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# Support to Phase 2 of the ORASECOM Basin-wide Integrated Water Resources Management Plan



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## LITERATURE SURVEY AND GAP ANALYSIS

WORKING PAPER

Assessment of Environmental  
Flow Requirements

Prepared by:



in association with



# SUPPORT TO PHASE 2 OF THE ORASECOM BASIN-WIDE INTEGRATED WATER RESOURCES MANAGEMENT PLAN

## WORK PACKAGE 5: ASSESSMENT OF ENVIRONMENTAL FLOW REQUIREMENTS

### LITERATURE SURVEY AND GAP ANALYSIS

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## **ACRONYMS, ABBREVIATIONS, TERMINOLOGY**

IFR	Instream flow requirements
EWR	Ecological water requirement
EFR	Environmental flow requirements
TOR	Terms of Reference
G&S	Goods and Services
LHWP	Lesotho Highlands Water Project
nMAR	Natural mean annual runoff
LHDA	Lesotho Highlands Development Authority
INR	Institute Natural Resources
DWA	Department of Water Affairs
DERM	Desktop Ecological Reserve model
ORETG	Orange River Environmental Task Group
LORMS	Lower Orange River Management Study
MAWF	Ministry of Agriculture, Water and Forestry

### **IFR, EWR, EFR, Ecological Reserve, Reserve:**

IFRs were used as the term for EFRs in South Africa since 1989. This was replaced during 2003 by the term EWRs for use in South Africa. EFRs are one of the terms used more generally internationally, and in this study, the term EFR will be used. The term IFR will only be used when it refers to IFR studies undertaken prior to the change to EWRs. EWRs will only be used in context of South Africa when reference is made to existing studies.

Ecological Reserve is the term used for the Ecological component of the Reserve as defined in the South African Water Act, 1998. The other component of the Reserve is the Basic Human Need Reserve. Reference to Ecological Reserves will only be made where it is directly applicable to Ecological Reserve studies in South Africa.

# 1 INTRODUCTION

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The TOR requested the following:

A review of previous environmental flow allocation studies in the Orange-Senqu River basin.

This task is covered by Task 2.2: Previous EFR studies: Analysis, gaps, pitfalls (inception report reference). The objective and approach was stated as the following:

*'All documents on previous EFR and G&S studies will be collated and gaps and problems determined. This has in effect been done with work undertaken by R Palmer and D Louw previously. The emphasis is on the Goods and Services which will not have been looked at in terms of EFR assessment. The work here will not include any review or evaluation of the Lesotho or Vaal EFR studies. Those results are and will be accepted as being current and undertaken at accepted methodologies.'*

The deliverable associated with this task is Deliverable 3: Available EFR studies: Evaluation and gap analysis.

This document provides an evaluation of readily available EFR studies undertaken.

According to the inception report, Lesotho and the Vaal River EFR studies will not be included. Some basic information will however be provided to put this in a catchment context. As the estuary does not form part of this study, the previous EFR studies on the estuary have not been included.

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## 2 LESOTHO

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### 2.1 COMPREHENSIVE AND INTERMEDIATE ASSESSMENTS

**Treaty 1986:** The Lesotho Highlands Water Project (LHWP) was established by Treaty between the Governments of Lesotho and South Africa in 1986. The Treaty specified compensation flows amounting to between 2 and 3% of the natural Mean Annual Runoff (nMAR). In order to protect the river until an IFR Policy was developed, Katse Dam and the Matsoku weir were being operated to release 750 litres per second (l/s) and 600 l/s, respectively. Other than control of releases, no downstream management or mitigation measures were undertaken, except for the regular monitoring of water quality in downstream rivers.

**Detailed Studies: 1997-2000:** Detailed assessments of the EWRs of the river reaches downstream of the LHWP structures were initiated in 1997 (LHDA Report 648). The studies addressed the Malibamats'o River downstream of Katse Dam, the Senqunyane River downstream of Mohale Dam, the Matsoku River downstream of the Matsoku Weir, and the Senqu River downstream of the Malibamats'o confluence. The studies were completed in 2000, and Final IFR Audit Report for Phase 1 Dams of the LHWP was undertaken in 2002 (LHDA 2003).

**Lesotho IFR Policy (LHDH 2002):** The Lesotho Highlands Development Authority (LHDA) revised the original Treaty stipulations, and modified its dam operating procedures to include recommended EWR releases. The revised programme was stipulated in an IFR Policy document (LHDH 2002). The purpose of the IFR Policy was *"...to provide for the management of flow releases for the maintenance of predetermined conditions for riverine ecosystems downstream of Phase 1 impoundments. It will also provide for the mitigation of, and compensation for, flow related impacts on resources, ecosystems and communities in downstream areas, and other secondary or indirect losses."*

**Lesotho IFR Policy Review (INR 2007):** A review of the Lesotho IFR Policy and its implementation was undertaken by the Institute of Natural Resources in 2007. The audit provides a detailed account of the virtues and limitations of the EWR Policy and its implementation, and recommended that the policy should be revised.

**Monitoring:** There have been several monitoring initiatives undertaken by Southern Waters since 2003 (Pemberton & Brown 2007). The most recent results are presented in a report by Pemberton and Brown (2007). The report commended LHDA's performance in managing releases, as bulk targets were met across the board. There were some differences between the actual flow regimes at the proximal IFR sites and those provided for in the IFR Policy, but these were considerably improved on from the previous period of review (2003-2005).

### 2.2 DESKTOP RESERVE STUDIES

The Desktop Ecological Reserve model (Hughes, DA and Hannart, P 2003) provides low confidence EFR estimates for every quaternary in the country including Lesotho. This information is therefore available, however it must be noted that it is low confidence and that there are constraints in using these results.

## **2.3 CONCLUSIONS**

Various analyses of these studies have been undertaken and are available in a range of LHDA reports. It must be noted that a detail Goods & Services (Ecosystem services) assessment formed part of this assessment

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### **3 VAAL RIVER EWR STUDIES**

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#### **3.1 COMPREHENSIVE AND INTERMEDIATE ASSESSMENTS**

The following consultants were appointed during 2007 to undertake a comprehensive EWR for the Vaal River catchment.

- Upper Vaal Comprehensive Reserve assessment: Water for Africa (now Rivers for Africa) and Koekemoer Aquatic Services.
- Middle and Lower Vaal Comprehensive Reserve assessment: Golder Associates Africa
- Comprehensive Reserve determination study for the integrated Vaal River System: Water quality component: Golder Associates Africa
- Water Resources Yield Modelling: WRP

This study is still ongoing and will be finalised during September 2010.

The methods followed were the most up to date methods for EFR assessments as prescribed by the Department of Water Affairs (DWA).

Various previous EFR studies following the Intermediate Ecological Reserve Methodology (referred to as Intermediate) were applied prior to 2007 and the results were either incorporated or refined within the comprehensive studies.

#### **3.2 RAPID III EFR STUDIES**

Various previous EFR studies following the Rapid Ecological Reserve Methodology Level III (referred to as Rapid III) were applied prior to 2007 and the results were either incorporated or refined within the comprehensive studies.

#### **3.3 DESKTOP RESERVE STUDIES**

The Desktop Ecological Reserve (DERM) model ((Hughes, DA and Hannart, P 2003) provides low confidence EFR estimates for every quaternary. This information is therefore available, however it must be noted that it is low confidence and that there are constraints in using these results. It must further be noted that the DERM is often applied in areas where it is not applicable in the licensing process. This has resulted in licenses being signed off based on Reserves that are irrelevant. The most obvious examples are where the DERM has been used in areas where the present flow regime exceeds the natural flow regime and where water quality issues dominate the situation.

#### **3.4 CONCLUSIONS**

The Vaal River Comprehensive EWR studies provide adequate EFR information to be used in the Orange River assessments.

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## **4 CALEDON RIVER AND TRIBUTARIES**

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### **4.1 RAPID III**

A Rapid III Level Reserve of the Caledon River was undertaken in 2003 by DWA. (Kotze and Niehaus 2003). Various EWR sites were selected in the Little Caledon, Grootspuit, Caledon, Meulspruit and the Leeuspruit (D21D, G, H; D22A, B, H; D23D). A subsequent evaluation of the water quality component of the Reserve of the Caledon River was undertaken by Boshoff (2007).

### **4.2 LIMITATIONS**

A Rapid III level study provides information which is normally at low to medium confidence, depending on the available information and quality of information generated. These Reserves were signed off by DWA, however no technical report to indicate how the EWRs were generated is available. The only documentation available are the specialist fish and invertebrate reports supplied by Kotze and Niehaus. The confidence in the DWA Resource Directed Measures database is evaluated as low.

### **4.3 CONCLUSIONS**

There are inherent limitations to a Rapid III study as it only addresses certain components of an EFR study, is done based on very limited information, and is often applied by inexperienced practitioners. Thus the perception has been created that the quicker the approach, the simpler the methods, when in reality it is the other way round.

The EFRs generated through these procedures will not be defensible because there are many problems regarding the application of the methods (opinion of Kotze) and because as the reports which could address many of these issues are not available.

Due to the importance of the Caledon system as a water resource for users, and the well-known biophysical problems associated with the river, a more detailed EFR assessment is required. Within this study, two sites will be selected in the main Caledon River and addressed at an Intermediate level in terms of EFRs. This will include the Goods & Services assessment.

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## **5 ORANGE RIVER (OUTSIDE OF LESOTHO)**

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No Comprehensive or Intermediate assessment as been undertaken for the Orange River. During 1990 and 1996 IFR determinations were undertaken amongst others. A summarised evaluation is provided below.

### **5.1 ORANGE RIVER ENVIRONMENTAL TASK GROUP 1990**

The first assessment of environmental flow requirements in the Orange River downstream of vanderkloof Dam was based on a workshop held at Golden Gate in August 1990 (ORETG 1990). The workshop recommended a minimum of 200 million m<sup>3</sup> per annum for environmental needs (ORETG 1990). The main limitations of this assessment (O'Keeffe undated) were that:

- No explicit link was made to natural flow patterns, so there was no reference against which change can be measured;
- No specific ecological objectives were set, so it was not clear if the aim of the recommended flow was to maintain the present ecological state or to improve conditions to resemble natural conditions;
- The ecological requirements were not defined separately from the requirements of other water users;
- No consideration was given to quantifying ecological goods and services or the extent to which local communities depend on a healthy river system;
- The recommended annual total of 200 million m<sup>3</sup> represents about 2% of the natural Mean Annual Runoff, which is a very low proportion compared to other studies on IFRs

### **5.2 ORANGE RIVER RE-PLANNING STUDY 1996**

The second assessment of environmental flow requirements in the Orange River downstream of vanderkloof Dam, and including the mouth, was based on a workshop held at Fish Hoek in April 1996 (Venter and Van Veelen 1996). The aim of the workshop was to refine the previous assessment of EWR, based on a future desired state of the river before 1984 (i.e. before the decline in water level started). The study recommended a minimum of 197 million m<sup>3</sup> per annum during drought years for the river and mouth, and a minimum of 294 million m<sup>3</sup> per annum during normal years (Venter and Van Veelen 1996). The main limitations of this assessment (Louw 2001) were as follows:

- The flows recommended have a small seasonal variation, mostly due to the lack of any medium to large floods recommended;
- The recommended flows have an incorrect seasonal variation because the process used to integrate the EWR of the river and the mouth was based on the highest requirement for each month, irrespective of the impact this had on the pattern of the recommended flow regime;
- The Present Ecological State of the river was not quantified;
- Hydraulic cross-sections were provided but it was noted in the documentation that in most cases this was of insufficient detail to be of use in assessing the IFR;
- Monthly hydrological data were available, but it is not clear how it was used to assist in setting the IFR;
- A geomorphologist was not included in the IFR team. This is a major short-coming of the

IFR assessment;

- No information was provided on the flow requirements of the indicator trees used, and vegetation zones were not marked on the hydraulic cross-sections;
- The recommended annual total represents about 2.27% of the natural Mean Annual Runoff, which is a very low proportion compared to other studies on EWRs.

Low (2001) recommended that the Desktop EFR results be used rather than the 1996 results which were obviously flawed. A detailed EFR study was also recommended.

### **5.3 LOWER ORANGE RIVER MANAGEMENT STUDY (LORMS) (BROWN 2004)**

The most recent assessment of EWRs in the lower Orange River was based on the Desktop Ecological Reserve Model, which provided results for two ecological categories (Category C and D).

The scenarios assessed were:

- 1) the current system with 2005 demands;
- 2) Vanderkloof Dam with lower level storage;
- 3) Vioolsdrift re-regulating dam and
- 4) large Vioolsdrift Dam.

The study included a reconnaissance assessment of the Present Ecological State of the river for various ecosystem components. The study concluded that the ecological conditions in the river are deteriorating rapidly, and that the most important aspects of the flow regime for maintaining or improving the current ecological condition are:

- 1) reinstating the winter low-flows (i.e. reducing current flows), and
- 2) providing a freshet in November.

The study recommended a flow of 1604 million m<sup>3</sup> per annum for a Category D river at Augrabies Falls (15% nMAR; 37% pMAR) (Brown 2004). The study noted that natural flows at Augrabies Falls are higher than at the mouth of the river because of high evaporation. The study recommended a comprehensive assessment of the EWR because of the following limitations of this study:

- The time taken for water to travel down the Orange River from vanderkloof Dam to Upington was not incorporated into the modelling results. The effect of these delays would be to retard the onset of seasons, and thus dampen seasonal variation in the lower Orange River.
- Flow data available for analysis were monthly data, so the number and frequency of flood events could not be determined;
- No hydraulic investigations were undertaken so volumetric considerations could not be linked to velocity, wetted area or depth in the river channel.
- The ecological assessments were based on available information and on observations made during a short field trip.

### **5.4 RAPID AND DESKTOP ASSESSMENTS**

No Rapid IIIs were undertaken in the Orange River. Various Rapid I and Rapid II Ecological Reserves were undertaken and signed off (RDM surface water database of December 2008) as well as various Desktop assessments.

Rapid I and II are inherently of low confidence as only the ecological state for which to run the Desktop Ecological Reserve Model to generate estimates of EFRs are checked (also using very rapid methods).

## **5.5 CONCLUSIONS**

As indicated by the Louw (2001) assessment, the 1996 IFR assessment are inadequate and cannot be implemented. Detailed EFR studies were recommended. The urgent need for detailed studies were further supported by a the largely desktop assessment undertaken for the LORMS (Brown, 2004).

No Goods and Services studies have been undertaken. There has been some socio-economic work undertaken that could address in general

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## **6 FISH, NOSSOB, MOLOPO SYSTEMS**

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### **6.1 FISH RIVER**

No assessments of EWRs in the Fish River have been undertaken. However, recent hydrological modelling assumed that the future ecological water requirements of the Orange River Mouth will be met entirely by releases from a proposed dam in the Orange River at Vioolsdrift, with no inputs from the Fish River (MAWF 2008). A discussion with Carole Roberts, Desert Research Foundation, highlighted that under the current development scenario, flows from the Fish River are essential for maintaining the ecological integrity of the lower Orange River and mouth. The contribution that the Fish River makes to flows in the lower Orange River and mouth has significant implications for the yield of the system.

Further dams are being planned in the Fish River and it is essential that the flow requirements are assessed.

### **6.2 NOSSOB AND MOLOPO SYSTEMS**

No EFRs have been undertaken in these systems. In the South African sections of these systems, no Ecological Reserves have been signed off.

### **6.3 CONCLUSIONS**

These rivers require assessment, especially from a Goods and Services viewpoint.

Some of the standard EFR methods might not be entirely applicable in the ephemeral sections of these rivers, neither in wetland areas. However, many of the tools are available to address the EFRs and can be applied or adjusted to be applicable for these situations.

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