IMPLEMENTATION OF THE WATER RESOURCES CLASSIFICATION SYSTEM AND DETERMINATION OF THE RESOURCE QUALITY OBJECTIVES FOR SIGNIFICANT WATER RESOURCES IN THE LETABA CATCHMENT

PROJECT NUMBER: WP 10640

CONSEQUENCES AND MANAGEMENT CLASS: SUPPORTING INFORMATION ON ECOLOGICAL CONSEQUENCES OF OPERATIONAL SCENARIOS

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DEPARTMENT OF WATER AFFAIRS

CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

CLASSIFICATION OF WATER RESOURCES AND DETERMINATION OF THE RESOURCE QUALITY OBJECTIVES IN THE LETABA CATCHMENT

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DEPARTMENT OF WATER AFFAIRS
CHIEF DIRECTORATE: RESOURCE DIRECTED MEASURES

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Report Number: RDM/WMA02/00/CON/CLA/0114

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REPORT SCHEDULE

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ACRONYMS

CD: RDM	*Chief Directorate: Resource Directed Measures*
DWA	*Department of Water Affairs*
EC	*Ecological Category*
EWR	*Ecological Water Requirements*
FRAI	*Fish Response Assessment Index*
FROC	*Frequency of Occurrence*
GAI	*Geomorphological Driver Assessment Index*
MCB	*Macro Channel Bank*
MIRAI	*Macroinvertebrate Response Assessment Index*
MRU	*Management Resource Unit*
PAI	*Physico-chemical Driver Assessment Index*
PD	*Present Day*
PES	*Present Ecological State*
PSP	*Professional Service Provider*
REC	*Recommended Ecological Category*
RQOs	*Resource Quality Objectives*
Sc	*Scenario*
SIC	*Stones-in-current*
VEGRAI	*Riparian Vegetation Response Assessment Index*
WRCS	*Water Resources Classification System*

1 INTRODUCTION

1.1 BACKGROUND

The Chief Directorate: Resource Directed Measures (CD: RDM) of the Department of Water Affairs (DWA) initiated a study for the provision of professional services to undertake the implementation of the Water Resources Classification System (WRCS) and determination of the Resource Quality Objectives (RQOs) for significant water resources in the Letaba catchment. Rivers for Africa was appointed as the Professional Service Provider (PSP) to undertake this study.

1.2 STUDY AREA OVERVIEW

The study area is the catchment of the Letaba River and illustrated in Figure 1.1.

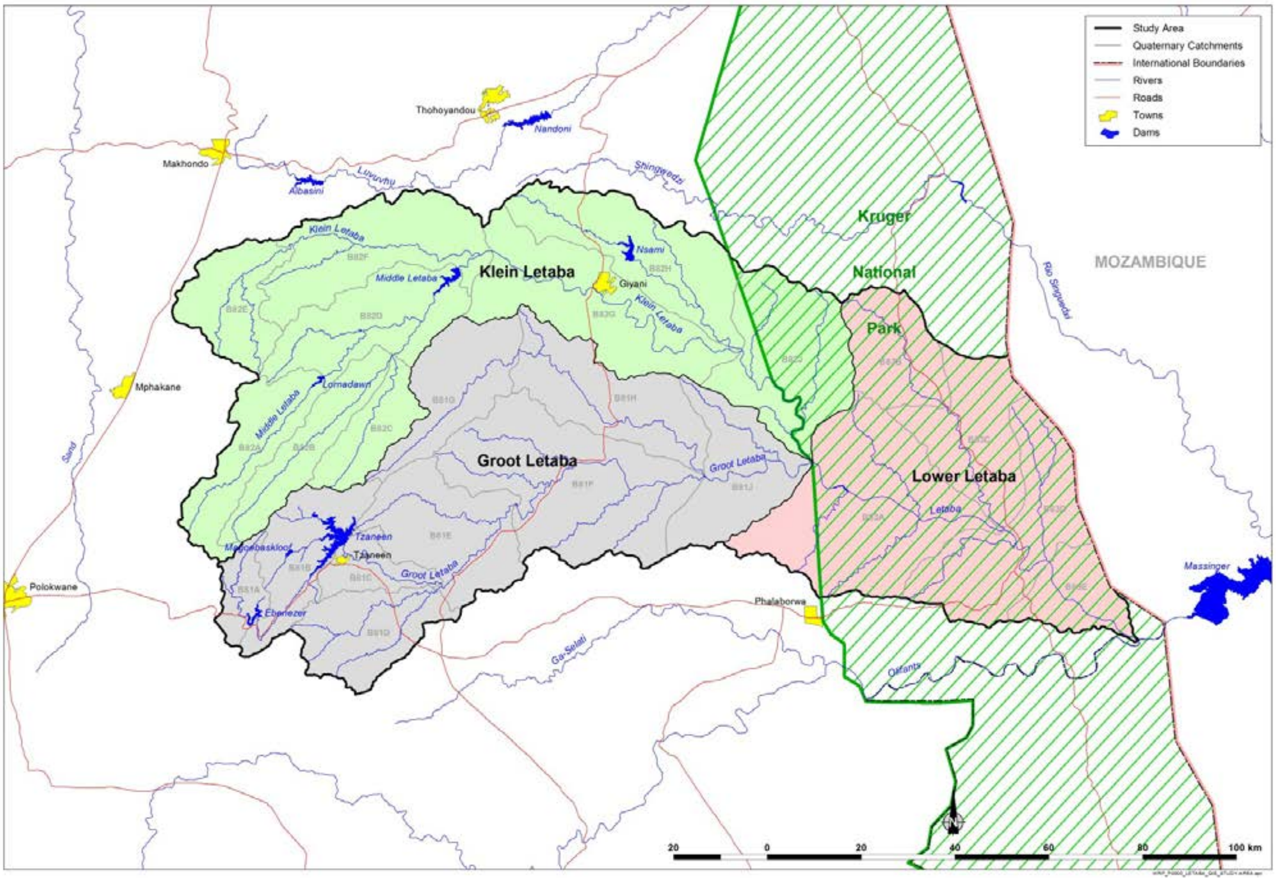

Figure 1.1 Study area: Letaba River Catchment

1.3 TASK D4: ID AND EVALUATION OF OPERATIONAL SCENARIOS TO IDENTIFY CONSEQUENCES

This task is associated with step 4 and 5 of the WRCS. In practice, these two steps function as one and are integrated as Task 4 (or step 4 within the integrated approach) (DWA, 2012). The objective of this task was to describe and document the following:

- *Identification of operating scenarios in accordance with the Reconciliation Strategy Study.*
- *River ecological consequences of the operational scenarios at the key biophysical nodes (Ecological Water Requirement (EWR) sites) by evaluating and determining the impact on the Ecological Category (EC).*
- *Economic consequences of operational scenarios by determining the impact of any water allocation changes.*
- *Assessment of the impacts of the various scenarios on Ecosystem Goods, Services and Attributes (EGSA) of operational scenarios to identify the direction of change (either positive or*

negative) and estimate the magnitude of the change in benefits and costs that may be experienced within the river system.

- *Water quality consequences (other than water quality consequences associated with the ecological component)*
- *Integrate the consequences to provide preliminary Management Class for stakeholder evaluation.*

1.4 PURPOSE OF THIS REPORT

The purpose of this report is to document the ecological consequences of various operational scenarios. This report provides supporting information to Report 4.1 where all the components addressed in Section 1.3 are summarised.

1.5 REPORT STRUCTURE

The report outline is provided below.

Chapter 1: Introduction
This Chapter provides general background to the project Task.

Chapter 2: Approach
This Chapter outlines the general approach to determining ecological consequences of operational scenarios

Chapter 3 – 8: Ecological Consequences
Detailed consequences of the operational scenarios on the various ecological components are provided.

Chapter 9: References

Appendix A: Report comments

2 APPROACH: DETERMINING THE ECOLOGICAL CONSEQUENCES OF OPERATIONAL SCENARIOS

2.1 AVAILABLE DATA

All information used during the revision of the 2006 EcoClassification and Ecological Water Requirement (EWR) scenario determination (DWA, 2013) was used as baseline for this assessment. The suite of EcoStatus models used during this task was:

- *Physico-chemical Driver Assessment Index (PAI): Kleynhans et al. (2005).*
- *Geomorphological Driver Assessment Index (GAI): Rountree and du Preez (in prep).*
- *Fish Response Assessment Index (FRAI): Kleynhans (2007).*
- *Macroinvertebrate Response Assessment Index (MIRAI): Thirion (2007).*
- *Riparian Vegetation Response Assessment Index (VEGRAI): Kleynhans et al. (2007).*

The results of the Present Ecological State (PES) revision are provided in Table 2.1.

Table 2.1 Summary of 2013 PES (Level IV) results

Component	EWR 1	EWR 3	EWR 4	EWR 7	EWR 2	EWR 5
Physico chemical	B	B/C	B/C	B	C	B/C
Geomorphology	C/D	D	C/D	C	D	C/D
Fish	C	C	C	C	C/D	C
Macro-invertebrates	C	C	C	C	C	C/D
Riparian vegetation	C	C/D	C	C	D	C
EcoStatus	C	C	C	C	D	C

2.2 PROCESS TO DETERMINE ECOLOGICAL CONSEQUENCES

The process is divided into chronological steps to determine the ecological consequences of the scenarios:

- *The operational scenarios were modelled and a time series was provided for each scenario at each EWR site.*
- *The time series was converted to a flow duration table and both was provided to the physico-chemical and geomorphology specialist.*
- *These specialists had to provide the consequences and resulting EC of the operational scenario at the EWR sites.*

Note: As only monthly modelling was available, the assessment of floods within scenarios will always be of low confidence

- *The riparian vegetation specialist then assessed the response on the marginal and other riparian zones and supplied this information to the instream biota specialists. This was done prior to the instream biota assessment as riparian vegetation is a driver in terms of important habitat for the instream biota.*
- *Where required, the riparian vegetation specialist ran the VEGRAI model to predict the EC for the operational scenario.*

This information formed the basis for the instream assessment to determine the responses to these driver changes for each scenario.

- *Each time series was converted into a stress duration table and provided on a graph for two months (the same months evaluated during the EWR scenario determination) that included the EWR scenarios, natural, and present day (PD) hydrology.*
- *The operational scenarios were then compared to the EWRs set for various ECs. For example, if the operational scenario lies between the B EC and C EC for fish for a flow in the dry season, the operational scenario could either be a B, a B/C or a C.*
- *The information on the driver responses were also used to interpret the response to the operational scenarios.*
- *If it was not obvious what the resulting EC was, the stress and habitat implications for the operational scenario were investigated and the responses modelled in the FRAI and MIRAI to determine the EC.*
- *The VEGRAI, MIRAI and FRAI results (EC percentages and confidence evaluation) was used to determine the EcoStatus.*

2.3 PROCESS TO DETERMINE THE RANKING OF SCENARIOS PER EWR SITE

Once the change in ecological state was determined for each of the scenarios at a site, the scenarios had to be ranked from better to worse. Note that at this stage the ranking was ONLY considering the change in ecological state. The ranking illustrated the degree to which a scenario meets the Recommended Ecological Category (REC) (or one can describe it as the degree to which the ecological objectives which is represented by the REC are met). The scoring of one to zero is defined as follows:

- *1: REC is met for all components[1].*
- *0: REC is not met at any component and each component would be evaluated individually as zero.*

The concept per component and overall is the same. The following illustration is for one component, i.e. fish. Therefore, if the REC for fish is 62% and the scenario results in the fish being at 62%, then the resulting score would be a 1 (or 100% successful in meeting the REC for fish). If the resulting scenario results in fish being at 48%, then the score would be 0.77 (or 77% successful in meeting the fish REC).

Each component score is then averaged to obtain an overall score for the scenario. Once all the scores for each scenario have been calculated, these can then be ranked and plotted on a traffic diagram illustrating the degree to which the EcoStatus is met.

2.4 EVALUATED SCENARIOS

The scenarios that were evaluated to assess ecological consequences are summarised in a matrix (Table 2.1). Detail regarding the scenarios and the yield modelling is supplied in Report 4.1.

For simplicity's sake, the scenarios below will be referred to by number and the letters will be left out. The numbering is an artefact of a larger set of scenarios developed for economic evaluation and determination of the impact on yield. Scenario 2 is only indicated in summary figures as it represents PD with a release of EWR, and this should equate to the PES or REC.

1 Components: Drivers (physico-chemical, geomorphology) and responses (fish, macro-invertebrates, and riparian vegetation).

Table 2.2 Scenarios for ecological consequences determination

Scenario	Groot Letaba Drivers								Middel Letaba Drivers			EWR Drivers						
	Restriction rule included	Raised Tzaneen Dam	Nwamitwa Dam	Letsitele River Dam	Mulele Dam GW[1] Recharge	Additional Allocation to Polokwane	Max GW use	Court order releases from Dap Naude	Crystalfontein Dam	Max GW use	Transfer from Nandoni Dam	KNP EWR of 0.6 m^3/s	EWR 1	EWR 2	EWR 3	EWR 4	EWR 5	EWR 7
1 (PES)	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*No*	*No*	*No*	*No*	*No*
2a	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Low*	*Low*	*Low PES*	*Low PES*	*Low*	*Low PES*
3a	*No*	*Yes*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*	*Yes*	*No*	*No*	*No*	*No*	*No*	*No*
4b	*No*	*Yes*	*Yes*	*No*	*No*	*Request*	*Yes*	*Yes*	*No*	*Yes*	*Yes*	*Yes*	*No*	*No*	*No*	*No*	*No*	*No*
5	*No*	*Yes*	*Yes*	*Yes*	*No*	*Request*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*No*	*No*	*No*	*No*	*No*
6	*No*	*Yes*	*Yes*	*Yes*	*No*	*Request*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*	*Low*	*Low*	*Low PES*	*Low PES*	*Low*	*Low PES*

Notes:	
1	*Ground Water*
Label	**Description**
Low	*Low flow requirements (PES and REC are the same).*
Total	*High and low flow requirements (PES and REC are the same).*
Low PES	*Low flow requirements for the PES scenario.*
Request and Yield	*Additional allocation to Polokwane: Request = Additional water requested, an increase from 16.2 MCM/annum current to 27 MCM/annum.* *Yield = Total yield available from Ebenezer Dam, 32 MCM/annum.*

3 ECOLOGICAL CONSEQUENCES AT EWR 1 (APPEL): GROOT LETABA

Scenario (Sc) 3, 5 and 6 were evaluated at EWR 1. Scenario 2 was not evaluated as it represents PD with a full EWR release, i.e. the consequences are known. The analysis of the operational scenarios indicated that Sc 4 was similar to Sc 5 and Sc 5 thus represents both scenarios.

3.1 CHANGES IN FLOW REGIME

A summary of the effects of the operational scenarios is provided below:

- *Sc 3: Relative the PD (spills from Ebenezer Dam occurring for 60% of the years); there will be a 3% increase in spill volumes and an increase in the frequency of spill years from 60% to 63%. In general low and high flows are similar to PD.*
- *Sc 5: Relative the PD, there will be a 20% reduction in spill volumes from Ebenezer Dam and a reduction in the frequency of spill years from 60% to 53%. Low flows maintain seasonality but are less than PD. In general high flows are similar to PD in the wet season and reduced in the dry season.*
- *Sc 6: Relative the PD, there will be a 23% reduction in spill volumes from Ebenezer Dam and a reduction in the frequency of spill years from 60% to 52%. In addition, with regard to large floods, this scenario proposes the largest reduction in flood spills. Wet season low flows are the same as Sc 5 but dry season low flows are better (less than PD).*

The driver components are summarised in Table 3.1 and the response components in Table 3.2. Summaries are provided in Table 3.3 and Figure 3.1.

3.2 EWR 1: ECOLOGICAL DRIVER COMPONENTS

Table 3.1 EWR 1: Consequences on the ECs of the driver components

Sc	EC	Consequences
Physico chemical: PES and REC B		
3	*B (84.8%).*	*Flows are similar to PD and the category is expected to remain a B EC.*
5	*B/C (77.8%)*	*Flows are lower under Sc 5 as compared to PD, particularly during low flows, with increases in nutrients and potentially a small increase in salts and toxics reducing the EC to a B/C.*
6	*B/C (76%)*	*Low flows are similar to Sc 5, with wet season flows being lower than PD and PES. This is expected to result in a drop in water quality category from a B at present state to a similar B/C category as Sc 5. Impacts are largely on salts and toxics, with slightly higher levels causing a category change.*
Geomorphology: PES and REC C/D		
3	*C/D (61%)*	*There is little perceptible difference in the baseflows or spills volume and frequencies relative to the Present Day, and thus no change from the PES is anticipated.*
5	*D (53.6%)*	*The consequent reduced floods will lead to further channel narrowing and less flushing of the channel bed.*
6	*D (53.6%)*	*Although the base flows EWR requirements will be provided, flood requirements (freshettes and other small intra-annual floods) are excluded in the provision of EWRs and the volume is inadequate to meet the wet season requirements. In addition, with regard to large floods, this scenario proposes the largest reduction in flood spills. This scenario is insufficient to meet the PES Reserve requirements due to insufficient wet season floods, as further channel narrowing and reduced flushing of the bed sediments will result.*

3.3 EWR 1: ECOLOGICAL RESPONSE COMPONENTS

Table 3.2 EWR 1: Consequences of the ECs on the response components

Sc	EC	Consequences
Fish: PES and REC C		
3	*C (62.3%)*	*Flows remain very similar to PD in both the wet and dry season. In some cases there may be a slight improvement (higher flows) than PD, but these changes are not significant enough to be able to change the PES notably.*
5	*C/D (58.2%)*	*It is estimated that the PES will decrease slightly towards a C/D due to decrease in fast habitats that will impact species such as Amphilius uranoscopus, Barbus eutaenia, Chiloglanis pretoriae and to a lesser degree decreased water quality and loss of undercut banks that may also impact slightly on some species.*
6	*C/D (60.6%)*	*Flows are slightly better than Sc 5 but still lower than PD. A slight increase is therefore expected in the PES of the fish (related to improved suitability and abundance of fast habitats). The PES will increase to a higher C/D but not reach a C EC (since the PES is on the borderline between a C and C/D EC and the flows under Sc 6 still remains below PES/PD conditions).*
Macro-invertebrates: PES and REC C		
3	*C (63.7%)*	*This scenario follows PD flows (wet and dry) and the influence of the small changes will not impact on the current PES of a C.*
5	*C/D (58.5%)*	*The lower flows, especially during the dry period, result in a decrease the fast-flowing habitats, thus impacting adversely on the rheophilic taxa. Fast flows over stones and rocks will be the habitats that are mostly impacted on. The decrease in flows also influences water quality adversely, increasing the stress on the macro-invertebrates. This leads to deterioration from a C to a C/D EC.*
6	*C/D (61.5%)*	*Flows are slightly better than Sc 5 but still lower than PD. The lower flows result in a decrease the fast-flowing habitats. The decrease in flows also influences water quality adversely, increasing the stress on the macro-invertebrates. The EC will deteriorate to a C/D.*
Riparian vegetation: PES and REC C		
3	*C (68.9%)*	*Because the flow regime is so similar to PD there is unlikely to be a notable response by vegetation and the EC improves slightly but remains in a C EC. This is due to slight reduction in non-woody vegetation in the marginal and lower zones.*
5	*C/D (61.9%)*	*Encroachment by marginal and lower zone vegetation likely to be exacerbated slightly. No response anticipated for upper zone vegetation.*
6	*C/D (61.9%)*	*Reduced wet season low flows also elicit an encroachment response in the marginal zone and the response to Sc 6 is similar to Sc 5.*

3.4 EWR 1: ECOSTATUS

The resulting ECs for each component and EcoStatus is provided in Table 3.3. The ranking of the scenarios are provided on a traffic diagram (Figure 3.1). The results illustrate that Sc 3 meets the PES and REC but Sc 4, 5 and 6 will fall below the PES/REC. In summary, the ecological objectives are unachievable under Sc 4, 5 and 6 due to the decreased flooding regime (i.e. decreased spills) as there is no impact on low flows and they are generally higher than the PD hydrology. Sc 6 is marginally better than Sc 4 and 5 due to a smaller impact on the fish and macro-invertebrate components.

Table 3.3 Ecological consequences at EWR 1

Component	PES/REC	Sc 3	Sc 4	Sc 5	Sc 6
Physico chemical	**B**	**B**	**B/C**	**B/C**	**B/C**
Geomorphology	**C/D**	**C/D**	**D**	**D**	**D**
Fish	**C**	**C**	**C/D**	**C/D**	**C/D**
Macro-invertebrates	**C**	**C**	**C/D**	**C/D**	**C/D**
Riparian vegetation	**C**	**C**	**C/D**	**C/D**	**C/D**
EcoStatus	**C**	**C**	**C/D**	**C/D**	**C/D**

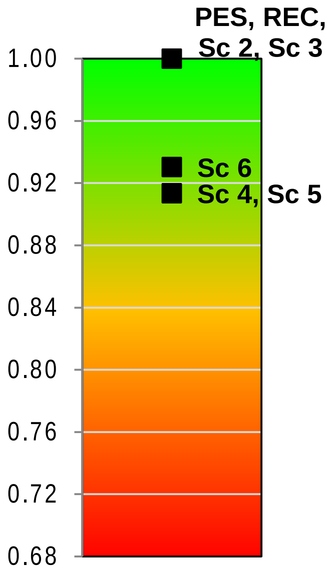

Figure 3.1 Ecological ranking of operational scenarios at EWR 1

4 ECOLOGICAL CONSEQUENCES AT EWR 3 (PRIESKA): GROOT LETABA

Scenario 3, 5 and 6 were evaluated at EWR 3. The analysis of the operational scenarios indicated that Sc 4 was similar to Sc 5 and thus represents both scenarios.

4.1 CHANGES IN FLOW REGIME

A summary of the effects of the operational scenarios is provided below:

- *Sc 3: Relative the PD, there will be a minor (4%) reduction in spill volumes from Ebenezer Dam and a small decrease in the frequency of spill years from 51% to 46%. Spills from Ebenezer Dam increase slightly in frequency but decrease more so from Tzaneen Dam. Low flows are similar to PD and generally higher than the environmental requirement in the dry season but less than the wet season requirement. In general this results in high flows similar to PD and more than the environmental requirement.*
- *Sc 5: Spills from Ebenezer and Tzaneen Dams decrease in frequency. There will be a 19% reduction in spill volumes from Ebenezer Dam and a reduction in the frequency of spill years from 51% to 37%. Baseflows are critically reduced; do not maintain seasonality; are less than PD and also much less than the environmental requirement in the wet season. In general high flows are similar to PD in the wet season and reduced in the dry season (flushing flows occur less frequently), but are more than the environmental requirement.*
- *Sc 6: Relative the PD, there will be a 27% reduction in spill volumes and a reduction in the frequency of spill years from 51% to 31%. Wet season base flows are better than Sc 5 but less than PD and the PES requirement while dry season base flows are much higher than PD and the PES requirement. However, this Sc proposes the largest reduction in flood spills and wet season flows are insufficient to meet even the intra-annual flood requirements. Dry season high flows are more than PD and more than the PES requirement. Wet season high flows are less than Sc 5, less than PD but more than the PES requirement.*

The driver components are summarised in Table 4.1 and the response components in Table 4.2. Summaries are provided in Table 4.3 and Figure 4.1.

4.2 EWR 3: ECOLOGICAL DRIVER COMPONENTS

Table 4.1 EWR 3: Consequences on the ECs of the driver components

Sc	EC	Consequences
Physico chemical: PES B/C; REC B		
3	B/C (81.8%)	*Flows are similar to Present Day and the EC is expected to remain a B/C.*
5	C (76.0%)	*Base flows are lower under Sc 5, with a reduction in spills and large floods (i.e. flushing flows) occurring less frequently. This is expected to result in an increase in nutrients and toxics, with a drop in category to a C EC.*
6	C (74.7%)	*The absence of flushing flows means nutrient and toxics build-up will not be flushed out of the system and water quality will deteriorate to a C EC.*
Geomorphology: PES D; REC C/D		
3	D (55.6%)	*There does not seem to be any difference in the baseflows and therefore there is no change in EC is expected.*
5	D (49.3%)	*The combination of reduced floods, causing less scour of fine bed sediments, and reduced wet season baseflows, which mean a smaller flowing channel, will result in a smaller channel of poorer instream habitat.*
6	D (49.3%)	*The combination of reduced floods, causing less scour of fine bed sediments, and reduced wet season baseflows, which mean a smaller flowing channel, will result in a smaller channel of poorer instream habitat.*

4.3 EWR 3: ECOLOGICAL RESPONSE COMPONENTS

Table 4.2 EWR 3: Consequences of the ECs on the response components

Sc	EC	Consequences
Fish: PES C; REC B/C		
3	*C (64.3%)*	*Flows remain very similar to PD and stress is mostly lower or set to maintain a C EC. In both the wet and dry season no change in PES is expected.*
5	*C/D (57.9%)*	*Reduced flows in the wet season will have a negative impact on especially the rheophilic (e.g. C. pretoriae, C. paratus and C. swierstrai)) and large semi-rheophilic species (Labeobarbus marequensis, Labeo cylindricus, and L. molybdinus) in terms of reduced fast habitats (especially important for spawning of species such as L. marequensis). The impact is aggravated by increased sedimentation due to reduced spills and floods, as well as water quality deterioration expected under this scenario. Possible deterioration in marginal habitat (overhanging vegetation and undercut banks) may also impact negatively on species such as Marcusenius macrolepidotus.*
6	*C (64.3%) or slightly lower*	*Flows are better than PD during the dry season and adequate to maintain required habitat diversity and especially fast habitats during the wet season. The lack of floods are however expected to reduce the substrate quality and suitability (sedimentation, algal growth) and therefore species with a preference for this habitat type will not improve in Frequency of Occurrence (FROC)/abundance, and may in fact undergo some deterioration. Water quality is also estimated to reduce slightly under this scenario. Non-flow related impacts (migration barriers and alien fish) also contribute to the PES, and will not be altered by this Sc, and furthermore supports the notion that the PES will most probably remain the same as PD (and potentially decrease slightly due to habitat deterioration associated with flood reduction).*
Macro-invertebrates: PES C; REC B/C		
3	*C (63.5%)*	*This scenario follows the present day flows (wet and dry) and the influence of the small changes will not impact on the current EC of a C.*
5	*C/D (60.7%)*	*The improved dry period flows will maintain a viable ecological condition for the macro-invertebrates, even though the water quality deteriorates to some extent. However, lower flows during the wet period will influence the very fast habitats, especially those with bedrock and boulders which will result in an EC of a C/D.*
6	*C (62.8%)*	*The improved dry period flows will maintain a viable ecological condition for the macro-invertebrates, even though the water quality deteriorates to some extent. The base flows during the wet period improve (i.e. PES), but there will be no flushing flows to remove sediment and stagnant pools. This will impact adversely on stones-in-current (SIC) habitats which will become silted up since the larger floods are not coming through to scour the riffles and rapids regularly.*
Riparian vegetation: PES C/D; REC C		
3	*C/D (59%)*	*The flow regime for Sc 3 is similar to PD and the requirement is generally met, but reduced base flows in the wet season will likely exacerbate the encroachment of marginal and lower zone vegetation. The EC deteriorates slightly but remains in a C/D.*
5	*D (56.9%)*	*Marginal and lower zone vegetation is likely to become water stressed and reduce in cover and abundance at its upper limits and encroach farther at its lower limits. Upper zone vegetation is likely to recruit less frequently as floods are reduced and these factors will lead to a deterioration in the PES.*
6	*C/D (58.1%)*	*Reduced wet season high and low flows will promote marginal zone vegetation encroachment, but not as much as under Sc 5. The PES will be maintained.*

4.4 EWR 3: ECOSTATUS

The resulting Ecological Categories for each component and EcoStatus is provided in Table 4.3. The ranking of the scenarios are provided in Figure 4.1. The results illustrate that none of the scenarios meet the REC or maintain the PES. Although Sc 3 is very similar to the PES, the reduced low flows during the wet season are the main reason for a deterioration in the EcoStatus. Sc 6 is a slight improvement from Sc 5 (and 4) due to improved base flows and better condition of the biota.

Table 4.3 Ecological consequences at EWR 3

Component	PES (2013)	REC (2013)	Sc 3	Sc 4	Sc 5	Sc 6
Physico chemical	B/C	B	B/C	C	C	C
Geomorphology	D	C/D	D	D	D	D
Fish	C	B/C	C	C/D	C/D	C
Macro-invertebrates	C	B/C	C	C/D	C/D	C
Riparian vegetation	C/D	C	C/D	D	D	C/D
EcoStatus	C	B/C	C/D	C/D	C/D	C/D

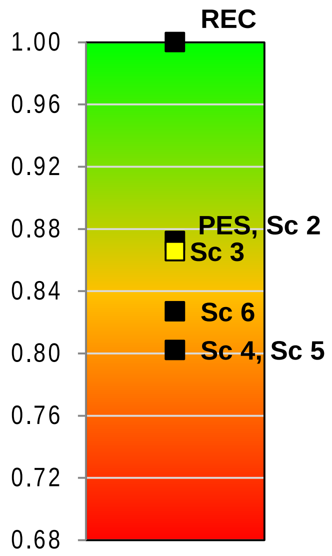

Figure 4.1 Ecological ranking of operational scenarios at EWR 3

5 ECOLOGICAL CONSEQUENCES AT EWR 4 (LETABA RANCH): GROOT LETABA

Scenario 3, 5 and 6 were evaluated at EWR 4. The analysis of the operational scenarios indicated that Sc 4 was similar to Sc 5 and thus represents both scenarios.

5.1 CHANGES IN FLOW REGIME

A summary of the effects of the operational scenarios is provided below:

- *Sc 3: Relative the PD, there will be a minor (4%) reduction in spill volumes from Tzaneen Dam and a small decrease in the frequency of spill years from 51% to 46% although in general high flows are similar to PD and more than the environmental requirement. Low flows are similar to PD and generally higher than the environmental requirement in the dry season but less than the wet season PES requirement.*
- *Sc 5: Relative the PD, there will be a 19% reduction in spill volumes from Tzaneen Dam and a reduction in the frequency of spill years from 51% to 37%. In general high flows are similar to PD in the wet season and higher than the PES requirement for most of the wet season (except November and December when flows are lower). Low flows do not maintain seasonality and are less than PD and are also much less than the environmental requirement especially in the wet season.*
- *Sc 6: Relative the PD, there will be a 27% reduction in spill volumes from Tzaneen Dam and a reduction in the frequency of spill years from 51% to 31%. Low flows are less than PD but better than Sc 5. During the dry season the high flows are higher than PD and Sc 5 and meet the PES requirement. Wet season high flows are less than PD and generally less than or the same as Sc 5.*

The driver components are summarised in Table 5.1 and the response components in Table 5.2. Summaries are provided in Table 5.3 and Figure 5.1.

5.2 EWR 4: ECOLOGICAL DRIVER COMPONENTS

Table 5.1 EWR 4: Consequences on the ECs of the driver components

Sc	EC	Consequences
Physico chemical: PES B/C; REC B		
3	*C (76.8%)*	*The EC is expected to drop slightly from the PD due to fewer high flows moving sediment and flushing nutrient build-up, i.e. a C category of a 76.8% and the REC of a B category will therefore not be met.*
5	*C (69.2%)*	*Reduction in frequency of floods and critical reduction in base flows will exacerbate conditions further as compared to Sc 3, with nutrient, clarity, temperature and oxygen conditions worsening under this scenario. The PES will therefore deteriorate and the REC will not be met.*
6	*B/C (78%)*	*The absence of flushing flows (i.e. fewer spills and freshets) in the wet season results in nutrient and sediment build-up not being moved and therefore Sc 6 lies under the PES requirement. The final assessment is that the water quality category will stay in a B/C, although it is expected to deteriorate within the category.*
Geomorphology: PES C/D; REC C		
3	*C/D (59.3%)*	*A reduction in the baseflows and curtailment of the wet season duration is expected to reduce small intra-annual floods, resulting in a small decline in instream condition due to reduced scour and sediment transport.*
5	*D (56.1%)*	*The baseflows are critically reduced and this will reduce the potential for sediment movement and scour, resulting in a decline of the physical habitat and change of the EC from a C/D to a D.*
6	*D (52.6%)*	*Only the baseflow EWR requirements are provided and the volumes are well below the Reserve requirements to allow for small floods. Additionally, with regard to large floods, this scenario proposes the largest reduction in flood spills and is insufficient to meet the PES requirements*

Sc	EC	Consequences
		during the wet season. The reduced scour of the channel, and reduction in sediment transport, will cause a reduction of inchannel habitat diversity and condition as the riffles become less common and more embedded.

5.3 EWR 4: ECOLOGICAL RESPONSE COMPONENTS

Table 5.2 EWR 4: Consequences of the ECs on the response components

Sc	EC	Consequences
Fish: PES C; REC B/C		
3	*C/D (60.5%)*	*Slight deterioration expected due to lower flows, especially impacting negatively on the fish assemblage in the wet season. Species with preference for fast habitats will be impacted by loss of fast habitats (L. marequensis, L. cylindricus, L. molybdinus), and species with preference for rapids will be impacted by reduced flow and increased sedimentation. A notable deterioration in marginal vegetation will also be expected which would reduce cover for species with a requirement for this habitat (Barbus spp. and cichlid species).*
5	*D (54.1%)*	*A decrease in abundance and quality of fast habitats, especially in the wet season, will result in decreased FROC of species such as L. marequensis, Labeo spp. and Chiloglanis spp. This will be aggravated by increased sedimentation related to reduced floods. A significant deterioration is expected in the marginal vegetation, which would be reflected by species with a preference for this habitat (Barbus spp. and cichlid species).*
6	*C/D (58.7%)*	*Flows are better than PD during the dry season and adequate to maintain some diversity during the wet season. The lack of floods are however expected to reduce the substrate quality and suitability (sedimentation, algal growth) and abundance of riffle/rapid habitats (due to sedimentation associated with lack of floods) while pools may be lost due to sedimentation. It can therefore be expected that especially fish species with a preference for rapid/riffle habitats as well as pools will be impacted negatively and the overall EC will deteriorate.*
Macro-invertebrates: PES C; REC B		
3	*C/D (60.2%)*	*Short periods of lowered flows are experienced in both the low flow and the high flow seasons, impacting on the very fast flowing, SIC habitat.*
5	*D (52.1%)*	*A shorter wet period with reduced flows and associated sediment build-up, will impact on the taxa particular to very fast flows, as well as taxa with a preference for bedrock and boulder habitats which will silt up as sediments will not be removed adequately. Lower base flows in the dry season will impact on rheophilic species and the deterioration in water quality will influence sensitive species. Deteriorating marginal vegetation and silting up of deeper habitats also impact the habitat integrity (overhanging vegetation and water column habitats).*
6	*C/D (58.1%)*	*The improved dry period flows will maintain a viable ecological condition for the macro-invertebrates, even though the water quality declines to some extent. The base flows during the wet period improve, but there will be even less flushing flows to remove sediment and stagnant water in pools. This will impact adversely on SIC habitats which will become silted up since the larger floods will not come through to scour the riffles and rapids regularly.*
Riparian vegetation: PES C; REC B/C		
3	*C (69.3%)*	*The flow regime is similar to PD and the requirement is generally met, but reduced base flows in the wet season and reduced floods (i.e. less scouring of marginal and lower zones) will likely exacerbate the encroachment of marginal and lower zone vegetation, especially non-woody vegetation. Reduced flooding is also likely to promote terrestrialization of the upper zone. The EC deteriorates within the C category.*
5	*C/D (58.9%)*	*Marginal and lower zone vegetation is likely to become water stressed and reduce in cover and abundance, especially at its upper limits. Encroachment is unlikely. Upper zone vegetation is likely to recruit less frequently as floods are reduced and terrestrialization is likely to increase.*
6	*C (62.5%)*	*Low flows are higher than PD and Sc 5 and meet the PES requirement. Reduced flooding and wet season high flow will promote marginal zone vegetation encroachment slightly.*

5.4 EWR 4: ECOSTATUS

The predicted Ecological Categories for each component and EcoStatus is provided in Table 5.3. The ranking of the scenarios are provided in Figure 5.1. The results illustrate that none of the scenarios meet the REC or maintain the PES. Although Sc 3 results in the same EcoStatus, only the vegetation EC is the same as the PES while the instream components are worse. Scenario 6 results in worse consequences than Sc 3 due to the reduction of baseflows with Sc 5 (and 4) being worse than Sc 6.

Table 5.3 Ecological consequences at EWR 4

Component	PES (2013)	REC (2013)	Sc 3	Sc 4	Sc 5	Sc 6
Physico chemical	B/C	B	C	C	C	B/C
Geomorphology	C/D	C	C/D	D	D	D
Fish	C	B/C	C/D	D	D	C/D
Macro-invertebrates	C	B	C/D	D	D	C/D
Riparian vegetation	C	B/C	C	C/D	C/D	C
EcoStatus	C	B/C	C	D	D	C/D

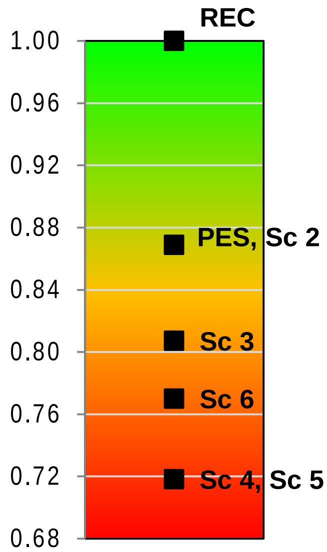

Figure 5.1 Ecological ranking of operational scenarios at EWR 4

6 ECOLOGICAL CONSEQUENCES AT EWR 7 (LETABA RANCH): GROOT LETABA

Scenario 3, 5 and 6 were evaluated at EWR 7. The analysis of the operational scenarios indicated that Sc 4 was similar to Sc 5 and thus represents both scenarios.

6.1 CHANGES IN FLOW REGIME

A summary of the effects of the operational scenarios is provided below:

- *Sc 3: Relative the PD, there will be almost no changes in the spill frequencies or volumes from either large (Tzaneen or Klein Letaba) dam. Low flows are similar to PD and generally lower than the PES requirement. In general high flows are similar to PD and more than the environmental requirement, except in December.*
- *Sc 5: Relative the PD, there will be no change in the spills from the Klein Letaba Dam, but a 19% reduction in spill volumes and a reduction in the frequency of spill years from 51% to 37% from the dams on the main Letaba. This should translate to reduced flood volumes and frequencies, especially given the additional attenuation of floods with the proposed Nwamitwa Dam. Low flows are less than PD and much less than the environmental requirement throughout the year. In general high flows are markedly less than PD in the wet season and higher than the PES requirement for most of the wet season (except December where flows are lower).*
- *Sc 6: Relative the PD, there will be no change in the spills from the Klein Letaba Dam, but a 27% reduction in spill volumes and a reduction in the frequency of spill years from 51% to 31% from the dams on the main Letaba. During the dry season, base flows are higher than PD and other scenarios while the wet season base flows are mostly less than PD but higher than Sc 5 and therefore PES requirements are not met. During high flows are the same as Sc 5 or less in places (less than PD). .*

The driver components are summarised in Table 6.1 and the response components in Table 6.2. Summaries are provided in Table 6.3 and Figure 6.1.

6.2 EWR 7: ECOLOGICAL DRIVER COMPONENTS

Table 6.1 EWR 7: Consequences on the ECs of the driver components

Sc	EC	Consequences
Physico chemical: PES B; REC B		
3	*C (76.2%)*	*The EC is expected to drop from PD due to lower and delayed high flows resulting in increased temperatures, elevated nutrients and salts and possibly some toxics due to upstream irrigation use.*
5	*C (69%)*	*The EC will deteriorate from PD to a C category due to a reduction in base flows, although conditions are better than at EWR 4 under this scenario due to the input of the Klein Letaba River. The reduction in base flows will therefore cause a slight increase in salt, nutrient and temperature levels, and a drop in dissolved oxygen.*
6	*C (72%)*	*The absence of flushing flows in the wet season means flows needed to move nutrient and sediment build-up is absent. Temperature and oxygen levels may also deteriorate. Scenario 6 therefore lies below the PES requirement and in a C category.*
Geomorphology: PES C; REC C		
3	*C/D (61.2%)*	*Baseflows reflect a shorter than required (in terms of Reserve flows for a C EC) wet season and, although ameliorated by inflows from the Klein Letaba, this will result in a slight decrease in the PES to a C/D EC because of the reduced duration of sand transport in the shortened wet season.*
5	*D (56.9%)*	*A reduction in some spills and severely reduced baseflows, with only a small, shortened wet season, will result in reduced bed mobility; channel size (reduction of instream channel habitat area) and flushing of fines. These impacts would cause the PES to decline to a D.*

Sc	EC	Consequences
6	*D (56.9%)*	*Only the baseflow EWR requirements are provided, but the volumes are well below the Reserve requirements to allow for small floods. Additionally, the large floods under this scenario propose the largest reduction in flood spills. The consequent reduced bed mobility; channel size (reduction of instream channel habitat area) and flushing of fines. These impacts would cause the PES to decline to a D.*

6.3 EWR 7: ECOLOGICAL RESPONSE COMPONENTS

Table 6.2 EWR 7: Consequences of the ECs on the response components

Sc	EC	Consequences
Fish: PES C; REC B		
3	*D (53.4%)*	*It is estimated that the fish will be reduced to a D EC. This is attributed to reduced fast habitats (especially in the wet season) impacting on species with a preference for this habitat type (L. marequensis, C. paratus, L. cylindricus, L. molybdinus). The delay in higher flows/floods during the wet season will also impact on spawning success and migratory activity of potadromous species (e.g. L. marequensis, Hydrocynus vittatus, Labeo spp.). A reduction in flow and decrease in floods may also reduce pool availability and condition, impacting on species with a preference for this habitat (Barbus spp., Brycinus imberi, Labeo rosae, Labeo ruddi, Schilbe intermedius, and Synodontis zambezensis). Decrease in condition and availability of marginal and instream vegetation will reduce cover for some species (Barbus spp. and cichlid species).*
5	*D (45.7%)*	*This scenario will have a similar but more severe impact than Sc 3. The wet season impact is especially more significant with even lower flows and more delayed floods. Vegetation as cover will be greatly reduced with an expected notable impact on various fish species. Water quality will also deteriorate and impact on the survival of some species (especially early life stages).*
6	*C/D (57.8%)*	*Although base flows will be suitable during wet and dry season, decrease in floods will result in loss of pools (sedimentation) and although riffle/rapid habitats are limited, the quality of these will also be reduced due to lack of flushing. The PES is therefore expected to be reduced.*
Macro-invertebrates: PES C; REC B		
3	*C/D (57.7%)*	*Lower dry and wet season flows will result in shorter duration of the higher flows and less small floods. This will impact on fast- and medium flow habitats, water quality (especially temperature), and vegetation due to water stress.*
5	*D (50.9%)*	*Compared to Sc 3 there are even lower dry and wet season flows and even shorter duration of the higher flows as well as much less small floods. This will result in a further deterioration of fast- and medium flow habitats, water quality as most parameters worsen, and loss in marginal cover due to water stress.*
6	*C/D (57.7%)*	*The improved dry period flows will maintain a viable ecological condition for the macro-invertebrates, even though the water quality declines to some extent. The base flows during the wet period improve, but there will be even less flushing flows to remove sediment and stagnant pools. This will impact adversely on SIC habitats which will become silted up since the larger floods are not coming through to scour the riffles and rapids regularly.*
Riparian vegetation: PES C; REC B		
3	*C (66.5%)*	*Terrestrialization in the upper zone will be promoted and reduced reed cover in the marginal and lower zones will occur. The EC deteriorates to 66.5% but remains a C category.*
5	*C/D (59.6%)*	*Marginal and lower zone vegetation is likely to become water stressed and reduce in cover and abundance, especially at its upper limits (reduced reed density). Encroachment is unlikely. Upper zone vegetation is likely to recruit less frequently as floods are reduced and terrestrialisation is likely to increase. The EC deteriorates to a C/D.*
6	*C (68%)*	*The PES requirement is met. Marginal zone vegetation is likely to encroach in summer due to reduced base flows and floods and survival probability is improved due to improved dry season base flows.*

6.4 EWR 7: ECOSTATUS

The results are summarised in Table 6.3 and Figure 6.1. The results illustrate that none of the scenarios meet the REC or the PES. Sc 3 and 6 impacts the instream biota due to reduced low flows as well as floods. Scenario 4 and 5 results in worse consequences due to the further reduction in low flows and floods.

Table 6.3 Ecological consequences at EWR 7

Component	PES (2013)	REC (2013)	Sc 3	Sc 4	Sc 5	Sc 6
Physico chemical	B	B	C	C	C	C
Geomorphology	C	C	C/D	D	D	D
Fish	C	B	D	D	D	C/D
Invertebrates	C	B	C/D	D	D	C/D
Riparian vegetation	C	B	C	C/D	C/D	C
EcoStatus	C	B	C/D	D	D	C

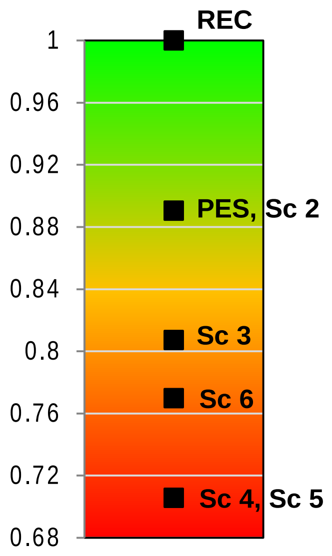

Figure 6.1 Ecological ranking of operational scenarios at EWR 7

7 ECOLOGICAL CONSEQUENCES AT EWR 2 (LETSITELE): LETSITELE RIVER

Scenario 4, 5 and 6 were evaluated at EWR 2. The analysis of the operational scenarios indicated that Sc 3 did not influence this site as flows were similar to PD and thus the consequences were not assessed.

7.1 CHANGES IN FLOW REGIME

A summary of the effects of the operational scenarios is provided below:

- *Sc 4: Dry season base flow is better than the PES requirement, but high flows are less. Wet season high flows are the same as PD, and more than the environmental requirement. Overall the flows are similar to PD.*
- *Sc 5: Includes a proposed dam (Letsitele River Valley Dam) upstream of EWR 2. This is expected to reduce flows especially in the wet season as well as the provision of floods during the wet season.*
- *Sc 6: Includes a proposed dam (Letsitele River Valley Dam) upstream of EWR 2, but baseflow EWRs will be provided. The volumes of flow are sufficient to meet the small (intra-annual) flood requirements, but the provision of large floods can be expected to decline (large floods are not included in the EWRs).*

The driver components are summarised in Table 7.1 and the response components in Table 7.2. Summaries are provided in Table 7.3 and Figure 7.1.

7.2 EWR 2: ECOLOGICAL DRIVER COMPONENTS

Table 7.1 EWR 2: Consequences on the ECs of the driver components

Sc	EC	Consequences
Physico chemical: PES and REC C		
4 *5*	*C* *(67.4%)*	*Some impact is seen for both Sc 4 and 5, particularly for high flows, with a flatter and shorter high flow season. However, the impact is not very high, probably due to the position of the site in the catchment. Flood requirements are small for this system. The only impact upstream of the site is the potential Letsitele River Valley Dam, although little information exists for the dam. It is possible that this dam may improve the water quality state, depending on operational rules and its position in the catchment. It is therefore assumed that the category will mostly stay the same under these scenarios, i.e. 67.4%.*
6	*C* *(67.4)*	*The absence of flushing flows in the wet season means flows needed to move nutrient and sediment build-up is absent. Temperature and oxygen levels may also deteriorate. Scenario 6 therefore lies below the PES requirement and in a C category.*
Geomorphology: PES and REC D		
4	*D* *(53%)*	*Sc 4b is similar to present day and therefore no change to the EC is expected.*
5	*D* *(44.4%)*	*This is expected to reduce flows and the provision of floods, and although this may degrade the site through further channel size and scour reductions, the decline in PES will be within the category for geomorphology.*
6	*D* *(44.4%)*	*The volumes of flow are sufficient to meet the small (intra-annual) flood requirements, but the provision of large floods can be expected to decline (large floods are not included in the EWRs). Although this may degrade the site through reduced flood scour, the decline in PES will be within the category for geomorphology.*

7.3 EWR 2: ECOLOGICAL RESPONSE COMPONENTS

Table 7.2 EWR 2: Consequences of the ECs on the response components

Sc	EC	Consequences
Fish: PES and REC C/D		
4	*C (61.2%)*	*Very similar to PD, no change in PES expected.*
5	*C/D (58.36%)*	*Condition remain similar or better during the dry season but a deterioration in the wet season is expected to impact the fish overall negatively. The reduced flows in the wet season will reduce abundance and suitability of fast habitats and impact on species with a preference for this habitat feature (also spawning success of some species may be negatively impacted). No notable change in marginal vegetation is expected.*
6	*C/D (58.36%)*	*Flows are very similar than Sc 5 for all flow durations, with the stress graph indicating slight improvement around the 50% flow duration. Overall the conditions are however not expected to change notably and a PES similar to that under Sc 5 can be expected.*
Macro-invertebrates: PES and REC C		
4	*C (63.8%)*	*Both the dry and wet season flows are similar to present flow, and thus acceptable, remaining in a EC of a C.*
5 6	*D (56.2%)*	*The dry season flows are acceptable, but the wet flows are lower and there will be fewer floods. The marginal vegetation will remain as good habitat, but the fewer high flows and the deteriorated water quality results result in a lower EC of a D.*
Riparian vegetation: PES C; REC D		
4	*D (46.9%)*	*No response by riparian vegetation is expected.*
5 6	*D/E (41.9%)*	*Encroachment by the marginal and lower zone vegetation is likely to be exacerbated because growth (and expansion) occurs in the wet season when base flows are often lower. No change to upper zone is expected.*

7.4 EWR 2: ECOSTATUS

The results are summarised in Table 7.3 and Figure 7.1. The ecological objectives are met under Sc 4 (and Sc 3) and therefore the PES/REC is maintained. Under Sc 5 and 6 the ecological objectives are not met due to reduced baseflows and floods and the resulting impact on the instream biota and riparian vegetation. Riparian vegetation will degrade to a D/E which is unsustainable.

Table 7.3 Ecological consequences at EWR 2

Component	PES/REC (2013)	Sc 4	Sc 5	Sc 6
Physico chemical	C	C	C	C
Geomorphology	D	D	D	D
Fish	C/D	C	C/D	C/D
Macro-invertebrates	C	C	D	D
Riparian vegetation	D	D	D/E	D/E
EcoStatus	D	D	D	D

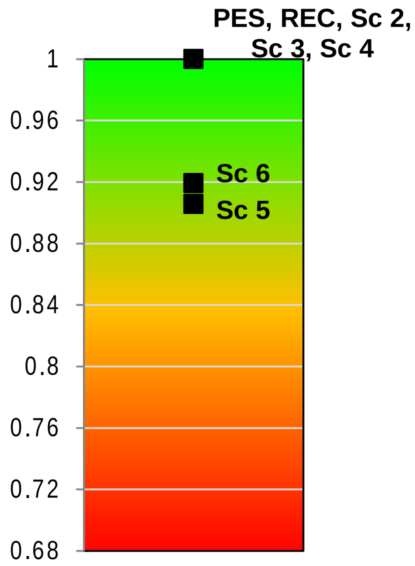

Figure 7.1 Ecological ranking of operational scenarios at EWR 2

8 ECOLOGICAL CONSEQUENCES AT EWR 5 (KLEIN LETABA): KLEIN LETABA RIVER

Scenario 3, 4, 5 and 6 were evaluated at EWR 5.

8.1 CHANGES IN FLOW REGIME

A summary of the effects of the operational scenarios is provided below:

- *Sc 3: Low flows are the same as PD. Dry season high flows are the same as PD, but less than the PES requirement. Wet season high flows are the same as PD and mostly higher than the PES requirement, except for December.*
- *Sc 4: No significant change in the spills from the Klein Letaba Dam will occur, but baseflows will be severely reduced. Low flows are less than PD especially in the wet season and wet and dry season high flows are similar to Sc 3.*
- *Sc 5: No significant change in the spills from the Klein Letaba Dam will occur, but baseflows will be severely reduced especially in the wet season while seasonality is lost in the dry season. Dry season high flows are less than PD and less than the PES requirement while wet season high flows are similar to PD.*
- *Sc 6: No significant change in the spills from the Klein Letaba Dam will occur. Base flows are much less than PD but more than Sc 5, but the volumes are well below the Reserve requirements to incorporate small floods during the wet season. Dry season high flows and base flows are higher than PD and all other scenarios and meet the PES requirement while wet season high flows are similar or slightly less than Sc 5.*

The driver components are summarised in Table 8.1 and the response components in Table 8.2. Summaries are provided in Table 8.3 and Figure 8.1.

8.2 EWR 5: ECOLOGICAL DRIVER COMPONENTS

Table 8.1 EWR 5: Consequences on the ECs of the driver components

Sc	EC	Consequences
Physico chemical: PES and REC B/C		
3	*B/C (77.6%)*	*No significant change from PD is expected.*
4	*C (75.2%)*	*Water quality is expected to deteriorate due to an increase in nutrients and sediment levels as a result of the shorter and flatter wet season.*
5	*C (63.6%)*	*The extreme reduction of flushing flows will impact on nutrients, toxics, salts, sediments and temperature/oxygen levels, resulting in deteriorated water quality.*
6	*C/D (62%)*	*Fewer flushing flows will result in a further deterioration in water quality to a low C EC, with a possibility of dropping into a C/D.*
Geomorphology: PES and REC C/D		
3	*C/D (59.6%)*	*The large dam located immediately upstream of the EWR site has severely reduced flows; does not release any baseflows downstream, and has only ever spilled once or twice due to its large size. Flow at the site is much reduced, but floods from the Klein Letaba are still occurring. This scenario is the same as PD, and no change in the spills from the Middel Letaba dam are predicted.*
4	*D (57.3%)*	*Reduced bed mobility, channel size (reduced in channel habitat) and flushing of fines can be expected and the EC is expected to decline to a D EC.*
5	*D (55.6%)*	*Reduced bed mobility, channel size (reduced in channel habitat) and flushing of fines can be expected and the EC is expected to decline to a D EC. It is unlikely that there will be much instream habitat under this scenario.*
6	*D (55.6%)*	*The impact will be the same as Sc 5, since all flow indicators bar a slightly higher dry season baseflow will occur. The volumes are well below the Reserve requirements and thus small flushes and floods in the wet season will be very infrequent. There will be limited stable*

Sc	EC	Consequences
		inchannel habitat under this scenario.

8.3 EWR 5: ECOLOGICAL RESPONSE COMPONENTS

Table 8.2 EWR 5: Consequences of the ECs on the response components

Sc	EC	Consequences
Fish: PES and REC C		
3	*C (68.7%)*	*Flows similar to PD, therefore EC estimated to remain the same as under PES.*
4	*C/D (57.8%)*	*Conditions are estimated to remain very similar to slightly worse than PD during the dry season but a notable deterioration is expected in the wet season due to the lower flows. Marginal vegetation will increase due to the altered flow regime and therefore species with preference for this habitat feature will not be impacted upon.*
5	*D (51.6%)*	*Although conditions will be better during the dry season, the extreme alteration (loss of flow) in the wet season will result in an overall deterioration. Species with a preference for fast habitats (L. marequensis, C. paratus, L. cylindricus and L. molybdinus) and with a requirement for pools (Barbus afrohamiltoni, L. rosae and Labeo rubromaculatus) can be expected to be impacted upon. Since marginal vegetation will encroach there will be no impact on the species with a preference for this habitat type (Barbus spp. and cichlids).*
6	*C (63.3%)*	*Although flow and thus habitat abundance will be better during dry and most of wet season, the lack of floods again results in deterioration of substrate quality and loss of pools (due to sedimentation related to reduction in floods). The EC is therefore estimated to be reduced from PES.*
Macro-invertebrates: PES and REC C/D		
3	*C/D (58.6%)*	*This flow resembles current daily flows, thus the EC is similar to Present Day.*
4	*D (55.2%)*	*Although the dry season flows are acceptable, the wet flows are much lower and do not follow the normal seasonal flow pattern. The lack of natural rhythm and fewer high flows results in the deterioration of the EC to a D.*
5	*D (51.8%)*	*The dry season flows quite low, but the wet flows are worse and most of the seasonality is lost, as well as the scouring floods and nutrients and sediments are not flushed. The vegetation will remain as marginal habitats. The lack of natural rhythm and fewer high flows to flush poor water quality results in a D EC.*
6	*D (57.4%)*	*The improved dry period flows will maintain a viable ecological condition for the macro-invertebrates. The base flows during the wet period also improve from PD, but there will be very little flushing flows to remove sediment and stagnant pools. This will impact adversely on SIC habitats which will become silted up since the larger floods are not coming through regularly to scour the riffle and rapid habitats.*
Riparian vegetation: PES C; REC C		
3	*C (67.3%)*	*No response by riparian vegetation is expected.*
4	*C/D (61.5%)*	*Reduced wet season flows (Dec) will facilitate expansion (encroachment) of reeds in the marginal zone, but loss elsewhere on the macro channel floor. No change expected on the Macro Channel Bank (MCB).*
5	*D (54.7%)*	*Reduced wet season flows will facilitate expansion (encroachment) of reeds in the marginal and lower zones, this being exacerbated by higher dry season base flows which will facilitate survival of additional vegetation in these zones. No change is expected on the MCB.*
6	*C/D (60.6%)*	*Reduced wet season base flows will facilitate expansion (encroachment) of reeds in the marginal zone.*

8.4 EWR 5: ECOSTATUS

The results are summarised in Table 8.3 and Figure 8.1. The ecological objectives of the PES/REC are met under Sc 3 as it is similar to PD. The ecological objectives of Sc 4, 5 and 6 are however not met. The consequences at Scenario 4 and 6 are of a similar nature whereas Sc 5 has the worst impact due to reduced baseflows and floods.

Table 8.3 Ecological consequences at EWR 5

Component	PES/REC	Sc 3	Sc 4	Sc 5	Sc 6
Physico chemical	B/C	B/C	C	C	C/D
Geomorphology	C/D	C/D	D	D	D
Fish	C	C	C/D	D	C
Macro-invertebrates	C/D	C/D	D	D	D
Riparian vegetation	C	C	C/D	D	C/D
EcoStatus	C	C	C/D	D	C/D

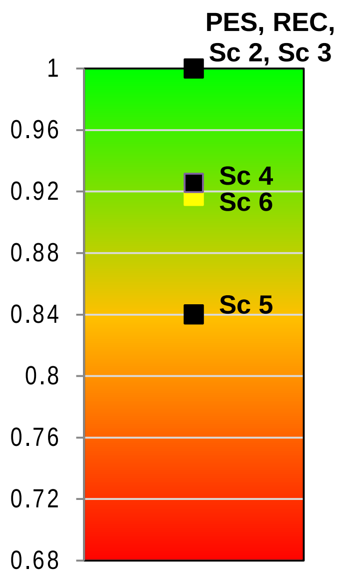

Figure 8.1 Ecological ranking of operational scenarios at EWR 5

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10 APPENDIX A: REPORT COMMENTS

Section	Report statement	Comments	Addressed in report?	Author comment