water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Report Number: P WMA 04/B50/00/8310/11

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE OLIFANTS RIVER WATER SUPPLY SYSTEM

WP10197

Evaluation of Ecological Consequences of Various Scenarios

Original

FINAL REPORT

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE OLIFANTS RIVER WATER SUPPLY SYSTEM

WP10197

Evaluation of Ecological Consequences of Various Scenarios

Report no.: P WMA 04/B50/00/8310/11

Prepared by:

Rivers for Africa eFlows Consulting

Contact person:
WP Comrie
Aurecon Centre,
Lynnwood Bridge Office Park,
4 Daventry Str, Lynnwood Manor, 0081, South Africa

T: +27 12 427 2000
F: +27 86 764 3649
M: +27 82 808 0435
E: Werner.Comrie@aurecongroup.com

In association with:

ILISO Consulting (Pty) Ltd

MBB Consulting Services (Nelspruit) (Pty) Ltd

Rivers for Africa eFlows Consulting (Pty) Ltd

Chuma Development Consultants CC

IWR Water Resources (Pty) Ltd

PROJECT NAME	:	**DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE OLIFANTS RIVER WATER SUPPLY SYSTEM (WP 10197)**
REPORT TITLE	:	**EVALUATION OF ECOLOGICAL CONSEQUENCES OF VARIOUS SCENARIOS**
AUTHORS	:	Ms D Louw *(Rivers for Africa)*, Dr P Kotze *(Clean Stream Biological Services)*, J Mackenzie *(Mackenzie Ecological & Development Services)*, Dr A Deacon *(SANPARKS)*, Ms C Thirion *(RQS, DWA)*, SJL Mallory *(IWR Water Resources)*
REPORT STATUS	:	Final Report
REPORT NO.	:	P WMA 04/B50/00/8310/11
DATE	:	December 2011

Submitted by:

..... 28/3/2012

W.P. COMRIE (Date)
Water Unit Manager

..... 28-03-2012

J BEUMER (Date)
Study Leader

Approved for the Department of Water Affairs:

..... 29-03-2012

T NDITWANI (Date)
Chief Water Resource Planner: NWRP (North)

..... 29/3/2012

J.A. VAN ROOYEN (Date)
Director NWRP

LIST OF REPORTS

Title	Report Number
Inception Report	P WMA 04/B50/00/8310/1
Summary Report	P WMA 04/B50/00/8310/2
Extent of Invasive Alien Plants and Removal Options	P WMA 04/B50/00/8310/3
Future Water Reuse and other Marginal Water Use Possibilities	P WMA 04/B50/00/8310/4
Possible Water Conservation and Demand Management Measures	P WMA 04/B50/00/8310/5
Water Requirements and Water Resources	P WMA 04/B50/00/8310/6
Water Quality	P WMA 04/B50/00/8310/7
Preliminary Screening and Schemes to be investigated	P WMA 04/B50/00/8310/8
Management and Development Options Alternatives and Cost Estimates	P WMA 04/B50/00/8310/9
Groundwater Options	P WMA 04/B50/00/8310/10
Evaluation of Ecological Consequences of Various Scenarios	**P WMA 04/B50/00/8310/11**
Environmental Screening Report	P WMA 04/B50/00/8310/12
Preliminary Reconciliation Strategy	P WMA 04/B50/00/8310/13
Final Reconciliation Strategy	P WMA 04/B50/00/8310/14
Main Report with Executive Summaries of Reconciliation Strategies	P WMA 04/B50/00/8310/15
Yield Assessment of De Hoop and Flag Boshielo Dam	P WMA 04/B50/00/8310/16
Liability of the Responsible Authority for Changes in Yield Assessment	P WMA 04/B50/00/8310/17
EcoClassification of the 1999 Assessment at EWR Sites in the Olifants River (WMA4)	P WMA 04/B50/00/8310/18

Glossary of Terms

Development Options
A development option is a capital intensive intervention that will establish physical infrastructure which will have the ability to increase the water supply (e.g. a dam).

Reserve
The Reserve is that portion of the natural flow that has to be available in a river or stream in order to sustain the aquatic ecology, and also to provide for basic human needs, in order to comply with Sections 16, 17 and 18 of the National Water Act (NWA), Act 36 of 1998. The Reserve is not a steady flow, but is a variable flow that mimics natural variations in flows in the river. The quantity that is required takes into account "normal" conditions, as well as drought conditions.

Resource Classification
A process of determining the management class of resources by achieving a balance between the Reserve needs and the beneficial use of the resources.

List of Abbreviations & Acronyms

BBM	Building Block Methodology
DRIFT	Downstream response to imposed flow transformation
EC	Ecological Category
EIS	Ecological Importance and Sensitivity
EWR	Ecological Water Requirements (Ecological Component of the Reserve)
FRAI	Fish Response Assessment Index
FROC	Frequency of Occurrence
HFSR	Habitat Flow Stressor Response
IFR	In-stream Flow Requirements
KNP	Kruger National Park
million m^3	Million cubic meters
MIRAI	Macroinvertebrate Response Assessment Index
PES	Present Ecological State
REC	Recommended Ecological Category
ROD	Record of Decisions
VEGRAI	Vegetation Response Assessment Index
WRYM	Water Resource Yield Model

EXECUTIVE SUMMARY

INTRODUCTION

The objective of the study is to formulate a reconciliation strategy for the entire Olifants River system up to the year 2035. The specific task documented in this report is to determine the ecological consequences of various flow scenarios in terms of changes to the Ecological Category (EC).

APPROACH

The following step by step process was followed at each EWR site and for each scenario.

- *Using the flow duration graphs for the wettest and driest months, a preliminary screening was undertaken to determine whether the EWR would be met or not.*
- *If the EWRs were not met, the EcoStatus models were applied for the relevant components to determine whether or not the Present Ecological State (PES) for the component will change.*
- *These results were then used to determine the EcoStatus for the site and assess whether it has changed.*

Three scenarios were analysed as described below:

***Scenario 1a**: REC plus De Hoop Dam*
This Scenario assumed that the De Hoop Dam is in place and applied the REC Reserve flow requirements at all sites in the system as highest priority requirements. Releases are made from upstream dams to meet these REC EWR requirements. This results in higher river flows and reduced yield available for other use. In theory, this should always supply the Reserve. However; it can result in oversupply at some sites to meet the driver site (which in this case is the EWR 16/17 site).

***Scenario 1b**: PES plus De Hoop Dam*
This Scenario is similar to Scenario 1a but applied the PES EWR (Table 2.1) at all sites in the system being released from upstream dams as highest priority.

***Scenario 2**: Present day (Scenario 3) with De Hoop Dam and no Reserve apart from EWR 9 downstream of De Hoop Dam.*
This scenario, based on Scenario 3, includes the De Hoop Dam. This scenario gives an indication of how the De Hoop Dam is going to impact on the river state. Note that the assumption is made that EWR 9 (downstream of the De Hoop Dam) is going to be fully in accordance with the Record of Decision (RoD) relating to the environmental approval to construct the De Hoop Dam. The conclusion reached from the scenario is that all scenarios must allow at least for the Reserve at EWR 9 since this is stipulated in the RoD.

***Scenario 3:** Present day flows without De Hoop Dam and no Reserve.*
Scenario 3 was provided to the EWR team as the first 'best estimate' of present day flow. This was based on the existing models received from previous studies and updated with the latest water use estimates. The De Hoop Dam and all EWR requirements were also removed from the model. However, the EWR team identified several discrepancies with this model, one of which

is the large irrigation use along the middle Olifants which are modelled but apparently not currently in use. These are former homeland irrigation schemes which fell into disuse and might be reinstated in future. The other major point of debate was Court Order release from the Witbank and Middelburg dams. These court orders are built into the model but it seems (from observed flow) that they are no longer being applied. This scenario 3 was therefore NOT accepted as a good representation of the present day flow but nevertheless retained as a possible scenario.

RESULTS

Table 1: *Summary of ecological consequences to various flow scenarios and recommendations regarding an optimised scenario*

EWR Site	SC 3	SC1a	SC1b	SC 2	Present operation	Recommendations of Optimised Scenario	Conclusion
OL1	X	X	X	X	✓	Maintain present operation according to the revised more realistic hydrology	Take out of model
OL3	✓	✓	✓	✓	✓	Maintain present operation	Take out of model
OL4	X	✓	✓	X	X	Improve to B.	Include the B EWR in the model
OL5	✓	✓	✓	✓	with changes	As invertebrates have degraded and the fish is 1 % away from degradation, it would be necessary to at least never have zero flows from Loskop.	Remove EWR as demand but provide a minimum of 5 m^3/s when there would have been zero flows.
OL6						Address operation from dam	Take out of model at this stage.
OL8	X	✓	✓	X	✓	Maintain present day hydrology according to the revised hydrology	Take out of model. Note: any decrease in flow from current will drop the category at this site and very definitely US of the Mohlapitse.
OL12						Address operation from dam	This will probably not impact on yield, i.e. take out of model
OL13 & 15						See 16	As long as EWR 16's water is provided from upstream of the barrage (i.e. Blyde, Olifants and other tributaries), then 13 should be catered for.
OL16/17	X	✓	X	X	X	Provide REC (1999 C rule)	Include in model as driver site.

RECOMMENDATIONS

In summary, the optimised scenario should provide EWR within the model ONLY at the following EWR sites:

- *EWR O4 – the improved B EWR*
- *EWR OL5 – minimum of 0.5m^3/s should be released from the Loskop Dam*
- *EWR OL6 – adjust operation of the Mkhombo Dam.*
- *EWR OL8 – maintain the present day releases of 1,35 m^3/s from the Flag Boshielo Dam.*
- *EWR OL9 as stipulated in the environmental authorisation for the De Hoop Dam.*
- *EWR OL12 – adjust operation of the Blydepoort Dam.*
- *EWR OL16/17 – provide the REC, but use the C EWR rule which is an improvement on present day flows.*

The decision to only provide the 1999 C EWR at EWR 16/17 is risky as there is uncertainty whether this could achieve the B REC. It is emphasized that the EWR should be reviewed using current state of the art methods and that monitoring be implemented urgently.

Table of Contents

List of Tables

List of Figures

1. BACKGROUND AND INTRODUCTION

1.1 INTRODUCTION

The Olifants River Catchment is made up of portions of three provinces, namely, Limpopo, Mpumalanga and Gauteng. A portion of the Kruger National Park (KNP) also falls within the area. The catchment is currently one of South Africa's most stressed catchments as far as water quantity and quality is concerned.

The objective of the study is to formulate a reconciliation strategy for the entire Olifants River system up to the year 2035. The strategy should:

- Address growing water demands as well as serious water quality problems experienced in the catchment,
- Identify water resource management and development options;
- Recommend reconciliation interventions - both structural and administrative/ regulatory, and
- Ensure that the technical requirements in terms of the future resource classification regulations are followed when seeking the optimum reconciliation interventions.

The specific task documented in this report is to determine the ecological consequences of various flow scenarios in terms of changes to the Ecological Category (EC). For further background, refer to Report PWMA 04/B50/00/8310/18 (Eco Classification of the 1999 Assessment at EWR sites in the Olifants River (WMA4)), which describes the update of the Ecological Categories.

1.2 STUDY AREA AND LOCATIONS OF EWR SITES

The original (1999) study area consisted of the 18 Ecological Water Requirement (EWR) sites (Figure 1.1) in the following rivers:

- Olifants
- Wilge
- Steelpoort
- Blyde
- Selati

For the purposes of this study the following sites were excluded for the reasons given:

- EWR 2 (Olifants River): This site is situated upstream of Loskop Dam. Access to this site is currently not possible. .
- EWR 7 (Olifants River): This site was known as the Hijack Site due to security reasons, and as the site does not provide good indicators for EWR assessment, it was not assessed.
- EWR 10 (Steelpoort River): Due to time constraints this site was not visited, as EWR 9 (upstream of EWR 10) is the key site for this reach.

- The results were then summarised in a table.

This was followed by summarising all the results for all the EWR sites and by providing concluding remarks regarding the scenarios.

The table below presents the results of the 1999 Eco Classification Study, which was used as a point of departure for the investigation presented in this report.

Table 1.1: PES and REC* used for modelling

EWR site	1999 PES	1999 REC	2010 PES	2010 REC	Change	EWR rule
1	D	C	D	D	-	D
3	D	C	D	D	-	D
4	B	B	C	B	-	B
5	C	B	C	C	=	C
6	E	D	C/D	C/D	+	C
8	E	D	C/D	C/D	=	D
9	D	D	C/D	C/D	=	D
12	B	B	B/C	B	=	B
13	C	B	C	C	=	C
15	C	B	C	B	=	C
16/17	C	B	C	B	=	B

*The 1999 value refer to the original EC estimates and the 2010 ECs to the current revised data. The change values refer to whether a negative (minus), positive (plus) or no (equal) change has taken place since 1999. The last column is the recommended EWR results that should be included in the yield modelling.

2. SCENARIO DESCRIPTION

The initial flow scenarios as described below were evaluated to determine ecological consequences. Some scenarios were modified as the need arose. Such a scenario is then described as it was modified during the site evaluation.

NOTE: All floods have been removed from the EWR requirements in all the scenarios. This is not because the floods are not required, but because:

- the floods cannot be provided in a way that mimics the real situation within the model;
- flood requirements further downstream of a dam cannot be provided from the dam due to attenuation of flood peaks and the model would therefore be drawing volumes out of dams that are not serving the ecological purposes for which it was set. This is due to attenuation and the lack of a hydrodynamic routing model that could supply information on the additional water that must be released over and above flood requirements at a EWR site to address the impact of attenuation;
- the floods are provided on a monthly basis that do not provide any useful information to evaluate changes in the flooding regime on the EC.

Floods are assessed at sites close to dams (i.e. EWR 1, 3, 5, 12 and 9) by evaluating spill analysis. Gauged daily data where, available, can be used to determine whether the flooding requirements are being provided under the current state.

2.1 SCENARIO 1

Scenario 1a: REC plus De Hoop Dam
This Scenario assumed that the De Hoop Dam is in place and applied the REC Reserve flow requirements at all sites in the system as highest priority requirements. Releases are made from upstream dams to meet these REC EWR requirements (Table 1.1). This results in higher river flows and reduced yield available for other use. In theory, this should always supply the Reserve. However; it can result in oversupply at some sites to meet the driver site (which in this case is the EWR 16/17 site).

There are only three sites where the REC is different from the PES, i.e. EWR 4 (Wilge) and EWR 15 and EWR 16/17:

- EWR 4: This site is one of the few EWR sites which show signs of degradation. The recommendation is therefore to improve this site to the B EC that was observed during the 1999 study.
- EWR 15: This site was previously used as a checking site only and specific flow requirements and motivations for EWR 15 are not available. Therefore, EWR 15 was not included in the model as a demand but rather the flow at this site was evaluated to check that it met the EWR flow requirements for the REC Ecological Class.

3. EWR OL1: OLIFANTS RIVER LODGE

3.1 SUMMARY OF THE ECOCLASSIFICATION RESULTS

The 1999 EWRs were set for a C and a D EC. The C EWR was for the REC based on the HIGH EIS. As the EIS is now MODERATE, and the REC a D, it was recommended that the D EC EWR (1999) should be used for yield modelling purposes and planning. The 2010 results are illustrated in **Figure 3.2**.

3.2 EVALUATED SCENARIOS

Scenario 1a, 1b, 2 and 3 are very similar and evaluated as one scenario. There is a large difference in flows in the 95% to 100% assurance, but this was ignored as a modelling artefact. What came to light is that Scenario 3 which is supposed to represent present day flows as close as possible includes court order releases that are not applied in practice. The court order releases are the following:

- Flow releases from May to July of approximately 1.2 m^3/s.
- A flow release of 2.4 m^3/s in October.

To put the EcoClassification results in context, a more realistic present day flow was generated by removing the court orders in the WRYM (Water Resource Yield Model). A comparison is provided in **Figure 3.1** which represents the 60% discharge in m^3/s. The revised present day is seen to be the flow that is maintaining the PES.

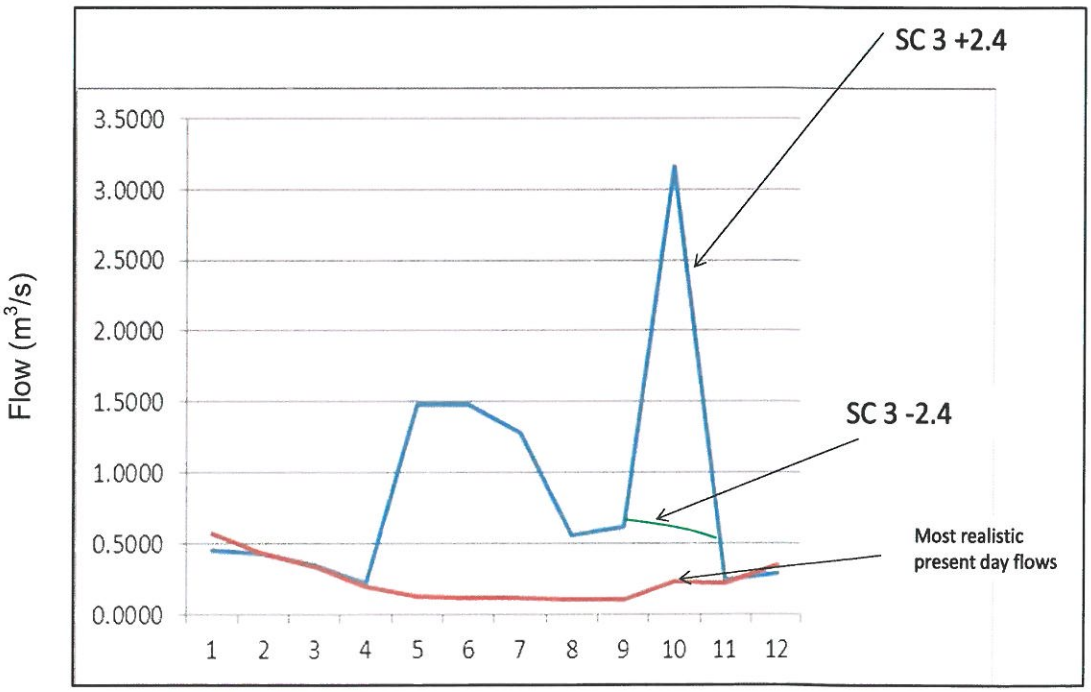


Figure 3.1: Comparison of discharge (m^3/a) at the 60% assurance at OL1 for October over 12 months (month 1 = January)

Response Components	2010 PES & REC	Change since 1999	Sc 3 +2.4	SC 3 -2.4	SC 1a & 1b	SC 2
FISH	D/E	-	E	D/E	E	E
MACRO INVERTS	D	-	E	E	E	E
INSTREAM	D	-	E	E	E	E
RIPARIAN VEGETATION	C	=	D	D	D	D
ECOSTATUS	D	-	D/E	D	D/E	D/E

EWR SITE	Sc 3	SC 1a	SC 1b	SC 2
EWR 1	X	X	X	X

REC & PES

All SC

E EC

Figure 3.2: Summary of biotic response results at OL1

4. EWR OL3: KLEIN OLIFANTS

4.1 SUMMARY OF THE ECOCLASSIFICATION RESULTS

The 1999 EWRs were set for a C and a D EC. The C EWR was used for the REC. As the Ecological Importance and Sensitivity (EIS) is MODERATE there is no motivation to improve the PES (which is a D) and therefore it is recommended that the D EC EWR (1999) is used for yield modelling purposes and planning. The 2010 results are illustrated in **Figure 4.1**.

4.2 EVALUATED SCENARIOS

All the results produce higher flows than the EWR requirements and there are no problems in terms of seasonality. The results therefore indicated that the PES/REC is being maintained and could improve under these scenarios. The results are summarised in **Figure 4.1**.

Response Components	2010 REC	Change	SC 3	SC 1a & 1b	SC 2
FISH	D	-	D	D	D
MACRO INVERTS	D	-	D	D	D
INSTREAM	D	-	D	D	D
RIP VEG	C/D	-	C/D	C/D	C/D
ECOSTATUS	D	-	D	D	D

REC, PES, All Sc

E EC

EWR SITE	Sc 3	SC 1a	SC 1b	SC 2
EWR 3	✓	✓	✓	✓

Figure 4.1: Summary of biotic response results at OL3

5. EWR OL4: WILGE RIVER

5.1 SUMMARY OF THE ECOCLASSIFICATION RESULTS

The 1999 EWRs were set for a B (PES) and a C EC. The current PES is a C and it was identified that this site has degraded from the B 1999 state. As the EIS is HIGH, the REC should be the B which is comparable to the 1999 PES. The 2010 results are illustrated in **Figure 5.1**.

5.2 EVALUATED SCENARIOS

Only the B EWR results from 1999 were available. Scenario 1a and 1b distinguish between the PES and the REC, but as the C results are not available, these two scenarios are treated as one. The B will therefore be achieved with Scenario 1.

Scenario 2 and 3 are the same and both reflect a realistic present flow regime. These scenarios representing present day flows are well below the 1999 B PES requirements. It was explained (S Mallory, (personal communication)) that during the last 10 years, flows would have decreased significantly due to a transfer from the system to other users. This, together with increased water quality problems from the mines, explained the ecological degradation since 1999. During the EcoClassification review, all the specialists acknowledged that something was amiss in the river, but as the habitat template was still intact, and there was at that stage no indication that flow has changed, it was difficult to assess the reasons for the change,

As the PES has now been set for the present day flow regime (C PES), the biotic response or consequences to Sc 2 and 3 which represents the present day flow regime is known. What is important in this case is that it is necessary to know whether the biotic responses have stabilised or whether it is still degrading. It is likely that the PES determined now was evaluated too conservatively as the reasons for the apparent degradation was not obvious at that stage. It was therefore decided to assess Sc 3 in the light of this new information and to determine what the EC would be if this current flow scenario continues.

Table 5.1: Biotic responses to the scenarios at OL4

BIOTIC RESPONSE COMPONENTS	PES	REC	SC 3	COMMENT ON TREND AND CHANGE IN EC
FISH	**C**	**B**	**D**	It is estimated that should the current flow scenario be maintained, the fish assemblage will gradually deteriorate over time to a lower EC (E: 54.45%). The continued low flows (especially during dry season), together with possible water quality deterioration associated with loss of dilution capacity will impact most of the fish species negatively.
INVERTS	**C/D**	**B/C**	**D**	It is likely that the invertebrates are already in a lower category than the C/D (MIRAI 58.2%) determined in 2010. At that stage there was no explanation for the low SASS scores obtained during the August 2010 survey. However the hydrology supplied during the April

6. EWR OL5: OLIFANTS RIVER DOWNSTREAM OF LOSKOP DAM

6.1 SUMMARY OF THE ECOCLASSIFICATION RESULTS

The 1999 EWRs were set for a B and a C EC. The B EWR was for the REC. As the EIS is now MODERATE, it is recommended that the C EC EWR (1999) be used for yield modelling purposes and planning. The 2010 results are illustrated in **Figure 6.1**.

6.2 EVALUATED SCENARIOS & RESULTS

Scenario 2 and 3 are the same and represent, according to available information, a realistic present day low regime. These flows therefore form the basis of the 2010 PES evaluation.

Scenario 1a and 1b are the same. The EWR (low flows) are supplied as first priority and is met. As the high flows are not included, it must be evaluated whether the flood requirements are being met through spills. The only way of assessing this was to evaluate the spill analysis against the monthly total volume of the high flow EWR requirement. The number of consecutive years of zero floods was first evaluated. Then, in the months where floods do occur, the volume of the spills compared to the volume of EWR floods required was compared. This is a low confidence way of analysing the floods, but it is the only option without a daily yield model.

The conclusions were that the current spill regime compared to the Sc 1 spill regime is similar. If this spill regime therefore continues, the PES should be maintained. The results are summarised in **Figure 6.1**.

Response Components	2010 PES & REC	CHANGE	SC 3 & 2	SC 1a & 1b
FISH	C/D	=	C/D	C/D
MACRO INVERTS	C/D	--	C/D	C/D
INSTREAM	C/D	-	C/D	C/D
RIP VEG	B/C	=	B/C	B/C
ECOSTATUS	C	-	C	C

PES Sc 2, 3, SC 1a&b

E EC

EWR SITE	Sc 3	SC 1a	SC 1b	SC 2
EWR 5	✓	✓	✓	✓

Figure 6.1: Summary of biotic response results at OL5

7. EWR OL6: ELANDS RIVER DOWNSTREAM OF MKHOMBO DAM

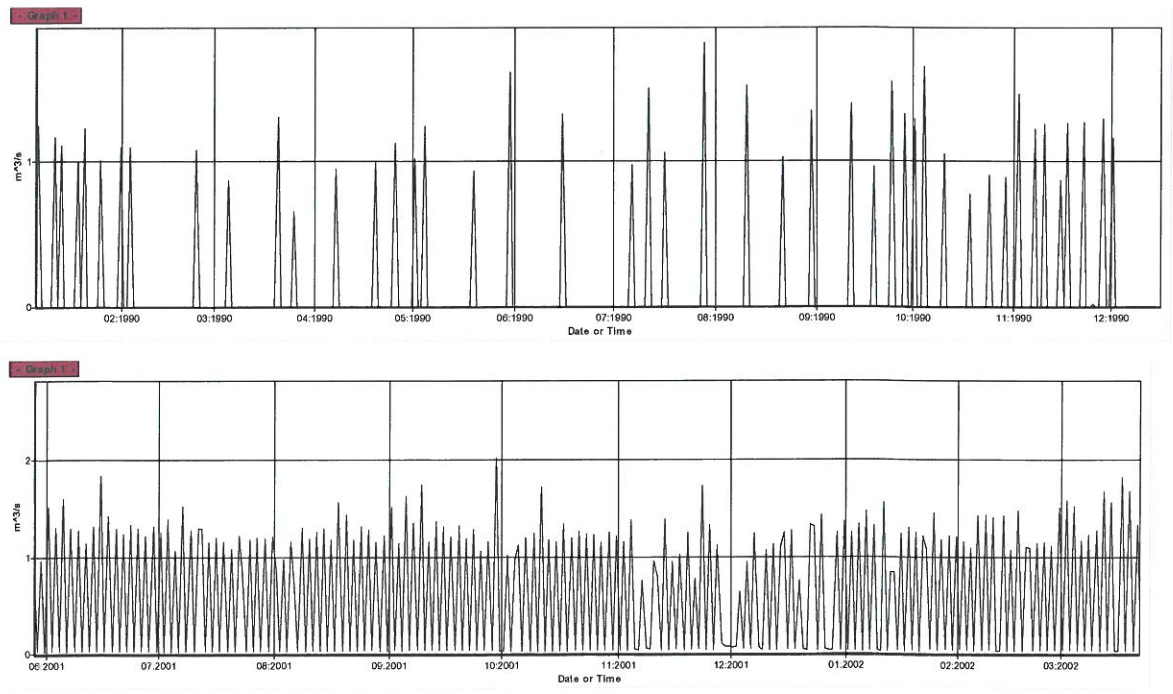
7.1 SUMMARY OF THE ECOCLASSIFICATION RESULTS

The 1999 EWRs were set for a D and a C EC. It was previously recommended that an EWR release from the dam is not realistic considering the current operation of the dam and the downstream demands. The EWR results were therefore not used in the yield analysis as, in this situation; modifications to the current operating rule could maintain and/or improve the PES. This would have a lesser impact on the users of the dam than an additional EWR release.

7.2 ECOLOGICAL SCENARIOS AND EVALUATION

The time series of releases were scrutinised to better understand the biological responses to these releases, especially as there has been a significant change in the operation since 1999. This site showed a slight improvement and it was previously recognised that this is probably due to a changed flow regime. According to the time series, it is clear that there has been three different ways of operation which is described below and illustrated in **Figure 7.1**.

- 1985 - 1996: Average of 4 releases per month between 1 and 2 m^3/s. After each release, the sluices were closed and it resulted in zero discharge at the EWR site
- 1998 - 2003: Much more frequent releases of about 15 a month.
- 2003 - current: On average two peaks a month and two drops to almost zero (30 litres a second) with a continuous flow on average of about 0.6 m^3/s.



8. EWR OL8: OLIFANTS RIVER DOWNSTREAM OF THE MOTHLAPITSE CONFLUENCE

8.1 SUMMARY OF THE ECOCLASSIFICATION RESULTS

The 1999 EWR was set for a D EC. As it is perceived that there has been no change in state since 1999, the EWR for the D EcoStatus would be applicable for the C/D (2010) EcoStatus.

8.2 EVALUATED SCENARIOS & RESULTS

Scenario 1a & b meet the EWR. Scenario 3 (representing the present day flow regime) was identified as unrealistically low. **Figure 8.1** illustrates this as the 60% discharge lies at 0.05 m^3/s which relates to an average depth of 7 cm. Under these conditions (maintenance flows), the fish and invertebrate biota would not have survived and the PES would not have been maintained since 1999. The following problems were identified in the WRYM:

- Locality of EWR 8 was wrong as it was upstream of the Mohlapitse confluence.
- Irrigated areas were too high. (Google Earth was scrutinised downstream of Flag Boshielo Dam and confirmed this).

With the above addressed, a more realistic present day flow regime was produced and compared to the Scenario 1 (which is similar to the EWR requirements) (**Figure 3.2**). As can be seen, these requirements are much closer to the EWR requirements which make logical sense since the 1999 objectives were to maintain the PES and the EWR should therefore be similar to the present day flow regime. The more realistic present day flow regime was produced by re-evaluating the irrigation demand. It would seem that the most of the irrigation schemes downstream of Flag Boshielo Dam are currently inactive (Google Earth evaluation). Once the irrigation was adjusted, the present day flow regime was much more realistic.

Table 8.1: Biotic responses to the Scenario 3

BIOTIC RESPONSE COMPONENTS	PES	SC 3	COMMENT ON TREND AND CHANGE IN EC
FISH	D	E	The ecological status of the fish will deteriorate significantly, falling in a category E (FRAI=27.7%). This is due to especially the poor conditions that will prevail during the dry season. Velocities and depth during this period will be inadequate to sustain many species. Various rheophilic species may disappear from the reach as a result of the loss in velocity and depth, as well as deterioration in quality and abundance of substrate as cover through increased siltation. There will also be a significant or even complete loss in vegetation, which will result in significant deterioration in the FROC of species with a requirement for vegetation as cover. The flows during the wet season are not adequate for maintenance of suitable and sufficient habitats, and deterioration in FROC of most species can be expected.
INVERTS	C/D	E	The prolonged extremely low flows are likely to have a very detrimental effect on the macro invertebrate assemblage. The flow in the river is reduced to a very small trickle of very slow shallow water. This is likely to result in very high temperatures and very low dissolved oxygen concentrations. The river is also likely to experience more sedimentation and a large reduction in marginal vegetation thereby virtually eliminating available habitat for macro invertebrates. Virtually all the flow and water quality sensitive invertebrates will disappear from the system. However because this site is downstream of the Mohlapitse River the invertebrates will probably be able to recolonise the site during wetter periods.
RIPARIAN VEG	C	D	Severe reduction in wet and dry season base flows together with marked increase in seasonality i.e. approaching a seasonal river at 60%: mortality of both non-woody vegetation (reeds and sedges) and woody shrubs and saplings in the marginal and lower zones likely, since substrate consists mainly of bedrock, boulder and cobble, survival not likely and encroachment also not likely. Associated cover of open cobble will increase.
ECOSTATUS	C/D	D/E	Unaccepted degradation of the river for all in-stream biota.

An additional scenario was evaluated (Scenario 4_EWR 8) which was only relevant for EWR 8. This scenario represents the decreased irrigation demand (as is currently the situation) as well as an increased demand for the water plant that supplies water to Lebowakgomo and Polokwane. This is necessary as a realistic future scenario which entails increasing the plant and supply the water from the new De Hoop Dam. A release of 18 million m^3 which represents a compensation release or an arbitrary Reserve release is also included in this. It was felt necessary to include this as it was a likely and realistic future scenario. The evaluation is provided in **Table 8.2**.

9. EWR OL9: STEELPOORT

This site is located a few kilometres downstream of the De Hoop Dam. . Since the Record of Decision to construct this dam allows for the provision of this EWR in full, all scenarios assumed that this Reserve will be met as stated in the Record of Decision. The Reserve at this site allows for an annual flood release of 15 m^3/s from the De Hoop Dam. It is noted that a EWR release rule still needs to be established. It is recommended that the RDM office be requested to develop the necessary operating rules and associated tools, to be in place before storage commences.

The only additional scenario considered at this site was the Present Day scenario in which the system was modelled without the De Hoop Dam and without EWR9. It was concluded that this had little impact on the flows in the Olifants River but under Present Day conditions EWR10 (located downstream of De Hoop Dam) cannot be met. Once the requirements at De Hoop Dam are complete and the flow requirements at EWR9 are fully met, the requirements at EWR10 will also be met under most flow conditions.

10. EWR OL12: BLYDE

10.1 RECOMMENDED ECOLOGICAL CATEGORY (REC)

The EIS at EWR OL12 is HIGH and the REC is therefore to improve the PES of a B/C EC to a B.

During 1999, the EIS was HIGH, but as the EcoStatus was a B, no improvement was recommended. It seems however that the B EC was not correct for fish and riparian vegetation and that improvement will be required. The fish improvement can be achieved by the similar volume of EWR set for the previous B EWR, as the present operation of consistent low flows and lack of flow variability seems to be the problem. The riparian vegetation improvement can be achieved by controlling alien vegetation and the release of sufficient small and moderate floods.

10.2 EVALUATION OF CURRENT BLYDEDAM OPERATION

The 1999 IFR study indicated that the fish assemblage was in B EC. During the 2010 EWR review, the use of new methods (FRAI model) not available during 1999 indicated that the fish assemblage is actually in a C EC. At the time of the review (2010) it was concluded that the differences in categories between the 1999 IFR study and 2010 EWR study were possibly related to a different methodology rather than a deterioration taking place in the fish assemblage between 1999 and 2010. The overall conclusion was therefore that conditions have not deteriorated.

Based on the evaluation of flow records, it is now evident that flow releases from the Blyde Dam changed in the period after 1999. These flows included significant spikes/flushes released for short periods, most probably for irrigation use as well as for water supply from the Phalaborwa Barrage. When comparing fish data between 1999 and 2010, some of the intolerant species were not found at the EWR site during the latter survey. Although the 2010 results was based on a single survey compared to various surveys conducted for the purpose of the 1999 IFR study, it may however indicate changes in the fish assemblage that have occurred between 1999 and 2010. Two species especially worth mentioning in this regard are *Barbus eutenia* and *Opsaridium peringueyi*. Although these fish species are still considered to be present in this section of the Blyde River, and interpreted as such in the 2010 study (category C evaluation), the absence of these species during the 2010 survey may be of concern. It is strongly recommended that their presence needs to be confirmed during a specialist investigation or implementation of a biomonitoring programme for this river reach.

The flow alterations that occurred since 1999 may possibly have resulted in a deterioration in the status of the in-stream biota in the Blyde River. The operation of the dam pre and post 2003 is illustrated in the time series in **Figure 10.1**.

It is recommended that the adjustment of the current operational rule be applied as this would likely have the least impact on yield and users of the system. The spiked releases are highly negative for the fish assemblage, as they alter habitats and may create false stimuli for migratory or breeding activity.

Monitoring is also essential to determine how the in-stream biota responds to the operation of the system. If monitoring results were now available, then there would have been high confidence in determining whether any changes have taken place and how the biota responded to the changed operation.

11. EWR OL17 & OL16: OLIFANTS AT BALULE

This assessment also addresses EWR 13 (EWR OL13: Olifants river between the Blyde and Selati rivers (Tulani) and EWR 15 (Mamba).

Note that EWR 16 and 17 are situated within a km from each other. The reason why two sites were selected was that the one site was more suitable for setting high flows and the other for low flows. In this assessment the two EWR sites are treated as one site.

11.1 CONCLUSIONS IN TERMS OF USE OF 1999 EWR RESULTS

The EWRs in 1999 were set for a C (PES) and a B (REC). As the PES of 1999 of a B REC is the same as the 2010 REC of a B EC, the EWRs set for the B (1999) must be used for yield modelling and planning.

Evaluation of the flow duration graphs showed that both the REC and the PES EWRs are significantly higher than present day flows (**Figure 11.1** (Red (REC), brown (PES) and light green (Revised present day hydrology)). The question that arises is why the flows representing the PES were set as significantly higher than the current flow regime. Maintaining the PES means that, unless the changes that have resulted in the PES is not flow related, the present day flows or less will maintain the PES. Of course, if a negative trend of the response (biota) components has been identified, this can also result in higher flows than the present day to maintain the PES. This was however not the case during the 1999 study.

The explanation lies in the process that was followed during the 1999 EWR. The Building Block Method (BBM) was followed and during this process, flows were set and motivated ONLY for the REC which results in flows obviously higher than the present day flow regime. The flows for the PES or lower category were then derived using the Desktop Reserve Model. The process of deriving these rules would have been to consider the changes made in the desktop reserve model from the desktop estimate for the B EC to create the 1999 B EWR rule. These same changes are then used to derive the C EWR rule from the desktop C estimate. The reference hydrology will be the natural hydrology and the present day hydrology would not have been considered. This is the reason why the 1999 PES resulted in higher flows than the present day hydrology. It must be noted that this gap in the methodology, i.e. the determination of flows for a range of ECs, was one of the key reasons why both DRIFT and HFSR were developed. It also again reiterates the crucial need for the revision of the Olifants EWR using the state of the art methods.

quality i.e. the sedimentation and filamentous algae on the rocks is improved, the invertebrates will not improve to a B or even a B/C category.

Elevated dry and wet season base flows facilitate expansion of marginal and lower zone non-woody species including reeds. Improvement is only on the marginal and lower zones and the riparian vegetation will therefore be maintained within the same category.

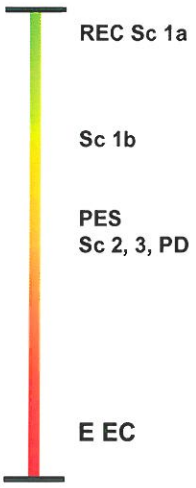
The conclusions are that the PES will improve within the C EC. This is largely due to the fact that all the EcoStatus models result in the biotic response components being at the lower end of the percentage range that represents a C EC. Insufficient information is available now to determine whether the PES flows can be lowered. But it is likely that the present flow regime will maintain the PES, albeit with a high risk of the river state decreasing into a C/D and even a D EC. The problems associated with this river are that flow increases have to be major to result in an improvement. This is due to the extreme sediment problems within the river as well as water quality. This therefore explains why the REC EWR is set so much higher than the present flow regime.

The above situation is mirrored at EWR 13 and 15.

11.3 EVALUATION OF SCENARIOS

The evaluation (**Figure 11.2**) shows that only Scenario 1a meets the REC. All the other scenarios will meet the PES, however it must be noted that this is a VERY low C and there is a high risk for all the scenarios apart from Scenario 1b that the river could end up in a C/D EC.

Driver Components	2010 PES	2010 REC	Change	SC 3 & 2	SC 1a	SC 1b	PD
FISH	C	B	=	C	B	C	C
MACRO INVERTEBRATES	C	B	=	C	B	C	C
INSTREAM	C	B	=	C	B	C	C
RIPARIAN VEGETATION	B/C	B	=	B/C	B	B/C	B/C
ECOSTATUS	C	B	=	C	B	C	C



EWR SITE	Sc 3	SC 1a	SC 1b	SC 2	PD
EWR 16,17	X	✓	X	X	X

Figure 11.2: Summary of biotic response results at OL16 and OL17

12. SUMMARY AND CONCLUSIONS

The Impact of the various scenarios on the Eco status of the sites that were analysed are summarised in **Table 12.1.**

Table 12.1: Summary of ecological consequences to various flow scenarios and recommendations regarding an optimised scenario

EWR Site	SC 3	SC1a	SC1b	SC 2	Present operation	Recommendations of Optimised Scenario	Conclusion
OL1	X	X	X	X	✓	Maintain present operation according to the revised more realistic hydrology	Take out of model
OL3	✓	✓	✓	✓	✓	Maintain present operation	Take out of model
OL4	X	✓	✓	X	X	Improve to B.	Include the B EWR in the model
OL5	✓	✓	✓	✓	with changes	As invertebrates have degraded and the fish is 1 % away from degradation, it would be necessary to at least never have zero flows from Loskop.	Remove EWR as demand but provide a minimum of .5 m^3/s when there would have been zero flows.
OL6						Address operation from dam	Take out of model at this stage.
OL8	X	✓	✓	X	✓	Maintain present day hydrology according to the revised hydrology	Take out of model. Note: any decrease in flow from current will drop the category at this site and very definitely US of the Mohlapitse.
OL12						Address operation from dam	This will probably not impact on yield, i.e. take out of model
OL13 & 15						See 16	As long as EWR 16's water is provided from upstream of the barrage (i.e. Blyde, Olifants and other tributaries), then 13 should be catered for.
OL16/ 17	X	✓	X	X	X	Provide REC (1999 C rule)	Include in model as driver site.

In conclusion, it is essential that the REC be provided at EWR 4 (Wilge River) and at EWR 16/17. Note that EWR 16/17 is the driver site and this will also result in the REC being met at EWR 15. These are the only sites that require changes to present operation of the system in terms of increased flow releases to achieve the ecological objectives. Recommendations to change the operation of the Blydepoort and Mkhombo Dam were also made as these could, with minimal impact on yield, achieve the ecological objectives. This is especially important for the Blyde River which has a HIGH EIS and its current state may possibly be degrading.