C	C (60%); AB (40%)	WA 5.8% of quat, 10% in AB
		E10F	Olifants	D	C (40%); AB (60%)	-
		E10G	Olifants/ Rondegat		C (70%); AB (30%)	-
		E10G	Olifants main	D	C (70%); AB (30%)	-
		E10H	Jan Dissels	D	D (95%); AB (5%)	WA 3.3% of quat, 10% in AB
		E10J	Olifants	D	D (80%); AB (20%)	WA 1.1% of quat, 5.5% in AB
		E10K	Olifants	D	D (95%); AB (5%)	WA 1.9% of quat, 50% in AB
Koue Bokkeveld	II	E21A	Kruis	D	C	-
		E21B	Welgemoed	D	D	-
		E21C	Winkelhaak	C	B	WA 0.5% of quat, 98% in AB
		E21D	Houdenbeks	D	D (95%); AB (5%)	-
		E21E	Riet	C	C (30%); AB (70%)	-
		E21F	Riet	C	C	WA 0.001% of quat, 91% in AB
		E21G	Groot/Leeu	D	D (95%); AB (5%)	-
		E21H	Groot/Leeu	AB	B (40%); AB (60%)	-
		E21J	Groot	AB	AB (100%)	-
		E21K	Maatjies	B	AB (100%)	WA 1.7% of quat, 99% in AB
		E21L	Groot	AB	AB (100%)	-
Doring Rangeland	I	E22A	Doring	B	AB	-
		E22B	Doring	AB	AB (16%)	-
		E22C	Tankwa	AB	AB (5%)	-
		E22D	Tankwa	B	AB (95%)	-
		E22E	Doring	B	AB (30%)	-
		E22F	Doring	B	AB (100%)	-
		E22G	Doring	C	AB (100%)	WA 0.3% of quat, 100% in AB
		E23A	Tankwa	AB	AB	WA 0.1% of quat, 100% in AB
		E23B	Tankwa	AB	AB (20%)	WA 0.1% of quat, 100% in AB
		E23C	Tankwa	AB	AB	WA 0.001% of quat, 100% in AB
		E23D	Tankwa	AB	AB	WA 0.7% of quat, 100% in AB
		E23E	Tankwa	B	AB (20%)	-
		E23F	Tankwa	B	B	WA 0.001% of quat, 100% in AB
Doring Rangeland (contd)	I	E23G	Ongeluks	B	B (95%), AB (5%)	-
		E23H	Ongeluks	AB	AB (5%)	-
		E23J	Ongeluks	B	AB (40%)	-
		E23K	Tankwa	B	AB (30%)	-
		E24A	Tra-tra	B	AB (100%)	WA 0.1% of quat, 100% in AB
		E24B	Tra-tra	B	B (50%); AB (50%)	WA 0.001% of quat, 95% in AB
		E24C	Bos	C	B	WA 0.8% of quat, 100% in AB
		E24D	Bos	C	B	WA 0.1% of quat, 100% in AB
		E24E	Wolf	AB	AB (5%)	-
		E24F	Wolf	B	AB	WA 0.001% of quat, 79% in AB
		E24G	Wolf	B	AB (40%)	WA 0.001% of quat, 100% in AB
		E24H	Doring	C	AB	-
		E40A	Oorlogskloof	C	C (90%); AB (10%)	-
		E40B	Oorlogskloof	C	C (70%); AB (30%)	WA 0.001% of quat, 100% in AB

IUA	MC for IUA	Quat	River name	Mainstem EC	Tributary EC* (% of Incremental quat area)	Wetland area (WA) and EC*
Knersvlakte	I	E31A	Kromme	B	B (85%); AB (15%)	WA 0.3% of quat, 100% in AB
		E31B	Kromme	B	B (10%); AB (90%)	WA 0.1% of quat, 99% in AB
		E31C	Kromme	B	B (65%); AB (35%)	WA 0.001% of quat, 100% in AB
		E31D	Kromme	B	B	-
		E31E	Kromme	B	B	-
		E31F	Kromme	B	B	-
		E31G	Kromme	B	B (90%); AB (10%)	-
		E31H	Hantams	B	B (80%); AB (20%)	-
		E32A	Hantams	B	B (85%); AB (15%)	WA 0.1% of quat, 95% in AB
		E32B	Hantams	B	B	WA 0.001% of quat, 100% in AB
		E32C	Hantams	B	B (70%); AB (30%)	WA 0.1% of quat 24% in AB
		E32D	Hantams	B	B (85%); AB (15%)	-
		E32E	Hantams	B	B (30%); AB (70%)	WA 2.2% of quat, 48% in AB
		E33A	Sout	B	B (60%); AB (40%)	WA 0.001% of quat, 100% in AB
		E33B	Sout	B	B (95%); AB (5%)	WA 0.2% of quat, 100% in AB
		E33C	Sout	D	D (95%); AB (5%)	WA 1.1% of quat, 92% in AB
		E33D	Sout	B	B (65%); AB (35%)	-
		E33E	Sout	C	B (75%); AB (25%)	WA 1% of quat, 99% in AB
		E33F	Hol	D	D	-
		F60A	Brak	B	B	WA 0.001% of quat, 1% in AB
		F60B	Klein Goerap	B	B	-
		F60C	Sout	B	B	WA 0.001% of quat, 1% in AB
		F60D	Groot Goerap	B	B	WA 0.001% of quat, 3.5% in AB
		F60E	Groot Goerap	B	B	WA 0.001% of quat, 19% in AB
Lower Olifants Irrigation	III	E33G	Hol	D	C	WA 1.9% of quat, 13% in AB
		E33H	Olifants	D	B (95%); AB (5%)	WA 3.8% of quat, 5% in AB
		E33H	Olifants estuary	C		
Olifants/ Doring Dryland Farming	III	E24J	Doring	C	AB (70%)	WA 0.001% of quat, 99% in AB
		E24K	Doring	C	AB (20%)	-
		E24L	Brandewyn	B	C (90%); AB (10%)	WA 0.001% of quat, 100% in AB
		E24M	Doring	C	C (40%); AB (60%)	WA 0.001% of quat, 100% in AB
		E40C	Oorlogskloof/ Koebee	D	B (25%); AB (75%)	-
		E40D	Oorlogskloof/ Koebee	B	B (30%); AB (70%)	-
Sandveld	III	G30A	Papkuils	C	C (95%); AB (5%)	WA 4.1% of quat, 35% in AB
		G30B	Kruismans	C	C (50%); AB (50%)	WA 0.9% of quat, 10% in AB
		G30C	Bergvallei	C	C (95%); AB (5%)	WA 1.5% of quat, 7% in AB
		G30D	Verlorevlei	C	C (80%); AB (20%)	WA 0.8% of quat, 3% in AB
		G30E	Verlorevlei	C	C (90%); AB (10%)	WA 7.9% of quat, 3% in AB
		G30E	Verlorenvlei Estuary	C		
		G30F	Langvlei	C	C	WA 1.5% of quat, 5% in AB
		G30G	Jakkalsvlei	C	C	WA 0.9% of quat, 11% in AB
		G30H	Sandlaagte	C	C	WA 1.4% of quat 25% in AB

* Percentage of catchment area in an AB condition relates to Freshwater Ecosystem Priority Areas mapped.

Table 3.2 Requirements for ecological condition for the Management Classes (Dollar et al. 2006)

Management Class	Description	Configuration guidelines
Class I: Minimally used	The configuration of water resources within an IUA results in an overall water resource condition that is minimally altered from its pre-development condition.	At least 60% of the freshwater ecosystems in a sub-basin are in an A or B category.
Class II: Moderately used	The configuration of water resources within an IUA results in an overall water resource condition that is moderately altered from its pre-development condition.	At least 40% of the freshwater ecosystems in a sub-basin are in an A or B category.
Class III: Heavily used	The configuration of water resources within an IUA results in an overall water resource condition that is significantly altered from its pre-development condition.	No requirement for A or B categories

4 UPDATED CONFIGURATION

Relatively few changes were made to the configuration recommended by the Classification Process. The Management Class are unchanged (see Table 3.1). The reasons for the other changes are given in Section 2.

Also, to meet the requirements of this project, several additional nodes were added:

- six nodes were added based on the disaggregation of the Kouebokkeveld (CAPE 2009);
- four nodes were added to include E31A, F60A, F60E, G30H;
- a node was added at the outlet of quaternary E33F, which is also an outlet of the Olifants-Doring dryland farm IUA, to align RU boundaries with IUA boundaries (RU9 now represents E33G);
- RU24 was split into two RUs (i.e. two RUs were added) to align with the Compulsory Licensing Study for the Jan Dissels River (DWAF 2008), as follows:
    - RU24 (in E10H) - from Boskloof to the DWA gauging weir (E1H006) at the quaternary outlet;
    - Q7 (in E10J) – E1H006 to confluence with Olifants.

The updated river and estuary ecological categories for the quaternaties based on the activities listed in Section 2.1 are provided in Table 4.1.

4.1 OVERARCHING IMPLICATIONS OF THE RECOMMENDED CONFIGURATION

4.1.1 Olifants-Doring Basin

The recommended configuration takes account of the dichotomy brought about by human utilisation of the area can be summarised as follows:

- Maintain the ecological integrity of the Doring River, and in so doing ensure sustainable utilisation of the Olifants estuary, i.e., no dams in the Doring or Groot Rivers.
- Maintain the ecological integrity of key tributaries on both the Olifants and Doring Rivers, thereby ensuring variability of flow, as well as provision of refuges and source areas, i.e., ensure perennial contact between tributaries and amin rivers as appropriate.
- Undertake some river rehabilitation aimed at reducing non-flow related impacts in the mainstem Olifants River between the Olifants Gorge and Clanwilliam Dam, thereby improving overall river condition in this reach.
- Undertake some river rehabilitation aimed at reducing water quality impacts in the mainstem Olifants River downstream of the confluence with the Doring River. This would also improve the quality of water entering the estuary.
- Undertake minor estuary rehabilitation measures, mainly aimed at controlling over-fishing.
- Keep Reserve releases from Clanwilliam Dam and Bulshoek Barrage to a minimum, so that water supply from Clanwilliam Dam and Bulshoek Barrage is maximised.

Note: The recommended configuration pre-supposes **no major developments in the Doring River**, as this water is required to maintain the Doring River in a good ecological condition (B-category) and maintain the C-category in the estuary.

4.1.2 Sandveld

The recommended configuration takes account of the need to redress past environmental degradation in the catchment, mainly through the control of groundwater use.

Table 4.1. Updated river and estuary ecological categories

	Incremental	Cumulative
E10A	C	C
E10B	B	C
E10C	B	B
E10D	C	D
E10E	C	D
E10F	C	D
E10G	C	D
E10G-Rond	B	B
E10H	C	C
E10J	C	D
E10J-Q7	D	D
E10K	C	D
E21A	C	C
E21B	D	D
E21C	B	C
E21D	D	D
E21E	B	B
E21F	B	B
E21G	D	D
E21H	B	B
E21J	B	B
E21K	B	B
E21L	B	B
E22A	B	B
E22B	B	B
E22C	AB	AB
E22D	AB	AB
E22E	B	B
E22F	B	B
E22G	B	B
E23A	AB	AB
E23B	AB	AB
E23C	AB	AB
E23D	AB	AB
E23E	AB	AB
E23F	AB	B
E23G	AB	AB
E23H	AB	AB
E23J	AB	AB
E23K	AB	B
E24A	B	B
E24B	B	B
E24C	AB	C
E24D	AB	C
E24E	AB	AB
E24F	AB	AB
E24G	AB	AB
E24H	B	B
E24J	B	B
E24K	B	B
E24L	B	B
E24M	B	B
E31A-Q2	B	B
E31B	B	B
E31C	B	B
E31D	B	B
E31E	B	B
E31F	B	B
E31G	B	B
E31H	B	B
E32A	B	B
E32B	B	B
E32C	B	B
E32D	B	B
E32E	B	B
E33A	B	C
E33B	B	C
E33C	C	C
E33D	C	C
E33E	C	C
E33F-Q1	D	D
E33G	C	D
E33H	B	D
E40A	C	C
E40B	C	C
E40C	B	C
E40D	B	B
F60A	B	B
F60B	B	B
F60C	B	B
F60D	B	B
F60E	B	B
G30A	C	C
G30B	C	C
G30C	C	C
G30D	C	C
G30E	C	B
G30F	C	C
G30G	C	C
G30H	C	C

5 HYDROLOGICAL RQOS - STANDARD ECOLOGICAL RESERVE DATA FOR UPDATED RECOMMENDED CONFIGURATION

Standard Ecological Reserve .tab files (Table 5.1) for updated recommended configuration are provided for the cumulative and incremental flow at the boundary of every sub-quaternary listed in Table 4.1 (see Appendix A). The corresponding .rul and .wrv files were also generated and are provided electronically.

An example of a standard Reserve data .tab file is given in Table 5.1 . The .tab files provide the annual volume of water required in millions of cubic metres (e.g. 1.045 MCM) and the percentages of the natural MAR (17.64%) of the river at that point (incrementally or cumulatively depending on the input data), and monthly volumes for the low-flow and high-flow requirements. Summary monthly values are also provided. All the relevant .tab files are provided in Appendix A.

Table 5.1 Example of the standard Ecological Reserve .tab file data provided (See Appendix A)

E23E

Desktop Version 2, Generated on 2011/08/06
Summary of Desktop (Version 2) estimate for Quaternary Catchment Area :
Total Runoff : Runoff :

Annual Flows (Mill. cu. m or index values):

MAR	=	5.922
S.Dev.	=	9.403
CV	=	1.588
Q75	=	0.000
Q75/MMF	=	0.000
BFI Index	=	0.169
CV(JJA+JFM) Index	=	6.574

Ecological Category = C

Total IFR	=	1.045 (17.64 %MAR)
Maint. Lowflow	=	0.314 (5.30 %MAR)
Drought Lowflow	=	0.000 (0.00 %MAR)
Maint. Highflow	=	0.731 (12.34 %MAR)

Monthly Distributions (Mill. cu. m.)
Distribution Type : W.Karoo

Month	Natural Flows			Modified Flows (IFR)			
				Low flows		High Flows	Total Flows
	Mean	SD	CV	Maint.	Drought	Maint.	Maint.
Oct	0.095	0.305	3.212	0.007	0.000	0.000	0.007
Nov	0.236	0.858	3.639	0.013	0.000	0.029	0.042
Dec	0.303	0.896	2.953	0.016	0.000	0.038	0.054
Jan	0.239	0.838	3.506	0.013	0.000	0.000	0.013
Feb	0.150	0.701	4.675	0.009	0.000	0.000	0.009
Mar	0.134	0.401	2.983	0.008	0.000	0.000	0.008
Apr	0.513	1.590	3.098	0.027	0.000	0.064	0.090
May	0.756	2.017	2.668	0.039	0.000	0.094	0.133
Jun	1.349	4.104	3.042	0.068	0.000	0.315	0.383
Jul	1.347	4.118	3.057	0.069	0.000	0.094	0.163
Aug	0.551	1.357	2.461	0.031	0.000	0.067	0.098
Sep	0.248	0.893	3.594	0.015	0.000	0.030	0.045

Part II: Prioritisation and Resource Unit evaluation

6 PRIORITISATION OF RESOURCE UNITS

RQOs over and above the standard Ecological Reserve hydrological data are only generated for prioiry resource units/sub-quaternaries.

To facilitate the standard selection of prioiry resource units/sub-quaternaries, a Resource Unit Prioritisation Tool was developed (DWA 2011), which uses criteria, ratings and weights to assist in prioritization of RUs for which RQOs should be developed. Separate Resource Unit Prioritisation Tools were applied in this project for rivers and estuaries; for groundwater, and; for wetlands, as different criteria and weights are relevant to different types of systems. Adjustments were made to the Resource Unit Prioritisation Tools as described In Section 6.1. .The resultant priority RUs from each were then combined to arrive at the final set of priority RUs.

The tool was not used for wetlands because the development of RQOs for wetlands was constrained entirely by the limited available data, i.e. the available data dictated the form of the RQOs (see Section 2.3). The criteria used to identify key wetland clusters for RQO purposes were:

- the conservation (FEPA) priority status assigned to the wetlands (important wetlands were identified from existing Freshwater Ecosystem Priority Area (FEPA) assessments. Nel *et al* (2011) identified several clusters of wetlands that, primarily because of their biodiversity attributes, are considered national priorities for conservation);
- the amount and level of available data to enable the development, implementation and monitoring of RQOs for these wetlands, and;
- the risks or threat to individual wetlands, which may make monitoring a priority.

6.1 ADJUSTMENTS TO THE RESOURCE UNIT PRIORITISATION TOOLS

6.1.1 Criteria

6.1.1.1 Rivers and estuaries

The criteria and rating guidelines provided in the Resource Unit Prioritisation Tool are shown in Table 6.1. These were adjusted as follows:

- Fine-scale planning sub-criterion (Criterion 4; Table 6.1) was omitted from the prioritisation because:
  - in the Olifants-Doorn WMA the fine-scale planning and FEPA coverages tend to overlap to a large extent, which results in double counting, and;
  - fine-scale planning data were not available for the whole WMA.
- Correction to the sub-criterion "RUs with PES lower than D category or lower than accepted gazetted category" (NEC; Criterion 6; Table 6.1). In the mode, the rating guidelines for a score of 0 referred to C category. It was assumed that the rating guideline should read D category, and the model was adjusted accordingly.

In addition:

- An additional rule was applied to ensure that at least one RU was selected per IUA.
- The default weights were adjusted (Figure 6.1).

Table 6.1 Criteria, sub-criteria and ratings for the prioritisation of RUs (from DWA 2011).

No.	Criterion	Sub-criteria	Rating Guideline
1	Position of resource unit within IUA	RUs located on a large mainstem river at downstream end of an IUA (IUA outlet node)	0 - RUs not associated with keystone sites 1 – RU on mainstem river and at base of IUA
2	Importance for users (current & anticipated future use)	RUs that provide important cultural services to society	0 - RUs with no known / limited provision of cultural services 0.5 - RUs providing some cultural services 1 - RUs providing very important or numerous cultural services
		RUs that are important in supporting livelihoods of significant vulnerable communities	0 - RUs that do not support / provide limited support for vulnerable communities 0.5 - RUs providing some support for vulnerable communities 1 - RUs playing an important role in supporting vulnerable communities
		RUs that are important in meeting strategic requirements and international obligations	0 -RUs not used for strategic purposes nor to meet international obligations 0.5 -RUs moderately important for strategic purposes or are somewhat useful for verifying compliance with international obligations 1 - RUs extremely important for strategic purposes or are ideally suited for verifying compliance with international obligations
		RUs that provide supporting and regulating services	0 - RUs that supply limited supporting & regulating services 0.5 - RUs that supply moderate supporting & regulating services 1 - RUs that supply extensive supporting & regulating services
		RUs most important in supporting activities contributing to economy (GDP, job creation) in catchment (e.g. commercial agriculture, industrial abstraction, bulk abstraction by water authorities)	0 - RUs that do not directly support any activities which contribute to economy 0.5 - RUs that support activities which provide a moderate contribution to economy 1 - RUs that support activities which contribute significantly to the economy
3	Threat posed to users	Level of threat posed to users	0 - RUs where potential threat to users is low 0.5 - RUs where potential threat to users is moderate 1 - RUs where potential threat to users is high
4	Ecological Importance	RUs with a high or very high EIS category	0 - RUs with a low or moderate EIS Category 0.5 - RUs with a high EIS Category 1 - RUs with a very high EIS Category
		RUs that have an A/B NEC and / or PES	0 - RUs with a PES or NEC lower than a B Category 0.5 - RUs with a PES or NEC in a B Category 1 - RUs with a PES or NEC in an A or A/B Category
		RUs identified as National Freshwater Ecosystem Priority Areas (FEPAs)	0 - RUs that are not identified as a priority area 0.5 - RUs located within 'Freshwater Ecosystem Support Areas' 1 - RUs located within 'Freshwater Ecosystem Priority Areas'
		RUs identified as a priority in provincial / fine scale aquatic biodiversity plans	0 - RUs with a low irreplaceability value (0 - 0.5) 0.5 - RUs with a moderate Irreplaceability value (0.51-0.99) or located within 'Ecological Support Areas' 1 - RUs that are irreplaceable (IR=1) or are located within 'Critical Biodiversity Areas'.

No.	Criterion	Sub-criteria	Rating Guideline
5	Threat faced by ecological component of RU	Level of threat posed to ecological components of the RU	0 - RUs where potential threat to ecological components is low 0.5 - RUs where potential threat to ecological components is moderate 1 - RUs where potential threat to ecological components is high
6	Management Considerations	RUs with PES lower than D or lower than accepted gazetted category (NEC)	0 - RUs with a PES higher than a D Category or a PES higher than the NEC 1 - RUs with a PES lower than a D Category or a PES lower than the NEC
7	Practical Considerations	Availability of EWR or other data (RHP, DWAF gauging weirs, etc.) located within reach?	0 - RUs where no resource quality information exists 0.5 - RUs for which a moderate level of resource quality information exists 1 - RUs for which there is a good availability of resource quality information
		Accessibility of RU for monitoring	0 - RUs with very poor accessibility 0.5 - RUs with moderate accessibility 1 - RUs with good accessibility
		Safety risk associated with monitoring RU	0 - RUs that are not safe to monitor 0.5 - RUs where safety is questionable 1 - RUs where safety is not a concern

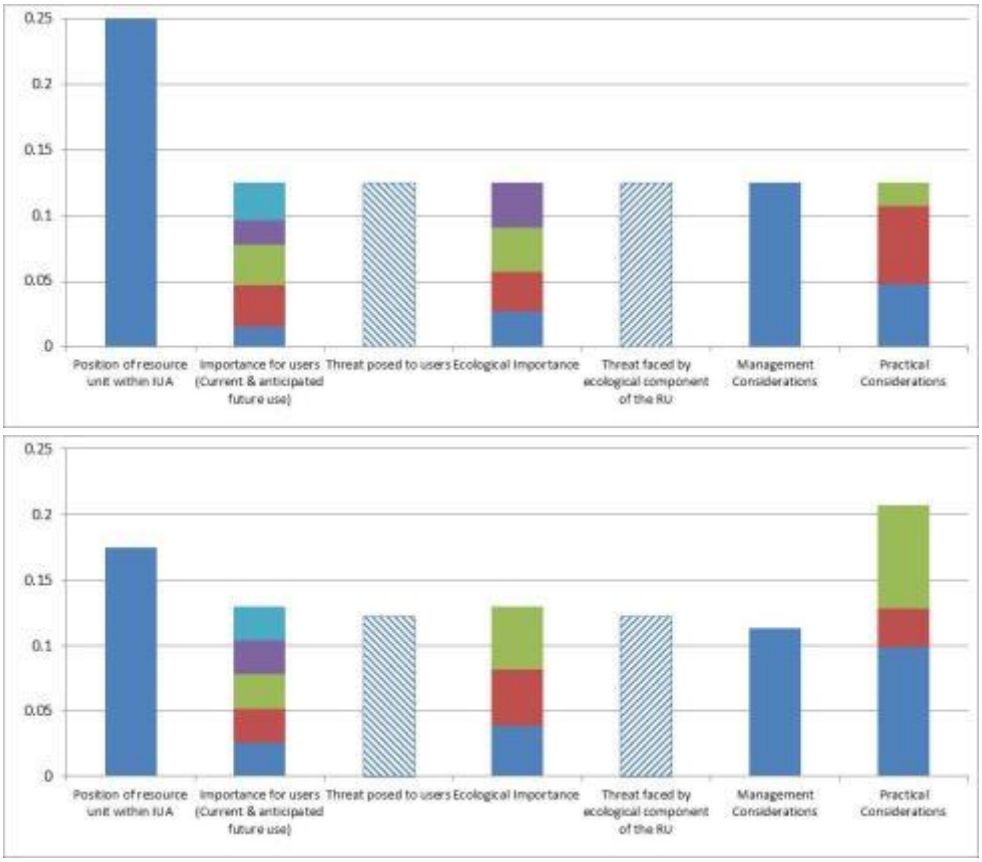

Figure 6.1 **Original criteria weights provided in the RU prioritization tool (top) and adjusted weights as used for rivers in this project (bottom). The colours refer to the sub-criteria listed in Table 6.1.**

6.1.1.2 Groundwater

The criteria and rating guidelines provided in the Resource Unit Prioritisation Tool were adjusted to make them more appropriate for groundwater (Table 6.2), as follows:

- **Importance for users**: Some aquifers in the WMA provide significant services for the environment and other users. The importance for users was evaluated with respect to the current and possible future use by the different water sectors. The direct or indirect contribution to other services such as regulating floods, buffering against droughts, maintaining ecological integrity etc. is covered by the surface water – groundwater interaction (see below).
- **Threat posed to users**: Depending on the pattern and scale of groundwater abstraction as well as the land use within the resource units the different aquifers might be at risk of over-abstraction (indicated by aquifer stress and decline in water level) and or pollution (indicated by decline in water quality), both of were considered in the prioritisation. A further threat to be considered is the lack or paucity of aquifer monitoring and management. Whether the impact is measured or inferred from the landuse activities was not relevant for the scoring.
- **Practical considerations**: RQOs can only be implemented and enforced if they can be measured. Hence, the focus was on identifying resource units with a sufficient groundwater monitoring network and existing baseline data to allow for comparison with data collected in the future.
- **Level of surface water – groundwater interaction**: Depending on the aquifer type and its interaction with surface water bodies it has greater or lesser relevance for maintaining the hydrological integrity and water quality of the ecosystem. The aquifer types occurring in the RU and their contribution to surface water lowflows were considered, as these could impact on possible management options.

Table 6.2 Criteria and sub-criteria for the prioritisation of RUs, considering the groundwater aspect (adapted from DWA 2011).

Criterion	Weight	Sub-criteria	Weight	Rating guidelines
Importance for users (current and anticipated future use)	20	RUs that are important in supporting livelihoods of significant vulnerable communities	50	0 – RUs that do not support / provide limited support for vulnerable communities 0.5 – RUs providing some support for vulnerable communities 1 – RUs playing an important role in supporting vulnerable communities
		RUs most important in supporting activities contributing to economy (GDP, job creation) in catchment (e.g. agricultural or industrial abstraction, bulk abstraction by water authorities)	50	0 – RUs that do not directly support any activities which contribute to economy 0.5 – RUs that support activities which provide a moderate contribution to economy 1 – RUs that support activities which contribute significantly to the economy
Threat posed to users	30	Medium to Long-term decline in natural water or piezometric levels	20	0 – RUs where potential threat to users is low 0.5 – RUs where potential threat to users is moderate 1 – RUs where potential threat to users is high
		Medium to Long-term decline in natural water quality	20	0 – RUs where potential threat to users is low 0.5 – RUs where potential threat to users is moderate 1 – RUs where potential threat to users is high
		Paucity of monitoring and management system	40	0 – RUs where potential threat to users is low 0.5 – RUs where potential threat to users is moderate 1 – RUs where potential threat to users is high

Criterion	Weight	Sub-criteria	Weight	Rating guidelines
Practical Considerations	50	Availability of water quality monitoring data (WMS monitoring boreholes) located within RU?	20	0 – RUs where no resource quality information exists 0.5 – RUs for which a moderate level of resource quality information exists 1 – RUs for which there is a good availability of resource quality information
		Availability of water level monitoring data (DWA monitoring boreholes) located within RU?	20	0 – RUs where no resource quality information exists 0.5 – RUs for which a moderate level of resource quality information exists 1 – RUs for which there is a good availability of resource quality information
Level of surface water – groundwater interaction	40	Relevance of groundwater contribution to maintain required low flow conditions	40	0 – RUs without relevant groundwater contribution 0.5 – RUs where groundwater contribution supports low flow condition 1 – RUs where groundwater contribution is crucial to maintain low flow condition
		Relevance of groundwater contribution to maintain required water quality	30	0 – RUs without relevant groundwater contribution 0.5 – RUs where groundwater contribution supports water quality during low flow condition 1 – RUs where groundwater contribution is crucial to maintain good water quality during low flow condition
		Alluvial aquifer associated with main stem rivers with short residence time	10	0 – RUs without alluvial aquifer on mainstem 0.5 – RUs s with small alluvial aquifer on mainstem 1 – RUs with significant alluvial aquifer on mainstem
		Primary aquifer not associated with main stem rivers	10	0 – RUs without primary aquifer outside the mainstem 0.5 – RUs with small primary aquifer, not associated with mainstem 1 – RUs with significant primary aquifer, not associated with mainstem
		Fractured aquifer with long residence time (>2 years) prior to groundwater discharge	10	0 – RUs without fractured rock aquifer 0.5 – RUs with fractured rock aquifer of medium size 1 – RUs with large, fractured rock aquifer, straddling several RUs

6.2 PRIORITISATION

The final list of priority RUs is provided in Table 6.3 and comprises:

- 13 river RUs;
- two estuary RUs;
- eight groundwater RUs;
- two wetland clusters in three quaternary catchments (E32E; E40C, and; G30H).

A total of 26 priority RUs were selected for developing detailed RQOs (Table 6.3) as there was some overlap between RUs selected for rivers, groundwater and wetlands. The application of the updated Resource Unit Prioritisation Tool and the resulting prioritisation are documented in Appendix C.

Table 6.3 Priority RUs selected for development of detailed RQOs

IUA	No.	Quaternary catchment	Ground-water	Surface water		Priority RUs		
			Resource Unit	River Node	River	SW	GW	Wetlands
Lower Olifants Irrigation	1	E33H	7	E	Olifants Estuary	x		
Upper Olifants Irrigation	2	E10K	13	R13	Olifants	x		
	3	E10J	23	R23	Olifants	x		
	4	E10H	24	R24	Jan Dissel	x		
	5	E10G	34	R34	Olifants / Rondegat	x		
	6	E10E	33	R33	Olifants	x	x	
	7	E10F						
	8	E10D	40	R40	Olifants		x	
Olifants - Doring Dryland Farming	9	E24M	14	R14	Doring	x		
	10	E40D	17	R17	Koebee	x		
	11	E40C	11	R11	Oorlogskloof			X[3]
	12	E33F	Q1	Q1	Droe / Troe-troe		x	
Koue Bokkeveld	13	E21K	37	R37	Matjies	x		
	14	E21L			Groot			
	15	E21H (part)	(portion of 38)	A1	Twee	x		
	16	E21G	41	41	Leeu	x	x	
Doring Rangelands	17	E23K	27	R27	Tankwa	x		
Knersvlakte	18	E33C	8	R8	Vars			
	19	E33D			Geelbek			
	20	E33E			Hol	x		
	21	E32E	3	R3	Doring(b)[4]			X[2]
Sandveld	22	G30D	53	R53	Verlorevlei		x	
	23	G30E	52	R52	Verlorevlei / Verlorenvlei estuary	x	x	
	24	G30F	56	R56	Langvlei	x	x	
	25	G30G	57	R57	Jakkals		x	
	26	G30H	Q5	Q5	Sandlaagte			X

The locations of the priority RUs for the Olifants-Doorn WMA are shown in Figure 6.2.

[3] The Nieuwoudtville wetlands extend over these two quaternary catchments / RUs, but are dealt with as a single entity in Part III.
[4] Doring(b) refers to a different Doring to the main Doring River, which flows to the east of the Cedarberg Mountains.

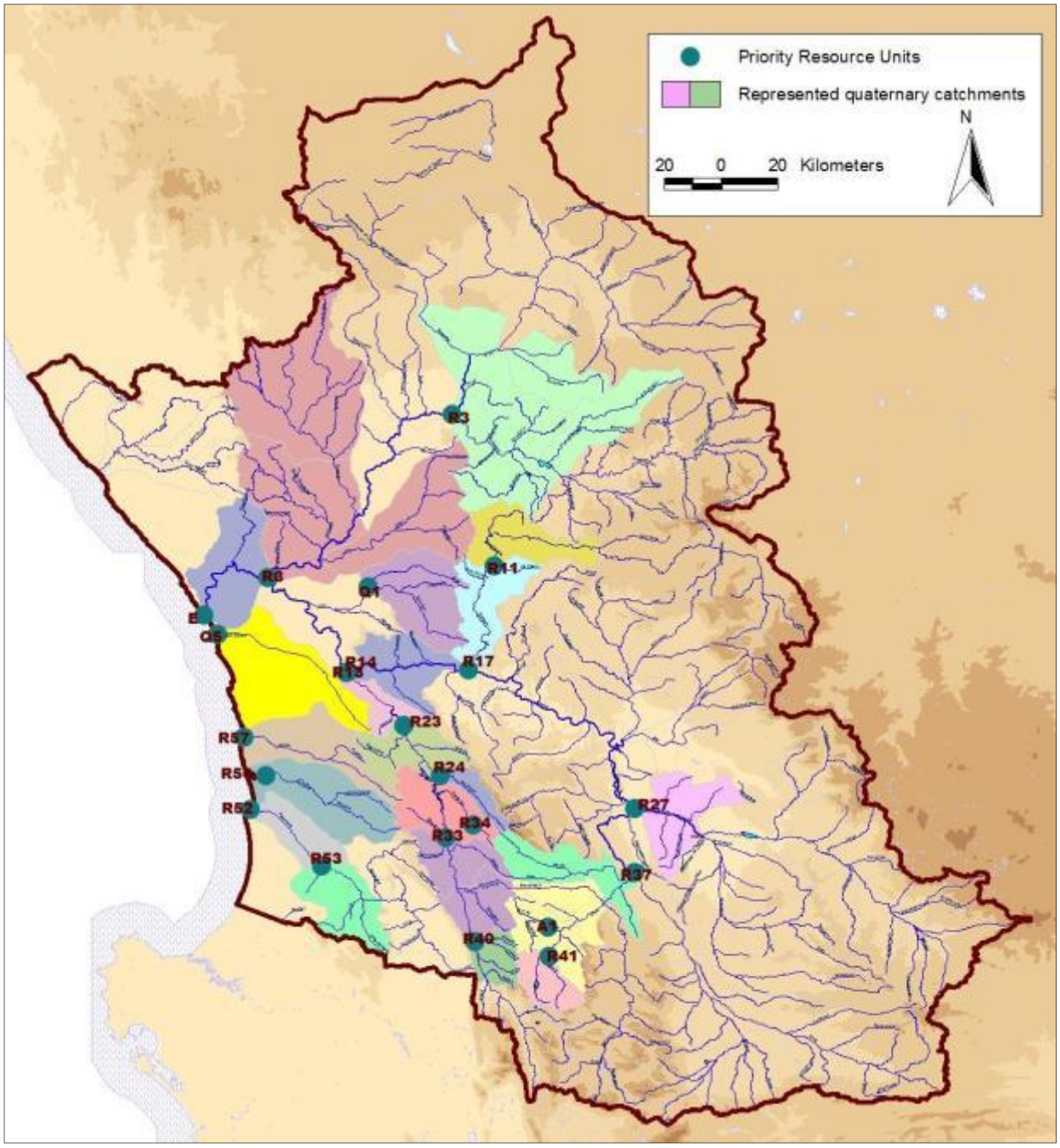

Figure 6.2 Olifants-Doorn WMA: Priority Resource Units

7 RESOURCE UNIT EVALUATION

7.1 RQO-RELATED INFORMATION AVAILABLE FOR RUS

The information for developing RQOs is patchy and spatially uneven for non-hydrological RQOs in rivers, and for groundwater and wetlands. This has implications for the detail at which some of the RQOs could be presented. In addition, there are some areas where the outcomes of the Classification project were insufficiently resolved for the RQOs to be developed without additional field work, data analysis and ground-truthing, which were outside the ToR for this project.

7.2 RESOURCE UNIT EVALUATION TOOL

The Resource Unit Evaluation Tool (DWA 2011) was used to decide which RQOs were relevant within each of the prioritised RUs. The options for RQOs as listed in the Resource Unit Evaluation Tool are shown in Table 7.1. The detailed steps of the Resource Unit Evaluation Tool per RU are documented in Appendix D (Data CD).

Table 7.1 RQOs listed in the Resource Unit Evaluation Tool (DWA 2011)

Rivers	
Quantity	Low Flows (Maintenance Flows)
	High Flows (Floods)
Quality	Nutrients
	Salts
	System variables
	Toxics
	Pathogens
Habitat	Instream habitat
	Riparian Habitat
Biota	Fish
	Aquatic & riparian plant species
	Mammals
	Birds
	Amphibians & reptiles
	Periphyton
	Aquatic Invertebrates
	Diatoms

Wetlands	
Quantity	Water inputs
	Water distribution and retention patterns
Quality	Nutrients
	Salts
	System variables
	Toxics
	Pathogens
Habitat	Geomorphology
	Wetland Vegetation
Biota	Fish
	Plant species
	Mammals
	Birds
	Amphibians & reptiles
	Periphyton
	Aquatic Invertebrates
	Diatoms

Estuaries	
Quantity	Low Flows
	High Flows (Floods)
Hydro-dynamics	Mouth Condition
	Abiotic states
Quality	Salinity
	Dissolved inorganic nitrogen
	Dissolved inorganic phosphate
	Water clarity
	Dissolved oxygen
	Toxic substances
	Pathogens
Physical Habitat	Intertidal
	Subtidal
	Substrate type
Biota	Microalgae
	Macrophytes
	Invertebrates
	Fish
	Birds

7.2.1 Rivers

Fifteen river reaches and the estuary were assessed using the Resource Unit Evaluation Tool. This resulted in the selection of the RQOs listed in Table 7.2.

Table 7.2 Summary of RQOs selected for the river priority RUs

Node	Quat.	River	Low Flows (Maintenance)	High Flows	Nutrients	Salts	System variables	Toxics	Pathogens	Instream habitat	Riparian Habitat	Fish	Aquatic & riparian plant s	Mammals	Birds	Amphibians & reptiles	Periphyton	Aquatic Invertebrates	Diatoms
E	E33H	Estuary	Y	Y	Y	Y	Y					Y	Y		Y		Y	Y	
R13	E10K	Olifants	Y	Y	Y	Y	Y			Y		Y	Y					Y	
R23	E10J	Olifants	Y	Y	Y	Y	Y					Y							
R24	E10H	Jan Dissels	Y	Y	Y	Y	Y			Y		Y	Y					Y	
R34	E10G	Rondegat	Y	Y	Y	Y	Y			Y		Y	Y					Y	
R33	(E10E), E10F	Olifants	Y	Y	Y	Y	Y			Y		Y	Y					Y	
R40	E10D	Olifants										Y							
R14	E24M	Doring	Y	Y	Y	Y	Y			Y		Y	Y					Y	
R17	E40D	Koebee	Y									Y							
R37	E21K, E21L	Groot	Y	Y	Y	Y	Y			Y		Y	Y					Y	
A1	E21H	Twee	Y																
R41	E21G	Leeu	Y	Y	Y	Y	Y					Y						Y	
R27	E23K	Tankwa		Y															
R8	E33C, E33D	Hol		Y															
R52	G30E	Verlorenvlei	Y	Y	Y	Y		Y	Y			Y	Y		Y			Y	
R56	G30F	Langvlei	Y	Y									Y		Y			Y	

7.2.2 Groundwater

The Resource Unit Evaluation Tool was amended for groundwater RUs. The relevant RQOs / parameters used were:

Quantity: recharge, discharge, water level, available yield

Quality: nutrients, salt, non-organic toxics, organic toxics, pathogens.

An assessment for the eight groundwater RUs resulted in the RQOs shown in Table 7.3.

Table 7.3 Summary of the RQOs selected for groundwater priority RUs

RU	Quaternary Catchment	Aquifer	Recharge	Discharge	Nutrients	Salts	Inorganic toxics	Organic toxics	Pathogens	Water level	Available yield
40	E10D	Alluvium		Y	Y	Y			Y		Y
		TMG			Y	Y			Y		Y
33	E10E & E10F	Alluvium		Y	Y	Y			Y		Y
		TMG		Y	Y	Y			Y		Y
41	E21G	Bokkeveld		Y	Y	Y			Y		Y
		TMG			Y	Y			Y		Y
	E33F	Gifberg			Y	Y			Y		Y
53	G30D	Sandveld		Y	Y	Y			Y		Y
52	G30E	Sandveld		Y	Y	Y			Y	Y	Y
56	G30F	Sandveld		Y	Y	Y			Y	Y	Y
57	G30G	Sandveld		Y	Y	Y			Y	Y	Y

Part III: Resource Quality Objectives for Priority RUs

8 SUMMARY OF PRIORITY RUS

Basic hydrological RQOs have been provided for every quaternary in the WMA (see Appenidx A). This section provides additional hydrological detail plus physico-chemical and biological RQOs where applicable and possible. It also provides groundwater and wetland RQOs where applicable and possible, and Threshholds of Potential Concern (TPCs) where available. The 22 RUs selected as priorities for RQO specification are listed in Table 8.1. Although it is desirable to have detailed RQOs for all of the quaternaries listed in Table 8.1, as they include the outlets for all the IUAs, it is not possible to set them for each RU, because there are no data that can be used for the following RUs:

- Hol River in E33E (R8) – outlet of Knersvlakte IUA.
- Tankwa River in E23K (R27) – outlet of Doring Rangelands IUA.
- Groot/Twee Rivers E21H, E21J (R31/A1) - outlet of Koebokkeveld IUA.

Table 8.1 RUs selected as priorities for RQO specification. IUAs arranged from downstream to upstream. * = not possible to set detailed RQOs, na=not applicable (see Table 6.3). Showing RQOs provided for each, excluding hydrology.

IUA	Quat	NODE	River	RQOs provided for		
				SW	GW	Wetlands
Lower Olifants Irrigation	E33H	E	Olifants Estuary	Water quality Geomorphology Riparian vegetation Macronvertebrates Fish	na	na
Upper Olifants Irrigation	E10K	R13	Olifants	Water quality Geomorphology Riparian vegetation Macronvertebrates Fish	na	na
	E10J	R23	Olifants	Water quality Fish	na	na
	E10H	R24	Jan Dissel	Water quality Geomorphology Riparian vegetation Macronvertebrates Fish	na	na
	E10G	R34	Rondegat	Water quality Geomorphology Riparian vegetation Macronvertebrates Fish	na	na
	E10E E10F	R33	Olifants	Water quality Geomorphology Riparian vegetation Macronvertebrates Fish	Alluvium Aquifer (quantity and quality) TMG Aquifer (quantity and quality)	na
	E10D	R40	Olifants	Fish	Alluvium Aquifer (quantity and quality) TMG Aquifer (quantity and quality)	na
Olifants/ Doring Dryland	E24M	R14	Doring	Water quality Geomorphology Riparian vegetation Macronvertebrates Fish	na	na
	E40D	R17	Koebee	Fish	na	na
	E40C	R11	Oorlogskloof	na	na	Wetland extent
	E33F	Q1	Troe-Troe	na	Gifberg Aquifer (quantity and quality)	na

IUA	Quat	NODE	River	RQOs provided for		
				SW	GW	Wetlands
Koue Bokkeveld	E21K	R37	Matjies	Water quality Geomorphology Riparian vegetation Macronvertebrates	na	na
	E21L		Groot	Fish	na	na
	E21H	R38 / A1	Twee	None	na	na
	E21J		Groot		na	na
	E21G	R41	Leeu	Water quality Fish	Alluivium and Bokkeveld (quantity and quality) TMG Aquifer (quantity and quality)	na
Doring Rangelands	E23K	R27*	Tankwa	None	na	na
Knersvlakte	E33C	R8*	Vars	None	na	na
	E33D		Geelbek		na	na
	E33E		Hol		na	na
	E32E	R3	Doring(b)[1]	na	na	Wetland extent
Sandveld	G30D	R53	Verlorevlei	Water quality Fish	Alluvium Aquifer (quantity and quality)	na
	G30E	R52*	Verlorevlei / Verlorenvlei estuary	Water quality Periphyton Fish Birds	Alluvium Aquifer (quantity, quality and water level)	na
	G30F	R56*	Langvlei	Fish Birds	Alluvium Aquifer (quantity, quality and water level)	na
	G30G	R57	Jakkals	na	Alluvium Aquifer (quantity, quality and water level)	na
	G30H	Q5	Sandlaagte	na	na	Wetland extent

8.1 SUMMARY OF KEY HYDROLOGICAL AND NARRATIVE RQOS FOR PRIORITY RUS

The key hydrological and narrative RQOs for the priority RUs are summarised as follows:

Rivers: Hydrological (Table 8.2)
Narrative (Table 8.3)

Estuaries and vleis: Hydrological (Table 8.4)
Narrative (Table 8.5)

Groundwater: Hydrological (see Appendix B)
Narrative (Table 8.6).

Table 8.2 Summary of key hydrological RQOs for RIVERS in priority RUs in the Olifants-Doorn WMA

IUA	Quat	Node	River	Location for monitoring	Ecological Category		RQO hydrology						
					PES	Target	Visual (lowflows)	Month with lowest flow	Mean of month with lowest flow (m^3/s)	Instantaneous drought absolute minimum (m^3/s)[5]	%nMAR (DWA 2013)	Floods in addition to Desktop Model (DWA 2013)	Implications of flood RQOs
Upper Olifants Irrigation	E10K	R 13	Olifants	E1R001/ EWR Site 2	E	D	Visible summer flow	February	0.200	0.050	9.3	-	None
	E10J[6]	R 23	Olifants	E1H016	D	D	Strong summer flow	February	Formal stipulations for lowflows are not appropriate at E10J because the Olifants River in this quaternary is used as a conduit for irrigation releases from Clanwilliam Dam. However, an absolute minimum of 0.02 m^3/s has been set as to protect the river in periods when irrigation releases are not being made.			-	None
	E10H	R 24	Jan Dissel	Above causeway	B	B	Strong summer flow	February	n/a	0.01	n/a	-	None
				Causeway to E1H006	C	C	Visible summer flow	February and March	0.060	0.01	19.7	-	None
		Q7 (in E10J)		E1H006 to confluence	D	D	No-flow conditions limited to February and March		0	0	n/a	-	None
	E10G	R 34	Rondegat	EWR Site 3	C	B	Strong summer flow	February	0.020	0.001	42.7	-	None
	E10E/ E10F	R 33	Olifants	E1H013/ EWR Site 1	D	D	Visible summer flow	February	0.110	0.003	37.8	-	None
	E10D	R 40	Olifants	E1H013	D	D	Visible summer flow	February	0.070	0.002	37.8	>60% of natural floods for July, August and September	Limited in-channel dams
	E10C	R42	Olifants	-	B	B	Visible summer flow	February	0.030	0.002	36.6	>60% of natural floods for July, August and September	Limited in-channel dams

5 In some cases the .rul files show zero flow for drought, but these rivers are historically perennial, so a lowflow value for drought has been provided.
6 The lower portion of the Jan Dissels River falls in the quaternary, but is discussed under E10H.

IUA	Quat	Node	River	Location for monitoring	Ecological Category		RQO hydrology						
					PES	Target	Visual (lowflows)	Month with lowest flow	Mean of month with lowest flow (m^3/s)	Instantaneous drought absolute minimum (m^3/s)[5]	%nMAR (DWA 2013)	Floods in addition to Desktop Model (DWA 2013)	Implications of flood RQOs
Olifants/ Doring Dryland	E24M	R 14	Doring	E2H003	B	B	No-flow conditions limited to December to April	February	0	0	48.5	>80% of natural floods for July, August and September	No in-channel dams
	E40D	R 17	Koebee	Koebee	B	B	Visible summer flow	February	0.030	0.001	26.5	>80% of natural floods for July, August and September	No in-channel dams
	E40C	R 11	Oorlogskloof	Upstream of Oorlogskloof Nature Reserve (ONR)	D	C	Visible summer flow	February	0.002	0.001	17.7	>80% of natural floods for July, August and September	No in-channel dams
				In ONR (Brakwater: -31° 27' 52.3368", 19° 4' 51.3192")	B	C							
	E33F	Q1	Troe-Troe	E3H001	D	D	No flow in summer	February	0	0	11.2	-	None
Koue Bokkeveld	E21K	R 37	Matjies	Matjies	B	B	Visible summer flow	December/ January	0.005	No .rul	60.4	>80% of natural floods for July, August and September	No in-channel dams
	E21L		Groot	E2H002	B	C/B	Visible summer flow	February	0.017	0.001	48.1	>80% of natural floods for July, August and September	No in-channel dams
	E21J	R38	Groot	EWR Site 6	B	B	Visible summer flow	February	0.010	0.001	48.1	>80% of natural floods for July, August and September	No in-channel dams
		-		Brandkraals	B	B	Visible summer flow	February	-	0.001	48.1	>80% of natural floods for July, August and September	No in-channel dams
	Tributary to E21H	A1	Twee	Twee	B	B	Visible summer flow	February	0.125	0.001	60.4	>80% of natural floods for July, August and September	No in-channel dams
	E21G	R 41	Leeu	E2H007	D	D	Visible summer flow	February	0.010	0.001	13.2	>60% of natural floods for July, August and September	Limited in-channel dams

IUA	Quat	Node	River	Location for monitoring	Ecological Category		RQO hydrology						
					PES	Target	Visual (lowflows)	Month with lowest flow	Mean of month with lowest flow (m^3/s)	Instantaneous drought absolute minimum (m^3/s)[5]	%nMAR (DWA 2013)	Floods in addition to Desktop Model (DWA 2013)	Implications of flood RQOs
Doring Rangelands	E23K	R27	Tankwa	Tankwa	B	B	The Tankwa River is ephemeral. Thus minimum lowflows do not apply.				26.4	>80% of natural floods for July, August and September	No in-channel dams
Knersvlakte	E33C	R8	Vars	None	D	C	The Vars, Geelbek and Hol Rivers are ephemeral. Thus minimum lowflows do not apply.				17.0	-	None
	E33D		Geelbek		C	C					17.1	-	None
	E33E		Hol		C	C					17.4	-	None
	E32E	R 3	Doring(b)[7]	None	B	B	The Doring(b) River is ephemeral. Thus minimum lowflows do not apply.				26.2	-	None
Sandveld	G30D	R 53	Verlorevlei	G3H001	D	C	Visible summer flow	March	0.019	0.001	20.7	>60% of natural floods for July, August and September	Limited in-channel dams
	G30F	R56	Langvlei	River Node R56: 32°12'40.05"S, 18°23'8.25"E / Upstream of the Wadrif Pan and Wetland	D	C	Visible summer flow	March	0.010	0.001	19.3	-	None
	G30G	R 57	Jakkals	River	D	C	Visible flow in November	March	0.005	0.001	19.2	-	None

[7] Different river from the main Doring River.

Table 8.3 Summary of the narrative RQOs for RIVERS in priority RUs in the Olifants-Doorn WMA. TWQR = Target Water Quality Range (DWAF 1996); Fitness for use = FFU (DWAF 1996b).

IUA	Quat	Node	River	Location for monitoring	WQ	Geomorphology	Riparian vegetation	Macronvertebrates	Fish
Upper Olifants Irrigation	E10K	R 13	Olifants	E1R001/ EWR Site 2	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	Abundance and diversity of habitats should be equal to or greater than those measured in 2005.	Dominated by indigenous species. No *Sesbania punicea* and only isolated individuals of *Acacia longifolia*, *A. mearnsii*, *A. melanoxylon*, *Eucalyptus camaldulensis*. No *Azolla filiculoides*, *Lemna gibba* or other aquatic weeds	The abundance and diversity shall be equal to or greater than those measured in 2005	No RQOs set for indigenous fish. The abundance and diversity of alien fish shall be equal to or greater than those measured in 2005.
	E10J	R 23	Olifants	E1H016	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	-
	E10H	R 24	Jan Dissel	Above causeway	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	Riffle-run sequence, with aquatic vegetation and stones in current.	Dominated by indigenous species. No Sesbania punicea and only isolated individuals of Acacia longifolia, A. mearnsii, A. melanoxylon, Eucalyptus camaldulensis. No Azolla filiculoides, Lemna gibba or other aquatic weeds.	Dominated by sensitive mountain stream taxa.	At least three of the following species should be present in the catch: *Labeobarbus capensis, Austroglanis gilli*, *Austroglanis barnardi*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Galaxias zebratus* should be present. There should be no alien species present
				Causeway to E1H006				-	
				E1H006 to confluence		-		-	-
	E10G	R 34	Rondegat	EWR Site 3	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	Riffle-run sequence, with aquatic vegetation and stones in current.	The indigenous riparian vegetation should be intact with no aliens	Dominated by sensitive mountain stream taxa.	At least three of the following species should be present in the catch: *Labeobarbus capensis, Austroglanis gilli*, *Austroglanis barnardi*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Galaxias zebratus* should be present. There should be no alien species present.
	E10E/ E10F	R 33	Olifants	E1H013/ EWR Site 1	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	Riffle-run sequence, with aquatic vegetation and stones in current.	Dominated by indigenous species. No Sesbania punicea and only isolated individuals of Acacia longifolia, A. mearnsii, A. melanoxylon, Eucalyptus camaldulensis.	Community should be representative of a slightly impacted Western Cape foothill river.	*Labeobarbus capensis* should be present.

IUA	Quat	Node	River	Location for monitoring	WQ	Geomorphology	Riparian vegetation	Macronvertebrates	Fish
Upper Olifants Irrigation (cont.)	E10C	R42	Olifants	-	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	*Labeobarbus capensis* should be present.
	E10D	R 40	Olifants	E1H013	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	*Labeobarbus capensis* should be present.
Olifants/ Doring Dryland	E24M	R 14	Doring	E2H003	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a)	Riffle/run-pool sequence, with deep pools.	Dominated nby indigenous species. The presence of Nerium oleander must be strictly controlled.	Community should be dominated by Ephemeroptera, Trichoptera.	At least one of the following species should be present in the catch: *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi.*
	E40D	R 17	Koebee	Koebee	-	-	-	-	At least one of the following species should be present in the catch: *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi.*
	E40C	R 11	Oorlogskloof	Upstream of Oorlogskloof Nature Reserve (ONR)	-	-	-	-	-
				In ONR (Brakwater: -31° 27' 52.3368", 19° 4' 51.3192")	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	At least three of the following species should be present in the catch: *Labeobarbus capensis*, *Barbus serra, Barbus anoplus* and *Labeo seeberi*.
	E33F	Q1	Troe-Troe	E3H001	-	-	-	-	-
Koue Bokkeveld	E21K	R 37	Matjies	Matjies	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	At least one of *Labeobarbus capensis*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Barbus serra*, *Labeo seeberi* should be present.
	E21L		Groot	E2H002	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	A riffle/run-pool sequence should be present at all flows.	Riparian vegetation should be intact and dominated by indigenous species. The presence of *Nerium oleander* should be strictly controlled. There should be no other alien species present.	Community should be dominated by Ephemeroptera, Trichoptera	At least one of the following species should be present in the catch: *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi*.

IUA	Quat	Node	River	Location for monitoring	WQ	Geomorphology	Riparian vegetation	Macronvertebrates	Fish
Koue Bokkeveld (cont.)	Tributary of Leeu in E21H	R38/ A1	Twee	Twee	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	At least one of *Labeobarbus capensis*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Barbus serra*, *Labeo seeberi* should be present.
	E21J	R38 / A1	Groot	EWR Site 6	Oligotrophic and should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWAF 1996b).	A riffle/run-pool sequence should be present at all flows.	Riparian vegetation should be intact and dominated by indigenous species. The presence of *Nerium oleander* should be strictly controlled. There should be no other alien species present.	Community should be dominated by Ephemeroptera, Trichoptera	At least one of the following species should be present in the catch: *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi*.
				Brandkraals	Oligotrophic and should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWAF 1996b).	-	-	-	At least one of *Labeobarbus capensis*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Barbus serra*, *Labeo seeberi* should be present.
	E21G	R 41	Leeu	E2H007	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a) and the Fitness for use - Class I for agricultural use (DWAF 1996b).	-	-	-	At least one of the following species should be present in the catch: *Labeobarbus capensis* and *Galaxias zebratus*.
Doring Rangelands	E23K	R27*	Tankwa	Tankwa	-	-	-	-	-
Knersvlakte	E33C	R8*	Vars	None	-	-	-	-	-
	E33D		Geelbek		-	-	-	-	-
	E33E		Hol		-	-	-	-	-
	E32E	R 3	Doring(b)[1]	None	-	-	-	-	-
Sandveld	G30D	R 53	Verlorevlei	G3H001	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a)	-	-	-	Indigenous species should dominate and *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus* and *Sandelia capensis* should be present.
	G30F	R56*	Langvlei	River Node R56: 32°12'40.05"S, 18°23'8.25"E / Upstream of the Wadrif Pan and Wetland	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a)	-	-	-	Indigenous species should dominate and *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus* and *Sandelia capensis* should be present.
	G30G	R 57	Jakkals	River	Should comply with the TWQRs for aquatic ecosystems (DWAF 1996a)	-	-	-	-

Table 8.4 Summary of key hydrological RQOs for ESTUARIES AND VLEIS in priority RUs in the Olifants-Doorn WMA

IUA	Quat	NODE	Waterbody	Ecological Category		Hydrology					
				PES	Target	Visual (lowflows)	Month with lowest flow	Mean of month with lowest flow (m3/s)	Instantaneous drought absolute minimum (m3/s)	Floods in addition to Desktop Model (DWA 2013)	%nMAR
Lower Olifants Irrigation	E33H	E	Olifants Estuary	C	C	Visible summer flow into the estuary from the river	April	1.23	0.01	Doring River floods unimpeded by large dams	57.6
Sandveld	G30E	R52	Verlorenvlei	B	B	Visible summer flow into the estuary from the river	March	0.29	0.04	>60% of natural floods for July, August and September	46.0
	G30F	R56*	Wadrift wetlands	D	C	Visible summer flow into the wetlands from the river	March	-	-	>60% of natural floods for July, August and September	14.8
			Wadrift saltpan	D	C	Visible summer flow into the wetlands from the river	March	-	-	>60% of natural floods for July, August and September	37.7
	G30G	R 57	Jakkals	C	C	Visable summer flow into the pan from the river every one in two years	March	0.03	0.006	>60% of natural floods for July, August and September	19.2
	G30H	Q5	Sandlaagte	C	C	Visable summer flow into the estuary from the river every one in two years	March	0.02	-	>60% of natural floods for July, August and September	12.8

Table 8.5 Summary of the narrative RQOs for ESTUARIES, VLEIS and WETLANDS in priority RUs in the Olifants-Doorn WMA

IUA	Quat	Waterbody	General conditions	WQ	Vegetation	Invertebrates	Fish	Amphibians	Birds
Lower Olifants Irrigation	E33H	Olifants Estuary	No major water resource developments in the Doring River (provision of the Reserve alone in the Doring River will be insufficient to maintain the ecological integrity of the Doring River in a B-category and estuary in a C-category).	Shall not deteriorate from that measured in 2004.	The diversity and extent of indigenous macrophytes shall equal that measured in summer 2004. The extent of invasive waterweeds and nuisance filamentous algae shall be less relative to summer 2004. Microalgae should be dominated by flagellates. Phytoplankton and blue-green algal growth should be limited.	The polychaete worm species *Capitella capitata* should not dominate the invertebrate fauna.	The fish fauna should be dominated by estuarine and partially estuarine dependent species, and should include a significant number of 0-1 year old fish, with no age classes missing.	-	The abundance and diversity of birds shall be equal to or greater than those measured summer 2004.
Olifants-Doring dryland farming & Knersvlakte	E40C & E32E	Nieuwoudtville wetlands (Oorlogskloof, Grasberg, Soetfontein and other rivers)	No expansion of agriculture or other landuses in to the remaining intact wetland areas (around 3000 ha taken together).	-	No further encroachment of woody alien vegetation into wetland areas and no change in WET-Health scores	-	-	-	-
Sandveld	G30E	Verlorenvlei / Verlorenvlei estuary	Mouth should open for an extended period from winter through into spring.	Shall not deteriorate from that measured prior to 2010.	Macrophytes, micro- and macro-algae community structure should not deteriorate from that measured in 2009.	-	The population should be dominated by indigenous species.	The Cape dainty frog (*Cacosternum capense)* should continue to occur.	The abundance and diversity of birds shall be equal to or greater than those measured prior to 2010.
	G30F	Wadrift wetlands	There should be no expansion of agriculture or other landuses in to remaining intact wetland areas.	-	The wetlands should remain intact and the extent of invasion by woody alien plants should not increase.	-	*Galaxias zebratus* and *Sandelia capensis* should be present.	-	The abundance and diversity shall be equal to or greater than those measured prior to 2010.
		Wadrift saltpan	-	-	-	-	-	-	-
	G30G	Jakkals	There should be no expansion of agriculture or other landuses in to remaining intact wetland areas.	-	-	-	-	-	-
	G30H	Sandlaagte	There should be no expansion of agriculture or other landuses in to remaining intact wetland areas (around 678 ha taken together).	-	-	-	-	-	-

Table 8.6 Summary of narrative RQOs for GROUNDWATER in priority RUs in the Olifants-Doorn WMA

RU	Quaternary Catchment	Aquifer	PS	Hydrology			Water Quality		
				Discharge	Water level	Available yield	Nutrients	Salts	Pathogens
40	E10D	Alluvium	A	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs. Compliance to the lowflow requirements in the river as per Reserve requirement	Not applicable	All users comply with the allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		
		TMG	A	Not sufficient data	Not applicable	All users comply with the allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background.		
33	E10E & E10F	Alluvium	B	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs. Compliance to the lowflow requirements in the river as per Reserve requirement	Not applicable	All users comply with the allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		
		TMG	B	Not sufficient data	Not applicable	All users comply with the allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background.		
41	E21G	Bokkeveld	C	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs. Compliance to the lowflow requirements in the river as per Reserve requirement	Not applicable	All users comply with the allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		
		TMG	B	Not sufficient data	Not applicable	All users comply with the allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background.		

RU	Quaternary Catchment	Aquifer	PS	Hydrology			Water Quality		
				Discharge	Water level	Available yield	Nutrients	Salts	Pathogens
Q1	E33F	Gifberg	E	Not applicable	Not applicable	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background.		
53	G30D	Sandveld	D	Compliance to the lowflow requirements in the river as per Reserve requirement	Not applicable	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		
52	G30E	Sandveld	F	Compliance to the lowflow requirements in the river as per Reserve requirement	Minimum water level in abstraction boreholes within 10km from the ocean to avoid saline intrusion	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		
56	G30F	Sandveld	F	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs. Compliance to the lowflow requirements in the river as per Reserve requirement	Minimum water level in abstraction boreholes within 10km from the ocean to avoid saline intrusion	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		
57	G30G	Sandveld	D	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs. Compliance to the lowflow requirements in the river as per Reserve requirement	Minimum water level in abstraction boreholes within 10km from the ocean to avoid saline intrusion	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	Shall not deteriorate from natural background. Fitness for use for domestic use in accordance with SANS 241:2011, after treatment		

9 E33H (E) RESOURCE QUALITY OBJECTIVES

9.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E33H	Olifants (upstream of estuary)	D	Droekraal se	D	wetland area 1.9% of quaternary, 13% in AB
	Olifants River Estuary	C			

9.2 OLIFANTS RIVER ESTUARY IN E33H

Key monitoring points for the Olifants River Estuary in E33H:

- E3H004 (Olifants River at Lutzville; Figure 9.1).
- Estuary (2006; Box 9.1), as specified for various components.

RQOs, thresholds of potential concern (TPC) and methods are taken from DWAF (2006b).

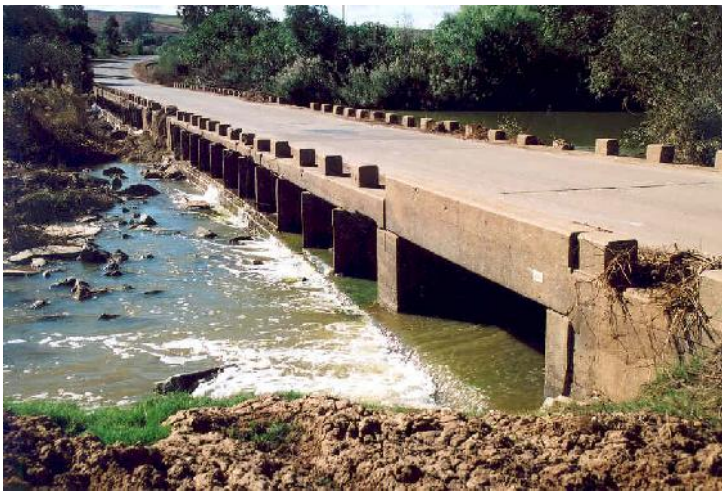

Figure 9.1 E3H004 on the Olifants River at Lutzville

Figure 9.2 Olifants River Estuary

Box 9.1 Relevant details for Olifants River Estuary

Downstream boundary: Estuary mouth (31° 42.00'S; 18° 11.34'E)
Upstream boundary: Extent of tidal influence, i.e. the causeway at Lutzville - about 36 km from the mouth (31° 33.80'S; 18° 19.78'E).
Lateral boundary: 5-m contour above MSL along each bank.
Hydrology: E3H004 (Olifants River at Lutzville).

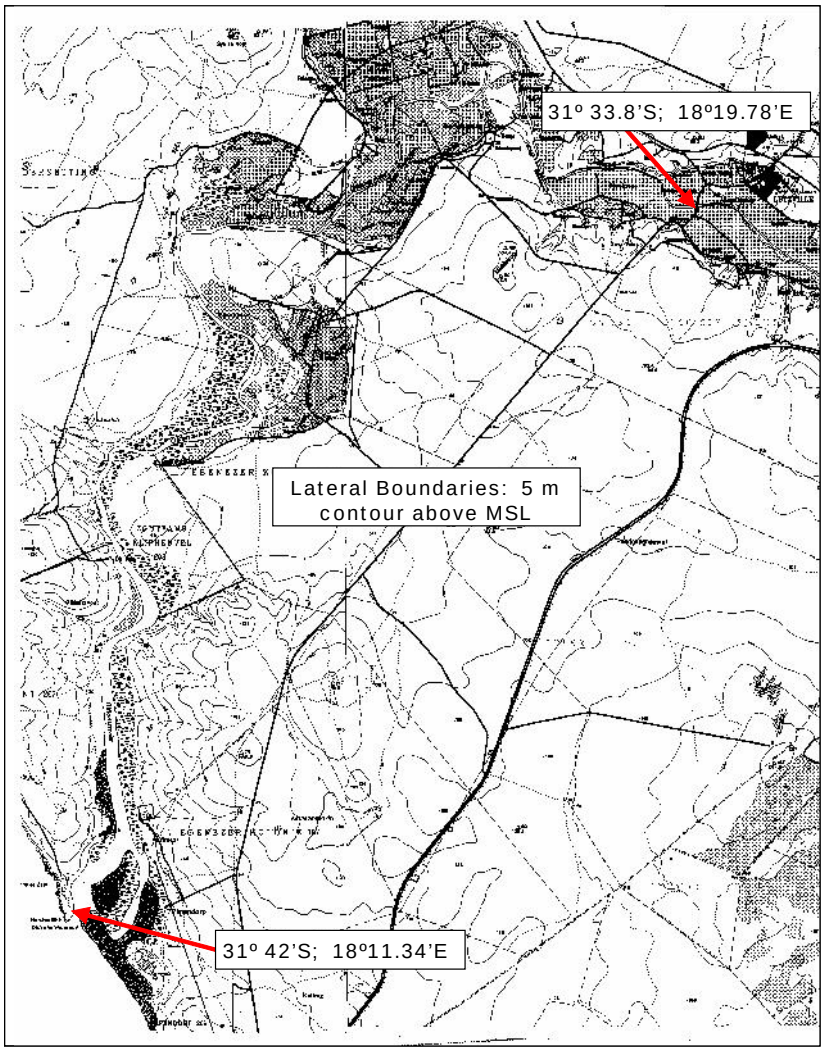

Figure 9.3 Geographical boundaries of the Olifants River Estuary.

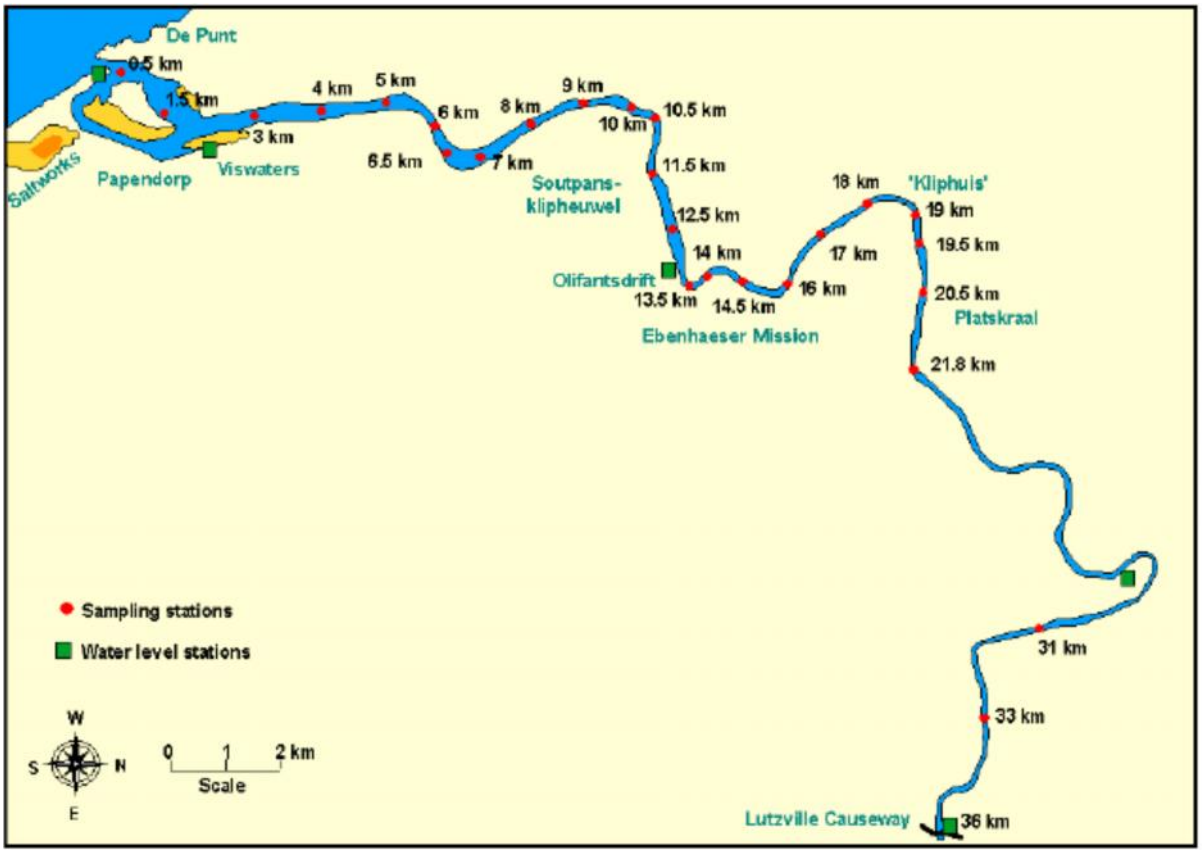

Figure 9.4 Map showing sampling locations in the Olifants Estuary (from DWAF 2006b).

9.2.1 Hydrology

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants Estuary.
Monitor at: E3H004 (Figure 9.1).
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E3H004.

9.2.1.1 Narrative

Flows to the estuary shall be sufficient to maintain the estuary in an ecological condition that is equal to or better than the ecological condition in June 2006.

9.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Table 9.1. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (February): 1.23 m^3/s
Even in extreme drought flow should not drop below: 0.01 m^3/s.

Note: River flow <2 m^3/s should never persist for longer than three months at E3H004.

Table 9.1 Hydrology RQOs for E33H for the REC of the estuary of a C. To be met at the E3H004 (Lutzville). Units m^3/s

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
99%ile	42.17	28.76	21.52	37.04	24.33	7.43	95.80	153.56	471.91	470.40	210.01	149.81
90%ile	23.61	7.85	7.27	3.66	3.84	4.07	9.43	66.69	112.14	150.96	116.78	65.34
80%ile	11.33	3.96	2.33	1.62	1.80	2.11	4.34	17.92	72.07	78.37	81.56	40.07
70%ile	7.85	2.16	1.64	1.53	1.46	1.73	2.24	8.84	44.03	53.49	52.19	30.07
60%ile	5.44	1.67	1.52	1.53	1.45	1.39	1.79	4.84	21.61	38.99	33.68	20.61
50%ile	4.36	1.42	1.52	1.53	1.41	1.32	1.23	2.33	14.39	22.60	27.35	13.96
40%ile	3.17	1.36	1.52	1.53	1.41	1.32	1.15	1.65	9.02	12.62	17.14	12.10
30%ile	2.00	1.36	1.52	1.53	1.41	1.32	1.15	0.90	5.01	8.22	11.91	8.78
20%ile	1.70	1.36	1.52	1.53	1.41	1.32	1.15	0.52	2.19	5.28	8.21	5.68
10%ile	1.43	1.36	1.52	1.24	0.95	0.70	0.80	0.43	0.84	2.91	3.92	3.28
1%ile	1.20	1.19	0.89	0.88	0.40	0.22	0.01	0.04	0.32	0.49	0.84	1.59

9.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants River Estuary.
Monitor at: E3H004 (formerly E1H016), plus periodic field measurements in the estuary as detailed in Table 9.2 as per DWAF (2006b).
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

9.2.2.1 Narrative

Salinity intrusion should not exceed of TPCs for fish, invertebrates, macrophytes and microalgae. System variables (temperature, pH, turbidity, dissolved oxygen, suspended solids and turbidity) should not exceed TPCs for biota.

9.2.2.2 Numerical

The suggested numerical limits for the water quality to achieve the above narrative RQOs are given in Table 9.2.

Table 9.2 Water quality RQOs and TPCs for the Olifants River Estuary (E33H)

Component	RQOs	TPCs
River inflow at E3H004		
Temperature	< 20°C (summer)	> 20°C (summer)
pH	> 6.5 and < 8.5	>7
Dissolved oxygen	> 4 mg /ℓ (1m from bottom)	< 4 mg /ℓ (1m from bottom)
Total dissolved solids	< 3500 mg /ℓ	< 3500 mg /ℓ
Dissolved inorganic nitrogen concentration	< 0.5 mg /ℓ at flows ≥ 20 m3/s	> 0.5 mg /ℓ at flows ≥ 20 m3/s
Dissolved Reactive Phosphorous concentration	< 0.1 mg /ℓ at E3H004	>0.1 mg /ℓ at E3H004
Turbidity	--to be determined	
>=8 km above mouth		
Turbidity	Secchi disc reading at the 8-km mark upstream of the mouth >1 m	None available
Salinity	Salinity never > 35 ppt anywhere in the estuary Salinity in the estuary at the 8-km mark upstream of the mouth < 20 ppt Salinity in the estuary at the 16-km mark upstream of the mouth < 10 ppt	

9.2.3 Macrophytes

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants Estuary.
Monitor at: Positions specified in Table 9.3, as per DWAF (2006b).
Baseline data: DWAF (2006b) – single data collection.

9.2.3.1 Narrative

The diversity and extent of indigenous macrophytes shall equal that measured in summer 2004. The extent of invasive waterweeds and nuisance filamentous algae shall be less relative to summer 2004.

9.2.3.2 Numerical

The suggested numerical limits for the spatial extent of different macrophyte communities to achieve the above narrative RQOs are given in Table 9.3.

Table 9.3 Macrophyte RQOs and TPCs for the Olifants River Estuary (E33H).

Component	RQO	TPCs

Area of plant communities	Maintain (summer 2004) distribution and abundance over the entire estuary:
	Zostera capensis = 48 ha;
	intertidal salt marsh = 92 ha;
	supratidal salt marsh = 143 ha;
	floodplain salt marsh = 797 ha;
	reeds and sedges = 60 ha.
		Greater than 20% change in areas

Area covered by invasive waterweeds (*Azolla filiculoides*); nuisance filamentous algae (e.g. *Enteromorpha*, *Ulva*, *Cladophora*); or pondweed (*Potamogeton pectinatus*)	Reduce area by 50% (relative to summer 2004). i.e. to ≤ 30 ha (half of channel)	Upper 15k of estuary with > 50% of channel covered by waterweeds, algae or pondweed.

9.2.4 Microalgae

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants Estuary.
Monitor at: Olifants River Estuary as per DWAF (2006b).
Baseline data: DWAF (2006b) – single data collection.

9.2.4.1 Narrative

Microalgae should be dominated by flagellates. Phytoplankton and blue-green algal growth should be limited.

9.2.4.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 9.4.

Table 9.4 Microalgal RQOs and TPCs for the Olifants River Estuary (E33H)

Component	RQO	TPCs
Benthic microphytobenthic biomass	<40 mg m^{-2} chlorophyll a	>40 mg m^{-2} chlorophyll a
Flagellates	Dominant	No dominant
Diatoms	>10 taxa per site	<11 taxa per site
Dinoflagellates	<5% of the total phytoplankton count	45% of the total phytoplankton count
Phytoplankton biomass	<15 µg/ ℓ chlorophyll a in summer <10 µg/ ℓ chlorophyll a in winter	>14 µg/ ℓ chlorophyll a in summer >9 µg/ ℓ chlorophyll a in winter
Blue-green algae	<10% of the total phytoplankton count	>8% of the total phytoplankton count

9.2.5 Invertebrates

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants Estuary.
Monitor at: Olifants River Estuary as per DWAF (2006b).
Baseline data: DWAF (2006b) – single data collection.

9.2.5.1 Narrative

The polychaete worm species *Capitella capitata* should not dominate the invertebrate fauna.

9.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 9.5.

Table 9.5 Invertebrate RQOs and TPCs for the Olifants River Estuary (E33H)

Component	RQO	TPCs
The indicator polychaete worm species *Capitella capitata*	<50% abundance of benthic species at any site	>50% abundance of benthic species at any site

9.2.6 Fish

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants Estuary.
Monitor at: Olifants River Estuary as per DWAF (2006b).
Baseline data: DWAF (2006b) – single data collection.
Method: Conduct fish surveys using seine and gill nets in winter and summer, every three years, along the estuary (12 stations).

9.2.6.1 Narrative

The fish fauna should be dominated by estuarine and partially estuarine dependent species, and should include a significant number of 0-1 year old fish, with no age classes missing.

9.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 9.6.

Table 9.6 Fish RQOs and TPCs for the Olifants River Estuary (E33H).

Component	RQO	TPCs
Fish assemblages Retain the following ratios of fish assemblages in the estuary:	Estuarine species (e.g. estuarine round-herring, Cape silverside, prison goby, commafin goby, longsnout pipefish) (35%)	Level of estuarine species drop below 30% of total abundance
	Partially estuarine dependent species (e.g. harder, elf, blackhand sole, white stumpnose) (50-60%)	Levels of partially estuarine dependent species drop below 50% or above 60% of total abundance
	Obligate estuarine dependent (e.g. white steenbras, leervis, freshwater mullet, flathead mullet); (>1%)	Levels of obligate estuarine dependent species drop below 1% of total abundance
	Indigenous freshwater species, (e.g. Clanwilliam yellofish, sawfin and Cape galaxias) (>1%)	Levels of exotic freshwater species above 0.5% (e.g. Mozambique tilapia out-competing resident species). Benthic dwellers species drop below 2% of total abundance in estuary above 18 km from the mouth
	Exotic freshwater species (e.g.smallmouth bass, bluegill sunfish, banded tilapia and Mozambique tilapia) (<0.5%)	
Demographics	There should be a significant number of 0 -1 year old fish and no age classes missing	Year class missing for a species.

9.2.7 Birds

Source: Comprehensive Reserve Determination Study (DWAF 2006b).
Applicable to: Olifants Estuary.
Monitor at: Olifants River Estuary.
Baseline data: DWAF (2006b) – single data collection.
Method: Combined summer and winter counts over the whole estuary of all water-associated birds. All birds should be identified to species level.

9.2.7.1 Narrative

The abundance and diversity of birds in the estuary shall be equal to or greater than those measured summer 2004.

9.2.7.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 9.7.

Table 9.7 Bird RQOs and TPCs for the Olifants River Estuary (E33H).

Component	RQO	TPCs
Birds	Retain the species richness, abundance and diversity of the bird community, representative of resident and migrant waders, wading birds and water fowl as under the Present State, except for that there would be a *higher abundance of water fowl (increasing by about 10% from Present State numbers*)	• Community composition or bird numbers deviates by more than 50% of average seasonal baseline counts for two consecutive summer or winter seasons, focusing on waders, wading birds, terns & water fowl (summer and winter), and specifically red data species which are supported by the system (e.g. Pelican, Oyster catchers, Chestnut banded plover) • In the case of water fowl - densities decline by 20% of average seasonal baseline counts for two consecutive summer or winter seasons

9.3 GROUNDWATER

No detailed RQOs have been set. The Groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 9.8.

Table 9.8 Groundwater Reserve Requirements for E33H.

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E33H	3.05	0.07	0.01	0%	2.97	2%	A

9.4 WETLANDS

Not applicable (see Table 6.3).

10 E10K (R13) RESOURCE QUALITY OBJECTIVES

10.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E10J	Olfiants	≥ D	Rietvlei	≥ C	wetland area 1.9% of quaternary, 50% in AB

10.2 OLIFANTS RIVER IN E10K

Key monitoring points for the Olifants River in E10K:

- E1R001 (Olifants River at Bulshoek Barrage; Figure 10.1).
- EWR Site 2 (2006; Figure 10.2; Box 10.1).

Figure 10.1 E1R001 at Bulshoek Barrage (www.dwa.gov.za)

Figure 10.2 EWR 2 (2006)

Box 10.1 **Relevant details for EWR Site 2 (2006): Olifants River**

Localition: Downstream of Bulshoek Barrage, just downstream of Cascade Pools.
Coordinates: S 31°57.974; E 18°44.463
Hydrology: There is no DWAF gauging weir but flows in the river can be estimated from Bulshoek Barrage (E1R1).
Access: Through a farm gate off the Clanwilliam/Klawer dirt road. The key for the gate is obtainable from the owner (Mr Worsie Lamprechts in 2006) at Cascade Pools. Permission to work the site should been obtained from the owner at Cascade Pools.
Cross-sections: One cross-section was selected at EWR Site 2 (Figure 10.3). This was CS 2a: Across the pool/run.

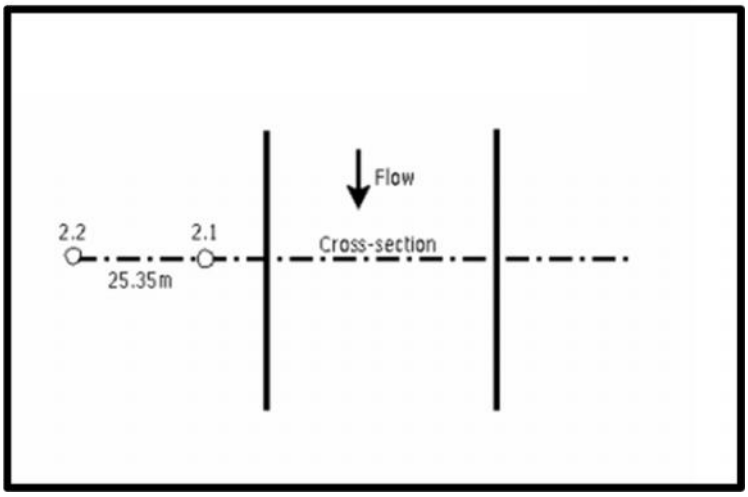

Figure 10.3 **Plan layout for EWR Site 2.**

Fixed stations were also installed at the site in November 2003. The elevations (above a local datum; Eald) of the fixed stations, the orientations of cross-sections relative to fixed stations and a description of the station type (steel peg in concrete or marked rock (MRK)) are given in Table 10.1.

Table 10.1 **Elevations of fixed stations, orientations of cross-sections relative to fixed stations and descriptions of station type.**

River	EWR Site No.	Cross-section	Station		Horizontal angle from orientation station to cross-section (dec. deg.)	Eald[8] (m)
			Set-up	Orientation		
Olifants	2	2	A	2.2(SPC)	2.1(SPC)	0.000

10.2.1 Hydrology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10K.
Monitor at: E1R001 (Figure 10.1).
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E1R001.

10.2.1.1 Narrative

Flows shall be suffient to maintain the river in an ecological condition that is equal to or better than a D category.

[8] Elevation above local datum.

10.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (February): 1.16 m^3/s
Even in extreme drought flow should not drop below: 0.01 m^3/s.

This minimum lowflow is to support the estuary, and is expected to be provided through releases made from Clanwilliam Dam and Bulshoek Barrage.

10.2.2 Water quality

Note: In the context of the irreversible habitat changes, and the knock-on biological degradation, as a result of the long-term presence and unfavourable operation of Bulshoek Barrage, water quality is one of the most important RQOs for this reach.

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10K.
Monitor at: E1R001 (Olifants River at Bulshoek Dam) and with periodic field measurements.
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

10.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

10.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given in Table 10.2.

Table 10.2 Water quality RQOs and TPCs for E10K

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg/ ℓ)	<37	Cascades	>35
$Na2SO_4$ (mg/ ℓ)	<51		>45
$MgCl_2$ (mg/ ℓ)	<51		>45
$CaCl_2$ (mg/ ℓ)	<105		>100
NaCl (mg/ ℓ)	<389		>350
Physical			
Water temperature (^oC)	Not specified	Cascades	>7
pH	6.5 – 9.0		>6
EC (mS/ m)	<25		>20
Dissolved oxygen (DO) (mg/ ℓ)	> 6.0		<5.8
Toxics			
Ammonia as NH_3 (mg/ ℓ)	<0.007	Cascades	>0.006
Nutrients			
Nitrates as N (mg/ ℓ)	<0.100	Cascades	>0.09
Phosphorus as PO_4-P (mg/ ℓ)	<0.015		>0.010

10.2.3 Geomorphology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10K.
Monitor at: EWR Site 2 (2006) - Box 10.1.
Baseline data: DWAF (2005) – single data collection.

10.2.3.1 Narrative

The abundance and diversity of habitats in the river shall be equal to or greater than those measured in 2005.

10.2.3.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 10.3.

Table 10.3 Geomorphological RQOs and TPCs for E10K

Component	Values: Cross-section A	TPCs
Dry season bed material composition (mm)		
D_{16}	0.1	> 20% increase or decrease
D_{50}	0.3	> 20% increase or decrease
D_{84}	0.9	> 20% increase or decrease
Channel geometry		
Dry season water surface slope (m/m)	0.0001	> 5% increase or decrease
Active channel width (m)	67	> 5% increase or decrease
Bankfull width (m)	70	> 5% increase or decrease
Key habitats		
Aquatic vegetation in and out of current	Present	None available
Stones-in-current, including riffle and run	Present	None available

10.2.4 Riparian vegetation

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10K.
Monitor at: EWR Site 2 (2006) - Box 10.1.
Baseline data: DWAF (2005) – single data collection.

10.2.4.1 Narrative

The abundance and diversity of vegetation alongside the river shall be equal to or greater than those measured in 2005 (see Table 10.4). There shall be no Sesbania punicea alongside the river and only isolated individuals of *Acacia longifolia*, *A. mearnsii*, *A. melanoxylon*, *Eucalyptus camaldulensis*. There shall be no *Azolla filiculoides*, *Lemna gibba* or other aquatic weeds in the river.

Table 10.4 Riparian vegetation RQOs and TPCs for E10K; * = exotic species.

Component	Species	RQO	TPCs
Aquatic Zone	Azolla filiculoides*	None present.	Increase
	Lemna gibba	None present.	Increase
	Nymphaea nouchali	Present in low leaf density around edges of waterways during dry season	Changes in densities
	Aponogeton distachyos	Present in low leaf density around edges of waterways during dry season	Increase
Lower Wet Bank	Panicum repens	Low density on channel margins.	Dense cover extending into floating aquatic zone
	Juncus lomatophyllus	Low density on coarse sandy substrates.	Increase extending into Aquatic Zone
	Isolepis prolifer	Low density on coarse sandy substrates exposed during lower flows.	Dense cover instead of low cover
	Paspalum urvillei*	Low leaf density around edges of waterways during dry season.	Increase extending into Tree-shrub and Back Dynamic Zone
Upper Wet Bank	Phragmites australis	Only a narrow banding should be present in Wet Bank.	Increase extending into Tree-shrub and Back Dynamic Zone
	Prionium serratum	Narrow banding should be present on pebbles and coarse sandy substrates exposed during lower flows.	Change in width and continuity of beds
Wet Bank	Salix mucronata	Must be present.	Decrease
Upper Wet Bank	Sesbania punicea*	None present.	Decrease of mature trees
Tree-shrub, Back Dynamic	Acacia karoo	Present lining parts of rivers and streams exposed to annual winter high flows	Increase in Wet Bank
All zones	Acacia longifolia*, A. mearnsii*, A. melanoxylon*, Eucalyptus camaldulensis*	Only isolated individuals present.	Increase.

10.2.4.2 Numerical

None available.

10.2.5 Macroinvertebrates

Source: Comprehensive Reserve Determination Study (DWAF 2005), adjusted to higher target category (D versus E).
Applicable to: E10K.
Monitor at: EWR Site 2 (2006) - Box 10.1.
Baseline data: DWAF (2005) – single data collection.

10.2.5.1 Narrative

The abundance and diversity of macroinvertebrates in the river shall be equal to or greater than those measured in 2005.

10.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 10.5.

Table 10.5 Macroinvertebrate RQOs and TPCs for E10K

Order	Taxa	RQO	TPCs
Family presence/absence			
Ephemeroptera	Baetidae	> 2 species	Absent from > 50% of samples
Hemiptera	Any	> 2 families	
Odonata	Any	> 2 families	Fewer than two families from each order
Plecoptera	Notonemouridae	Present in 50% of replicate samples of stones-in-current	Absent from > 30% of samples
SASS results			
SASS Score		>50	< 30
ASPT		>5	< 4.5

10.2.6 Fish

No RQOs were set for indigenous fish: Indigenous fish species in the mainstem of the Olifants and Doring Rivers are functionally extinct (Paxton et al. 2002). Due to the highly disturbed nature of this reach, i.e. the absence of spawning habitat (gravel and cobble-bed riffles), the lack of access to upstream spawning habitat, and the predominance of introduced species, it is considered unlikely that native species will recover and recolonise these reaches under any management scenario (DWAF 2005).

At sites where this is known to be the case, the alien fish community has been used as a substitute for the indigenous fish community and an indicator of river condition since some of the alien species have physical habitat and water quality requirements that relate to reference conditions.

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: EWR Site 2 (2006) - Box 10.1.
Monitor at: EWR Site 2 (2006).
Baseline data: DWAF (2005) – single data collection, Paxton (unpublished data), SAIAB database
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

10.2.6.1 Narrative

The abundance and diversity of alien fish in the river shall be equal to or greater than those measured in 2005.

10.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 10.6.

Table 10.6 Fish RQOs and TPCs for E10K

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	There are no indigenous fish remaining in this section	None available
	Demographics	There is no recruitment of indigenous fish in the mainstem at E10K	
	Fish Health	-	
Alien	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % bluegill sunfish *Lepomis macrochirus* Present: *Tilapia sparrmanii, Oreochromis mossambicus*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus, T. sparrmanii, O. mossambicus* and *T. sparrmanii* and < 70 mm TL for bass).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

10.3 TRIBUTARIES

There are no FEPAs identified within this quaternary catchment. RQOs cannot be set for the tributaries with the current level of data available.

10.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 10.7.

Table 10.7 Groundwater Reserve Requirements for E10K

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E10K	6.67	2.01	0.36	5%	4.66	30%	C

10.5 WETLANDS

Not applicable (see Table 6.3).

11 E10J (R23) RESOURCE QUALITY OBJECTIVES

11.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E10J	Olfiants	≥ D	Seekoei River	≥ C	wetland area 1.1% of quaternary, 5.5% in AB
			Kliphuis River, upstream of 32° 7'4.63"S; 18°53'45.48"E	≥ A/B	
			Kliphuis River, downstream of 32° 7'4.63"S; 18°53'45.48"E	≥ D	

11.2 OLIFANTS RIVER IN E10J

Key monitoring points for the Olifants River in E10J:

- E1H016 (Olifants River at Clanwilliam Dam; Figure 11.1).
- Olifants River immediately downstream of Clanwilliam Bridge.

Figure 11.1 E1H016 on the Olifants River at Clanwilliam Dam (www.dwa.gov.za)

11.2.1 Hydrology

Source: Clanwilliam Raising Feasibility Study (Southern Waters 2007).
Applicable to: E10F and E10E.
Monitor at: E1H016 (Figure 14.1).
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E1H013.

11.2.1.1 Narrative

Flows shall be suffient to maintain the river in an ecological condition that is ≥ D category.

11.2.1.2 Numerical

Formal stipulations for lowflows are not appropriate at E10J because the Olifants River in this quaternary is used as a conduit for irrigation releases from Clanwilliam Dam (and to maintain levels at Bulshoek Barrage). Thus lowflows exceed those require for hydrological RQOs in the dry summer months and are probably less than those required in the wet winter months. However, consideration of hydrological RQOs for E10J must take into consideration:

1. The river is in a Category D, despite having been subjected to the operating regime of Clanwilliam for *c*. 40 years (since 1962/64).
2. Natural variation will be impossible to achieve as long as the river is used as a conduit for irrigation supply. If assessed at the level of overall volume of lowflows in the wet and dry season, seasonal reversal does not currently occur. Seasonal reversal (at the level of overall volume of lowflows) will however occur if Clanwilliam Dam is raised by 10- and 15-m.
3. Cessation of flows in May and June is frequent under the simulated hydrology used for the Clanwilliam Raising Study for present day, the 10- and 15-m raising scenarios. These are NOT acceptable, and minimum flows in the system should **not ever drop below 0.02 m^3/s**.

The flood requirements for E10J (and the downstream river) should be built into the irrigation releases from the raised Clanwilliiam Dam. Class 1 flood releases can be made in September and October (17 m^3/s for 12 hrs) providing the water level in Bulshoek Barrage can be drawn down below about 4.4 MCM without affecting the yield of the Clanwilliam Dam/Bulshoek Barrage system. The flood requirements are based on the requirement for spawning releases for yellowfish (Cambray *et al*. 1997; King *et al.* 1998). In wet years it is recommended that Class 1 releases are also made in November and December, as these are key spawning months (Table 11.1).

The Class 2, 3 and 4 floods (Table 11.1) occurred in the simulated record presumably as spills and have been included in the RQOs to ensure that the dam operation remains such that they can be supplied, albeit as spill.

Table 11.1 Summary of the flood requirements for E10J for REC of Category D.

Flood type	Daily average peak (m^3/s)	Duration (days)	Volume (MCM)	Number requested[9]	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	20	3	4	4 (10 m) 4 (15 m)	Aug-Dec
Class 2	59	4	11	1 (10 m) 1 (15 m)	Jul-Sep
Class 3	117	6	23	0 (10 m) 1 (15 m)	Jul-Aug-8
Class 4	234	7	49	1 (10 m) 0 (15 m)	June-Aug
Inter-annual Class (return period given below)					
1:2	260	8	78	Present	Not stipulated
1:5	255.7	8	134	Present	Not stipulated
1:10	394.8	11	140	Present	Not stipulated
1:20	481.2	8	140	Present	Not stipulated

[9] The flood requirements differ slightly depending on whether Clanwilliam Dam is raised by 10 or 15 m.

11.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10J.
Monitor at: E1H016 (Olifants River at Clanwilliam Dam) and with periodic field measurements.
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

11.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

11.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given in Table 11.2.

Table 11.2 Water quality RQOs and TPCs for E10J

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg/ ℓ)	< 37	E1H016	>37
Na_2SO_4 (mg/ ℓ)	< 51	E1H016	>51
$MgCl_2$ (mg/ ℓ)	< 51	E1H016	>51
$CaCl_2$ (mg/ ℓ)	< 105	E1H016	>105
NaCl (mg/ ℓ)	< 389	E1H016	>389
Physical			
Water temperature (^oC)	Not specified	No known temperature dependencies for biota in this reach.	None available
pH	6.5 – 9.0	E1H016	>6
EC (mS/ m)	< 15	E1H016	>20
Dissolved oxygen (DO) (mg/ ℓ)	> 6.0	Periodic field measurements	<5.8
Toxics			
Ammonia as NH_3 (mg/ ℓ)	< 0.007	Periodic field measurements	>0.006
Nutrients			
Nitrates as N (mg/ ℓ)	< 0.100	E1H016	>0.09
Phosphorus as PO_4-P (mg/ ℓ)	< 0.020	E1H016	>0.014
Bacteria			
E. coli	0	E1H016	>0

11.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

11.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

11.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

11.2.6 Fish

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.

Monitor at: Olifants River immediately downstream of Clanwilliam Bridge.
Baseline data: Cambray *et al*. 1997; King *et al.* 1998, Paxton (unpublished data), SAIAB database.

11.2.6.1 Narrative
Labeobarbus capensis should be present.

11.2.6.2 Numerical
The suggested numerical limits to achieve the above narrative RQOs are given below.

Table 11.3 Fish RQOs and TPCs for E10J

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	There should be ≥ 1 of the following fish species present in the catch: *Labeobarbus capensis*	None available
	Demographics	There is currently no recruitment of indigenous fish in the mainstem at E10J. All fish are expected to be >150 mm TL	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Aliens	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % *Lepomis macrochirus* Present: *Tilapia sparrmanii, Oreochromis mossambicus*	
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus* and *T. sparrmanii* and < 70 mm TL for bass).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

11.3 TRIBUTARIES

Detailed RQOs have been set for the Jan Dissels River which runs from E10H into E10J, and is the main tributary in this quaternary (see Section 12). Detailed hydrological RQOs cannot be set for the Kliphuis and Seekoei Rivers with the current level of data available.

The Kliphuis River (upstream of 32° 7’4.63"S; 18°53’45.48"E) has been identified as a FEPA and has a PES of B (DWAF 2012d). Its condition should thus be improved to an A/B. The Seekoei River is also a FEPA. Its current condition is C Category.

Basic hydrological RQOs have been set for incremental inflow to E10J as a whole (see Section 11.3.1).

11.3.1 Hydrology

Basic RQOs: Appendix A.

11.3.1.1 Narrative
The ecological Reserve should be sufficient to maintain:

- Category A/B in the Kliphuis River, upstream of 32° 7’4.63"S; 18°53’45.48"E.
- Category D in the Kliphuis River, downstream of 32° 7’4.63"S; 18°53’45.48"E (DWAF 2012d).
- Category C in the Seekoei River.

11.3.1.2 Numerical

See Appendix A.

11.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 11.4.

Table 11.4 Groundwater Reserve Requirements for E10J

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E10J	19.32	2.00	1.63	8%	17.32	10%	B

11.5 WETLANDS

Not applicable (see Table 6.3).

12 E10H (R24) RESOURCE QUALITY OBJECTIVES

12.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E10H	Jan Dissels (above causeway)	≥ B	All small tributaries	≥ B	wetland area 3.3% of quaternary, 10% in AB
E10H	Jan Dissels (between causeway and E1H006)	≥ C	Klip River	≥ B	
			Boschkloof River upstream of 32°12'15.30"S; 18°58'38.51"E	≥ B	
			Boschkloof River downstream of 32°12'15.30"S; 18°58'38.51"E	≥ C	

12.2 JAN DISSELS RIVER IN E10H

Key monitoring points for the Jan Dissels River in E10H:

- E1H006 (Jan Dissels River at Clanwilliam (Figure 12.1).
- Jan Dissels River at causeway at Boskloof (Figure 12.2).

Figure 12.1 E1H006 on the Jan Dissels River at Clanwilliam

Figure 12.2 Jan Dissels River at causeway at Boskloof

12.2.1 Hydrology

Source: Rapid II Reserve Study on the Jan Dissels River (Southern Waters 2007).
Basic RQOs: Appendix A.
Applicable to: E10H at E1H006.
Monitor at: E1H006 (Figure 12.1).
Baseline data: http://www.dwa.gov.za/Hydrology/HyImage.aspx?Station=E1H006.

12.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to:

- Above the Boskloof Causeway: ≥ B Category;
- Boskloof Causeway to E1H006: ≥ C Category;
- In E10J: E1H006 to the confluence with Olifants River: ≥ D Category.

12.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below, and the detail with respect to flood requirements is given in Table 12.1.

Mean flow in driest month at E1H006 (February): 0.03 m^3/s
Even in extreme drought flow should not drop below: 0.01 m^3/s.

Table 12.1 Summary of the flood requirements for E10H

Flood type	Daily average peak (m^3/s)	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	1.60-3.20	2	0.29	3	April - June September - November
Class 2	3.21-6.30	3	0.64	21	June- September
Class 3	6.31-12.50	4	0.93	1	June- September
Class 4	12.51-25.00	5	-	-	Not applicable
Inter-annual Class (return period given below)					
1:2	Not calculated			Present	Not stipulated
1:5	Not calculated			Present	Not stipulated
1:10	Not calculated			Present	Not stipulated
1:20	Not calculated			Present	Not stipulated

12.2.2 Water quality

Source: Rapid II Reserve Study on the Jan Dissels River (Southern Waters 2007).
Applicable to: E10H.
Monitor at: E1H006Q01 (Jan Dissels River at Clanwilliam) and with periodic field measurements.
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

12.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

12.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given in Table 12.2.

Table 12.2 Water quality RQOs and TPCs for E10H

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg/ ℓ)	<23	E1H006	>23
Na_2SO_4 (mg/ ℓ)	<33	E1H006	>33
$MgCl_2$ (mg/ ℓ)	<30	E1H006	>30
$CaCl_2$ (mg/ ℓ)	<57	E1H006	>57
NaCl (mg/ ℓ)	<191	E1H006	>191
Physical			
Water temperature (oC)	Not specified	No known temperature dependencies for biota in this reach.	
pH	5.2 – 7.0	E1H006	>6
EC (mS m^{-1})	<10	E1H006	
Dissolved oxygen (DO) (mg ℓ-1)	> 6.0	Periodic field measurements	<6.0
Toxics			
Ammonia as NH_3 (mg ℓ-1)	< 0.007	Periodic field measurements	None available
Nutrients			
Nitrates as N (mg ℓ-1)	<0.020	E1H006	None available
Phosphorus as PO4-P (mg ℓ-1)	<0.010	E1H006	

12.2.3 Geomorphology

Source: Field visit in 2012.
RQOs: Table 12.3.
Applicable to: EWR Site 1 (2006) - Box 14.1.
Monitor at: Jan Dissels River at causeway at Boskloof (Figure 12.2).
Baseline data: DWAF (2005) – single data collection.

12.2.3.1 Narrative

A riffle run sequence, with aquatic vegetation and stones in current, must be present.

12.2.3.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given below.

Table 12.3 Geomorphological RQOs and TPCs for E10H

Component	Specifications	TPCs
Key habitats		
Aquatic vegetation in and out of current	Must be present	None available
Stones-in-current, including riffle and run	Must be present over at least 50% of the site	None available

12.2.4 Riparian vegetation

Source: Rapid II Reserve Study on the Jan Dissels River (Southern Waters 2007).
Applicable to: E10H.
Monitor at: Jan Dissels River at causeway at Boskloof (Figure 12.2).
Baseline data: DWAF (2007) – single data collection.

12.2.4.1 Narrative

The riparian vegetation should be dominated by indigenous species (see Table 12.4). There shall be no *Sesbania punicea* alongside the river and only isolated individuals of *Acacia longifolia*, *A. mearnsii*, *A. melanoxylon*, *Eucalyptus camaldulensis*. There shall be no *Azolla filiculoides*, *Lemna gibba* or other aquatic weeds in the river.

Table 12.4 Riparian vegetation RQOs and TPCs for E10H; * = exotic species.

Component	Species	RQO	TPCs
Aquatic Zone	*Azolla filiculoides**	None present.	Presence
Aquatic Zone	*Lemna gibba*	None present.	Presence
Upper Wet Bank	*Phragmites australis*	Only a narrow banding should be present in Wet Bank.	None available
Wet Bank	*Prionium serratum*	Narrow banding should be present on pebbles and coarse sandy substrates exposed during lower flows.	None available
Upper Wet Bank	Sesbania punicea*	None present.	Presence
All zones	*Acacia longifolia**, *A. mearnsii**, *A. melanoxylon**, *Eucalyptus camaldulensis**	Only isolated individuals present.	None available

12.2.4.2 Numerical

None available.

12.2.5 Macroinvertebrates

Source: Rapid II Reserve Study on the Jan Dissels River (Southern Waters 2007).
Applicable to: E10H.
Monitor at: Jan Dissels River at causeway at Boskloof (Figure 12.2).
Baseline data: DWAF (2007) – single data collection.

12.2.5.1 Narrative

The macroinvertebrate community should be dominated by sensitive mountan stream taxa.

12.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 12.5.

Table 12.5 Macroinvertebrate RQOs and TPCs for E10H

Component			RQO	TPCs
	Order	Taxa		
Family presence/ absence	Ephemeroptera	Baetidae	> 4 species	Fewer than 7 species present overall at site (all biotopes combined)
		Demoreptus capensis	Present in summer	Absent in summer
		Leptophlebiidae	Present in at least 50% of replicate samples	Fewer than Baetidae in summer samples
		Heptageniidae	Present in summer in stones-in-current / stones-out-of-current	
	Coleoptera	Any	> 3 families	< 3 families present
	Trichoptera	Any	> 3 families	Fewer than 5 species present overall at site, and two or fewer of the following families: Barbarochthonidae, Leptoceridae, Petrothrincidae, Sericostomatidae
	Odonata	Any	> 1 family	Absent
		Corydalidae	Present in summer	
		Philopotamidae	Present in winter	
	Plecoptera	Notonemouridae	Present in 50% of replicate samples of stones-in-current	Absent from samples
SASS results	SASS Score		>150	<150
	ASPT		>7.5	<8

12.2.6 Fish

Source: Paxton (unpublished data), SAIAB database.
Applicable to: E10F and E10E.
Monitor at: Boskloof Causeway.
Baseline data: Paxton (unpublished data), SAIAB database.
Gear: RQOs for the fish assemblages assume the use of a range of gears including: small fyke nets (20-m wing length) in tributary pools, seine nets on sandy beaches if present (5X2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

12.2.6.1 Narrative

At least three of the following species should be present in the catch: *Labeobarbus capensis, Austroglanis gilli*, *Austroglanis barnardi*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Galaxias zebratus*. There should be no alien species present.

12.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 12.6.

Table 12.6 Fish RQOs and TPCs for E10H

Indigenous	Sub-component	RQOs	TPCs
	Species assemblage	At least three of the following species should be present in the catch: Labeobarbus capensis, Austroglanis gilli, Austroglanis barnardi, Barbus calidus, Pseudobarbus phlegethon, Galaxias zebratus	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 40 mm FL for small cyprinids; < 70 mm TL for large cyprinids).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	There should be no alien fish species present in the tributaries	Presence of <u>any</u> alien fish
	Demographics	No alien fish species present	
	Fish Health	No alien fish species present	

12.3 TRIBUTARIES

The Boskloof has been identified as a FEPA and has a PES of B. Its condition should thus be improved to an A/B.

Basic hydrological RQOs have been set for incremental inflow to E10H as a whole (see Section 12.3.1).

12.3.1 Hydrology

Basic RQOs: Appendix A.

12.3.1.1 Narrative

The ecological Reserve should be sufficient to maintain:

- Category A/B in the Boskloof River upstream of 32°12’15.30"S; 18°58’38.51"E.
- Category C in the Boskloof River downstream of 32°12’15.30"S; 18°58’38.51"E.
- Category B in the Klip River.

12.3.1.2 Numerical

See Appendix A.

RQOs cannot be set for the tributaries of the Jan Dissels with the current level of data available.

12.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 12.7.

Table 12.7 Groundwater Reserve Requirements for E10H

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E10H	9.62	0.33	1.51	16%	9.30	3%	A

12.5 WETLANDS

Not applicable (see Table 6.3).

13 E10G (R34) RESOURCE QUALITY OBJECTIVES

13.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E10G	Olifants	≥ D	Rondegat	≥ B	-
			Elandskloof	≥ D	

13.2 OLIFANTS RIVER IN E10G

The Olifants River within quaternary catchment E10G is mainly inundated by the backwaters of the Clanwilliam Dam. The RQOs at E10F apply to the uninundated reaches of the mainstem (see Section 14).

13.3 TRIBUTARIES

Detailed RQOs have been set for the Rondegat River, which is the main tributary in this quaternary (see Section 12). Detailed hydrological RQOs cannot be set for the Kliphuis River with the current level of data available.

13.3.1 Kliphuis River

The Kliphuis River (upstream of 32° 7'4.63"S; 18°53'45.48"E) has been identified as a FEPA and has a PES of B (DWAF 2012d). Its condition should thus be improved to an A/B.

The ecological Reserve should be sufficient to maintain:

- Category A/B in the Kliphuis River, upstream of 32° 7'4.63"S; 18°53'45.48"E.
- Category D in the Kliphuis River, downstream of 32° 7'4.63"S; 18°53'45.48"E (DWAF 2012d).

13.3.2 Rondegat River

The Rondegat has been identified as a FEPA. It is currently in a B Category. Efforts should thus be made to improve the condition of the upper reaches (above EWR3) to an A/B.

Key monitoring points for the Rondegat River in E10G:

- EWR Site 3 (2006; Figure 12.1; Box 10.1).

Figure 13.1 Rondegat River at EWR Site 3 (2006)

13.3.2.1 Hydrology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10G-Rondegat.
Monitor at: EWR Site 3.

13.3.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to B Category.

13.3.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below, and the detail with respect to flood requirements is given in Table 13.2.

Mean flow in driest month (February): 0.11 m^3/s
Even in extreme drought flow should not drop below: 0.01 m^3/s.

Box 13.1 Relevant details for EWR Site 3 (2006): Olifants River

Location: Upstream of the Algeria staff accommodation, on the road between Algeria and Clanwilliam Dam.
Coordinates: S 32°21.760; E 19°02.618.
Hydrology: There is no DWAF gauging weir on the Rondegat River.
Access: Take the dirt road at the cemetery on the Algeria/Clanwilliam road, on the Clanwilliam side of the bridge across the river.
Cross-sections: Two cross-sections were selected at EWR Site 3 (Figure 13.2). These were:
CS 3a: Across a pool/run.
CS 3b: Across a riffle/cascade.

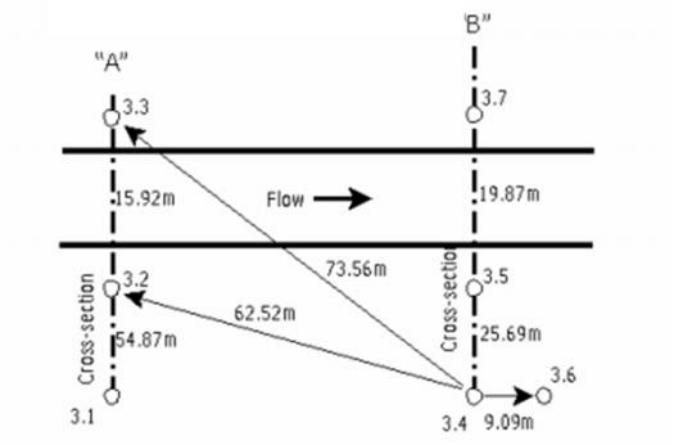

Figure 13.2 Plan layout for EWR Site 3.

Fixed stations were also installed at the site in November 2003. The elevations (above a local datum; Eald) of the fixed stations, the orientations of cross-sections relative to fixed stations and a description of the station type (steel peg in concrete or marked rock (MRK)) are given in Table 13.1.

Table 13.1 Elevations of fixed stations, orientations of cross-sections relative to fixed stations and descriptions of station type.

River	EWR Site No.	Cross-section	Station		Horizontal angle from orientation station to cross-section (dec. deg.)	Eald[10] (m)
			Set-up	Orientation		
Rondegat	3	A	3.2(SPC)	3.1(PIC)	180.000	99.936
				3.3(MRK)	0.000	89.151
		B	3.4(MRK)	3.2(SPC)	58.187	89.421
				3.3(MRK)	48.440	
				3.5(SPC)	0.000	88.319
				3.6(MRK)	258.402	95.931
				3.7(MRK)	0.000	87.705

[10] Elevation above local datum.

Table 13.2 Summary of the flood requirements for Rondegat in E10G

Flood type	Daily average peak (m^3/s)	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	0.32	3	0.05	4	April - June September - November
Class 2	0.64	3	0.11	3	June- September
Class 3	1.28	4	0.22	2	June- September
Class 4	2.56	4	0.44	2	June- September
Inter-annual Class (return period given below)					
1:2	2.8	7	1.02	Present	Not stipulated
1:5	3.9	8	1.3	Present	Not stipulated
1:10	6.5	8	1.88	Present	Not stipulated
1:20	11.0	10	2.87	Present	Not stipulated

13.3.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10G.
Monitor at: EWR Site 3.
Baseline data: Comprehensive Reserve Determination Study (DWAF 2005).

13.3.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

13.3.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given in Table 13.3.

Table 13.3 Water quality RQOs and TPCs for Rondegat in E10G

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg/ ℓ)	<23	EWR Site 3 (2006); Periodic field measurements	>23
Na_2SO_4 (mg/ ℓ)	<33		>33
$MgCl_2$ (mg/ ℓ)	<30		>30
$CaCl_2$ (mg/ ℓ)	<57		>57
NaCl (mg/ ℓ)	<191		>191
Physical			
Water temperature (oC)	Not specified	No known temperature dependencies for biota in this reach.	
pH	5.2 – 7.0	Periodic field measurements	>6
EC ($mS\ m^{-1}$)	<10		
Dissolved oxygen (DO) (mg ℓ-1)	> 6.0		<6.0
Toxics			
Ammonia as NH_3 (mg ℓ-1)	< 0.007	Periodic field measurements	None available
Nutrients			
Nitrates as N (mg ℓ-1)	<0.020	E1H006	None available
Phosphorus as PO4-P (mg ℓ-1)	<0.010	E1H006	

13.3.2.3 Geomorphology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: EWR Site 2 (2006) - Box 13.1.
Monitor at: EWR Site 3 (2006).
Baseline data: DWAF (2005) – single data collection.

13.3.2.3.1 Narrative

A riffle run sequence, with aquatic vegetation and stones in current, must be present.

13.3.2.3.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 13.4.

Table 13.4 Geomorphological RQOs and TPCs for Rondegat in E10G

Key habitats		
Aquatic vegetation in and out of current	Must be present	None available
Stones-in-current, including riffle and run	Must be present over at least 50% of the site	None available

13.3.2.4 Riparian vegetation

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: EWR Site 3 (2006) - Box 13.1.
Monitor at: EWR Site 3 (2006)
Baseline data: DWAF (2005) – single data collection.

13.3.2.4.1 Narrative

The indigenous riparian vegetation should be intact with no aliens present.

13.3.2.4.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 13.5.

Table 13.5 Riparian vegetation RQOs and TPCs s for Rondegat in E10G; * = exotic species.

Component	Species	RQO	TPCs
Aquatic Zone	*Azolla filiculoides**	None present.	Present
Aquatic Zone	*Lemna gibba*	None present.	Present
Aquatic Zone	*Isolepis digitata*	Plants totally immersed during high flows, only just dry during low dry season flows	None available
Lower Wet Bank	*Juncus lomatophyllus*	Low density on coarse sandy substrates.	None available
Lower Wet Bank	*Isolepis prolifer*	Low density on coarse sandy substrates exposed during lower flows.	None available
Lower Wet Bank	*Paspalum urvillei**	Low leaf density around edges of waterways during dry season.	None available
Upper Wet Bank	*Phragmites australis*	Not present.	None available
Upper Wet Bank	*Prionium serratum*	Narrow banding should be present	None available

Component	Species	RQO	TPCs
		on pebbles and coarse sandy substrates exposed during lower flows.	
Wet Bank	*Salix mucronata*	Must be present.	Absent
Upper Wet Bank	*Brabejum stellatifolium*	Lining parts of rivers and streams exposed to annual winter high flows	None available
	*Sesbania punicea**	None present.	Present
All zones	*Acacia longifolia*, A. mearnsii*, A. melanoxylon*, Eucalyptus camaldulensis**	None present.	Present

13.3.2.5 Macroinvertebrates

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: EWR Site 3 (2006) - Box 13.1.
Monitor at: EWR Site 3 (2006).
Baseline data: DWAF (2005) – single data collection.

13.3.2.5.1 Narrative

The macroinvertebrate community should be dominated by sensitive mountan stream taxa.

13.3.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 13.6.

Table 13.6 Macroinvertebrate RQOs and TPCs for Rondegat in E10G

Component			RQO	TPCs
	Order	Taxa		
Family presence/ absence	Ephemeroptera	Baetidae	At least 7 species overall at site (all biotopes combined) on any sampling occasion	Fewer than 7 species present overall at site (all biotopes combined)
		Demoreptus capensis	Present in summer	Absent in summer
		Leptophlebiidae	Present in at least 80% of replicate samples	Fewer than Baetidae in summer samples
		Heptageniidae	Present in summer; dominant (over Baetidae)	
	Coleoptera	Any	> 3 families	< 3 families present
	Trichoptera	Any	> 3 families	Fewer than 5 species present overall and < 3 of the following families: Barbarochthonidae, Leptoceridae, Petrothrincidae, Sericostomatidae
	Odonata	Any	> 1 family	Absent
		Corydalidae	Present in summer	
		Philopotamidae	Present in winter	
	Plecoptera	Blephariceridae	Present in low numbers in winter	Absent from winter samples
		Notonemouridae	Present in 50% of replicate samples of stones-in-current	Absent from samples
SASS results	SASS Score		>170	<150
	ASPT		>7.5	<8

13.3.2.6 Fish

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: EWR Site 3 (2006) - Box 13.1.
Monitor at: EWR Site 3 (2006).
Baseline data: DWAF (2005) – single data collection, Paxton (unpublished data), SAIAB database
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: small fyke nets (20-m wing length) in tributary pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

13.3.2.6.1 Narrative

At least three of the following species should be present in the catch: *Labeobarbus capensis, Austroglanis gilli*, *Austroglanis barnardi*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Galaxias zebratus*. There should be no alien species present.

13.3.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 13.7.

Table 13.7 Fish RQOs and TPCs for Rondegat in E10G

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	At least three of the following species should be present in the catch: Labeobarbus capensis, Austroglanis gilli, Austroglanis barnardi, Barbus calidus, Pseudobarbus phlegethon, Galaxias zebratus	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 40 mm FL for small cyprinids; < 70 mm TL for large cyprinids).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	There should be no alien fish species present in the tributaries	Presence of any alien fish
	Demographics	No alien fish species present	
	Fish Health	No alien fish species present	

13.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 13.8.

Table 13.8 Groundwater Reserve Requirements for E10G

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E10G	26.88	1.91	4.21	16%	24.97	7%	B

13.5 WETLANDS

Not applicable (see Table 6.3).

14 E10F AND E10E (R33) RESOURCE QUALITY OBJECTIVES

14.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E10E	Olifants	≥ D	Boskloof River, upstream of 32°33'33.31"S; 19° 3'27.17"E (FEPA)	≥ A/B	wetland area 5.8% of quaternary, 10% in AB
			Boskloof River, downstream of 32°33'33.31"S; 19° 3'27.17"E	≥ D	
			Boontjies River, upstream of 32°34'43.37"S; 19° 2'8.04"E	≥ A/B	
			Boontjies River, downstream of 32°34'43.37"S; 19° 2'8.04"E.	≥ D	
E10F	Olifants	≥ D	Heks River, upstream of 32°26'15.71"S; 18°58'44.78"E (FEPA)	≥ A/B	-
			Heks River, downstream of 32°26'15.71"S; 18°58'44.78"E	≥ D	
			Palmietfontein River	≥ D	

14.2 OLIFANTS RIVER IN E10F (AND E10E)

Key monitoring points for the Olifants River in E10F (and E10E):

- E1H013 (Olifants River at Citrusdal; Figure 14.1).
- EWR Site 1 (2006; Box 14.1; Figure 14.3).

Figure 14.1 E1H013 on the Olifants River at the Citrusdal Bridge

Box 14.1 Relevant details for EWR Site 1 (2006): Olifants River

Location: Adjacent to the N7 near the confluence with the Hex River.
Coordinates: S 32°26.764; E 18°57.601.
Hydrology: There is no DWAF gauging weir at the site but flows can be determined from E1H013.
Access: From a lay-by on the N7. Permission to work the site should be obtained from the owner, Mr Visser, at Hex Rivier Farm on the opposite site of the river from the N2.
Cross-sections: Two cross-sections were surveyed at the site in November 2003 (Figure 14.2). These were:
CS A: Across a riffle.
CS B: Across a pool section.

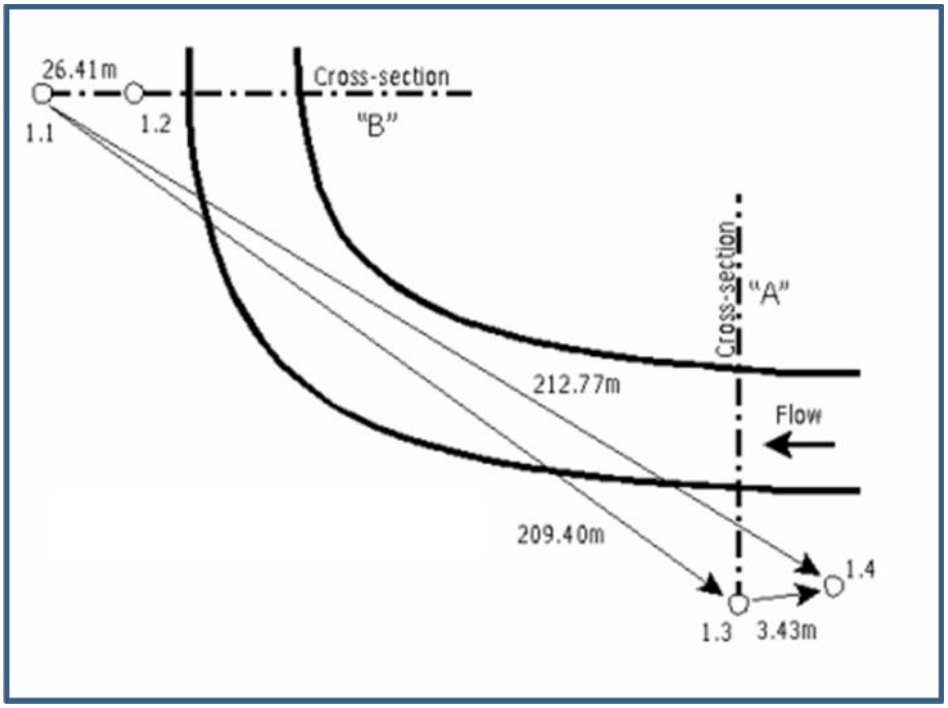

Figure 14.2 Plan layout for EWR Site 1.

Fixed stations were also installed at the site in November 2003. The elevations (above a local datum; Eald) of the fixed stations, the orientations of cross-sections relative to fixed stations and a description of the station type (steel peg in concrete or marked rock (MRK)) are given in Table 14.1.

Table 14.1 Elevations of fixed stations, orientations of cross-sections relative to fixed stations and descriptions of station type.

River	EWR Site No.	Cross-section	Station		Horizontal angle from orientation station to cross-section (dec. deg.)	Eald[11] (m)
			Set-up	Orientation		
Olifants	1	A	1.3(SPC)	1.4(MRK)	265.394	91.995
		B	1.1(SPC)	1.2(MRK) 1.3 1.4	0.000 309.816 309.984	88.466 91.836

[11] Elevation above local datum.

Figure 14.3 EWR 1 (Olifants River; 2006) from the N2

14.2.1 Hydrology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.
Monitor at: E1H013 (Figure 14.1).
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E1H013.

14.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to D Category.

14.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below, and the detail with respect to flood requirements is given in Table 14.2.

Mean flow in driest month (February): 0.6 m^3/s
Minimum Dry Season Lowflow: 0.01 m^3/s.

Table 14.2 Summary of the flood requirements for E10F.

Flood type	Daily average peak (m^3/s)	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	9	3	3.3	10	April - June September - November
Class 2	20	6	6.5	1	June- September
Class 3	36	7	12.4	1	June- September
Class 4	85	10	30.4	0	Not applicable
Inter-annual Class (return period given below)					
1:2	380	12	52.5	Present	Not stipulated
1:5	530	14	81.29	Present	Not stipulated
1:10	665	14	164.4	Present	Not stipulated
1:20	870	14	164.4	Present	Not stipulated

14.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.
Monitor at: E1H013 (Olifants River at Citrusdal) and with periodic field measurements.
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

14.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

14.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given in Table 14.3.

Table 14.3 Water quality RQOs and TPCs for E10F

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg/ ℓ)	< 37	E1H013	>37
Na_2SO_4 (mg/ ℓ)	< 51	E1H013	>51
$MgCl_2$ (mg/ ℓ)	< 51	E1H013	>51
$CaCl_2$ (mg/ ℓ)	< 105	E1H013	>105
NaCl (mg/ ℓ)	< 389	E1H013	>389
Physical			
Water temperature (^oC)	Not specified	No known temperature dependencies for biota in this reach.	None available
pH	6.5 – 9.0	E1H013	>6
EC (mS/ m)	< 15	E1H013	>20
Dissolved oxygen (DO) (mg/ ℓ)	> 6.0	Periodic field measurements	<5.8
Toxics			
Ammonia as NH_3 (mg/ ℓ)	< 0.007	Periodic field measurements	>0.006
Nutrients			
Nitrates as N (mg/ ℓ)	< 0.100	E1H013	>0.09
Phosphorus as PO_4-P (mg/ ℓ)	< 0.020	E1H013	>0.014
Bacteria			
E. coli	0	E1H016	>0

14.2.3 Geomorphology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.
Monitor at: EWR Site 1 (2006) - Box 14.1.
Baseline data: DWAF (2005) – single data collection.

14.2.3.1 Narrative

The river channel structure and habitats should be in a minimum of a D-category. A riffle/run-pool sequence should be present at all flows. Sediment-size should be consistent with a Western Cape foothill river.

14.2.3.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 14.4.

Table 14.4 Geomorphological RQOs and TPCs for E10F

Component	Values: Cross-section A	Values: Cross-section B	TPCs
Dry season bed material composition (mm)			
D16	0.6	0.4	> 20% increase or decrease
D50	48	0.7	> 20% increase or decrease
D84	180	0.9	> 30% increase or decrease
Channel geometry			
Dry season water surface slope (m/m)	0.015	0.00005	> 5% increase or decrease
Active channel width (m)	20.5	14.5	> 5% increase or decrease
Bankfull width (m)	27.5	28	> 5% increase or decrease
Key habitats			
Aquatic vegetation in and out of current	Must be present		None available
Stones-in-current, including riffle and run	Must be present over at least 50% of the site		None available

14.2.4 Riparian vegetation

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.
Monitor at: EWR Site 1 (2006) - Box 14.1.
Baseline data: DWAF (2005) – single data collection.

14.2.4.1 Narrative

The indigenous marginal vegetation should be intact and dominated by indigenous species. There should be no *Sesbania punicea* and only isolated individuals of *Acacia longifolia, A. mearnsii, A. melanoxylon* and *Eucalyptus camaldulensis* present.

14.2.4.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 14.5.

Table 14.5 Riparian vegetation RQOs and TPCs for E10F; * = exotic species.

Component	Species	RQO	TPCs
Indigenous species			
Aquatic Zone	*Lemna gibba*	None present.	Present
Lower Wet Bank	*Panicum repens*	Low density on channel margins.	None available
Lower Wet Bank	*Juncus lomatophyllus*	Low density on coarse sandy substrates.	None available
Lower Wet Bank	*Isolepis prolifer*	Low density on coarse sandy substrates exposed during lower flows.	None available
Upper Wet Bank	*Phragmites australis*	Only a narrow banding should be present in Wet Bank.	None available
Upper Wet Bank	*Prionium serratum*	Narrow banding should be present on pebbles and coarse sandy substrates exposed during lower flows.	None available
Wet Bank	*Salix mucronata*	Must be present.	None available
Exotic species			
Aquatic Zone	*Azolla filiculoides*	None present.	Present
Lower Wet Bank	*Paspalum urvillei*	Low leaf density around edges of waterways during dry season.	None available
Upper Wet Bank	*Sesbania punicea*	None present.	Present
All zones	*Acacia longifolia, A. mearnsii, A. melanoxylon, Eucalyptus camaldulensis*	Only isolated individuals present.	

14.2.5 Macroinvertebrates

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.
Monitor at: EWR Site 1 (2006) - Box 14.1.
Baseline data: DWAF (2005) – single data collection.

14.2.5.1 Narrative

The macroinvertebrate community should be representative of a slightly impacted Western Cape foothill river.

14.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 14.6.

Table 14.6 Macroinvertebrate RQOs and TPCs for E10F

Component			RQO	TPCs
Family presence/ absence	Order	Taxa		
	Ephemeroptera	Baetidae	> 4 species	<4 species
		Demoreptus capensis	Present in summer	Absent in summer
		Leptophlebiidae	Present in at least 50% of replicate samples	-
		Heptageniidae	Present in summer in stones-in-current / stones-out-of-current	Absent in summer
	Coleoptera	Any	> 3 families	< 3 families
	Trichoptera	Any	> 3 families	< 3 families
	Odonata	Any	> 1 family	Absent
		Corydalidae	Present in summer	Absent in summer
		Philopotamidae	Present in winter	Absent in winter
	Plecoptera	Notonemouridae	Present in 50% of replicate samples of stones-in-current	-
SASS results	SASS Score		>100	<90
	ASPT		>7.5	<7

14.2.6 Fish

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E10F and E10E.
Monitor at: EWR Site 1 (2006) - Box 14.1.
Baseline data: DWAF (2005) – single data collection, Paxton (unpublished data), SAIAB database.
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

14.2.6.1 Narrative

Labeobarbus capensis should be present.

14.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 14.7.

Table 14.7 Fish RQOs and TPCs for E10F

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	There should be ≥ 1 of the following fish species present in the catch: *Labeobarbus capensis*	None available
	Demographics	There is currently no recruitment of indigenous fish in the mainstem at E10F. All fish are expected to be >150 mm TL	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % *Lepomis macrochirus* Present: *Tilapia sparrmanii*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus* and *T. sparrmanii* and < 70 mm TL for bass)	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

14.3 TRIBUTARIES

The upper reaches of the Heks (B Category) and Boskloof (B Category) tributaries (DWAF 2012d) have been identified as FEPAs. The Palmietfontein River was also identified as a FEPA, although it is currently in a D Category. Efforts should be made to improve the condition of the Palmietfontein.

Detailed hydrological RQOs cannot be set for individual tributaries with the current level of data available, however, there are data for fish and this is area is important since it supports a good representation of the indigenous species.

14.3.1 Hydrology

Basic RQOs: Appendix A.

14.3.1.1 Narrative

The ecological Reserve should be sufficient to maintain:

- E10E:
  - Category A/B in the Tee River, upstream of 32°33’33.31"S; 19° 3’27.17"E.
  - Category D in the Tee River, downstream of 32°33’33.31"S; 19° 3’27.17"E (DWAF 2012d).
  - Category A/B in the Boontjies River, upstream of 32°34’43.37"S; 19° 2’8.04"E.
  - Category D in the Boontjies River, downstream of 32°34’43.37"S; 19° 2’8.04"E.
- E10F:
  - Category A/B in the Heks River, upstream of 32°26’15.71"S; 18°58’44.78"E.
  - Category D in the Heks River, downstream of 32°26’15.71"S; 18°58’44.78"E (DWAF 2012d).
  - Category D in the Palmietfontein River.

14.3.1.2 Numerical

The combined incremental Reserve allocation is given in Appendix A.

14.3.2 Fish

Source: Paxton (unpublished data)
Applicable to: Tributaries in E10F and E10E.
Monitor at: The Heks River: 32°26'14.21"S, 18°58'52.69"E (E10F), Tee River: 32°34'3.80"S, 19° 2'33.49"E (E10E)
Baseline data: Paxton (unpublished data), SAIAB database.
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: small fyke nets (20-m wing length) in tributary pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

14.3.2.1 Narrative

Barbus anoplus and *Austrolganis barnardi* should be present. There should be no alien species present.

14.3.2.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 14.7.

Table 14.8 Fish RQOs and TPCs for E10F tributaries

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	At least one of the following species should be present in the catch: *Barbus anoplus, Austrolganis barnardi*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 40 mm FL for small cyprinids; < 70 mm TL for large cyprinids)	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	There should be no alien fish species present in the tributaries	Presence of any alien species
	Demographics	No alien fish species present	
	Fish Health	No alien fish species present	

14.4 GROUNDWATER - OVERVIEW

The area is dominated by fractured, folded TMG aquifers (Peninsula and Nardouw aquifers) on both sides of the valley and thick alluvium aquifer which occurs along the Olifants River course underlain by the Bokkeveld Group. The thick alluvium deposits can be considered an extension of the river system storing surplus water from flood events and releasing the water back into the river during low flow conditions.

The groundwater Reserve requirements per quaternary catchment, based on the surface water low flow requirements, are given in Table 14.9.

Table 14.9 Groundwater Reserve Requirements for E10E and E10F.

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E10E	30.67	2.49	7.35	24%	28.18	8%	B
E10F	28.28	2.45	5.13	18%	25.83	9%	B

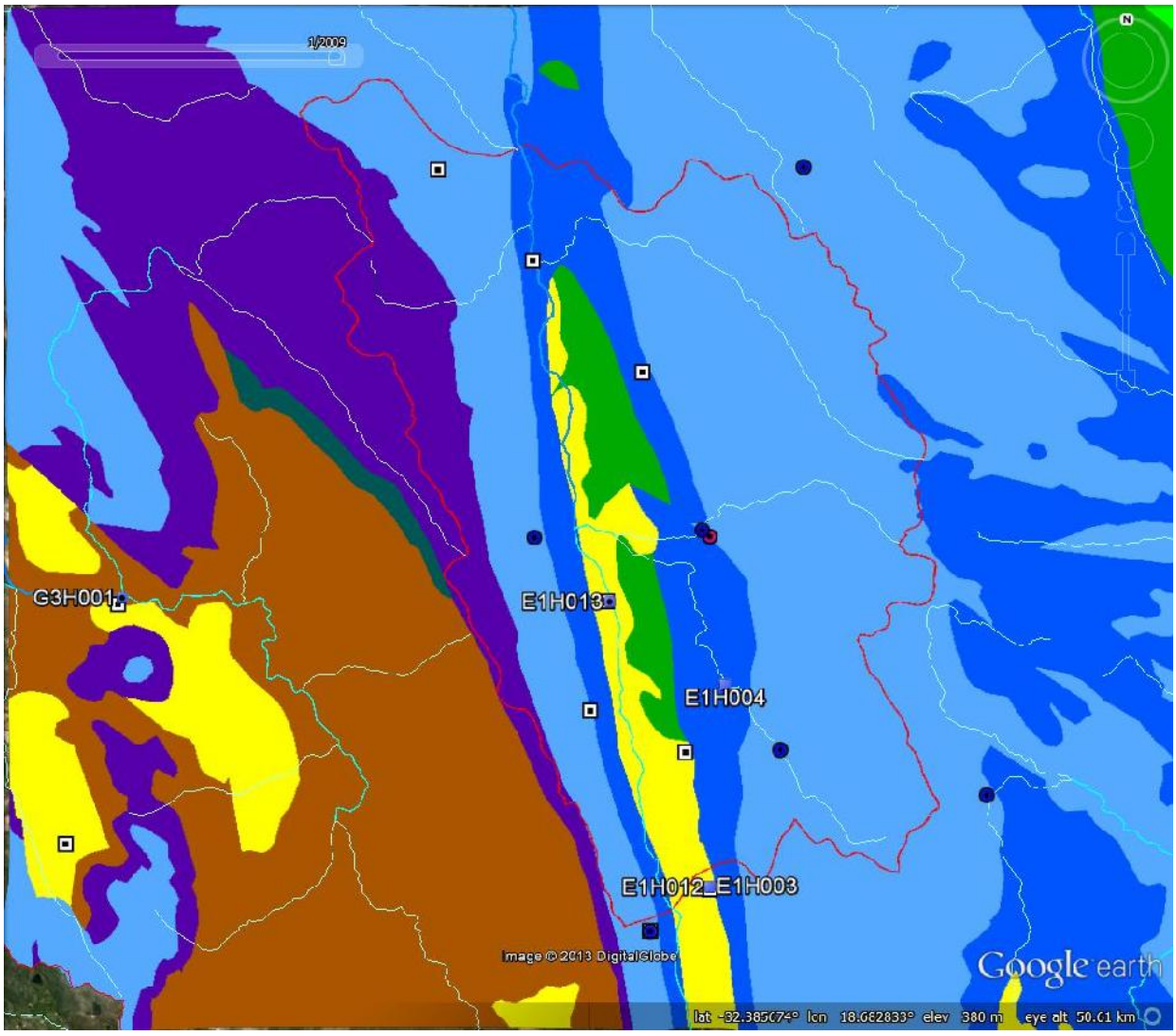

Figure 14.4 Map of RU33 with aquifer delineation (light and dark blue: TMG Aquifer, yellow: Alluvium, green: Bokkeveld), existing monitoring points (blue: WMS boreholes, red: HYDSTRA borehole water level) and proposed monitoring points (white squares)

14.5 ALLUVIUM AQUIFER

Groundwater is extensively used in the area and possibly subjected to over-abstraction within the Olifants River valley during dry periods, which could have a negative impact on water availability and water quality, as well as the low flow conditions in the receiving surface waters. The intensive irrigation could lead to declining water quality due to the effect of return flows. Urban and industrial areas could also have an impact on water quality.

14.5.1 Water quantity

The setting of water quantity related RQOs (see Table 14.10) is aimed at maintaining or improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

14.5.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

14.5.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 14.10.

Table 14.10 Water quantity RQOs for the Alluvium Aquifer in RU33

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the allocation schedule and individual licence conditions	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Water level monitoring network required
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Water level	Water level in the aquifer must be higher than the water level in the surface water.	n/a	
	Low flow in river	Compliance to the lowflow requirements in the river as per Reserve requirement (see above)	0.6 m^3/s / 0.01 m^3/s	E1H013

14.5.2 Water quality

The setting of water quality related RQOs (see Table 14.11) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

14.5.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

14.5.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 14.11.

Table 14.11 Water quality RQOs for the Alluvium Aquifer in RU33

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Extension of WMS network required
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network & parameters required
	Total Coliform		10 counts / 100ml	

14.6 TMG AQUIFERS

Groundwater is used in the area to supplement the water use from the Olifants River during dry periods, which could have a negative impact on water availability and water quality, as well as the low flow conditions in the receiving surface waters.

14.6.1 Water quantity

The setting of water quantity related RQOs (see Table 14.12) is aimed at maintaining the groundwater discharge towards wetland and river FEPAs and ensuring sufficient yield for all users.

14.6.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

14.6.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 14.12.

Table 14.12 Water quantity RQOs for the TMG Aquifer in RU33

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the allocation schedule and individual licence conditions	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Water level monitoring network required
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Buffer zones	Around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	250m	

14.6.2 Water quality

The setting of water quality related RQOs (see Table 14.13) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

14.6.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

14.6.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 14.13.

Table 14.13 Water quality RQOs for the TMG Aquifer in RU33

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Extension of WMS network required
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network & parameters required
	Total Coliform		10 counts / 100ml	

14.7 WETLANDS

Not applicable (see Table 6.3).

15 E10D (R40), E10C (R42) AND E10B (R44) RESOURCE QUALITY OBJECTIVES

15.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E10D	Olifants	≥ C	Tee upstream of 32°47'41.57"S; 19° 5'36.76"E (FEPA)	≥ A/B	wetland area 5.4% of quaternary, 16% in AB
			Tee downstream of 32°47'41.57"S; 19° 5'36.76"E	≥ D	
E10C	Olifants (FEPA)	≥ B	Ratel (FEPA) and Dwars (FEPA)	≥B	wetland area 1.2% of quaternary, 85% in AB
E10B		≥ C	Unnamed tributary with confluence at 32°58'19.96"S; 19°10'57.03"	≥ D	-
			Unnamed tributary with confluence at 33°00'25.19"S; 19°12'05.90" (FEPA)	≥ B	

15.2 OLIFANTS RIVER IN E10D, E10C AND E10B

While E10D was not selected as a river priority (see Table 6.3), certain RQOs are relevant as provided below. A section of the Olifants mainstem in E10C (R42) and in E10B (R44) (both reaches in B Categories) has been identified as FEPAs, and their condition should not be allowed to deteriorate.

15.2.1 Hydrology

Basic RQOs: Appendix A.

15.2.1.1 Narrative

Flows shall be sufficient to maintain:

- E10D in ≥ C Category;
- E10C in ≥ B Category (FEPA);
- E10B in ≥ B Category (FEPA).

15.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (February):
E10D: 0.41 m^3/s
E10C: 0.19 m^3/s
E10B: 0.1 m^3/s
Even in extreme drought flow should not drop below:
E10D: 0.004 m^3/s
E10C: 0.001 m^3/s
E10B: 0.001 m^3/s

15.2.2 Water quality

15.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

15.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits cannot be set with the current level of data available.

15.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

15.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

15.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

15.2.6 Fish

Source:	Paxton (unpublished data),
Applicable to:	E10D.
Monitor at:	River Node R40: 32°43'56.66"S, 19° 2'51.87"E
Baseline data:	Paxton (unpublished data), SAIAB database.
Gear:	The RQOs for the fish assemblages assume the application a range of gear types including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

15.2.6.1 Narrative

Labeobarbus capensis should be present.

15.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 15.1.

Table 15.1 Fish RQOs and TPCs for E10D

Indigenous	Sub-component	RQOs	TPCs
	Species assemblage	There should be ≥1 of the following fish species present in the catch: *Labeobarbus capensis*	None available
	Demographics	There is currently no recruitment of indigenous fish in the mainstem at E10D. All fish are expected to be >150 mm TL.	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % *Lepomis macrochirus* Present: *Tilapia sparrmanii*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus* and *T. sparrmanii* and < 70 mm TL for bass).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

15.3 TRIBUTARIES

The Tee (C Category), Ratel (C Category), Dwars (B Category) and another tributary which is not named in the DWA shapefiles (PES of B) have been identified as FEPAs. Their condition should not be allowed to deteriorate further and efforts should be made to improve the condition of the Tee and the Ratel.

Detailed hydrological RQOs cannot be set for individual tributaries with the current level of data available, however, there are data for fish in the Thee River and this is area is important since it supports a good representation of the indigenous species.

15.3.1 Hydrology

Basic RQOs: Appendix A.

15.3.1.1 Narrative

The ecological Reserve should be sufficient to maintain:

- Category ≥ B in the Thee River, upstream of 32°33'33.31"S; 19° 3'27.17"E;
- Category ≥ A/B in the Ratel River;
- Category ≥ A/B in the Dwars River.

15.3.1.2 Numerical

The combined incremental Reserve allocations are given in Appendix A.

15.3.2 Fish

The Tee River supports a good representation of the indigenous fish species.

Source: Paxton (unpublished data),
Applicable to: E10D tributaries.
Monitor at: Thee River, 32°48'0.88"S; 19° 5'13.08"E.

Baseline data: Paxton (unpublished data), SAIAB database.

Gear: The RQOs for the fish assemblages assume the application a range of gear types including: small fyke nets (20-m wing length) in tributary pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

15.3.2.1 Narrative

At least three of the following five species should be present at the site *Labeobarbus capensis*, *Austroglanis gilli*, *Austroglanis barnardi*, *Barbus calidus*, *Pseudobarbus phlegethon* and *Galaxias zebratus.*

15.3.2.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 15.2.

Table 15.2 Fish RQOs and TPCs for E10D tributaries

Indigenous	Sub-component	RQOs	TPCs
	Species assemblage	At least three of the following five species should be present in the catch: *Labeobarbus capensis*, *Austroglanis gilli*, *Austroglanis barnardi*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Galaxias zebratus*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 40 mm FL for small cyprinids; < 70 mm TL for large cyprinids).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	There should be no alien fish species present in the tributaries	Presence
	Demographics	No alien fish species present	
	Fish Health	No alien fish species present	

15.4 GROUNDWATER – OVERVIEW

The area is dominated by fractured, folded TMG aquifers (Peninsula and Nardouw aquifers) on both sides of the valley and an alluvium aquifer which occurs along the Olifants River course. The thick alluvium deposits can be considered an extension of the river system storing surplus water from flood events and releasing the water back into the river during low flow conditions.

The groundwater Reserve requirements for the whole quaternary catchment, based on the surface water low flow requirements, are given in Table 15.3.

Table 15.3 Groundwater Reserve Requirements for E10D

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E10D	24.35	0.50	5.74	24%	23.85	2%	A

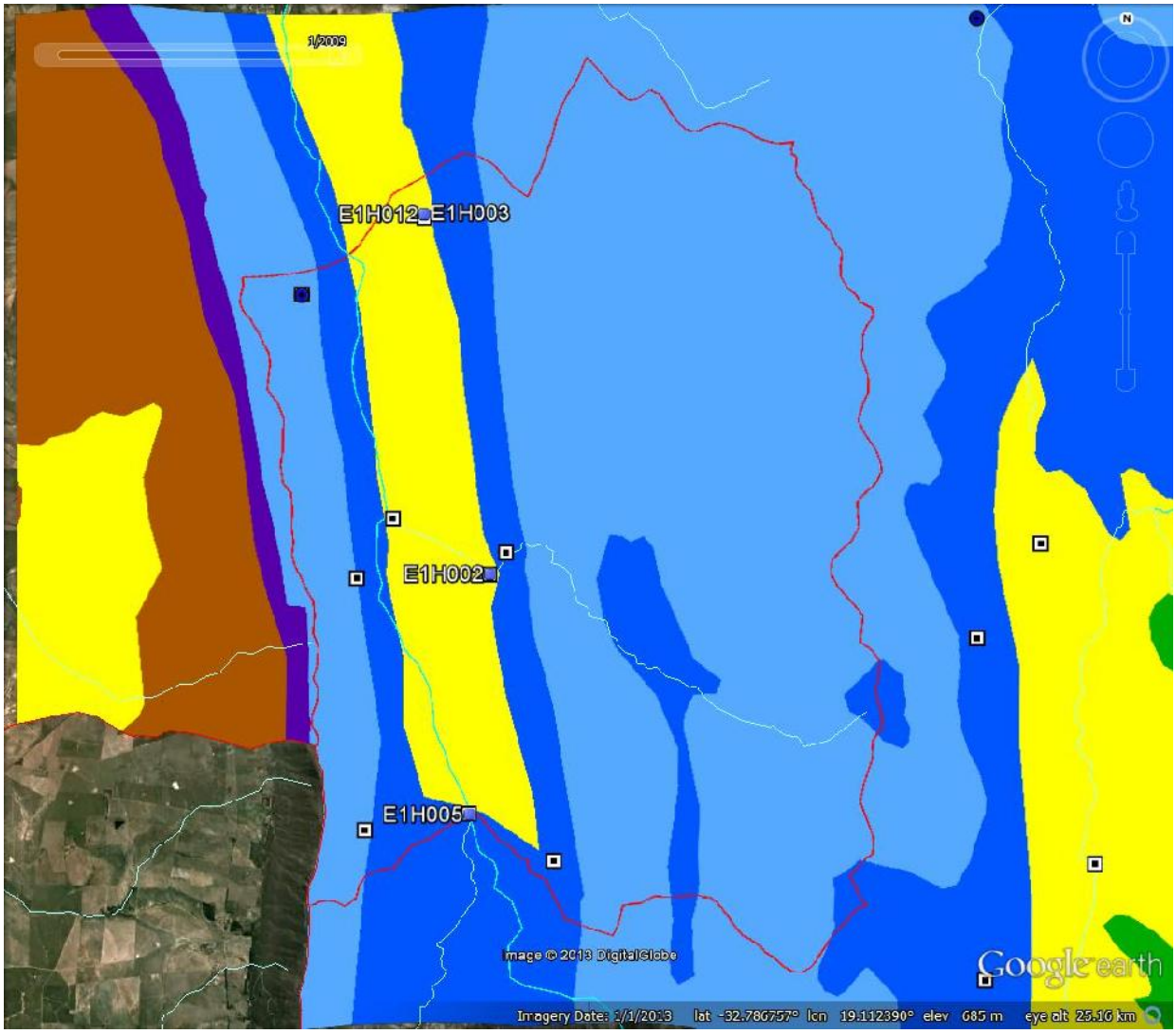

Figure 15.1 **Map of RU40 with aquifer delineation (light and dark blue: TMG Aquifer, yellow: Alluvium, green: Bokkeveld), existing monitoring points (blue: WMS boreholes, red: HYDSTRA borehole water level) and proposed monitoring points (white squares)**

15.5 ALLUVIUM AQUIFER

Groundwater is subjected to possible over-abstraction within the Olifants River valley during peak demand period, which could have a negative impact on water availability and water quality, as well as the low flow conditions in the receiving surface waters. The irrigated areas (which are located along the river valley) contribute to the groundwater recharge but have a possible water quality threat to the existing and future users. Urban and industrial areas could also have an impact on water quality.

15.5.1 Water quantity

The setting of water quantity related RQOs (see Table 15.4) is aimed at maintaining or improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

15.5.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

15.5.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 15.4.

Table 15.4 Water quantity RQOs for the Alluvium Aquifer in RU40

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the allocation schedule and individual licence conditions	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Water level monitoring network required
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Buffer zones	Around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	250m	

15.5.2 Water quality

The setting of water quality related RQOs (see Table 15.5) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

15.5.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

15.5.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 15.5.

Table 15.5 Water quality RQOs for the Alluvium Aquifer in RU40

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Extension of WMS network required
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network & parameters required
	Total Coliform		10 counts / 100ml	

15.6 TMG AQUIFERS

Groundwater is used in the area to supplement the water use from the Olifants River during dry periods, which could have a negative impact on water availability and water quality, as well as the low flow conditions in the receiving surface waters.

15.6.1 Water quantity

The setting of water quantity related RQOs (see Table 15.6) is aimed at maintaining or improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

15.6.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

15.6.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 15.6.

Table 15.6 Water quantity RQOs for the TMG Aquifer in RU40

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the allocation schedule and individual licence conditions	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Water level monitoring network required
		Water level recovers from abstraction impact during wet season.	n/a	

15.6.2 Water quality

The setting of water quality related RQOs (see Table 15.7) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

15.6.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

15.6.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 15.7.

Table 15.7 Water quality RQOs for the TMG Aquifer in RU40

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Extension of WMS network required
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network & parameters required
	Total Coliform		10 counts / 100ml	

15.7 WETLANDS

Not applicable (see Table 6.3).

16 E24M (R14) RESOURCE QUALITY OBJECTIVES

16.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E24M	Doring	≥ B	Olienhouts	≥ A/B	wetland area 0.001% of quaternary, 100% in AB
			Gifberg	≥ A/B	
			Unnamed tributary with confluence at 31°52'35.81"S; 18°46'48.75"	≥ D	

16.2 DORING RIVER IN E24M

The Doring River downstream of the Gifberg confluence has been identified as a FEPA, together with its tributaries in this quaternary, the Gifberg and the Olienhouts Rivers. All are currently in a B Category.

Key monitoring points for the Doring River in E24M:

- E2H003 (Doring River at Melkboom; Figure 16.1).
- EWR Site 5 (2006; Box 16.1; Figure 16.3).

Figure 16.1 E2H003 at Melkboom on the Doring River (www.dwa.gov.za)

Box 16.1 Relevant details for EWR Site 5 (2006): Doring River

Location: At Oudrif on the Doring River[12].
Coordinates: S 31°51.446; E 18°54.754
Hydrology: There is no DWAF gauging weir at the site but instantaneous flows in the river can be estimated from a rated section set up in a pool at the solar panel for the Oudrif Guest Farm (Figure 16.4). For longer term records: There is a DWAF gauging weir *c.* 20 km downstream of the site at Melkboom.
Access: Direct access to the site from Oudrif Farm. Permission to work the site has been obtained from Mr Bill Mitchell at Oudrif Farm.
Cross-sections: Two cross-sections were selected at EWR Site 5 (Figure 2.3). These were:

CS 5a: Across the pool habitat.
CS 5b: Across the riffle downstream of the pool.

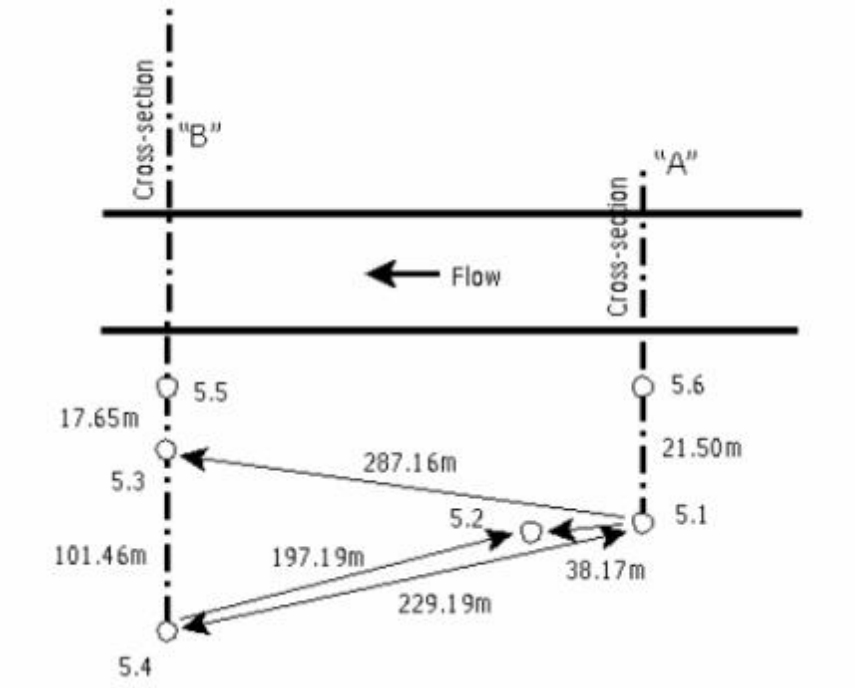

Figure 16.2 Plan layout for EWR Site 5.

Fixed stations were also installed at the site in November 2003. The elevations (above a local datum; Eald) of the fixed stations, the orientations of cross-sections relative to fixed stations and a description of the station type (steel peg in concrete or marked rock (MRK)) are given in Table 16.1.

Table 16.1 Elevations of fixed stations, orientations of cross-sections relative to fixed stations and descriptions of station type.

River	EWR Site No.	Cross-section	Station		Horizontal angle from orientation station to cross-section (dec. deg.)	Eald[13] (m)
			Set-up	Orientation		
Doring	5	A	5.1(MRK)	5.6(MRK) 5.2(MRK) 5.3 5.4(MRK)	0.000 84.683 96.375 115.059	92.028 98.229 95.094 98.590
		B	5.3(MRK)	5.5(MRK) 5.4	0.000 180.000	90.643

[12] The solar pump delimits the upstream extent of the site.
[13] Elevation above local datum.

Figure 16.3 **EWR 5 (2006) in E24M**

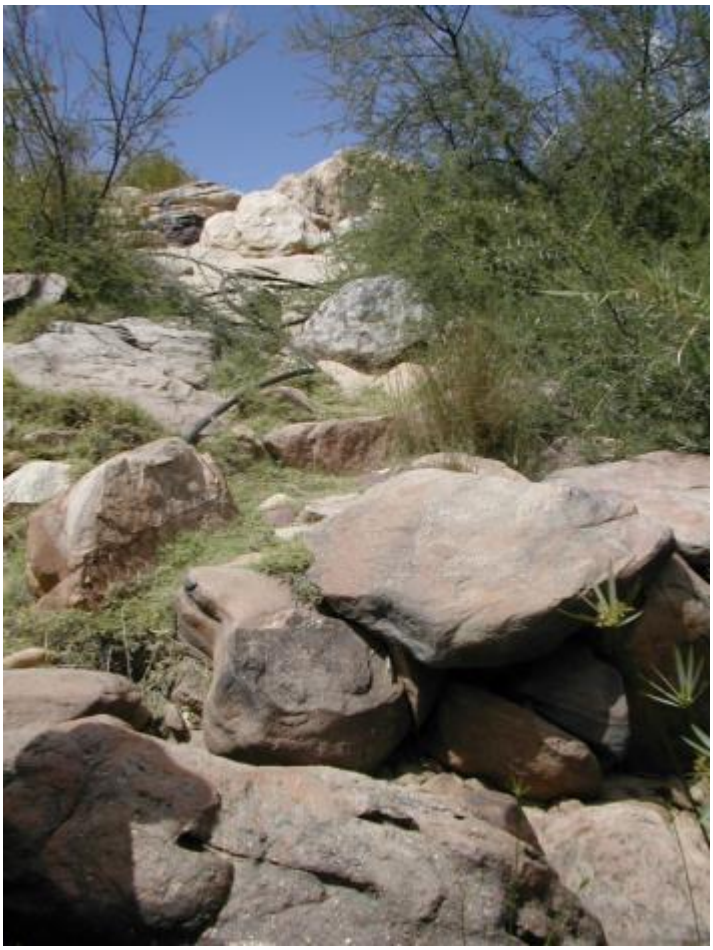

Figure 16.4 **Lateral orientation of the rated section set up in a pool at the solar panel for the Oudrif Guest Farm**

16.2.1 Hydrology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Basic RQOs: Appendix A.
Applicable to: E24M.
Monitor at: E2H003 (Figure 16.1).
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E2H003.

16.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to B Category.

16.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below, and the detail with respect to flood requirements is given in Table 16.2.

Note: The Doring River is naturally seasonal, thus the minimum dry season lowflow is zero. However, the duration of no-flow conditions in the dry season is important in terms of implementation of the Ecological Reserve. Flow in NOVEMBER should NEVER drop below 0.03 m^3/s, and flow in April should NEVER drop below 0.03 m^3/s.

Mean flow in November and April: 0.03 m^3/s
Even in extreme drought, November and April flow should not drop below: 0.03 m^3/s.

Table 16.2 Summary of the flood requirements for E24M.

Flood type	Daily average peak (m^3/s)	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	35.05	2	4	6	September-June
Class 2	70.11	4	15	2	June-September
Class 3	140.22	5	27	2	June-September
Class 4	280.43	6	59	1	June-September
Inter-annual Class (return period given below)					
1:2	311.59	7	136.88	Absent	Not applicable
1:5	535.57	8	140.46	Present	Not stipulated
1:10	1057.70	8	234.56	Present	Not stipulated
1:20	1396.40	8	284.65	Present	Not stipulated

16.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E24M.
Monitor at: E2H003 (Doring River at Melkboom) and with periodic field measurements.
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

16.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a).

16.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a). Additional numerical limits to achieve the above narrative RQOs are given in Table 16.3.

Table 16.3 Water quality RQOs and TPCs for E24M

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg ℓ^{-1})	<23	E2H003	>23
Na_2SO_4 (mg ℓ^{-1})	<33		>33
$MgCl_2$ (mg ℓ^{-1})	<30		>30
$CaCl_2$ (mg ℓ^{-1})	<57		>57
NaCl (mg ℓ^{-1})	<191		>191
Physical			
Water temperature (^oC)	25-28 ^oC (November to January)	EWR Site 5/E2H003	>28
pH	6.5 – 8.5		>7
EC (mS m^{-1})	<50		>50
Dissolved oxygen (DO) (mg ℓ^{-1})	> 6.0		<6.0
Toxics			
Ammonia as NH_3 (mg ℓ^{-1})	<0.007	EWR Site 5/E2H003	>0.007
Nutrients			
Nitrates as N (mg ℓ^{-1})	<0.020	EWR Site 5/E2H003	>0.020
Phosphorus as PO_4-P (mg ℓ^{-1})	<0.020		>0.020

16.2.3 Geomorphology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
RQOs: Table 16.4.
Applicable to: E24M.
Monitor at: EWR Site 5 (2006) - Box 16.1.
Baseline data: DWAF (2005) – single data collection.

16.2.3.1 Narrative

The river channel structure and habitats should be in a minimum of a B-category. A riffle/run-pool sequence should be present at all flows. Deep pools should be present. Sediment-size should be consistent with a Western Cape foothill river.

16.2.3.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given below.

Table 16.4 Geomorphological RQOs and TPCs for E24M

Component	Values: Cross-section A	Values: Cross-section B	TPCs
Dry season bed material composition (mm)			
D_{16}	0.4	8	> 20% increase or decrease
D_{50}	18	45	> 20% increase or decrease
D_{84}	30	180	> 30% increase or decrease
Channel geometry			
Dry season water surface slope (m/m)	0.00006	0.05	> 5% increase or decrease
Active channel width (m)	34	60	> 5% increase or decrease
Bankfull width (m)	38	82	> 5% increase or decrease
Key habitats			
Aquatic vegetation in and out of current	-	Present all year (this habitat is threatened by livestock)	None available
Stones-in-current, including riffle and run	-	All winter, spring and early summer	None available

16.2.4 Riparian vegetation

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E24M.
Monitor at: EWR Site 5 (2006) - Box 16.1.
Baseline data: DWAF (2005) – single data collection.

16.2.4.1 Narrative

The marginal vegetation should be intact and dominated by indigenous species. The presence of *Nerium oleander* must be controlled.

16.2.4.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 16.5.

Table 16.5 Riparian vegetation RQOs and TPCs for E24M; * = exotic species.

Component	Species	RQO	TPCs
Aquatic Zone	Azolla filiculoides*	None present.	Present
Lower Wet Bank	Paspalum urvillei*	Low leaf density around edges of waterways during dry season.	None available
Lower Wet Bank	Cyperus textilis	Spread between LD and Lower Wet Bank with concentration in Upper Wet Bank	None available
Lower Dynamic and Wet Bank	Phragmites australis	Only a narrow banding should be present in Wet Bank.	None available
Tree-shrub, Back Dynamic	Acacia karoo	Present lining parts of rivers and streams exposed to annual winter high flows	None available
All zones	Nerium oleander	Present but not dominant	Any increase
	Acacia longifolia*, A. mearnsii*, A. melanoxylon*, Eucalyptus camaldulensis*	Not present.	Present

16.2.5 Macroinvertebrates

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E24M.
Monitor at: EWR Site 5 (2006) - Box 16.1.
Baseline data: DWAF (2005) – single data collection.

16.2.5.1 Narrative

The macroinvertebrate community should be dominated by Ephemeroptera, Trichoptera.

16.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 16.6.

Table 16.6 Macroinvertebrate RQOs and TPCs for E24M

Component			RQO	TPCs
Family presence/ absence	Order	Taxa		
	Ephemeroptera	Leptophlebiidae	present 80% of the time (cumulative for the site)	Absent
	Trichoptera: Ecnomidae, Philopotamidae (winter), Hydropsychidae, Hydroptilidae		at least 2 present	None availale
	Diptera	Simuliidae	Present in <50% of replicate samples of stones-in-current	None availale
SASS results	SASS Score		>120	<110
	ASPT		>6	<6

16.2.6 Fish

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E24M.
Monitor at: EWR Site 5 (2006) -Box 16.1.
Baseline data: DWAF (2005) – single data collection, Paxton (unpublished data), SAIAB database
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

16.2.6.1 Narrative

At least one of the following species should be present in the catch: *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi*.

16.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 16.7.

Table 16.7 Fish RQOs for E24M.

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	At least one of the following three species should be present in the catch: Labeobarbus capensis, Barbus serra, Labeo seeberi	None available
	Demographics	There is no recruitment of indigenous fish in the mainstem at E24M	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % *Lepomis macrochirus* Present: *Tilapia sparrmanii*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus* and < 70 mm TL for bass)	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

16.3 TRIBUTARIES

The Gifberg and the Olienhouts Rivers (both in B Category), tributaries to the Doring in this quaternary have been identified as FEPAS.

Detailed RQOs cannot be set for the tributaries with the current level of data available.

16.3.1 Hydrology

Basic RQOs: Appendix A.

16.3.1.1 Narrative

The ecological Reserve should be sufficient to maintain:

- Category A/B in the Gifberg River;
- Category A/B in the Olienhouts River;
- Category D in the unnamed tributary with confluence at 31°52'35.81"S; 18°46'48.75"E.

16.3.1.2 Numerical

See Appendix A.

16.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 16.8.

Table 16.8 Groundwater Reserve Requirements for E24M.

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E24M	8.41	0.50	0.71	8%	7.91	6%	B

16.5 WETLANDS

Not applicable (see Table 6.3).

17 E40C (R11) AND E40D (R17) RESOURCE QUALITY OBJECTIVES

17.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E40C	Oorlogskloof (FEPA)	≥C[14]	Unnamed tributary through Niewoudville	≥ B	> 3 000 hectares of wetland (E40C and E32C); individual wetlands range from <1 hectare to 300. These should be protected. (wetland area 0.001% of quaternary, 100% in AB)
E40D	Koebee (FEPA)	≥ B	Klein Koebee	≥ B (A/B (FEPA)	-

17.2 OORLOGSKLOOF RIVER IN E40C AND KOEBEE RIVER IN E40D

Key monitoring points in E40C and E40D:

- E40C-06492: Oologskloof River sampling site at Brakwater: -31° 27’ 52.3368", 19° 4’ 51.3192" (Figure 17.1).
- E40D: Koebee River sampling site at Rietvlei: -31° 35’ 2.997", 19° 4’ 21" (Figure 17.2).

Figure 17.1 Brakwater in the Oorlogskloof Nature Reserve, Oorlogskloof River.

[14] PES is D, followed by C in lower reaches (E40C-06492) and then B (E40D-06588) before becoming the Koebee River after confluence with Klein-Koebee.

Figure 17.2 Rietvlei on the Koebee River

The Koebee (Category B), the Oorlogskloof (Category B) and the Klein-Koebee (Category B) have been identified as FEPAs.

Oologskloof River sampling site at Brakwater: Located in Oorlogskloof Nature Reserve roughly 18 km south of Nieuwoudtville where the main access road into the reserve crosses the river at the Brakwater camp. Contact the reserve manager, Mr Wessel Pretorius oorlogskloof@gmail.com (027) 218 1010

Koebee River sampling site at Rietvlei: Take the unmarked turn-off 16 km outside Vanrhynsdorp. Follow the dirt road over the Koebee pass for 15 km. Turn north along the Koebee River for another 9 km crossing the river twice. Contact the Rietkuil Trust, Mr. JC van der Walt, JC.vanderWalt@cobham.com for the gate key and permission to enter the Rietkuil Trust property.

17.2.1 Hydrology

17.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to B Category.

17.2.1.2 Numerical

There is no gauging weir on the Koebee River. The Basic Ecological Reserve requirements (hydrology) for the quaternary are given in Appendix A, but there is currently no way of measuring the flow time-series.

The Koebee River is naturally seasonal, thus the minimum dry season lowflow is zero. However, the duration of no-flow conditions in the dry season is important in terms of implementation of the Ecological Reserve. Flow in NOVEMBER should NEVER drop below 0.001 m^3/s, and flow in April should NEVER drop below 0.003 m^3/s.

Mean flow in driest month (February):
E40C: 0.01 m^3/s
E40D: 0.03 m^3/s
Even in extreme drought flow should not drop below:
E40C: 0.001 m^3/s
E40D: 0.001 m^3/s

17.2.2 Water quality

17.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

17.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits cannot be set with the current level of data available.

17.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

17.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

17.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

17.2.6 Fish

Source:	Paxton et al. (2002), Paxton unpublished data.
Applicable to:	E40C-06492 (lower reaches in Oorlogskloof) and E40D.
Monitor at:	Brakwater on the Oorlogskloof: -31° 27’ 52.3368", 19° 4’ 51.3192"
	Rietvlei on the Koebee: -31° 35’ 2.997", 19° 4’ 21".
Baseline data:	Paxton et al. (2002), Paxton unpublished data.

17.2.6.1 Narrative

At least three of the following four species should be represented in the catch: *Labeobarbus capensis*, *Barbus serra, Barbus anoplus* and *Labeo seeberi*.

17.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 17.1.

Table 17.1 Fish RQOs and TPCs for E40C-06492 (lower reaches in Oorlogskloof) and E40D

Indigenous	Sub-component	RQOs	TPCs
	Species assemblage	At least three of the following four species should be represented in the catch by >100 individuals: Labeobarbus capensis, Barbus serra, Labeo seeberi, Barbus anoplus	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 70 mm TL for bass)	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	*Tilapia sparrmanii* should represent <5% of the catch	None available
	Demographics	Not relevant	
	Fish Health	Parasites, lesions and deformities should be present on <5 % of the catch	

17.3 TRIBUTARIES

The Klein-Koebee (Category B) has been identified as a FEPA.

Detailed hydrological RQOs cannot be set for individual tributaries with the current level of data available.

17.3.1 Hydrology

Basic RQOs: Appendix A.

17.3.1.1 Narrative

The ecological Reserve should be sufficient to maintain:

- Category ≥ B in the Niewoudville River;
- Category ≥ B iin the Klein-Koebee.

17.3.1.2 Numerical

See Appendix A.

17.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements in E40D, are given in Table 17.2.

Table 17.2 Groundwater Reserve Requirements for E40D

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E40D	3.09	0.00	1.00	32%	3.09	0%	A

17.5 WETLANDS IN E40C AND E32E (THE "NIEUWOUDTVILLE WETLANDS")

NOTE: The Nieuwoudtville wetlands are addressed as a single unit although they occur across two quaternary catchments, *viz*.: E40C and E32E.

Most of the wetlands in the region are located within quaternary catchments E32E and E40C. Over 3 000 hectares of wetland have been mapped here, with individual wetlands ranging in size from less than a hectare to 300 hectares. The wetland types present include a diverse range of valley bottom, flats (understood in this context to mean wetlands forming over shallow bedrock in low gradient areas where there is no unidirectional runoff), seep and depressional wetlands.

The vast majority of wetlands on the Plateau occur within Bokkeveld sandstone fynbos habitat type, which is dominated by Cape Table Mountain Group fractured sandstone and flanks the escarpment edge. This is an area that receives significantly higher rainfall than all other areas on the Plateau. The landscape here is a combination of shallow sandy soils over sandstone, with bedrock at the surface in many places, and areas of deeper sands in valleys, providing a mosaic of habitat types and wetness regimes. The area has a high density of small springs.

Valley bottom wetlands predominate along natural drainage lines in deep sands, often supported by springs, and are most commonly vegetated with *Pennisetum macrourum* but with many other grass, sedge, bulb and restio species represented. Several wetland plants are palatable within these areas and provide livestock with grazing. These wetlands also support several rare and endemic plant species.

The relatively flat landscape in areas has also favoured the formation of a high density of seasonal pans (depressions). These occur across widely varying geology / vegetation types throughout the Plateau, suggesting a wide-ranging set of hydrological and biodiversity habitat conditions. Some have sandstone bedrock or ferricrete (koffieklip) at the surface, others have clay / silt sediments while still others are located within deeper sands. They range from never vegetated, to seasonal support of plant species and permanently vegetated deeper sands. The seasonally wet areas support a diversity of bulb plant species, along with sedges and other herbaceous species. Some support plant species of conservation concern, such as *Sparaxis elegans*, and the floating aquatic *Oxalis disticha*, and many other rare and endemic plant species.

Key threats include:

- Over-grazing
- Cultivation of rooibos
- Lack of buffers, and thus a high risk of erosion

The valley bottom wetlands and flats wetlands are the most heavily impacted within this sub-catchment, while pans (depressional wetlands) are more likely to have a buffer or be embedded within natural vegetation.

17.5.1 Physical attributes

Source:	Job *et al.* (2011).
Applicable to:	E32E and E40C.
Monitor using:	Monitor changes in landuse and extent at 2 year intervals using Google Earth.
Baseline data:	Job (2011) and CapeNature, C.A.P.E fine scale map (2008) - the areas of wetlands and invasive woody vegetation are included in the deliverables of this study in .shp (ArcGIS) and .kml. (Google Earth) format.

In general the RQOs require that the wetlands should remain intact and the extent of invasion by woody alien plants should not increase.

The locations of priority wetlands in the Nieuwoudtville cluster (partially in E40C) are given in Table 17.3.

17.5.1.1 Narrative

There should be no expansion of agriculture or other landuses in to remaining intact wetland areas. There should also be no further encroachment of woody alien vegetation into wetland areas.

17.5.1.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 17.4 and Table 17.5.

Table 17.3 Locations of priority wetlands in the Nieuwoudtville cluster (partially in E40C)

Wetland Name	Wetland type	GPS (lat, long)	Quat
Biekos	Channelled Valley Bottom	-31.30420°, 19.058780°	E32E
Meulsteensvlei	Depression (pan)	-31.363917°, 19.031694°	E32E
Meulsteensvlei	Channelled Valley Bottom	-31.369417°, 19.024806°	E32E
Arendskraal	Hillslope Seep	-31.38432°,19.03904°	E40C
Klein Arendskraal	Hillslope Seep	-31.399440°, 19.042700°	E40C
Hantam	Depression (pan)	-31.382258°, 19.151340°	E40C
McGregor pan	Depression	-31.389660°, 19.144970°	E40C
Boschkloof	Channelled Valley Bottom	-31.665630°, 19.096590°	E40D
Papkuilsfontein	Hillslope Seep	-31.549990°, 19.161900°	E40D

Table 17.4 Wetland RQOs for Nieuwoudtville Wetlands cluster (partially in E40C)

Sub-component	Baseline data source	RQO
Wetland extent	CapeNature fine scale map (2008)	No expansion of agriculture or other landuses in to the remaining intact wetland areas
Woody alien vegetation extent		No further encroachment of woody alien vegetation into wetland areas
Wetland condition	Job *et al*. (2011)	No change in WET-Health scores (see Table 17.5)

Table 17.5 WET-Health scores for priority wetlands in the Nieuwoudtville cluster (partially in E40C)

Wetland Name	Wetland type	Area (ha)	WET-Health scores		
			Hydrology	Geomorphology	Vegetation
Biekos	Channelled Valley Bottom	10	C	B	C
Meulsteensvlei	Depression (pan)	5	A	A	B
Meulsteensvlei	Channelled Valley Bottom	50	B	A	C
Arendskraal	Hillslope Seep	14	D	B	D
Klein Arendskraal	Hillslope Seep	32	D	C	D
Hantam	Depression (pan)	0.5	A	A	B
McGregor pan	Depression	0.8	A	A	B
Boschkloof	Channelled Valley Bottom	9.5	C	B	C
Papkuilsfontein	Hillslope Seep	4	A	A	B

18 E33F (Q1) RESOURCE QUALITY OBJECTIVES

18.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E33F	Troe troe	≥ D	Droë and Langkloof	≥ D	-

18.2 TROE-TROE RIVER IN E33F

Key monitoring points for the Troe-troe River in E33F:

- E3H001 (Troe-troe River at Farm 256).

18.2.1 Hydrology

18.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to D Category.

18.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in December and April: 0.003 and 0.01 m^3/s, respectively
In extreme drought, December and April flow will be 0 m^3/s.

18.2.2 Water quality

RQOs cannot be set with the current level of data available.

18.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

18.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

18.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

18.2.6 Fish

RQOs cannot be set with the current level of data available.

18.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

18.4 GROUNDWATER

The area is dominated by the dolomitic Gifberg Formation aquifer, which is overlain by thin Alluvium layer. The fractured, folded TMG aquifers are found on the southern part of the catchment and constitute the high mountains. TMG aquifer contributes to baseflow by discharging as springs or by interaction with the rivers through the weathered zone.

The groundwater Reserve requirements for the whole quaternary catchment, based on the surface water low flow requirements, are given in Table 18.1.

Table 18.1 Groundwater Reserve Requirements for E33F

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E33F	15.87	14.50	0.05	0%	1.37	91%	E

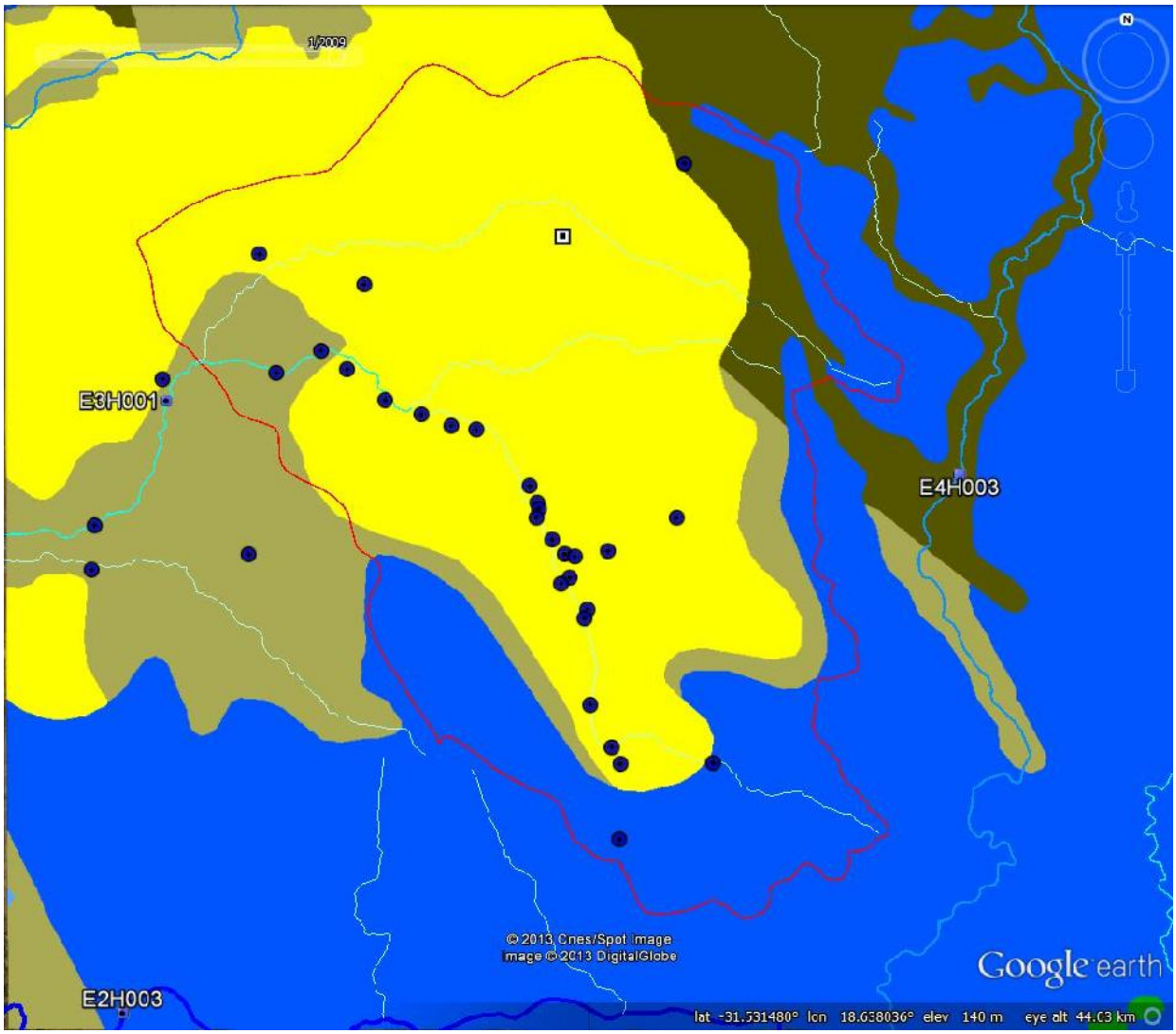

Figure 18.1 Map of E33F with aquifer delineation (blue: TMG Aquifer, yellow: Alluvium, light olive: Gifberg), existing monitoring points (blue: WMS boreholes) and proposed monitoring points (white squares)

Groundwater is extracted from the Gifberg aquifer in this quaternary catchment. Groundwater is subjected to over-abstraction in the area, which could have negative impacts on water availability and water quality. The intense agriculture poses an additional threat to the water quality of the area.

18.4.1 Water quantity

The setting of water quantity related RQOs (see Table 18.2) is aimed at ensuring sufficient yield for all users within the limits of the total available yield.

18.4.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

18.4.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 18.2.

Table 18.2 Water quantity RQOs for the Aquifers in E33F

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Existing water level monitoring network by DWA and Vanrhynsdorp WUA
		Water level recovers from abstraction impact during wet season.	n/a	

18.4.2 Water quality

The setting of water quality related RQOs (see Table 18.3) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU. However, it is noted that it will not be possible to guarantee a constant supply of acceptable water quality, due to the general poor, natural water quality.

18.4.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

18.4.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 18.3. Exemption from these values can be granted, if exceeding is due to poor natural water quality.

Table 18.3 Water quality RQOs for the Aquifers in E33F

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Existing WMS network by DWA and Vanrhynsdorp WUA
Salts	Cl		< 300 mg/l	
	EC		< 170 mS/m	
	SO_4		< 500 mg/l	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network parameters required
	Total Coliform		10 counts / 100ml	

18.5 WETLANDS

Not applicable (see Table 6.3).

19 E21H (A1) AND E21J (R38), E21K AND E21L (R37) RESOURCE QUALITY OBJECTIVES

19.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E21H A1	Twee	≥ B	Suurvlei, Middeldeur	≥ B	-
E21H	Leeu B	≥ B	Twee	≥ B	
E21J	Groot	≥ B	Riet River between 33° 0'31.52"S; 19°29'59.08"E and 32°36'46.48"S; 19°27'10.74"E	A/B	-
			Remainder of Riet	≥ B	
			No name tributary	A/B	
			Brandkraal River	≥ B	
E21L	Groot	≥ B	Matjies River and	≥ B	wetland area 1.7% of quaternary, 99% in AB (E21K)
			No name tributary	A/B	

19.2 GROOT RIVER IN E21J AND E21L

Key monitoring points for the Groot River for E21J and E21L:

- E2H002 (Doring River @ Elands Drift (Aspoort) in E22G – summer only).
- EWR Site 6 in E21J (2006; Figure 19.1; Box 19.1).

Figure 19.1 EWR 6 (2006) in E21J

Box 19.1 Relevant details for EWR Site 6 (2006): Groot River

Location: At Mount Cedar on the Groot River; upstream of the bridge at Groot Rivier.
Coordinates: S 32°39.552; E 19°23.786
Hydrology: There is no DWAF gauging weir. Summer flows should be monitored at Aspoort.
Access: Follow the Mount Cedar roads alongside the river upstream to as far as the road goes. The pool cross-section is situated slightly downstream of this point and the riffle is situated upstream of this point. Permission to work the site must be obtained from the manager at Mount Cedar at each visit.
Cross-sections: Two cross-sections were selected at EWR Site (Figure 19.2). These were:

CS 6a: Across the riffle upstream of the pool.
CS 6b: Across the pool habitat.

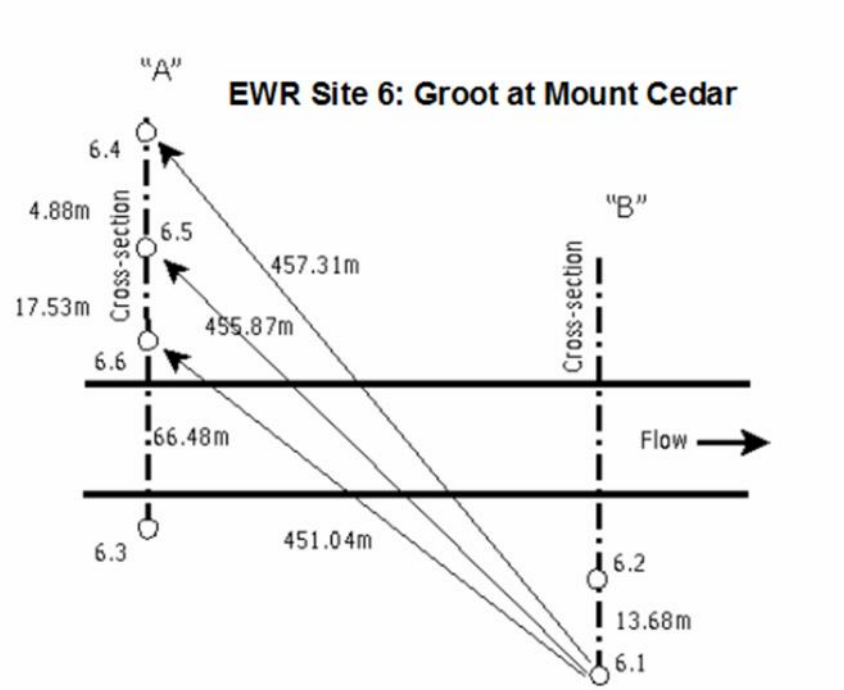

Figure 19.2 Plan layout for EWR Site 6.

Fixed stations were also installed at the site in November 2003. The elevations (above a local datum; Eald) of the fixed stations, the orientations of cross-sections relative to fixed stations and a description of the station type (steel peg in concrete or marked rock (MRK)) are given in Table 19.1.

Table 19.1 Elevations of fixed stations, orientations of cross-sections relative to fixed stations and descriptions of station type.

River	EWR Site No.	Cross-section	Station		Horizontal angle from orientation station to cross-section (dec. deg.)	Eald[15] (m)
			Set-up	Orientation		
Groot	6	A	6.3(MRK)	6.4(MRK) 6.5(MRK) 6.6(MRK)	0.000 0.000 0.000	86.448 84.876 83.281
		B	6.1(MRK)	6.2(SPC) 6.6 6.5 6.4	0.000 77.409 75.096 74.512	84.256

[15] Elevation above local datum.

19.2.1 Hydrology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E21J and E21L.
Monitor at: EWR 6 (2006) and E2H002 (Box 17.1) – summer only.
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E2H002.

19.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is equal to B Category.

19.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below, and the detail with respect to flood requirements is given in Table 19.2.

Mean flow in driest month (February):
E21J: 0.06 m^3/s
E21L: 0.1 m^3/s
Even in extreme drought flow should not drop below:
E21J: 0.001 m^3/s
E21L: 0.002 m^3/s

Please note: The Reserve allocations upstream of this site DO NOT meet the second Class 4 flood (Table 19.2). This cannot be managed and may or may not come through from the surrounding catchment.

Table 19.2 Summary of the flood requirements for E21J andE21L.

Flood type	Daily average peak (m^3/s)	Duration (days)	Volume (MCM)	Number requested	Months
Intra-annual Class (i.e., each flood has a return period of 1:1)					
Class 1	5.51	3	1.0	7[1]	September-June
Class 2	11.02	5	2.0	2	June - September
Class 3	22.03	5	4.0	2	June - September
Class 4	44.06	7	11.0	2	June - September
Inter-annual Class (return period given below)					
1:2	48.96	-	15.5	Present	Not stipulated
1:5	66.26	-	29.5	Present	Not stipulated
1:10	77.89	-	33.7	Present	Not stipulated
1:20	162.55	-	43.2	Present	Not stipulated

1 This is highlighting the perceived need for variability in flow in the Groot River.

19.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E21J and E21L.
Monitor at: EWR 6 (2006) – with periodic field measurements (Box 19.1).
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

19.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

19.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given in Table 19.3.

Table 19.3 Water quality RQOs and TPCs for E21J and E21L

Component	Value	Monitor at	TPCs
Salts			
$MgSO_4$ (mg ℓ^{-1})	<23	EWR Site 6	>23
Na_2SO_4 (mg ℓ^{-1})	<33		>33
$MgCl_2$ (mg ℓ^{-1})	<30		>30
$CaCl_2$ (mg ℓ^{-1})	<57		>57
NaCl (mg ℓ^{-1})	<191		>191
Physical			
Water temperature (^oC)	25-28 ^oC (November to January)	EWR Site 6	None available
pH	6.0 – 8.5		>7
EC (mS m^{-1})	<15		>15
Dissolved oxygen (DO) (mg ℓ^{-1})	> 6.0		<6
Toxics			
Ammonia as NH_3 (mg ℓ^{-1})	<0.007	EWR Site 6	>0.007
Nutrients			
Nitrates as N (mg ℓ^{-1})	<0.050	EWR Site 6	>0.050
Phosphorus as PO_4-P (mg ℓ^{-1})	<0.020		>0.020

19.2.3 Geomorphology

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E21J and E21L.
Monitor at: EWR Site 6 (2006) - Box 19.1.
Baseline data: DWAF (2005) – single data collection.

19.2.3.1 Narrative

The river channel structure and habitats should be in a minimum of a B-category. A riffle/run-pool sequence should be present at all flows. Sediment-size should be consistent with a Western Cape foothill river.

19.2.3.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 19.4.

Table 19.4 Geomorphological RQOs and TPCs for E21J and E21L at EWR6

Component	Values: Cross-section A	Values: Cross-section B	TPCs
Dry season bed material composition (mm)			
D_{16}	13	38	> 20% increase or decrease
D_{50}	64	80	> 20% increase or decrease
D_{84}	360	120	> 30% increase or decrease
Channel geometry			
Dry season water surface slope (m/m)	0.004	0.0001	> 5% increase or decrease
Active channel width (m)	38	67	> 5% increase or decrease
Bankfull width (m)	44	74	> 5% increase or decrease
Key habitats			
Aquatic vegetation in and out of current	present throughout the year	present throughout the year	None available
Stones-in-current, including riffle and run	should be present and available for habitation by invertebrates	-	

19.2.4 Riparian vegetation

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E21J and E21L.
Monitor at: EWR Site 6 (2006) - Box 19.1.
Baseline data: DWAF (2005) – single data collection.

19.2.4.1 Narrative

The riparian vegetation should be intact and dominated by indigenous species. The presence of *Nerium oleander* must be controlled. There should be no other alien species present.

19.2.4.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 16.5.

Table 19.5 Riparian vegetation RQOs and TPCs for E21J and E21L; * = exotic species.

Component	Species	RQO	TPcs
Aquatic Zone	*Azolla filiculoides**	None present.	Present
Lower Wet Bank	*Paspalum urvillei**	Low leaf density around edges of waterways during dry season.	None available
Lower Dynamic and Wet Bank	*Phragmites australis*	Narrow banding in Wet Bank only	
Wet Bank	*Salix mucronata*	Lining parts of rivers and streams exposed to annual winter high flows	
Tree-shrub, Back Dynamic	*Brabejum stellatifolium*	Present lining parts of rivers and streams exposed to annual winter high flows	
All zones	*Nerium oleander*	Present but not dominant	
	*Acacia longifolia**, *A. mearnsii**, *A. melanoxylon**, *Eucalyptus camaldulensis**	Not present.	Present

19.2.5 Macroinvertebrates

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E21J and E21L.
Monitor at: EWR Site 5 (2006) - Box 19.1.
Baseline data: DWAF (2005) – single data collection.

19.2.5.1 Narrative

The macroinvertebrate community should be dominated by Ephemeroptera, Trichoptera.

19.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 19.6.

Table 19.6 Macroinvertebrate RQOs for E21J and E21L (no TPCs available)

Component			RQO
Family presence/ absence	Order	Taxa	
	Ephemeroptera	Leptophlebiidae	present in 90% of samples (cumulative for the site, taken over time)
		Heptageniidae	present in 80% of samples (cumulative for the site, taken over time)
	Trichoptera	Ecnomidae Leptoceridae Philopotamidae Sericostomatidae	at least three families of cased caddis present overall at site, with at least two of the listed families
	Megaloptera	Corydalidae	present in 40% of samples (cumulative for the site, taken over time)
	Coleoptera	-	at least three families
		Blephariceridae and Notonemouridae	should remain present in low numbers until at least early summer (November / December) in most years
SASS results	SASS Score		>170
	ASPT		>7.5

19.2.6 Fish

Source: Comprehensive Reserve Determination Study (DWAF 2005).
Applicable to: E21J and E21L.
Monitor at: EWR Site 6 (2006) - Box 19.1.
Baseline data: DWAF (2005) – single data collection, Paxton (unpublished data), SAIAB database
Gear: RQOs for the fish assemblages assume the use of a range of gears including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if present (5X2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

19.2.6.1 Narrative

At least one of the following three species should be present in the catch: *Labeobarbus capensis*, *Barbus serra* and *Labeo seeberi* should be present.

19.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 19.7.

Table 19.7 Fish RQOs for E21J and E21L (no TPCs available)

	Sub-component	RQOs
Indigenous	Species assemblage	At least one of the following three species should be present in the catch: *Labeobarbus capensis*, *Barbus serra*, *Labeo seeberi*
	Demographics	There is no recruitment of indigenous fish in the mainstem at E21J and E21L.
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch
	Sub-component	RQOs
Alien	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % *Lepomis macrochirus*
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus* and < 70 mm TL for bass).
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch

19.3 TRIBUTARIES

Detailed hydrological and biological RQOs cannot be set for the tributaries with the current level of data, except for fish for which there are some data available (Paxton, unpublished data). In general however, the RQOs for the Twee River require a halt to future development in the Twee River, so as to ensure that the Reserve for the **Twee River is sufficient to meet the Reserve EC of a B, plus provide a portion of the contribution of the Leeu River to the downstream rivers**, i.e., 14% MAR instead of 21% MAR.

Within E21H, the Middeldeur, Twee and Suurvlei tributaries have been identified as FEPAs, as well as some of the mainstem Leeu, after the confluence with the Twee. The FEPA status continues where the Leeu becomes the Groot and goes through E21J and E21L. Tributaries Brandkraal and an un-named one in E21J are FEPAs, as well as the Matjies and an un-named tributary in E21L.

Detailed RQOs cannot be set for the tributaries with the current level of data available.

19.3.1 Hydrology

19.3.1.1 Narrative

The ecological Reserve should be sufficient to maintain:

- ≥ Category B in the Middeldeur River;
- ≥ Category B in the Suurvlei River;
- ≥ Category B in the Twee River;
- ≥ Category D in the Leeu River;
- ≥ Category B in the Riet River between 33° 0'31.52"S; 19°29'59.08"E and 32°36'46.48"S; 19°27'10.74"E (confluence with the Groot River);
- ≥ Category B in the Brandkraal River;
- ≥ Category B in the Matjies River.

19.3.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month:
Twee (March): 0.87 m^3/s
Brandkraals (February): unknown (c. 0.01 m^3/s)
Matjies (E21K; December and January): 0.03 m^3/s
Even in extreme drought flow should not drop below:
Twee: 0.001 m^3/s
Brandkraals: 0.001 m^3/s
Matjies (E21K): 0.001 m^3/s

19.3.2 Fish

Source: Paxton (unpublished data), SAIAB database.
Applicable to: E21J and E21L tributaries.
Monitor at: Brandkraals River: RHP Site E2BRAN-VOGEL upstream of the road: 32°33'55.57"S, 19°21'29.03"E; Twee River: River Node A1, 32°41'7.17"S, 19°16'44.36"E.
Baseline data: Paxton (unpublished data), SAIAB database
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: small fyke nets (20-m wing length) in tributary pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

19.3.2.1 Narrative

At least one of *Labeobarbus capensis*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Barbus serra*, *Labeo seeberi* should be present.

19.3.2.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 19.8.

Table 19.8 Fish RQOs for the Brandkraals (E21J) and Twee (E21H (A1)) (no TPCs available)

Indigenous	Sub-component	RQOs
	Species assemblage	At least one of the following five species should be present in the catch: *Labeobarbus capensis*, *Barbus calidus*, *Pseudobarbus phlegethon*, *Barbus serra*, *Labeo seeberi*
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 40 mm FL for small cyprinids; < 70 mm TL for large cyprinids).
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch
Alien	Sub-component	RQOs
	Species assemblage	There should be no alien fish species present in the tributaries
	Demographics	No alien fish present
	Fish Health	No alien fish present

19.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 19.9.

Table 19.9 Groundwater Reserve Requirements for E21J and E21L.

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E21J	16.07	0.20	0.32	2%	15.87	1%	A
E21K	11.62	0.10	0.18	2%	11.52	1%	A
E21L	2.53	0.05	0.14	6%	2.48	2%	A

19.5 WETLANDS

Not applicable (see Table 6.3).

20 E21G (R41) RESOURCE QUALITY OBJECTIVES

20.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E21G	Leeu	D	Lang	≥ D	-

20.2 LEEU RIVER IN E21G

Key monitoring points for the Leeu River in E21H:

- E2H007 in E21G (Leeu River at Leeuw River).

20.2.1 Hydrology

Source: CAPE Ecological Reserve Implementation Project (Southern Waters 2009).
Applicable to: E21G.
Monitor at: E2H007.
Baseline data: http://www.dwa.gov.za/Hydrology/HyDataSets.aspx?Station=E2H007.

20.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ to D Category.

20.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (February): 0.07 m^3/s
Even in extreme drought flow should not drop below: 0.001 m^3/s.

20.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
RQOs: Table 20.1.
Applicable to: E21G.
Monitor at: E2H007 – with periodic field measurements.
Baseline data: www.dwaf.gov.za/iwqs/wms/data/WMS_pri_txt.asp (Olifants W).

20.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a) and the Fitness for use -Class I for agricultural use (DWA 1996b).

20.2.2.2 Numerical

The numerical limits can be found in DWAF (1996a) and (1996b). Additional numerical limits to achieve the above narrative RQOs are given below.

Table 20.1 Water quality RQOs for E21G (no TPCs available)

Component	Value	Monitor at
Salts		
$MgSO_4$ (mg ℓ^{-1})	<23	E2H007
Na_2SO_4 (mg ℓ^{-1})	<33	
$MgCl_2$ (mg ℓ^{-1})	<30	
$CaCl_2$ (mg ℓ^{-1})	<57	
NaCl (mg ℓ^{-1})	<191	
Physical		
Water temperature (^oC)	25-28 ^oC (November to January)	Periodic measurements at E2H007
pH	6.0 – 8.5	
EC (mS m^{-1})	<15	
Dissolved oxygen (DO) (mg ℓ^{-1})	> 6.0	
Toxics		
Ammonia as NH_3 (mg ℓ^{-1})	<0.007	E2H007
Nutrients		
Nitrates as N (mg ℓ^{-1})	<0.050	E2H007
Phosphorus as PO_4-P (mg ℓ^{-1})	<0.020	

20.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

20.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

20.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

20.2.6 Fish

Source: Paxton (unpublished data), SAIAB database.
RQOs: Table 20.2.
Applicable to: E21G.
Monitor at: E2H007, River Node R41.
Baseline data: Paxton (unpublished data), SAIAB database
Gear: The RQOs for the fish assemblages assume the application a range of gear types including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

20.2.6.1 Narrative

At least one of the following two species should be present in the catch: *Labeobarbus capensis, Galaxias zebratus*.

20.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given below.

Table 20.2 Fish RQOs and TPCs for E21G

Indigenous	Sub-component	RQOs	TPCs
	Species assemblage	At least one of the following two species should be present in the catch: *Labeobarbus capensis*, *Galaxias zebratus*	None available
	Demographics	There is no recruitment of indigenous fish in the mainstem at E21G.	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	> 5 % bass (*Micropterus dolomieu* or *M. salmoides* or *M. punctulatus*) < 90 % *Lepomis macrochirus*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL for *L. macrochirus* and < 70 mm TL for bass).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

20.3 TRIBUTARIES

Detailed hydrological and biological RQOs cannot be set for the tributaries with the current level of data. The RQOs for the Twee River (Section 19.3) require a halt to future development in the Twee River, so as to ensure that the Reserve for the Twee River is sufficient to meet the Reserve EC of a B, plus provide a portion of the contribution of the Leeu River to the downstream rivers, i.e., 14% MAR instead of 21% MAR.

20.4 GROUNDWATER – OVERVIEW

The area is primarily dominated by Bokkeveld Group (south-east), with fractured, folded TMG aquifers (Peninsula and Nardouw aquifers) and thick Quaternary alluvium aquifer which occurs along the Olifants River course with the Bokkeveld Group (north-west). The thick alluvium deposits can be considered an extension of the river system storing surplus water from flood events and releasing the water back into the river during low flow conditions.

The groundwater Reserve requirements for E21G, based on the surface water low flow requirements, are given in Table 20.3.

Table 20.3 Groundwater Reserve Requirements for E21G

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E21G	18.95	4.00	2.07	11%	14.95	21%	C

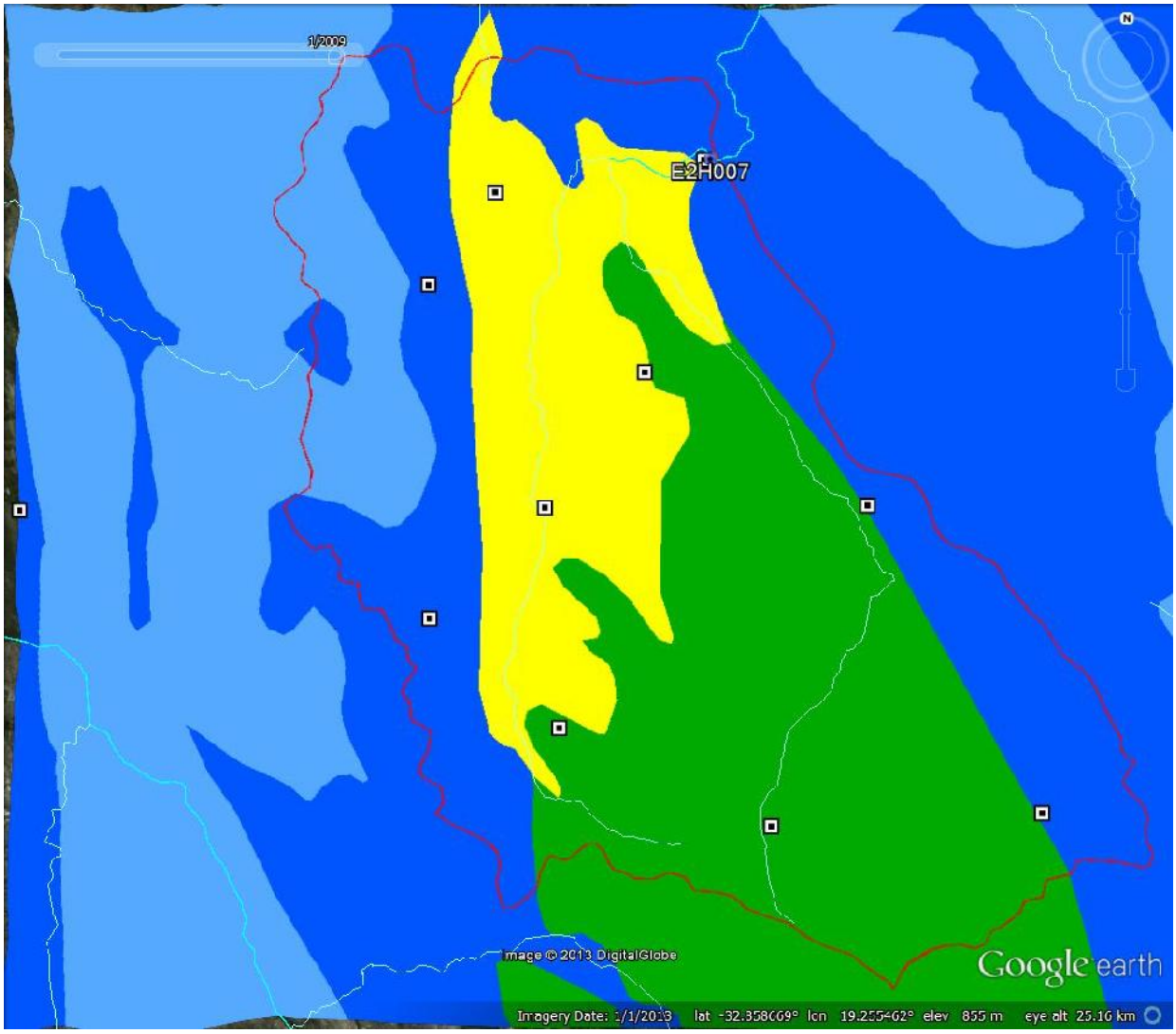

Figure 20.1 **Map of RU41 with aquifer delineation (light and dark blue: TMG Aquifer, yellow: Alluvium, green: Bokkeveld), existing monitoring points (none) and proposed monitoring points (white squares)**

20.5 ALLUVIUM AND BOKKEVELD AQUIFER

Groundwater is heavily used in the area, especially during the dry season and peak demand period. Intense agriculture, irrigation and over-abstraction can result in degradation in water quality. Residential areas could also have an impact on water quality.

20.5.1 Water quantity

The setting of water quantity related RQOs (see Table 20.4) is aimed at maintaining or improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

20.5.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

20.5.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 20.4.

Table 20.4 Water quantity RQOs for the Alluvium and Bokkeveld Aquifer in RU41

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the allocation schedule and individual licence conditions	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Water level monitoring network required
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Water level	Water level in the aquifer must be higher than the water level in the surface water.	n/a	
	Buffer zones	Around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	250m	
	Low flow in river	Compliance to the lowflow requirements in the river as per Reserve requirement (see above)	0.07 m^3/s / 0.001 m^3/s	E2H007

20.5.2 Water quality

The setting of water quality related RQOs (see Table 20.5) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

20.5.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

20.5.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 20.5. Exemption from these values can be granted, if exceeding is due to poor natural water quality.

Table 20.5 Water quality RQOs for the Alluvium and Bokkeveld Aquifer in RU41

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Extension of WMS network required
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network & parameters required
	Total Coliform		10 counts / 100ml	

20.6 TMG AQUIFERS

Groundwater from the TMG aquifers is used only in small portions of the catchment due to the accessibility. Intense agriculture, irrigation and over-abstraction can result in degradation in water quality. Residential areas could also have an impact on water quality.

20.6.1 Water quantity

The setting of water quantity related RQOs (see Table 20.6) is aimed at maintaining the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

20.6.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

20.6.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 20.6.

Table 20.6 Water quantity RQOs for the TMG Aquifer in RU41

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the allocation schedule and individual licence conditions	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Water level monitoring network required
		Water level recovers from abstraction impact during wet season.	n/a	

20.6.2 Water quality

The setting of water quality related RQOs (see Table 20.7) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

20.6.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

20.6.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 20.7.

Table 20.7 Water quality RQOs for the TMG Aquifer in RU41

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Extension of WMS network required
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network & parameters required
	Total Coliform		10 counts / 100ml	

20.7 WETLANDS

Not applicable (see Table 6.3).

21 E23K (R27) RESOURCE QUALITY OBJECTIVES

21.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E23K	Tankwa	B	Pakhuislaagte, plus three no-name tributaries, southern one a FEPA	A/B	-

21.2 TANKWA RIVER IN E23K

21.2.1 Hydrology

21.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ B Category.

21.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A.

The Tankwa River is ephemeral. Thus minimum lowflows do not apply.

21.2.2 Water quality

RQOs cannot be set with the current level of data available.

21.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

21.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

21.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

21.2.6 Fish

RQOs cannot be set with the current level of data available.

21.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available. An un-named tributary of the Tankwa in E23K has been identified as a FEPA.

21.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 21.1.

Table 21.1 Groundwater Reserve Requirements for E23K

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E23K	1.08	0.00	0.61	57%	1.08	0%	A

21.5 WETLANDS

Not applicable (see Table 6.3).

22 E33E, E33D, E33C (R8) RESOURCE QUALITY OBJECTIVES

22.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E33C	Vars	C	Kraai and Grootdrif	C	wetland area 1.1% of quaternary, 92% in AB
E33D	Geelbek	C	Klein Riet (part FEPA), Nabeeb (FEPA) and four others (two are FEPA)	C	-
E33E	Hol (and Sout)	C	Geelbek, Rooiberg (part FEPA), Volstruisleegte, Moedverloor	C	wetland area 1% of quaternary, 99% in AB

22.2 HOL RIVER (B) IN E33E

22.2.1 Hydrology

22.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ C Category.

22.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A.

The Hol River is ephemeral. Thus minimum lowflows do not apply.

22.2.2 Water quality

RQOs cannot be set with the current level of data available.

22.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

22.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

22.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

22.2.6 Fish

RQOs cannot be set with the current level of data available.

22.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

22.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 22.1.

Table 22.1 Groundwater Reserve Requirements for RU8 (E33C, E33D and E33E)

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
E33C	1.37	0.27	0.00	0%	1.10	20%	B
E33D	2.04	0.05	0.14	7%	1.99	2%	A
E33E	1.59	0.41	0.06	4%	1.18	26%	C

22.5 WETLANDS

Not applicable (see Table 6.3).

23 E32E (R3) RESOURCE QUALITY OBJECTIVES

23.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
E32E	Hantams and Doring (b) (FEPA)	B	Rondekop (part FEPA), Grasberg (FEPA), Soetfontein (FEPA), Bloukrans (FEPA)	B	wetland area 2.2% of quaternary, 48% in AB

23.2 DORING RIVER (B) IN E32E

23.2.1 Hydrology

23.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ B Category.

23.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A.

The Doring River in E32E is ephemeral. Thus minimum lowflows do not apply.

23.2.2 Water quality

RQOs cannot be set with the current level of data available.

23.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

23.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

23.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

23.2.6 Fish

RQOs cannot be set with the current level of data available.

23.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

23.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 23.1.

Table 23.1 Groundwater Reserve Requirements for E32E

Quaternary	Recharge (hm3/a)	Total Usage (hm3/a)	EWR Low Flow (hm3/a)	Groundwater Reserve [% of Re]	Water Balance (hm3/a)	GW Stress Index	PS
E32E	3.86	0.70	0.36	9%	3.16	18%	B

23.5 WETLANDS IN E32E AND E40C ("NIEUWOUDTVILLE WETLANDS")

NOTE: The Nieuwoudtville wetlands are addressed as a single unit although they occur across two quaternary catchments, *viz*.: E40C and E32E. Please refer to Section 17.5 for the RQOs for this cluster of wetlands.

24 G30D (R53) RESOURCE QUALITY OBJECTIVES

24.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
G30D	Verlorevlei (part FEPA)	≥ C	Krom Antonies, Hol (part FEPA) and one with no name	C	wetland area 0.8% of quaternary, 3% in AB

24.2 VERLOREVLEI RIVER IN G30D

A Reserve (Rapid Level II) has been signed off by DWA for the rivers in G30D. RQOs are given at a lower level of detail than for those RUs specifically selected for surface water (see Table 6.3). See also Appendix A.

24.2.1 Hydrology

Source: CAPE Olifants-Doorn Catchment Management Aagency Project (Ninham Shand 2009), Estuary Management Plan: Verlorenvlei (CSIR 2010) and Sandveld Preliminary Reserve Determinations (Southen Waters 2003).
Applicable to: G30D.
Monitor at: -32.61139, 18.77444 (top of the quaternary at Duikerfontein); G3H001 at Het Kruis.
Baseline data: G3H001, Ninham Shand (2009) and Southern Waters (2003).

24.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ C Category.

24.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (March): 0.019 m^3/s
Even in extreme drought flow should not drop below: 0.001 m^3/s.

24.2.2 Water quality

Source: Comprehensive Reserve Determination Study (DWAF 2005).
RQOs: The following are being monitored: pH, Conductivity (mS/l), suspended solids(mg/l), free and saline ammonia as N (mg/l), Nitrate as N (mg/l), Ortho-phosphate as P (mg/l), chemical oxygen demand as O_2 (mg/l), Sodium as Na (mg/l)
Applicable to: G30D.
Monitor at: -32.61139, 18.77444; G3H001.
Baseline data: G30H001, Ninham Shand (2009) and Southern Waters (2003).
Inflow water quality is currently being monitored (monthly) by DWA at:

- Kruismans River bridge;
- Kruismans Tributary roadbridge;
- Krom Antonies River at Twisniet Farm abstraction point;
- Hol River at Farm Kliphoek;
- Verlorenvlei River on Farm Shrik Van Rondom;

- Verlorenvlei River down stream of Redelinghuys; and
- Verlorenvlei River Grootdrif Farm.

24.2.2.1 Narrative

The water should be oligotrophic and should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a).

24.2.2.2 Numerical

None.

24.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

24.2.4 Riparian vegetation

RQOs cannot be set with the current level of data available.

24.2.5 Macroinvertebrates

RQOs cannot be set with the current level of data available.

24.2.6 Fish

Source:	C.A.P.E., SAIAB database
Applicable to:	G30D, G30E (and tributaries)
Monitor at:	River node R53; 32°29’37.82"S, 18°33’44.75"E
Baseline data:	SAIAB database.

24.2.6.1 Narrative

Indigenous species should dominate and *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus* and *Sandelia capensis* should be present.

24.2.6.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 24.1.

Table 24.1 Fish RQOs and TPCs for G30D

Indigenous	Sub-component	RQOs	TPCs
	Species assemblage	There should be 2 of the following fish species present in the catch: *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus*, *Sandelia capensis*	None available
	Demographics	There should be at least 2 age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	The following species should represent < 10 % of the catch: bass (*Micropterus dolomieu*, *M. salmoides*), *Oreochromis mossambicus*, *Tilapia sparrmanii*, *Cyprinus carpio*, *Tinca tinca*	None available
	Demographics	There should be at least 2 age classes present in each species. Approximately 30% of the catch should comprise juvenile fish.	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	

24.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

24.4 GROUNDWATER

The aquifers in the quaternary catchment G30D comprise mainly the TMG aquifers (Peninsula and Piekenierskloof) on the southern part of the catchment and the alluvium aquifer. The alluvium aquifer represents a substantial water resource covering most part of the catchment. Groundwater flow is from east to west following the Verlorenvlei River draining to the Atlantic Ocean.

The main water use in the catchment is for irrigation, mainly relying on groundwater. Local over-abstraction of groundwater has resulted in the resource being stressed, with low water levels and the available yield being reduced. Groundwater quality is also being under threat due to irrigation return flows and other diffuse and point source pollution.

The groundwater Reserve requirements for the whole catchment, based on the surface water low flow requirements, are given in Table 24.2.

Table 24.2 Groundwater Reserve Requirements for G30D

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
G30D	13.12	7.56	1.27	10%	5.56	58%	D

24.4.1 Water quantity

The setting of water quantity related RQOs (see Table 24.3) is aimed at maintaining or improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

24.4.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

24.4.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 24.3.

Table 24.3 Water quantity RQOs for the Aquifers in RU53

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Existing water level monitoring network by DWA
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Water level	Water level in the aquifer must be higher than the water level in the surface water.	n/a	
	Low flow in river	Compliance to the lowflow requirements in the river as per Reserve requirement (see above)	0.14 m^3/s / 0.04 m^3/s	-

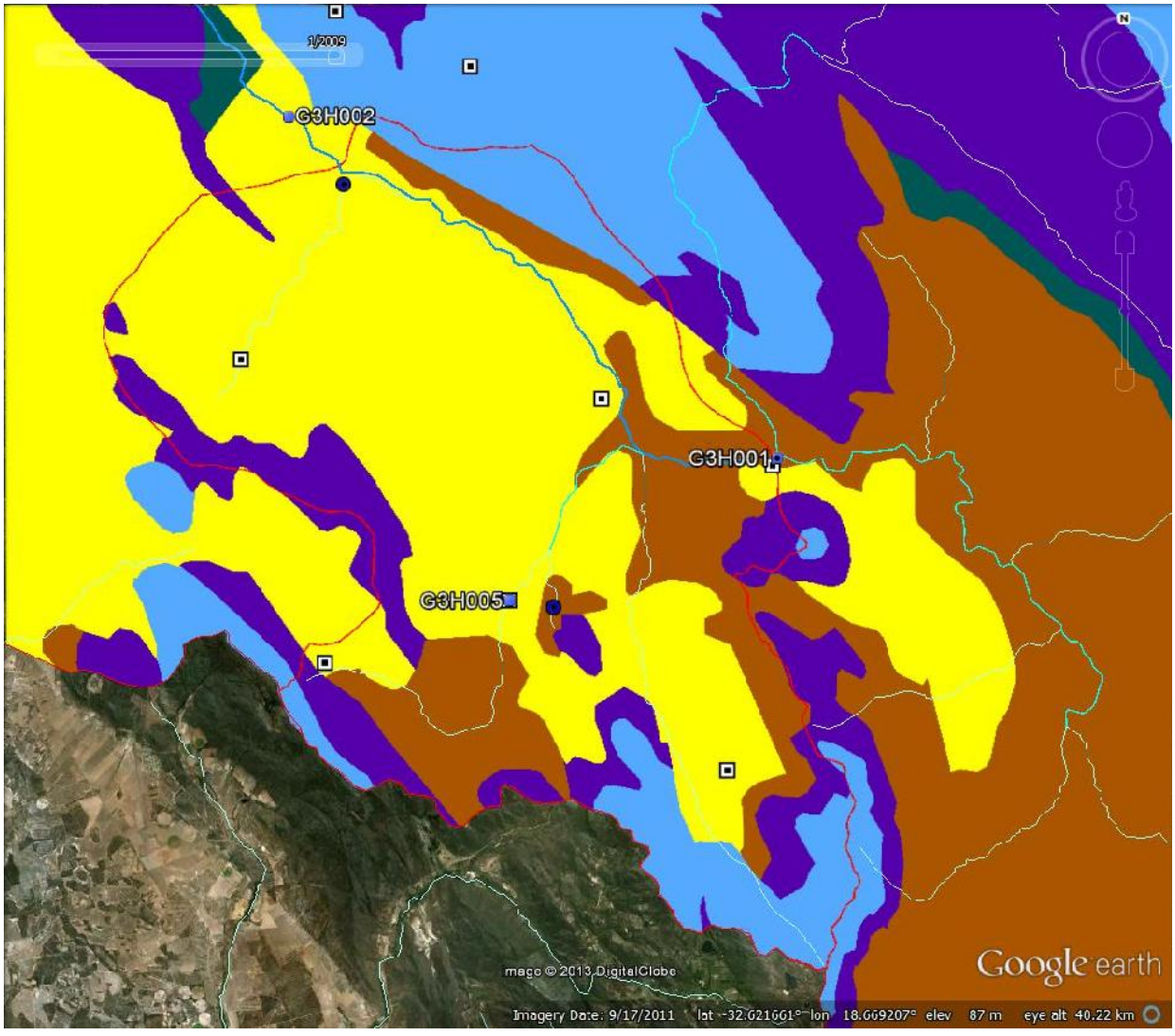

Figure 24.1 Map of RU53 with aquifer delineation (light blue and pink: TMG Aquifer, yellow: Alluvium), existing monitoring points (blue: WMS boreholes) and proposed monitoring points (white squares)

24.4.2 Water quality

The setting of water quality related RQOs (see Table 24.4) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

24.4.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

24.4.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 24.4. Exemption from these values can be granted, if exceeding is due to poor natural water quality.

Table 24.4 Water quality RQOs for the Aquifers in RU53

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Existing WMS network by DWA
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network parameters required
	Total Coliform		10 counts / 100ml	

24.5 WETLANDS

Not applicable (see Table 6.3), but refer to Section 25 for the vlei and estuary.

25 G30E (R52) RESOURCE QUALITY OBJECTIVES

25.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
G30E	Verlorevlei (RAMSAR)	≥ B	Sandveld	C	wetland area 7.9% of quaternary, 3% in AB

25.2 VERLOREVLEI RIVER IN G30E

The bulk of G30E consists of Verlorenvlei Lake / Estuary and is discussed in Section 25.5. The river upstream (G30D) is discussed in Section 24.2. See also Appendix A.

25.2.1 Hydrology

Source: CAPE Olifants-Doorn Catchment Management Aagency Project (Ninham Shand 2009), Estuary Management Plan: Verlorenvlei (CSIR 2010) and Sandveld Preliminary Reserve Determinations (Southen Waters 2003).
Applicable to: upper section of G30E.
Monitor at: -32.46556; 18.51667; just upstream of Redelinghuys, somewhat between Redelinghuys wetland and Verlorenvlei proper.
Baseline data: Ninham Shand (2009) and Southern Waters (2003).

25.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ B Category.

25.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (March): 0.29 m^3/s
Even in extreme drought flow should not drop below: 0.04 m^3/s.

25.2.2 Water quality

RQOs cannot be set with the current level of data available.

25.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

25.2.4 Macroinvertebrates

RQOs cannot be set with the current level of data available.

25.2.5 Fish

The RQOs for fish for the Verlorevlei River in G30E are the same as those for G30D.

25.2.5.1 Narrative

Indigenous species should dominate and *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus* and *Sandelia capensis* should be present.

25.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 24.1.

25.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

25.4 GROUNDWATER

The quaternary catchment G30E is mainly made up of the TMG aquifer (Peninsula and Piekenierskloof) and alluvium aquifer (Figure 25.1). The alluvium aquifer represents a substantial water resource covering most part of the catchment. Groundwater flow is from east to west following the Verlorenvlei River connected to the Verlorenvlei wetland, which drains to the Atlantic Ocean.

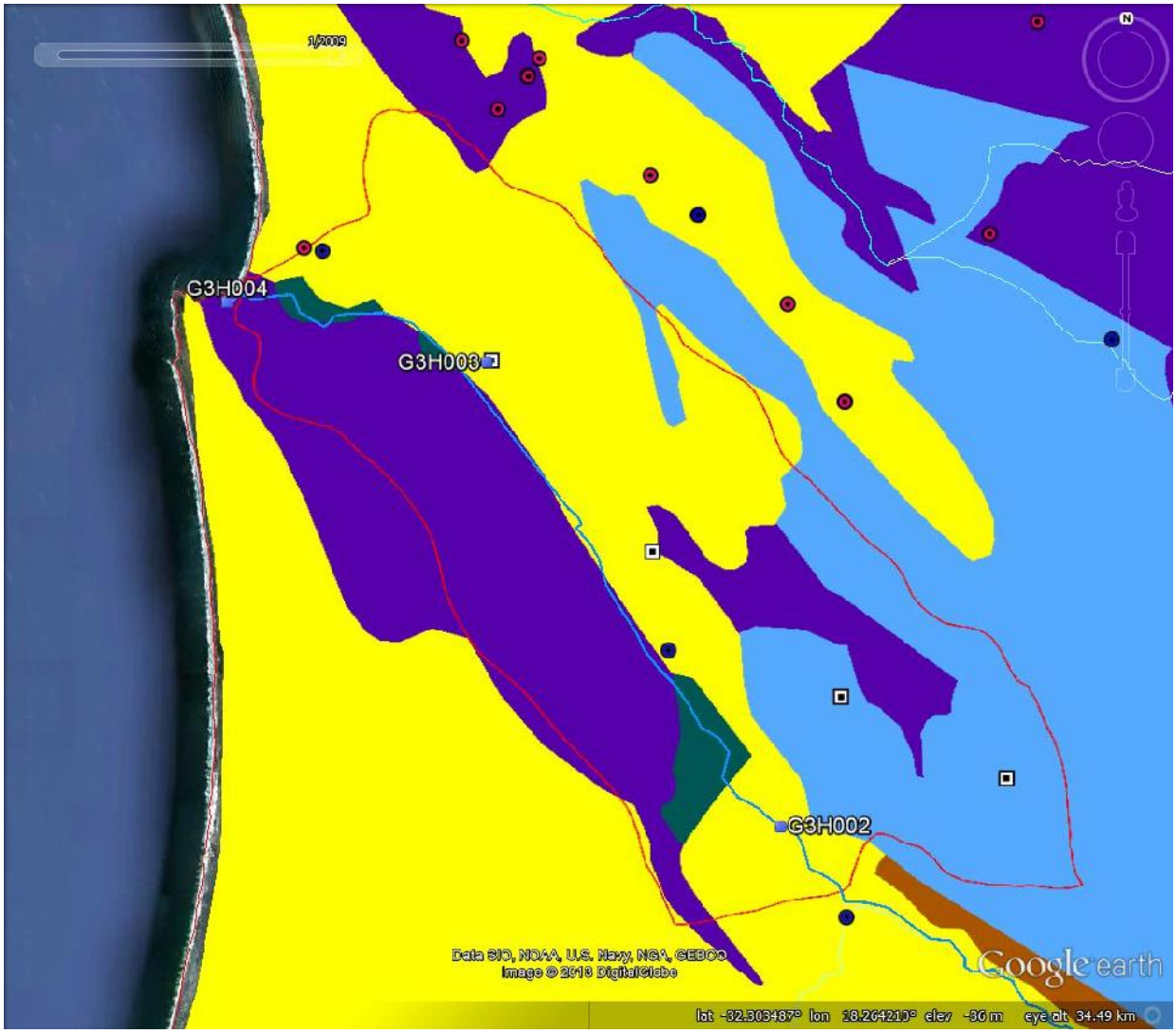

Figure 25.1 **Map of RU52 with aquifer delineation (light blue and pink: TMG Aquifer, yellow: Alluvium), existing monitoring points (blue: WMS boreholes, red: HYDSTRA borehole water level) and proposed monitoring points (white squares)**

The catchment consists of two small towns, Redelinghuys and the coastal town of Elands Bay. Groundwater is the only source of water for both towns. The Sandveld area is primarily an irrigation farming area where the main water resource is also groundwater. Over-abstraction in the area has resulted in the resource being heavily stressed, with low water levels and a reduction in the available yield for the supply to the residential areas. It is estimated that the groundwater abstraction currently exceeds the average annual recharge. Groundwater quality is also being depleted in close proximity to the ocean because of agricultural activities and abstraction for water supply. These considerably increase the risk of saline intrusion, which would render the water unusable.

The groundwater Reserve requirements for the whole catchment, based on the surface water low flow requirements, are given in Table 25.1.

Table 25.1 Groundwater Reserve Requirements for G30E.

Quaternary	Recharge (hm3/a)	Total Usage (hm3/a)	EWR Low Flow (hm3/a)	Groundwater Reserve [% of Re]	Water Balance (hm3/a)	GW Stress Index	PS
G30E	4.56	7.53	0.60	13%	-2.97	165%	F

25.4.1 Water quantity

The setting of water quantity related RQOs (see Table 25.2) is aimed at improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

25.4.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

25.4.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 25.2.

Table 25.2 Water quantity RQOs for the Alluvium Aquifer in RU52

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Existing water level monitoring network by DWA
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Water level	Water level in the aquifer must be higher than the water level in the surface water.	n/a	
	Buffer zones	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	500m	WARMS registration, licensing
	Low flow in river	Compliance to the lowflow requirements in the river as per Reserve requirement (see above)	0.29 m^3/s / 0.04 m^3/s	-

25.4.2 Water quality

The setting of water quality related RQOs (see Table 25.3) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

25.4.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

25.4.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 25.3. Exemption from these values can be granted, if exceeding is due to poor natural water quality.

Table 25.3 Water quality RQOs for the Alluvium Aquifer in RU52

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Existing WMS network by DWA
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network parameters required
	Total Coliform		10 counts / 100ml	

25.4.3 Water Level

The setting of water level related RQOs (see Table 25.4) is aimed at avoiding saline intrusion.

25.4.3.1 Narrative

No saline intrusion of seawater into the aquifer.

25.4.3.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 25.4.

Table 25.4 Water Level RQOs for the Alluvium Aquifer in RU52

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Water Level	Water level	Minimum water level in abstraction boreholes within 10km from the ocean to avoid saline intrusion	1 mamsl	Existing WMS network by DWA, plus local municipality's monitoring

25.5 VERLORENVLEI

The Verlorenvlei is a coastal lake with a short estuarine connection (about 2.5 km), situated about 25 km north of Lambert's Bay on the west coast and is a designated RAMSAR site (No. 525. Wetlands International Site Reference No. 1ZA009). It has an area of 1 500 ha (one of the largest lakes and one of the country's few coastal freshwater lakes).

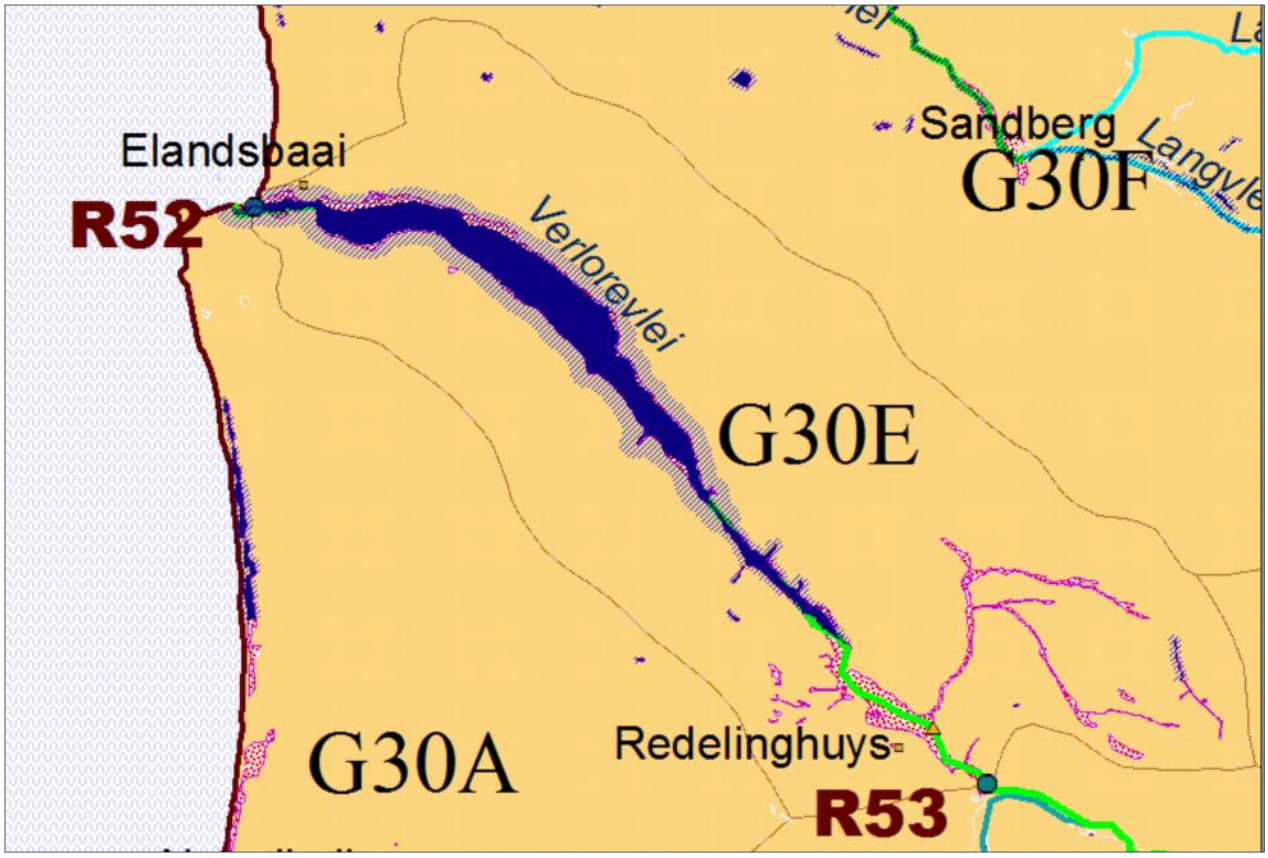

Figure 25.2. Spatial extent of Verloernvlei (dark blue area) as identified in CapeNature, C.A.P.E fine scale planning

25.5.1 Hydrology and hydrodynamics

Source:	CAPE Olifants-Doorn Catchment Management Agency Project (Ninham Shand 2009), Estuary Management Plan: Verlorenvlei (CSIR 2010) and Sandveld Preliminary Reserve Determinations (Southen Waters 2003).
RQOs:	Table 25.5.
Applicable to:	G30E: Verlorenvlei Estuary.
Monitor at:	Verlorenvlei Estuary: the DWA surface water level recorder in Verlorenvlei, G3T001 at Bonteheuvel (ex G3R001).
Baseline data:	DWA permanent water level recorder, Ninham Shand (2009) and Southern Waters (2003).

25.5.1.1 Narrative

Flows shall be sufficient to maintain the vlei in an ecological condition that is ≥ C Category.

25.5.1.2 Numerical

The suggested numerical limits for water levels and mouth condition to achieve the above narrative RQOs are given Table 25.5.

Table 25.5 Volume and water level RQOs for Verlorenvlei (G30E) for Category C (Ninham Shand 2009)

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

Note: There are no determinations of the volumes or distribution of water required for the maintenance of Verlorenvlei. In the absence of a Comprehensive Reserve assessment for the vlei, the suggested approach is to use the Reserve for the river at Redelinghuys (top of G30E, just before lake/wetland/estuary) with a target Ecological Condition of B, plus 60% of the floods from July to September: This would provide an allocation of 16.5 MCM (30.7% nMAR, and 3.2 MCM more than recommended by the Rapid Reserve determineation (Southern Waters 2003). In addition, if it is assumed that 60% of the large floods still come down the catchment, then the total volume allocated to the vlei is 26.3 MCM.

This approach necessitates limiting abstraction (in particular additional inchannel dams) in the upper catchment in order to protect Verlorenvlei, as indication are that the upper reaches of the Verlorenvlei River will not provide sufficient water to meet the Reserve at Redelinghuis.

It is important to note that the above approach will not be sufficient to protect water quality in the vlei without other catchment management interventions. Trophic state modelling showed that a volume of 13.3 MCM produced a negative water loading (Southern Waters 2003). Using the model, and assuming all inflow from the river, the acceptable breakeven annual volume was c. 25 MCM. Thus, if Verlorenvlei is to be protected, the Reserve allocation will need to go hand-in-hand with catchment management to reduce the nutrient loading in the river and vlei.

25.5.2 Water quality

DWA is not currently monitoring water quality downstream of Grootdrif Farm or in Verlorenvlei.

Source: Estuary Management Plan: Verlorenvlei (CSIR 2010).
Applicable to: G30E: Verlorenvlei Estuary.
Monitor at: Verlorenvlei Estuary: the DWA permanent water level recorder in Verlorenvlei / G3R001.
Baseline data: Ninham Shand (2009) and Southern Waters (2003).

25.5.2.1 Narrative

The water quality in the vlei shall not deteriorate from that measured prior to 2010.

25.5.2.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 25.6.

Table 25.6 Water quality RQOs and TPCs for Verlorenvlei estuary (G30E) (CSIR 2010)

Component	RQO	TPCs
Salinity	Salinity concentrations in the estuary < 35 ppt Salinity concentrations in the Verlorenvlei < 10 ppt	None available
Dissolved Oxygen	Dissolved oxygen concentrations in Verlorenvlei >= 4 mg/l	
Turbidity	Average suspended solid concentrations in river inflow should not increase by more than 10% of present conc's (to be determined)	
Inorganic nutrients	Average DIN concentrations in river inflow < 300 ug/l Average DIP concentrations in river inflow < 50 ug/l	
Toxins	Toxic substance concentrations (e.g. trace metals) in river inflow and the water column of Verlorenvlei < South African Water quality guidelines for coastal marine waters (DWAF 1995)	

25.5.3 Riparian vegetation

Source: Estuary Management Plan: Verlorenvlei (CSIR 2010). Objectives from stakeholder workshops
Applicable to: G30E: Verlorenvlei Estuary.
Monitor at: Verlorenvlei Estuary

25.5.3.1 Narrative

There should be no alien vegetation in Verlorenvlei.

25.5.3.2 Numerical

None.

25.5.4 Macrophytes, micro- and macro-algae

Source: Estuary Management Plan: Verlorenvlei (CSIR 2010).
Applicable to: G30E: Verlorenvlei Estuary.
Monitor at: Verlorenvlei Estuary: the DWA permanent water level recorder in Verlorenvlei.
Baseline data: Ninham Shand (2009) and Southern Waters (2003).

25.5.4.1 Narrative

Macrophytes, micro- and macro-algae community structure should not deteriorate from that measured in 2009.

25.5.4.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 25.7.

Table 25.7 Macrophytes and algae RQOs and TPCs for Verlorenvlei estuary (G30E) (CSIR 2010)

Component	RQO	TPCs
Phytoplankton	Maintain low phytoplankton biomass.	None available
Benthic microalgae	Maintain microalgal group diversity as measured for the baseline survey. Maintain high subtidal benthic microalgal biomass during the closed-mouth phase.	None available
Macrophytes	Maintain the distribution of plant community types.	None available
	Prevent excessive filamentous macroalgal growth.	Area covered >/=50 % of the open water surface area
	Ensure the long-term persistence of salt marsh species.	Decline in salt marsh species
	Prevent hypersaline sediment and groundwater conditions in the salt marsh.	Sediment electrical conductivity > 30 mS

25.5.5 Fish

Source: Estuary Management Plan: Verlorenvlei (CSIR 2010).
Applicable to: G30E: Verlorenvlei Estuary.
Monitor at: Verlorenvlei Estuary: the DWA permanent water level recorder in Verlorenvlei.
Baseline data: Ninham Shand (2009) and Southern Waters (2003).

25.5.5.1 Narrative

The population should be dominated by indigenous species.

25.5.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 25.8.

Table 25.8 Fish RQOs for Verlorenvlei estuary / wetland in G30E (CSIR 2010).

Component	RQO	TPCs
Fish assemblages	Retain the following fish assemblages in the estuary (based on abundance): • Estuarine species (10-20 %); • Estuarine associated marine species (80-90 %); • Indigenous freshwater species (1 %);	• Level of estuarine species increases above 60 % of total abundance. • Level of estuary associated marine species drops below 60 % of total abundance. • Alien *Lepomis macrochirus* and *Micropterus spp.* dominate in the upper reaches.
Demographics	• All numerically dominant species are represented by 0+ juveniles.	• Absence of 0+ juveniles of any of the dominant fish species.

25.5.6 Amphibians

Verlorenvlei provides habitat for the Cape dainty frog (*Cacosternum capense*), which is listed as Vulnerable by IUCN.

25.5.6.1 Narrative

The Cape dainty frog (*Cacosternum capense)* should continue to occur.

25.5.6.2 Numerical

None.

25.5.7 Birds

Source: Estuary Management Plan: Verlorenvlei (CSIR 2010).
Applicable to: G30E: Verlorenvlei Estuary.
Monitor at: Verlorenvlei Estuary: CWAC counts are regularly undertaken at Verlorenvlei.
Baseline data: CWAC counts: Animal Demography Unit, University of Cape Town [XXWebsite]. Ninham Shand (2009) and Southern Waters (2003).

25.5.7.1 Narrative

The abundance and diversity of birds in the estuary shall be equal to or greater than those measured prior to 2010.

25.5.7.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 25.9.

Table 25.9 Birds RQOs and TPCs for Verlorenvlei estuary / wetland in G30E (CSIR 2010)

Component	RQO	TPCs
Birds	Retain representative presence and abundance of Red Data species (Greater Flamingoes, Little Bittern, Caspian Tern, Great White Pelican)	Waders or terns are absent from the estuary for five consecutive counts.
	Retain representative species richness including those uncommon in south-western Cape (Glossy Ibises, African Spoonbills, and those typical in this habitat (e.g White-backed Duck)	

26 G30F (R56) RESOURCE QUALITY OBJECTIVES

26.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
G30F	Langvlei	≥ C	Lambertshoek	C	wetland area 1.5% of quaternary, 5% in AB

26.2 LANGVLEI RIVER IN G30F

A Rapid Level II Reserve has been undertaken for the Langvlei River providing EWRs for the lower reach of the Langvlei River, for the Wadrif wetland and for the Wadrif Pan.

26.2.1 Hydrology

Source: CAPE Olifants-Doorn Catchment Management Aagency Project (Ninham Shand 2009), Estuary Management Plan: Verlorenvlei (CSIR 2010) and Sandveld Preliminary Reserve Determinations (Southen Waters 2003).
Applicable to: G30F.
Monitor at: -32.21050; 18.37825; Immediately downstream of Wadrif farm, and immediately upstream of the Wadrif Pan and wetland.
Baseline data: Ninham Shand (2009) and Southern Waters (2003).

26.2.1.1 Narrative

Flows shall be sufficient to maintain the vlei in an ecological condition that is ≥ C Category.

26.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (March): 0.07 m^3/s
Even in extreme drought flow should not drop below: 0.001 m^3/s.

26.2.2 Water quality

The water should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a).

26.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

26.2.4 Macroinvertebrates

RQOs cannot be set with the current level of data available.

26.2.5 Fish

Source: SAIAB database
Applicable to: G30F

Monitor at: River Node R56: 32°12'40.05"S, 18°23'8.25"E / Upstream of the Wadrif Pan and Wetland
Baseline data: SAIAB database.

26.2.5.1 Narrative

Indigenous species should dominate and *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus* and *Sandelia capensis* should be present.

26.2.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 26.1.

Table 26.1 Fish RQOs and TPCs for Langvlei River (G30F) (Ninham Shand. 2009)

	Sub-component	RQOs	TPCs
Indigenous	Species assemblage	There should be 2 of the following fish species present in the catch: *Pseudobarbus burgi* (Verlorenvlei), *Galaxias zebratus*, *Sandelia capensis*	None available
	Demographics	There should be at least two age classes present in each species. Approximately 30% of the catch should comprise juvenile fish (< 30 mm FL).	
	Fish Health	Parasites, lesions and deformities should be present on < 5 % of the catch	
Alien	Sub-component	RQOs	
	Species assemblage	Insufficient data	None available
	Demographics	Alien species should be <10% of the catch.	
	Fish Health	Insufficient data	

26.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

26.4 GROUNDWATER

The Quaternary catchment G30F is mainly made up of the TMG aquifer (Peninsula and Piekenierskloof) and alluvium aquifer. Groundwater flow is from east to west following the Langvlei River draining to the Atlantic Ocean.

The catchment is mainly an irrigation farming area where the main water resource is groundwater. Over abstraction in the area has resulted in the resource being heavily stressed, with low water levels and the available yield being reduced. Groundwater quality is also being depleted due to agricultural activities and abstraction for water supply in close proximity to the ocean with the risk of saline intrusion.

The groundwater Reserve requirements for the whole catchment, based on the surface water low flow requirements, are given in Table 26.2.

Table 26.2 Groundwater Reserve Requirements for G30F

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
G30F	14.23	20.00	1.05	7%	-5.77	141%	F

Groundwater is heavily used in the area, especially during the dry season and peak demand period, and it is currently estimated that the groundwater abstraction exceeds the average annual recharge.

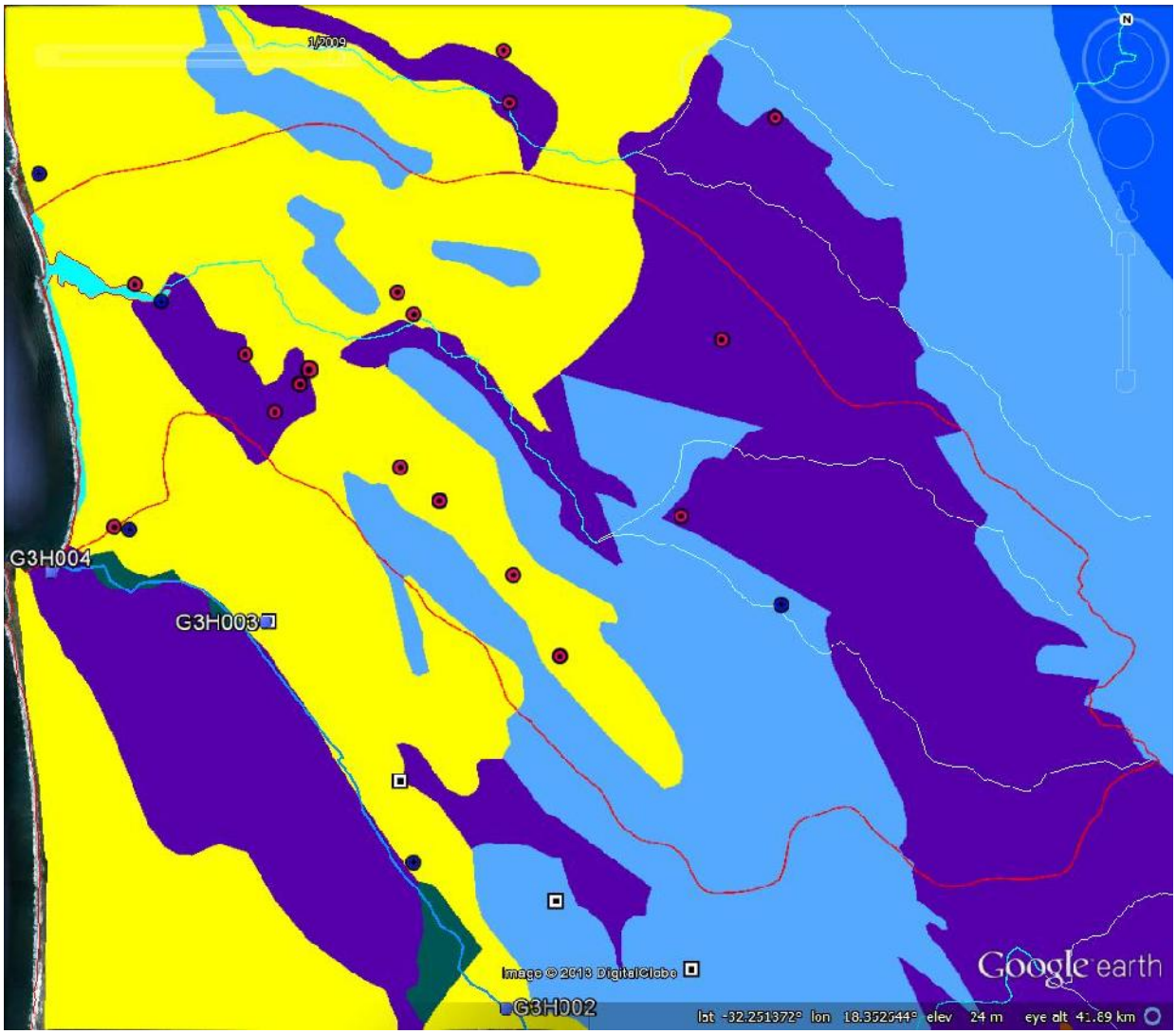

Figure 26.1 **Map of RU56 with aquifer delineation (light blue and pink: TMG Aquifer, yellow: Alluvium), existing monitoring points (blue: WMS boreholes, red: HYDSTRA borehole water level) and proposed monitoring points (white squares)**

26.4.1 Water quantity

The setting of water quantity related RQOs (see Table 26.3) is aimed at improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

26.4.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

26.4.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 26.3.

Table 26.3 Water quantity RQOs for the Alluvium Aquifer in RU56

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Existing water level monitoring network by DWA
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Water level	Water level in the aquifer must be higher than the water level in the surface water.	n/a	
	Buffer zones	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	500m	WARMS registration, licensing
	Low flow in river	Compliance to the lowflow requirements in the river as per Reserve requirement (see above)	0.07 m^3/s / 0.001 m^3/s	-

26.4.2 Water quality

The setting of water quality related RQOs (see Table 26.4) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

26.4.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

26.4.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 26.4. Exemption from these values can be granted, if exceeding is due to poor natural water quality.

Table 26.4 Water quality RQOs for the Alluvium Aquifer in RU56

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Existing WMS network by DWA
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS parameters required
	Total Coliform		10 counts / 100ml	

26.4.3 Water Level

The setting of water level related RQOs (see Table 26.5) is aimed at avoiding saline intrusion.

26.4.3.1 Narrative

No saline intrusion of seawater into the aquifer.

26.4.3.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 26.5.

Table 26.5 Water Level RQOs for the Alluvium Aquifer in RU56

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Water Level	Water level	Minimum water level in abstraction boreholes within 10km from the ocean to avoid saline intrusion	1 mamsl	Existing WMS network by DWA, plus local municipality's monitoring

26.5 WETLANDS – WADRIF WETLANDS AND WADRIF SALTPAN

The Wadrif Wetland is a small wetland at the point of discharge of the Langvlei River onto the coastal plain, immediately upstream of and grading into the Wadrif Pan. Category C was recommended for both.

26.5.1 Hydrology and hydrodynamics

Source: CAPE Olifants-Doorn Catchment Management Agency Project (Ninham Shand 2009), and Sandveld Preliminary Reserve Determinations (Southen Waters 2003).

Applicable to: G30F: Wadrif Wetlands and Wadrif Pan.

Monitor at: DWA permanent water level recorder G3H002 (Wadriftsoutpan); Wadrif Wetlands, -32.21325, 18.37721; and Wadrif Pan -32.20523, 18.33834.

Baseline data: DWA permanent water level recorder, Ninham Shand (2009), Southern Waters (2003).

26.5.1.1 Narrative

Flows shall be sufficient to maintain the Wadrif wetlands and saltpan in an ecological condition that is equal to C Category.

26.5.1.2 Numerical

The suggested numerical limits for volumes and water levels required to achieve the above narrative RQOs are given in Table 26.6, Table 26.7 and Table 26.8.

Table 26.6 Annual Volume RQOs for Wadrif Wetland and Wadrif Pan (G30F) (Southern Waters 2003)

Component	Location	REC	RQO
Wadrif Wetland	-32.21325 18.37721	≥ C	1.957 MCM
Wadris Pan	-32.20523 18.33834	≥ C	5.000 MCM

Note: Integration of the Reserves for the Wadrif Pan, the Wadrif Wetland and the lower Langvlei River indicate that, even if the river Reserve is met (1.957 MCM per annum), surface flows will not support the requirements for the pan (5 MCM per annum; Table 26.7). Accordingly, while the C-Category Reserve for the river will go some way to offsetting the present level of devastation in the river and pan but it will not maintain a C category in the pan (Southern Waters 2003).

Table 26.7 Aspects of the RQOs for Wadrif Wetland (G30F) (Southern Waters 2003)

Component	RQO
Period of inundation	Perennial wetness to surface. Standing pools of water within the stands of palmiet
Depth	Not relevant. Wetland is essentially on a descending bend in the river, and should evidence groundwater discharge.
Downward seepage losses	Moderate to high
Groundwater discharge	High, quantity undetermined
Evaporation loss	Exacerbated by evapotranspiration
Contribution from groundwater	Significant
Volume requirement	Surface component will be met by EFR. However, a significant proportion of the EFR will be required from groundwater. Volume of the groundwater component has crucial and important implications for the Wadrif Pan.
Frequency for meeting requirement	Annually

Table 26.8 Water level and inundation RQOs for Wadrif Pan (G30F) (Southern Waters 2003)

Component	RQO
Period of inundation	July to December, with water entering the system from April (standing water present for between six and eight months of the annual cycle).
Depth	Wet season maximum 1.5 m AMSL (1.0 m above lowest point of pan). This depth to be achieved during July to August. Wet season minimum. 0.8 m AMSL (provisional). Dry season maximum. 0.55 m AMSL (0.15 m above lowest point of pan during 1st week of December).
Downward seepage losses	Negligible (estimated <0.001 m/d)
Evaporation loss	1.2- 1.6 m/a
Contribution from groundwater	Undetermined
Volume requirement	5 MCM (wet year), 1.5-2.5 MCM dry year.
Frequency for meeting requirement	2/3 years (provisional)

26.5.2 Water quality

RQOs cannot be set for water quality with the current level of data available.

26.5.3 Vegetation

Genetically distinct vegetation assemblages are known to occur but RQOs cannot be set for vegetation with the current level of data available.

26.5.4 Fish

26.5.4.1 Narrative

Galaxias zebratus and *Sandelia capensis* should be present.

26.5.4.2 Numerical

There are insufficient data to set numerical RQOs.

26.5.5 Birds

The Wadrif Wetland system is considered more important for birds than Verlorenvlei, in particular for the Southern Africa Pan-Coastal migrants (DWAF 2003).

Source: DWAF 2003.
Applicable to: G30F: Wadrif Wetland.
Monitor at: Wadrif Wetland: Regular CWAC counts are undertaken.
Baseline data: CWAC (Animal Demography Unit, University of Cape Town, WEB).

26.5.5.1 Narrative

The abundance and diversity of birds in the wetland shall be equal to or greater than those measured prior to 2010.

26.5.5.2 Numerical

The suggested numerical limits to achieve the above narrative RQOs are given in Table 26.9.

Table 26.9 Birds RQOs and TPCs for Wadrif Wetland in G30F (CSIR 2010)

Component	RQO	TPCs
Birds	Retain representative presence of rare or threatened species (e.g. Lesser Flamingo)	Waders or terns are absent from the estuary for five consecutive counts.
	Retain representative species richness in particular of Southern Africa Pan-Coastal migrants	

26.5.6 Wetland extent and vegetation

In general the RQOs require that the wetlands should remain intact and the extent of invasion by woody alien plants should not increase.

Source: CapeNature, C.A.P.E fine scale map (2008), Job *et al*. (2011).
Applicable to: G30F.
Monitor at: Wadrif Wetland and Wadrif Pan.
Baseline data: CapeNature, C.A.P.E fine scale map (2008), Job *et al*. (2011).
Monitor using: Google Earth.

26.5.6.1 Narrative

Narrative RQOs for are provided in Table 26.10.

Table 26.10 Wetland RQOs for Wadrif Wetlands (G30F)

Sub-component	Baseline data source	RQO
Wetland extent	CapeNature, C.A.P.E fine scale map (2008)	No expansion of agriculture or other landuses into the remaining intact wetland areas
Woody alien vegetation extent		No further expansion of woody alien vegetation in to wetland areas
Wetland condition	Job *et al*. (2011)	No change in WET-Health scores

26.5.6.2 Numerical

None – insufficient data.

27 G30G (R57) RESOURCE QUALITY OBJECTIVES

27.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
G30G	Jakkals / Jakkelsvlei	≥ C	Peddies	C	wetland area 0.9% of quaternary, 11% in AB

27.2 JAKKALSVLEI RIVER IN G30G

A Rapid Level II Reserve has been undertaken for the River providing EWRs for the lower reach of the river and for the Jakkalsvlei pan.

27.2.1 Hydrology

Source: CAPE Olifants-Doorn Catchment Management Agency Project (Ninham Shand 2009), Sandveld Preliminary Reserve Determinations (Southen Waters 2003).
RQOs: Appendix A.
Applicable to: G30G: Jakkals River.
Monitor at: Jakkals River at Kookfontein; -32.08942, 18.35242.
Baseline data: Ninham Shand (2009), Southern Waters (2003).

27.2.1.1 Narrative

Flows shall be sufficient to maintain the river in an ecological condition that is ≥ C Category.

27.2.1.2 Numerical

The suggested numerical limits for river flows to achieve the above narrative RQOs are given in Appendix A. Driest month lowflow and absolute minimum (drought) instantaneous dry season lowflows are stipulated below.

Mean flow in driest month (March): 0.03 m^3/s
Even in extreme drought flow should not drop below: 0.001 m^3/s.

27.2.2 Water quality

The water should comply with the Target Water Quality Ranges for aquatic ecosystem (DWAF 1996a).

27.2.3 Geomorphology

RQOs cannot be set with the current level of data available.

27.2.4 Macroinvertebrates

RQOs cannot be set with the current level of data available.

27.2.5 Fish

RQOs cannot be set for fish with the current level of data available.

27.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

27.4 GROUNDWATER

The quaternary catchment G30G is mainly made up of the TMG aquifer (Peninsula and Piekenierskloof) and the alluvium aquifer. The alluvium aquifer represents a substantial water resource covering most part of the catchment. Groundwater flow is from east to west following the Jakkals River draining to the Atlantic Ocean.

The catchment comprises two small towns (Graafwater and Lamberts Bay) which are solely reliant on groundwater for their water supply. The area is primarily an irrigation farming area where the main water resource is groundwater. Over abstraction in the area has resulted in the resource being heavily stressed, with low water levels and the available yield for the supply to the residential areas being reduced. Groundwater quality is also being depleted due to agricultural activities and abstraction for water supply in close proximity to the ocean with the risk of saline intrusion.

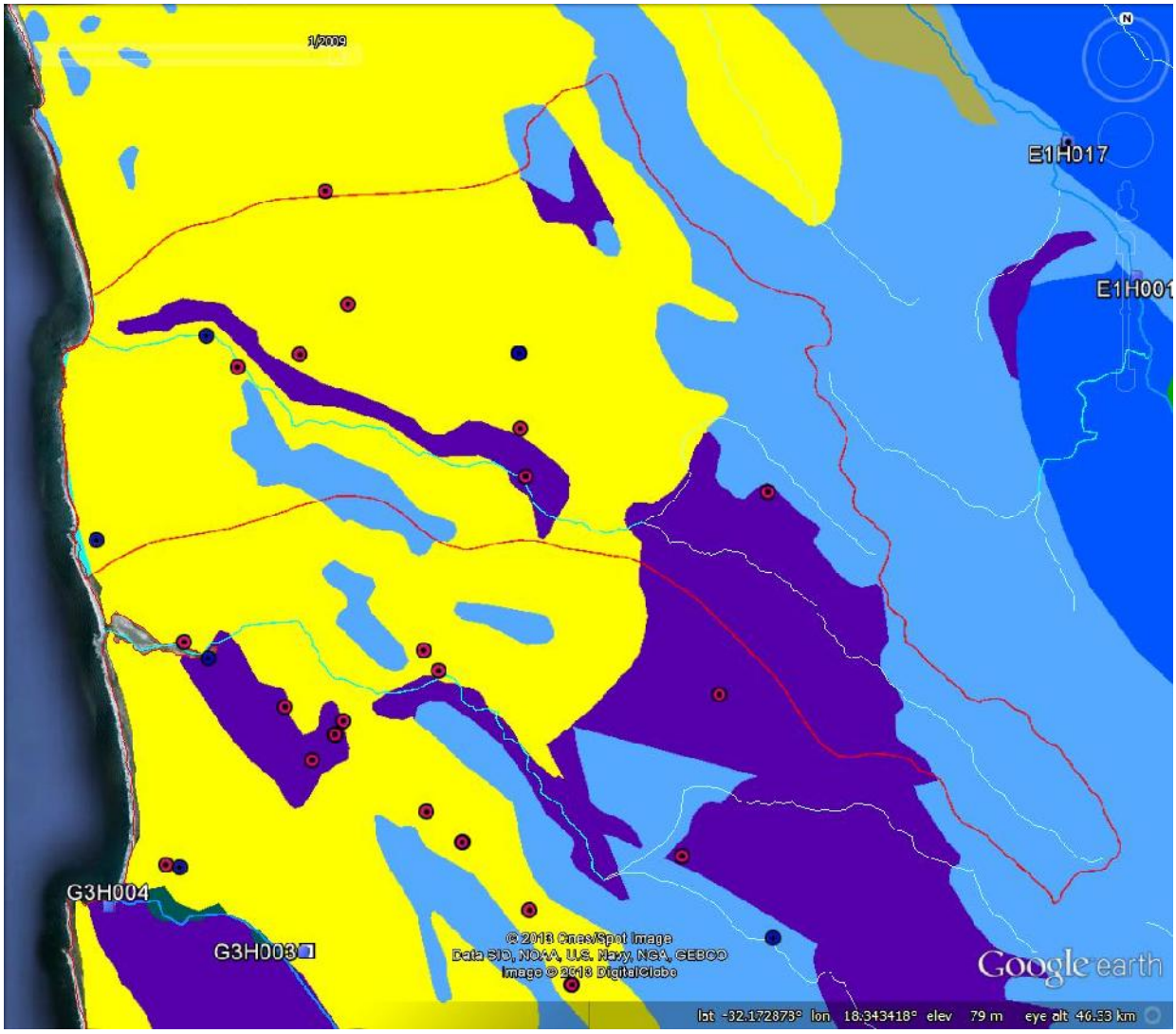

Figure 27.1 **Map of RU57 with aquifer delineation (light blue and pink: TMG Aquifer, yellow: Alluvium), existing monitoring points (blue: WMS boreholes, red: HYDSTRA borehole water level) and proposed monitoring points (white squares)**

The groundwater Reserve requirements for the whole catchment, based on the surface water low flow requirements, are given in Table 27.1.

Table 27.1 Groundwater Reserve Requirements for G30G

Quaternar	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
G30G	10.48	6.74	0.41	4%	3.74	64%	D

Groundwater is heavily used in the area, especially during the dry season and peak demand period, and it is currently estimated that the groundwater abstraction is close to the average annual recharge.

27.4.1 Water quantity

The setting of water quantity related RQOs (see Table 27.2) is aimed at improving the groundwater discharge to support the low flow requirements and ensuring sufficient yield for all users.

27.4.1.1 Narrative

The groundwater use is sustainable for the environment and all users.

27.4.1.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 27.2.

Table 27.2 Water quantity RQOs for the Alluvium Aquifer in RU57

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Available Yield	Abstraction	All users comply with the revised allocation schedule and individual licence conditions within the confirmed available yield	n/a	Annual licence audit by DWA
	Water level trend	No negative trend between peak drawdowns during dry seasons	n/a	Existing water level monitoring network by DWA
		Water level recovers from abstraction impact during wet season.	n/a	
Discharge	Water level	Water level in the aquifer must be higher than the water level in the surface water.	n/a	
	Buffer zones	No groundwater abstraction around wetland and river FEPAs in accordance with the implementation manual for FEPAs.	500m	WARMS registration, licensing
	Low flow in river	Compliance to the lowflow requirements in the river as per Reserve requirement (see above)	0.03 m^3/s / 0.001 m^3/s	-

27.4.2 Water quality

The setting of water quality related RQOs (see Table 27.3) is aimed at maintaining the groundwater quality in relation to its background level, or ensuring compliance with water quality standards for domestic use (SANS 241: 2011) after treatment, as this is the more stringent requirement for the variety of users in the RU.

27.4.2.1 Narrative

The water quality shall not deteriorate from the natural background, and the water shall be fit for domestic use in accordance with SANS 241:2011, after treatment.

27.4.2.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 27.3. Exemption from these values can be granted, if exceeding is due to poor natural water quality.

Table 27.3 Water quality RQOs for the Alluvium Aquifer in RU57

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Nutrients	NO_3/NO_2	Fitness for use for domestic use after treatment, and shall not deteriorate from natural background	< 11 mg/l	Existing WMS network by DWA
Salts	EC		< 170 mS/m	
Pathogens	E-coli		0 counts / 100 ml	Extension of WMS network parameters required
	Total Coliform		10 counts / 100ml	

27.4.3 Water Level

The setting of water level related RQOs (see Table 27.4) is aimed at avoiding saline intrusion.

27.4.3.1 Narrative

No saline intrusion of seawater into the aquifer.

27.4.3.2 Numerical

The indicators and numerical limits to achieve the narrative statements are listed in Table 27.4.

Table 27.4 Water Level RQOs for the Alluvium Aquifer in RU57

Sub-component	Indicator	RQO Description	Numerical Value	Monitoring
Water Level	Water level	Minimum water level in abstraction boreholes within 10km from the ocean to avoid saline intrusion	1 mamsl	Existing WMS network by DWA, plus local municipality's monitoring

27.5 WETLANDS - JAKKALSVLEI PAN

Source: CAPE Olifants-Doorn Catchment Management Agency Project (Ninham Shand 2009), Sandveld Preliminary Reserve Determinations (Southen Waters 2003).
Applicable to: G30G: Jakkalsvlei Pan.
Monitor at: Jakkalsvlei Pan, -32.08776, 18.32152.
Baseline data: Ninham Shand (2009), Southern Waters (2003).

27.5.1 Narrative

Flows shall be sufficient to maintain the Jakkkalsvlei Pan in an ecological condition that is equal to a C Category.

27.5.2 Numerical

The suggested numerical limits for volume and depth requirements in Jakkalsvlei Pan to achieve the above narrative RQOs are given in Table 27.5.

Table 27.5 Water level and inundation RQOs for Jakkalsvlei Pan (G30G) for a C category (Southern Waters 2003).

Component	RQO
Period of inundation	July to November/December
Depth	1 m average depth
Volume at average depth	0.155 MCM
Surface area at average depth	25 ha
Downward seepage losses	Negligible (estimated <0.001 m/d)
Evaporation loss	1.2 m/a
Contribution from groundwater	Undetermined
Volume requirement	0.5 MCM
Frequency for meeting requirement	1 in 2 years (provisional)

28 G30H (Q5) RESOURCE QUALITY OBJECTIVES

28.1 UPDATED RESOURCE CLASSIFICATION

Quaternary	Target Ecological Categories				
	Mainstem		Key tributaries		Wetlands
G30H	Sandlaagte	≥ C	-	-	wetland area 1.4% of quaternary, 25% in AB

28.2 SANDLAAGTE RIVER IN G30H

28.2.1 Hydrology

Not applicable (see Table 6.3). For basic RQOs - See Appendix A.

28.3 TRIBUTARIES

RQOs cannot be set for the tributaries with the current level of data available.

28.4 GROUNDWATER

No detailed RQOs have been set. The groundwater Reserve requirements, based on the surface water low flow requirements, are given in Table 28.1.

Table 28.1 Groundwater Reserve Requirements for G30H.

Quaternary	Recharge (hm^3/a)	Total Usage (hm^3/a)	EWR Low Flow (hm^3/a)	Groundwater Reserve [% of Re]	Water Balance (hm^3/a)	GW Stress Index	PS
G30H	15.90	0.36	0.59	4%	15.54	2%	A

28.5 WETLANDS – UPPER SANDLAAGTE

The focus of the RQOs is on habitat extent (area of remaining intact wetlands) of wetlands within the cluster. There is no available information on wetland condition for individual wetlands within this cluster.

28.5.1 Hydrology

None – insufficient data.

28.5.2 Physical attributes

Source: CapeNature, C.A.P.E fine scale map (2008).
RQOs: Table 28.2.
Applicable to: G30H.
Monitor using: Google Earth.
Baseline data: CapeNature, C.A.P.E fine scale map (2008) - the areas of wetlands are included in the deliverables of this study in .shp (ArcGIS) and .kml. (Google Earth) format.

28.5.2.1 Narrative

There should be no expansion of agriculture or other landuses in to remaining intact wetland areas.

28.5.2.2 Numerical

Numerical RQOs cannot be set with the current level of data available.

Table 28.2 Wetland RQOs for Sandlaagte Wetlands cluster (G30H)

Wetland Indicator	Baseline data source	RQO	Monitoring frequency and approach
Wetland cluster extent (around 678 ha taken together)	CapeNature, C.A.P.E fine scale map (2008)	No expansion of agriculture or other landuses in to remaining intact wetland areas	2 years intervals: Monitor changes in landuse and extent of wetland areas from updated fine scale mapping or updated aerial/satellite imagery (such as Google Earth)

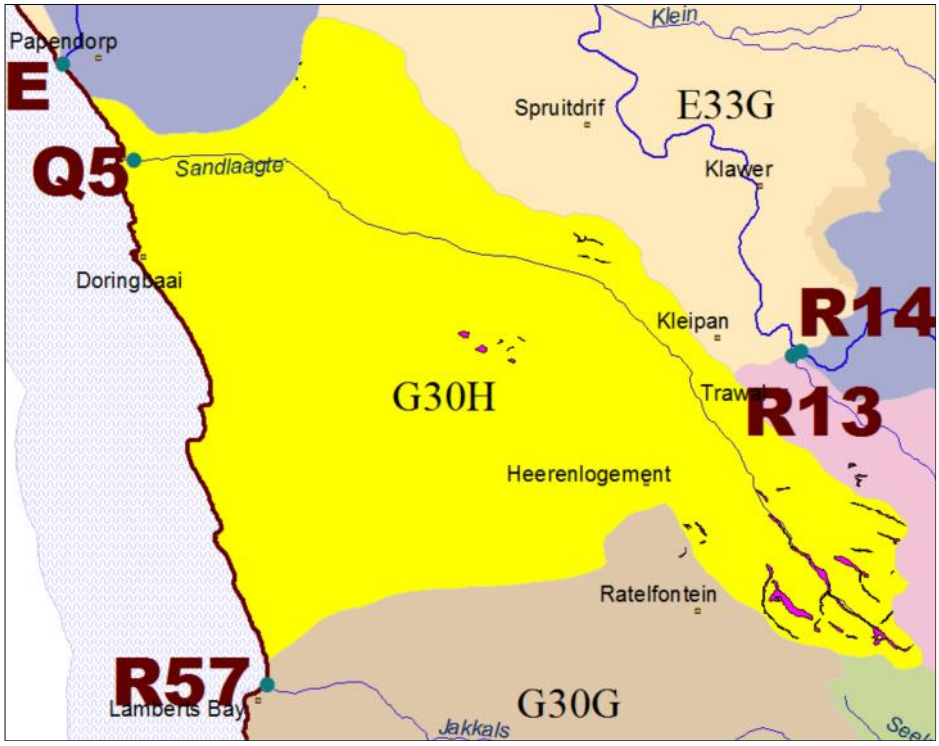

Figure 28.1 Location of Sandlaagte wetlands (denoted in pink on the yellow quaternary G30H).

Part IV: Monitoring methods

29 MONITORING METHODS FOR ESTUARIES

In the absence of more detailed information, and in an effort to retain some continuity between studies, the monitoring methods outlined here are those recommended by the specialists responsible for the Comprehensive Reserve determination (Taljaard *et al*. 2006).

29.1 OLIFANTS ESTUARY

Recommended monitoring actions from the Coomprehensive reserve study are provided in Table 29.1.

Table 29.1 Monitoring methods for Olifants Estuary RQOs

Component	Monitoring action	Timing	Location
BIRDS	Undertake counts of all water associated birds. All birds should be identified to species level and total number of each counted.	Winter and summer survey, yearly	Entire estuary
FISH	Conduct fish surveys using both seine and gill nets as primary gear.	Summer and winter survey every 2 years	Entire estuary (10-15 stns)
INVERTEBRATES	Zooplankton: Collect quantitative samples using a flow meter after dark, preferably during neap tides (mid to high tide). Sampling to be done at mid- water level, i.e. not surface. (Include chlorophyll a measurements on benthic microalgae and water column chlorophyll a to establish feeding links)		Entire estuary (10-15 stns)
	Benthic invertebrates: Collect (subtidal) samples using a Zabalocki-type Eckman grab sampler with 5-9 randomly placed grabs (replicates) at each station. Collect intertidal samples at spring low tide using core sampling.		Entire estuary (10-15 stns)
	Macrocrustaceans: Collected quantitative samples during neap tides (mid to high tide), at the same stations used for zooplankton, using a benthic sled with flow meter.		Entire estuary (10-15 stns)
MACROPHYTES	Use aerial photographs to quantify area covered by different plant community types and produce a vegetation map. Conduct ground survey to: 1) verify areas covered by different plant community types, 2) check the spread of alien vegetation, 3) check the spread of aquatic weeds and algae in the upper estuarine reaches 4) check the extent of bareground in the floodplain salt marsh, depth to groundwater and groundwater salinity. 5) check the distribution of reeds, sedges and brackish salt marsh up the length of the estuary in relation to the longitudinal salinity gradient.		Entire estuary
MICROALGAE	Phytoplankton: Conduct water column chlorophyll a measurements and counts of dominant phytoplankton group.		Entire estuary (8 stns)
	Benthic microalgae: Conduct benthic chlorophyll a measurements		Entire estuary (8 stns)

Component	Monitoring action	Timing	Location
WATER QUALITY	Collect data on conductivity, temperature, suspended matter/turbidity, dissolved oxygen, pH, inorganic nutrients and organic content in river inflow	At least monthly	At Lutzville causeway
	Monitor inorganic nutrient inflow from agricultural return flow in upper reaches (e.g. bore hole sampling)		3-5 stns along upper banks
	Collected longitudinal salinity & temperature profiles (*in situ*)	To be measured when biotic surveys require information for interpretation	Entire estuar
	Water quality measurements taken along the length of the estuary (surface and bottom samples) for pH, dissolved oxygen, suspended solids/turbidity and inorganic nutrients.		
	Baseline data set for pesticides/herbicides accumulation in sediments	Every 3 – 6 years	Focus on depositional areas
HYDRODYNAMICS	Water level recordings	Hourly	Near mouth
	Flow gauging	Daily	Near Lutzville causeway
	Aerial photographs of estuary (spring low tide)	Annual	Entire estuary
SEDIMENT DYNAMICS	Bathymetric survey: Series of cross-section profiles and a longitudinal profile collected at fixed 500 m intervals, but more detailed in the mouth (vertical accuracy better than 300 mm)	Every 3-6 years, depending on time scale of dominant sedimentation/erosion processes in estuary, as well as after flood events	
	Set sediment grab samples (at cross section profiles) for analysis of particle size distribution (PSD) and origin (i.e. using microscopic observations)		
	Daily sampling of suspended sediment (and organic matter)	Daily	Sishen-Saldanha

29.2 VERLORENVLEI

The monitoring requirements and methods for Verlorenvlei are detailed in CSIR (2010).

29.3 OTHER SANDVELD ESTUARIES

Only hydrological RQOs. Monitoring as per recommendations in Sections 26 - 28.

30 MONITORING METHODS

30.1 RIVERS

In the absence of more detailed information, and in an effort to retain some continuity between studies, the monitoring methods outlined here are those recommended by the specialists responsible for the Comprehensive Reserve determination (Brown and Pemberton 2006). One exception to this is the fish, which has been updated according to information from Dr Bruce Paxton. The RQO monitoring will need to be integrated with other, in some cases on-going monitoring programmes. However, this level of integration and monitoring programme design is outside the ToR for this project. Additional information on analysis and interpretation is available in Brown and Pemberton (2006).

The RQOs that require monitoring at each priority site are listed in Table 8.2. Where available, site specific information on position of the monitoring is provided for each site in Sections 9 to 28.

30.1.1 Hydrology

Routine analysis of the daily hydrological data from the relevant weirs, listed for each node.

In addition, regular (daily/sub-daily) visual monitoring of flow in the dry season is essential at each and every site, as per the descriptive hydrological RQOs for that site.

30.1.2 Water Quality

In addition to the data collected from the DWA gauging weirs, the main issue with respect to water quality monitoring for the Olifants-Doorn WMA relates to the collection of high frequency data, event-driven data collection - both what happens to the water quality during flows of particular magnitude, as well as what happens during the period that the river is drying up. Crucial data gaps for the rivers include data on the fundamental physicochemical parameters as the water starts to get shallower over the riffles (temperature and dissolved oxygen) and how the EC changes with changes in blending.

Based on the data that we have to hand, the water quality in the Olifants-Doring River appears to be good. However, no information is available for the critical periods when the flow-related monitoring stops, i.e., during extremely low flow events. Monitoring at these times would entail sample collection at locations remote from the DWA weirs. This would thus necessitate unattended loggers for temperature and salinity at various sites.

Ideally, such loggers should also be installed to monitor dissolved oxygen but the practicalities of collecting viable DO data are likely to mean that this could not be done outside of a controlled experimental arrangement that will ensure that the loggers are in the right place and correctly calibrated.

Finally, it is imperative that routine water quality data collection be resumed at all DWAF gauging weirs in the catchment. Specifically the following four stations:

- E1H013Q01 (Olifants River at Citrusdal).
- E1R001Q01 (Bulshoek Dam near wall).
- E1H007Q01 (Bulshoek Dam on Olifants River, left canal).
- E1H002Q01 (Doring River at Aspoort).

30.1.3 Geomorphology

Note: Pool sections to be more sensitive to change than the riffle sections. Pools are therefore likely to change more rapidly than riffles, so if necessary, focus monitoring on pools.

30.1.3.1 Short-term monitoring (every 2nd year)

- Update of the daily hydrological time series.
- Fixed-point photography.
- Interact with riparian vegetation specialist to assess the impacts of > bankfull flows.
- Any 10-year return period flood or greater, re-survey cross-section, re-rate the section, re-survey bed material distribution, fixed point photography, and if possible, do aerial photographic survey.

30.1.3.2 Long-term monitoring (every 5 to 10 years)

- Re-survey of fixed cross-sections.
- Analysis of aerial photographs (if available).
- Analyse satellite/digital photogrammetry if available.
- Re-survey of bed material distribution for original sections.

30.1.4 Riparian vegetation

Permanently marked plots should be established along the cross-sections at the relevant sites and density counts of shrubs within them should be done every second year.

- Vertical photographs should be taken of each marked plot. The photographs should be analysed for evidence of recruitment, changes in plant density, changes in species composition and plant development, with respect to the indicator plant species outlined in the Ecostatus table for each site.
- Lateral fixed-point photographs should be taken using a surveyor pole, and the height and composition of plants recorded.

In order to reduce time and financial costs, it is possible to restrict the transects to one side of the river, only.

30.1.5 Macroinvertebrates

Monitoring should take place twice a year, using the SASS method (Dickens and Graham 2002), in winter (between July and August) and summer (between mid-November and mid-December). Sampling should be undertaken separately in each of the following biotopes if they are present:

- Riffle.
- Run (may differentiate shallow, slow trickle run from deep/fast run).
- Stones out of current (slackwaters and backwaters).
- Emergent vegetation in current.
- Submerged vegetation.
- Vegetation out of current (usually emergent).
- Sand / gravel.

In addition, specimens of Trichoptera and Baetidae should be collected, preserved and identified in the laboratory. This additional requirement is to facilitate better understanding of possible shifts in ecosystem integrity as a result of a loss of species diversity.

30.1.6 Fish

The RQOs for the fish assemblages assume the application a range of gear types including: large fyke nets (40-m wing length) in mainstem pools, seine nets on sandy beaches if they are present (5 X 2 m). Electrofishing should be conducted in rocky riffles and runs. Relative abundances of target species and size classes will differ between gear types. Proportions should therefore be compared within catches of the same gear type.

Fyke nets are used to capture the larger adult cyprinids in order minimise damage and stress caused by the gill nets. The fyke is anchored in the water facing downstream by means of a line rigged from bank to bank and held afloat near the trap entrance by three buoys. The wings are held open by attaching a rope to the bank, and the centre wing (leader) was held in place by means of a weight. This net is set overnight for 15 hours (17h00 – 08h00) at each site and cleared in the morning.

Electrofishing is applied in shallow (<0.5 m) water. A portable backpack electrofisher should be used, powered by a 220 V generator.

30.2 WETLANDS

Monitor changes in landuse and extent at 2-year intervals using Google Earth.

30.3 GROUNDWATER

The monitoring methods outlined here are standard methods in groundwater studies.

30.3.1 Monitoring network

The RQOs that require monitoring at each priority site are listed in Table 8.6 and detailed in Sections 9 to 28. Where available, site specific information on position of the monitoring (existing and proposed) is provided for each site in Sections 9 to 28. A summary of required monitoring networks is provided in Table 30.1. It is envisaged that the water level and water quality monitoring networks are combined as far as possible to avoid unnecessary capital expenditure and monitoring costs.

30.3.2 Water use

As per the draft RQOs, all groundwater users within a specific RU must comply with the allocation schedule and individual licence conditions within the available yield. Hence, they have to record their groundwater abstraction on a regular basis, as stipulated in their individual licences. Depending upon the total volume, the frequency of readings should be daily or weekly. The data must be submitted to the DWA six-monthly.

30.3.3 Water level

Water level measurements are required for the regional monitoring network to identify regional trends and compliance, and for individual abstraction boreholes to verify compliance with licence conditions:

- Regional monitoring boreholes (see existing and proposed monitoring network) should be equipped with automatic water level sensors and data loggers, set for at least hourly readings. Downloading of these data loggers is required every 3 months. Manual water level measurements are required while downloading to calibrate and verify the logger data.
- Water level records from abstraction boreholes are required from users with at least daily readings; to be submitted to the DWA six-monthly together with the abstraction volume data.

Data analysis of these data is required six-monthly for

- Identifying trends of water level
- Identifying aquifer response to abstraction
- Identifying aquifer response to rainfall

Table 30.1 Existing and proposed monitoring networks for priority RUs

RU	Quaternary Catchment	Aquifer	Water abstraction		Water level		Water quality	
			Exist	Proposed	Exist	Proposed	Exist	Proposed
40	E10D	Alluvium	Unknown	X	-	New	-	New
		TMG	Unknown	X	-	New	1	New
33	E10E & E10F	Alluvium	Unknown	X	-	New	-	New
		TMG	Unknown	X	1	New	3	New
41	E21G	Bokkeveld	Unknown	X	-	New	-	New
		TMG	Unknown	X	-	New	-	New
	E33F	Gifberg	WUA	-	WUA	1	X	1
53	G30D	Sandveld	X	Extend	-	New	X	Extend
52	G30E	Sandveld	X	Extend	DWA	Extend	X	Extend
56	G30F	Sandveld	X	Extend	DWA	-	X	-
57	G30G	Sandveld	X	Extend	DWA	-	X	-

30.3.4 Water Quality

All monitoring and selected abstraction boreholes will need to be sampled quarterly in January, April, July and October each year in accordance with SANS ISO 5667, Part 11. Where possible, samples must be taken using a dedicated sampling pump or installed pumping equipment. Bailers are only to be used, if the borehole diameter is not sufficient for using a sampling pump. Field measurements of pH, EC and Temperature must be carried out during each sampling round.

The samples need to be analysed for

- Macro chemical analysis (Ca, Na, Mg, K, Alkalinity, Cl, SO_4, NO_2, NO_3, NH_4), quarterly
- Microbiological analysis (total coliforms, faecal coliforms, e coli), quarterly
- Micro and trace chemical analysis (Fe, Mn, trace metals, DOC, TOC), annually

Selected boreholes close to the sea or potential pollution sources should be equipped with an EC sensor and datalogger (combined with water level sensor above).

Part V: Confidence Assessment

31 CONFIDENCE ASSESSMENT

For the most part, confidence in the RQOs is directly related to the quality and quantity of data available for use in their determination. In the Olifants-Doorn WMA highlights that there are serious gaps with respect to useful data sets for river and estuary RQOs, while the information for the groundwater and wetland RQOs is even scarcer. Furthermore, the data that are available are spatially and temporally patchy and mostly old, particularly for non-hydrological RQOs in rivers and for groundwater and wetlands (e.g., data for Reserve determination studies, which are for 6 sites and were collected in 2004). This lack of reliable data impacts on the confidence in the RQO process at vitually ever level from the prioritisation of Resource Units, to the detail at which the RQOs can be presented. In some areas there are insufficient data to allow for the development of even low- RQOs.

The Classification and RQO projects in the Olifants / Doorn WMA are the first of their kind to be implemented in South Africa, and the Terms of Reference (and hence the proposal) for the RQO determination project assumed that the finalisation of the Classification Process would be concurrent with the start of the RQO project, so that the RQO project could link directly to the Classification Process' public participation activities, as well as have an opportunity to discuss the transfer of data between the two projects. It was also assumed that the basin configuration, Reserve allocations and other data provided by the Classification Process could be used without needing to do any significant re-working. However, the start of the RQO project was delayed and only commenced after the Classification Process had been completed, and the data required considerable checking and reworking. If anything, the data highlighted disparities in the scale between those required for determining the RQOs and those provided by past studies and monitoring activities in the WMA (see Sections 31.1.1, 31.1.2 and 31.1.3).

In general, therefore, the confidence in the RQO assessment is low. Additional explanations are provided below.

31.1.1 Rivers and estuaries

There were several issues related to the data available for the RQO project:

- The whole of the WMA, but particularly the Olifants-Doring catchment, suffers from a dearth of reliable hydrological and other biophysical data that can be used to determine of RQOs.
    - For the Olifants-Doring catchments:
        - there are only 10 functioning gauging wiers in a catchment of 46 625 km^2, and only two on the Olifants River itself (Table 31.1);
        - the Comprehensive Reserve determination study focused on only six river sites for the whole catchment;
        - the estuary Reserve determination was at an Intermediate level;
        - very few of the tributaries contributing to the incremental inflow of a quaternary are gauged, and as such it is difficult or impossible to disaggregate these flows into requiremets for individual tributaries.
    - For the Sandveld catchments:
        - there are only two functioning gauging wiers in Sandveld;
        - the river Reserve determinations were done at a Rapid 2 level;
        - none of the estuaries have a Reserve determination, although some data were available for water levels in Velorenvlei;

Table 31.1 DWA gauging Weirs in the Olifants-Doring catchment (from www.dwa.gov.za)

Station	Place	Catchment Area (km²)	Latitude	Longitude	Dates of record	Used for RQOs?	Reason
E1H001	Olifants River @ Langkloof	2659	32.0474	18.82328	1910-10-01 1937-09-30	NO	Record stops in 1937
E1H002	Tee River @ Thee Rivier	45	32.80014	19.0869	1938-02-01 1943-01-31	NO	Record stops in 1943
E1H003	Noordhoeks River @ Misgunst	68	32.72098	19.06606	1938-03-01 1943-02-28	NO	Record stops in 1943
E1H004	Boontjies River @ Allendale	61	32.63126	19.07023	1938-02-22 1943-01-31	NO	Record stops in 1943
E1H005	Olifants River @ Keerom	532	32.85292	19.08384	1938-01-01 1943-01-31	NO	Record stops in 1943
E1H006	Jan Dissels River @ Clanwilliam	160	32.21167	18.93667	1971-03-05 2013-02-27	Yes	Used
E1H009	Turbine-Outlet@(Right) @ Andriesgrond	n/a	32.18489	18.87439	1939-02-01 1991-10-01	NO	Record stops in 1939
E1H011	Olifants River @ Andriesgrond	2033	32.18489	18.87439	1935-05-29 1997-07-17	NO	Record stops in 1997
E1H012	Tributary Of@Noordhoeks River @ Misgunst	n/a	32.72098	19.06606	1938-07-06 1943-02-28	NO	Record stops in 1943
E1H013	Olifants River @ Citrusdal	880.8	32.59639	19.00833	1992-06-17 2012-11-13	Yes	Used
E1H015	Olifants River @ Rosendaal	n/a	33.12818	19.2344	1996-03-30 2002-08-19	NO	Record stops in 2002
E1H016	Olifants River @ Andriesgrond	n/a	32.18389	18.87389	2001-11-03 2013-02-27	Yes	Name change to E3H004
E1H018	Visgat @ Olifant river	n/a	33.08883	19.21878	2011-10-25 2013-02-27	Yes	Used
E2H001	Doring River @ Elands Drift	3774	32.54154	19.56858	1908-10-01 1924-03-31	NO	Record stops in 1924
E2H002	Doring River @ Elands Drift (Aspoort)	6903	32.50278	19.535	1923-03-12 2013-03-01	Yes	Used
E2H003	Doring River @ Melkboom	24044	31.8625	18.68639	1908-05-17 2013-02-28	Yes	Used
E2H004	Tankwa River @ Elandsvlei	6426	32.321	19.58691	1929-07-01 1948-04-30	NO	Record stops in 1948

Station	Place	Catchment Area (km²)	Latitude	Longitude	Dates of record	Used for RQOs?	Reason
E2H005	Little Brak River @ Schoor Kraal	85	31.93213	19.75776	1928-08-01 1947-01-31	NO	Record stops in 1931
E2H006	Kruis River @ De Kruis	40	33.14874	19.37301	1929-08-02 1982-01-31	NO	Record stops in 1982
E2H007	Leeu River @ Leeuw River	265	32.78028	19.28333	1930-04-01 2013-02-27	Yes	Used
E2H008	Riet River @ De Naauwte	1178	32.86097	19.51608	1935-02-01 1970-08-02	NO	Record stops in 1970
E2H010	Kruis River @ Ebenezer	76	33.11528	19.3925	1982-10-25 2013-02-27	NO	Not at node
E2H011	Doring River @ Melkboom	24044	31.86046	18.68689	1948-07-23 1957-10-10	NO	Record stops in 1957
E3H001	Troe-Troe River @ Farm 256	746	31.62583	18.69472	1982-01-26 2013-02-28	Yes	Used
E3H002	Hantams River @ Brakke Rivier	1731	31.25878	19.47056	1990-04-14 2013-02-28	Yes	Used
E3H004	OLIFANTS RIVER @ LUTZVILLE	n/a	31.565	18.32778	2002-11-01 2008-06-18	Yes	Used

- The synthesised hydrology used in the Classification Process difffered (in some cases considerably) from that used in the Reserve determination studies (c. 2004). Thus, the Reserve requirements needed to be recalculated. This entailed entering the information in the "IFREDIT" tool, and then using it in the "DESKTOP" model to create the .tab, .rul and .mrv files.
- The temporal scale (annual) of "Balance Sheet" tool used for Classification is too coarse to allow for consideration of seasonal variations in flows needed to meet Reserve allocations, particularly in the dry season, when pressures on the system are highest. Thus, the RQO projected needed to develop a monthly version of the "Balance sheet" tool.
- The monthly version of the "Balance Sheet" tool highlighted discrepancies between upstream and downstream sites that were not evident at an annual timestep, which meant that recommended catchment configuration from the Classification project had to be adjusted to take account of these, i.e., it needed to be "re-balanced".
- The Classification project incorporated the NFEPA information into the "Balance sheet" tool by, allocating an A/B category and 60% of the nMAR to each NFEPA. However, this approach considerably overestimated the volume of water that reaches the mainstem. This was because whole tributaries were designated NFEPAs although some of the lower sections run through intensely-cultivated farms, where the rivers are in poor condition. Realistically, the NFEPA designated reaches should stop short of the cultivated áreas, as it is unlikely and unrealistic that rivers through the farmlands will ever be returned to an A/B condition. It is equally unlikely that 60% of nMAR of these tributaries reaches the mainstem in the dry season or will do so in the near future. Thus, the RQO project had to adjust the boundaries of the NFEPAs where appropriate and recalculate the Reserve requirements for the lower portions of the NFEPA catchments.
    - Reserve data for the incremental inflows from tributaries were provided as lump sums of all tributaries in a quaternary catchment, even for areas (e.g., kouebkkeveld) where disaggregation data were available. Thus, the RQO project had to incorporate the available data, and adjust the "Balance Sheet" accordingly.
- The .tab and .rul files provided as part of Reserve determination studies and Classification do not provided information in a format that is easily monitored, even if there is a nearby gauging weir. Particularly since these were provided as MCM rather than m^3s^{-1}. Thus, the RQO project needed to determine the mean dry season requirements, and set lowest absolute limits for flow (under any conditions) in priority rivers. Similarly, flood requirements also needed to be provided for those areas where they were available.

31.1.2 Groundwater

The Groundwater Reserve requirements are usually determined at quaternary scale, with only few studies available that are more site specific. However, RQOs must be determined on a finer spatial and temporal scale otherwises they are meaningless for the water resource managers as they cannot be implemented or monitored. Several issues of scale were identified:

- Groundwater PS and RC are usually determined on quaternary catchment scale and are not aquifer specific. However, different RQOs must be determined per relevant aquifer depending upon their contribution to the environmental wáter requirements of the surface water bodies. Data is usually not sufficient to provide RQOs on a borehole specific basis.
- A variety of regional and local groundwater studies were undertaken in the WMA within the last decade. However, only few of these studies focused on or at least addressed the surface water – groundwater interaction on an aquifer specific scale that is fine enough to use the data and information for developing site-specific RQOs.

Furthermore, gazetting of the Recommended Categories from the Classification Process was deemed unrealistic as they would have significant detrimental impacts on the current and future allocation of groundwater resources. For instance:

- The Present Status (PS), as defined by the aquifer stress (i.e. ratio of abstraction over recharge) and reported in the Classification Report, was questionable for a number of catchments and needed adjustments; e.g.
    - PS of A in E10E, Citrusdal and the farmers in the valley utilize groundwater to augment the water supply for domestic and agricultural use;
    - PS of A in E33F, Vanrhynsdorp and the farmers in the catchment utilize groundwater to augment the water supply for domestic and agricultural use;
    - PS of A in F60B, Bitterfontein and Nuwerus are supplied from the Southern Namaqualand Government Regional Water Supply Scheme (GRWSS), situated at the watershed between F60B and E33D.
- The Recommended Category (RC) for most catchments requires a decrease in abstraction, as it constitutes an improvement from the Present Status; e.g. from a PS of B to a RC of A. This would require a curtailment of current allocation and abstraction with significant impacts on the agricultural sector and domestic supply.
- The water supply for a number of towns depends upon the abstraction of groundwater, which is not taken into account in the assignment of the RC; e.g.
    - Citrusdal is in E10E, RC of A;
    - Wupperthal is in E24A / E24B, RC of A;
    - Calvinia is in E40B, change from PS of C to RC of B;
    - Vanrhynsdorp is in E33F, RC of A;
    - Bitterfontein and Rietpoort are in F60B and C, RC of A;
    - Piketberg is in G30B, RC of A (WARMS: groundwater use of 6.2 million m^3/a).
- The potential of future groundwater development within the WMA, as outlined in several previous reports (e.g. Olifants River Basin Study, WODRIS, Clanwilliam Dam Raising Study, All Towns Reconciliation Strategy Study), was not taken into account in determining the RC. The gazetting of the proposed RCs would foreclose these identified options for groundwater development and negate the strategic intent by the Department of promoting groundwater as future water supply option; e.g.
    - The WODRIS identified several possible target areas for groundwater development for agricultural use in the lower Olifants River Valley, situated along the Olifants River (i.e. E10K and E33G, H), the lower Doring River (i.e. E24L and M) and the Sandlaagte (i.e. G30H);
    - The Clanwilliam Dam Raising Study identified a number of possible target areas for groundwater development of the TMG aquifers along the Olifants River Valley from above Citrusdal (i.e. E10D) to the confluence with the Doring River (i.e. E10K);
    - Groundwater development was identified as a possible future augmentation option for most towns in the WMA during the All Towns Reconciliation Strategy Study.

Based on the issues above, it was agreed that no groundwater RC be determined and no groundwater RC be included in the gazetting document. Hoiwever, Resource Quality Objectives are usually defined in relation to a Recommended Category and not a Present Status. As such, certain assumptions about a desirable or acceptable status for the relevant aquifers in relation to the receiving environment and other users were required to determine meaningful and implementable RQOs.

31.1.3 Wetlands

Apart from one or two exceptions, data for use in deriving RQOs for wetlands in the Olifants-Doorn WMA is almost non-existent. Where available it is often limited to lines drawn on a map. It was unrealistic to try to define RQOs for each NFEPA wetland (which together total c. 25 000 ha), and even more so to expect that these could be monitored and enforced. Hence, summary RQOs could only be provided for wetlands of very high importance, and for areas that had received particular attention, such as Velorenvlei.

31.1.4 Expectations of DWA Regional Office

During the discussions with officials from the DWA Regional Office on the draft RQOs it became clear that they require strategies or action plans for enforcement and monitoring of RQOs, rather than just the RQOs themselves. While it was agreed that provision and design of strategies or action plans did not form part of the ToR for this project, every effort was made, within the limitations of the data, to provide RQOs that could be implemented relatively easily, and that acknowledged the limitations of the catchment in terms of hydrological gauges.

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Appendix A. BASIC HYDROLOGICAL RQOS (ECOLOGICAL RESERVE REQUIREMENTS) FOR QUATERNARIES IN THE OLIFANTS-DOORN WMA

SEE SEPARATE DOCUMENT

Appendix B. GROUNDWATER RESERVE REQUIREMENTS FOR QUATERNARIES IN THE OLIFANTS-DOORN WMA

SEE SEPARATE DOCUMENT

Appendix C. **FINAL PRIORITISATION OF RESOURCE UNITS FOR THE DEVELOPMENT OF RQOS**

SEE SEPARATE DOCUMENT