# Drought mitigation for water security: Interim Operating Rules for the Lower Olifants River

## Technical Documentation

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# Abbreviations

| | |
|---|---|
| DWS | Department of Water and Sanitation |
| DSS | Decision Support System |
| EWR | Ecological Water Requirement |
| FSC | Full Supply Capacity |
| KNP | Kruger National Park |
| LNW | Lepelle Northern Water |
| LOROC | Lower Olifants River Operations Committee |
| MAP | Mean Annual Precipitation |
| MAR | Mean Annual Runoff |
| ORWRDP | Olifants River Water Resources Development Project |
| RESILIM-O | Resilience in the Limpopo Basin - Olifants |
| WMA | Water Management Area |
| WReMP | Water Resources Modelling Platform |

# 1. Introduction and rationale

The extreme drought conditions experienced in the north-eastern region of South Africa for the past 12 months as a result of the current El Nino conditions pose challenges for sustainable water management in the Olifants Catchment (Figure 1.1) as a matter of urgency. Previous experience has highlighted the potential impacts including flow cessation especially within the Kruger National Park, non-compliance with the Reserve, compromised domestic water supplies, and reduced cross-border flows to neighbouring Mozambique. For example in 2005, despite the massive legislative changes of 1998, the Olifants River stopped flowing within the Kruger National Park (KNP) such that cross-border flows to Mozambique also ceased for 78 days. During January 2016 (at the height of the wet season), the flows for the Olifants River at Mamba Weir (B7H015) in the KNP dropped to 1 $m^3/s$ for significant periods, despite the Environmental Water Requirements (EWR, or ecological reserve) being 4.3 $m^3/s$ (drought requirement at $99^{th}$ percentile). This situation posed serious risks of flow cessation once more and also for Lepelle Northern Water (LNW[1]) which is already constrained by limited storage capacity, to supply bulk water to users from the Phalaborwa Barrage, and also to operate the barrage in such a way that the EWR would be maintained downstream toward the KNP.

The KNP and LNW notified the Department of Water & Sanitation (DWS) on 6 January 2016 that inflows to the Phalaborwa Barrage were inadequate to meet the EWR releases from the barrage. Uncertainties remained on appropriate augmentation options from the Blyderivierspoort dam to initiate the recommended operating rules for that system (DWA, 2011), for which LNW and the EWR have an allocation. As a result a Lower Olifants River Operations Committee (LOROC) was established during February 2016 to address these water supply issues amongst key sectors in the lower Olifants Catchment, through the:

- Implementation of the Operating Rules to Integrate the Blyde system with the Olifants River System, and thereto

- Promote urgent development and implementation of Operating Rules for the De Hoop dam[2]

With no sign of the drought lifting, and indeed potentially continuing into the wet season emergency plans were discussed. Through the LOROC, recommendations (see below) were made to the Director-General of DWS in July 2016 to utilise products being developed through the RESilience in the LIMpopo Olifants (RESILIM-O) program. This is being run via a USAID grant through the Association for Water & Rural Development (AWARD). Fortunately the LOROC received positive response from the DG's office in the letter dated 15 July 2016, to: shift LNWs demand to de Hoop Dam in times of stress and implement the EWR in the lower Olifants, without compromising storage in said dam at the start if the water year (April), and use the Decision Support System developed through RESILIM-O to do this (see Appendix C: Letter of Response, DWS).

This document is therefore a technical description for urgent consideration by DWS (System Operations and Planning Departments, plus the Olifants Letaba CMA) of planned activities to operationalise and test the recommended changes. The recommendation is that these activities are initiated as soon as possible particularly given that the seasonal outlook suggests neutral El Nino conditions for the spring of 2016-2017 with average rainfall and - importantly - the persistence of exceptionally high temperatures will result in extremely high evaporation rates. This suggests that the situation is unlikely to improve over the next 6-8 months.

[1] LNW based on a 50 $Mm^3/a$ allocation (from Blyde and Flag Boshielo) to LNW, their abstraction would be 1.63 m3/s

[2] bring on-line ahead of schedule for emergency flow augmentation

According to the 2016/17 operating rules (OLLI Forum July 2016[3]), Blyde Dam releases should meet demands for domestic (100%; LNW and Maruleng Local Municipality), agriculture (95% assurance) and EWRs (Blyde and contribute to EWR 13 and 16). Using September as an example, the current release is 0.85 $m^3/s$. Based on static releases these requirements are not being met currently even when considering the EWR needs and domestic demands which alone totals 1.38 $m^3/s$ (i.e. this does not taken into account agricultural demand).

- EWR: 0.74 $m^3/s$ (under drought conditions, absolute minimum based on EWR 12 (September drought RQOs and annual dam allocation of ~30.5 $Mm^3/a$)
- Domestic: 0.64 $m^3/s$ (DWS 2016. Draft Sekhukhuene Water Supply System 2016/17 Performance Report

Thus the focus of the recommendation to DWS is that the allocation for the consumptive demand from the Blyde Dam for domestic demand for LNW[4] be shifted to the de Hoop Dam as an interim, emergency measure.

The Blyde Dam is currently at 53% capacity which is concerning with the seasonal forecast showing late rains.

## 1.2 Purpose of the report

The purpose of this report is to document the recommendations for an interim operating rule from de Hoop Dam as a dynamic flow release that takes into account dynamic EWRs and the demand for domestic mining and industry as supplied by LNW (static amount) and evaporative water losses.

We present the approach and methodology used to simulate (a) near-real time EWRs and the releases needed from the Dam to meet these and LNW's demand, and (b) if the Dam would fail under the above recommendations. This report firstly describes the Olifants Catchment in terms of it hydrology, water related infrastructure, water use and current operating rules. The methodology and theoretical basis for real-time compliance monitoring is described in Section 2 and examples are given of model scenarios developed to assist with real-time compliance monitoring in the lower Olifants.

The objectives of the report include the following:

- Provide the technical support to shift some or all of LNWs demand[5] from the Blyderivierspoort Dam to De Hoop Dam in extreme circumstances, in order to reduce the pressure on the Blyde Dam; This would also provide a buffer for the commercial agricultural sector along the Blyde River for the 2016-2017 growing season[6], and water supply to Maruleng Local Municipality at a high level of assurance (a relook at the management options was deemed crucial since the Blyde Dam is also required to initiate a portion of the environmental water requirements to the lower Olifants).

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[3] Development of Operating Rules for water supply and drought management for stand-alone dams and schemes; presented by DWS (Directorate: Water Resource Planning Systems)

[4] LNW based on a 50 $Mm^3/a$ allocation (from Blyde and Flag Boshielo) to LNW, their abstraction would be 1.63 m3/s

[5] LNW has an annual demand of 51 $Mm^3$/annum from the Blyde system, DWA 2011c

[6] As of September 2015 voluntary restrictions had already been applied by the Lower Blyde Water Users by reducing irrigation rate from 0.66 l/s/ha to 0.4 l/s/ha (20% restriction). For all practical reasons the pipeline will be non-operational should the dam level reach 25% at which stage no water delivery would be possible through the network and 100% restrictions would effectively apply. The Blyde region is highly dependent on the Agricultural sector with more than 10 000 permanent and seasonal jobs at risk. The economic impact on the region should the dam level reach the 25% critical level would be devastating to the Hoedspruit, Acornhoek, Oaks and surrounding areas.

- The need to implement the 2011 Blyde river operating rules, and implement an interim operating rule for De Hoop dam, noting that the dam itself was having a potential impact on the natural baseflow of the Steelpoort river.

- Use the Decision-Support System (DSS) based on the WReMP model (Mallory et al, 2013), which has already been developed through RESILIM-O to provide operational support for releases from the De Hoop dam for multiple users downstream.

- Establish a technical team to track a short controlled release (slug pulse) from De Hoop dam to examine the effectiveness of controlled releases for meeting downstream targets (Phalaborwa Barrage, KNP, International Flows) in times of need.

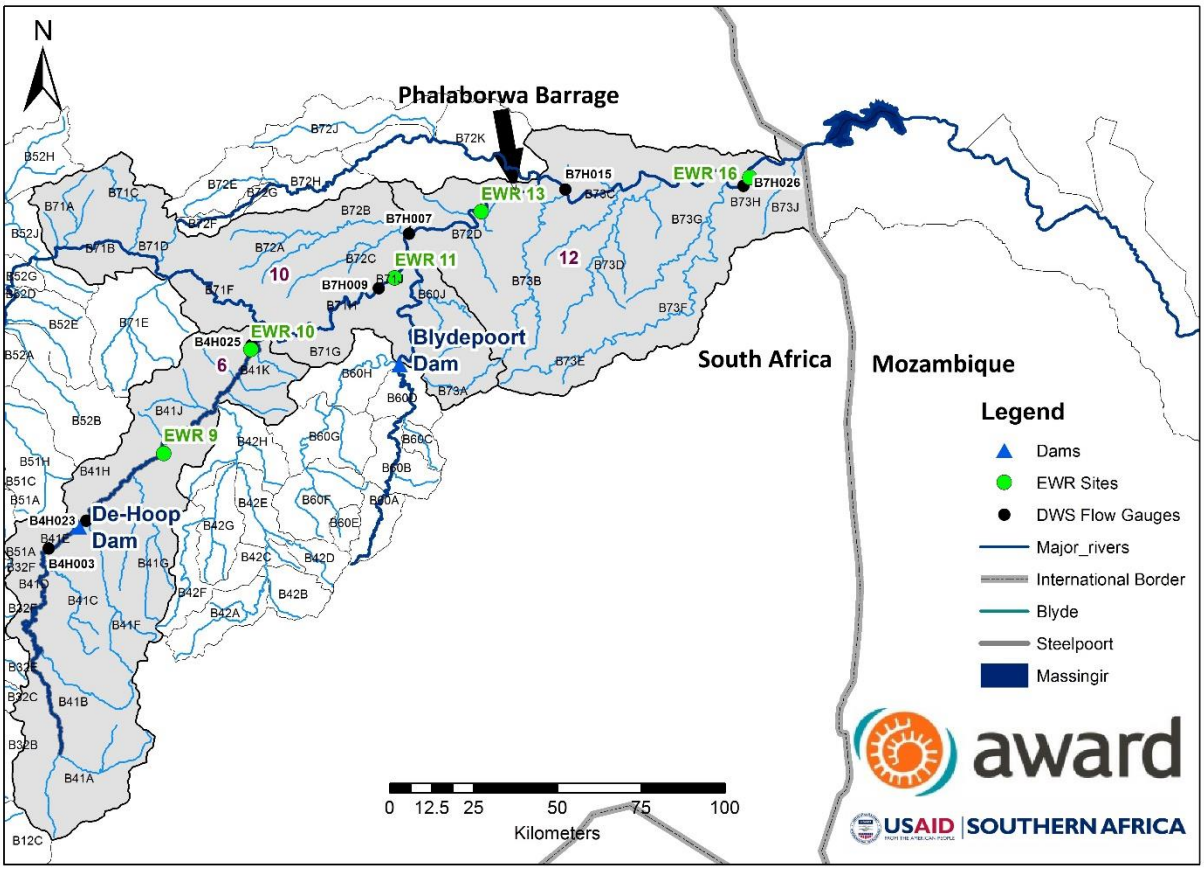


*Figure 1.1: The Lower Olifants River Basin. The key EWR sites that are near a gauge station are indicated.*

# 2. Determination of De-Hoop dam releases needed to meet target flows downstream

## 2.1 Overview of approach

This section describes the methodology used to determine the dynamic operating rule and to simulate the downstream flows within the catchment. To this end, the following approach was used for a 200 km length of river along the Steelpoort and Olifants River up to EWR 16. This includes the EWR sites that are near gauge stations (EWR 9,11, 13 and 16).

- Acquire WR2012 hydrological data
- Calculate near-real time EWRs
    - Set-up systems model
    - Back calculate water use using WReMP based on near-real time inputs of flows to get naturalised flows
    - Using naturalised flows calculate EWR from the RQO flow duration curve
- Calculate target flows based on
    - flow requirement: Determined through addition of domestic, mining and industrial demands to the EWRs plus water losses over 200km stretch
    - Target flow (early warning system) - target flow determined from the above plus 25% flow

Following an overview of the hydrology, these steps are described below.

## 2.2 Hydrology

The hydrological modelling of the entire Olifants River Basin was based on the latest available hydrological data, using the WR2012. The water use within the Catchment is constantly changing and while the Olifants Water Availability Assessment (OWAAS, DWA 2010) was used in the initial model setup, this information was updated as part of the Olifants Reconciliation Strategy (DWA, 2011a). This latter study is now in a second phase and water use has again been updated. The latest water use data set was obtained from this study in 2015 (Seago, 2015). A summary of the hydrology in terms of natural and present day flow as well as estimated water requirements is shown in Table 2.1.

*Table 2. 1: Summary of hydrology and water use cumulative at each EWR site (units are million $m^3$/annum) based on WR2012 data*

| EWR Site | Natural flow | Present Day Flow | Water requirements | | | | |
|---|---|---|---|---|---|---|---|
| | | | Urban | Irrigation | Industrial | Mining | Forestry |
| 1 | 221.2 | 98.7 | 34.0 | 39.8 | 8.0 | 7.8 | 1.5 |
| 5 | 643.6 | 257.8 | 73.5 | 227.9 | 9.2 | 9.8 | 8.1 |
| 6 | 76.1 | 13.3 | 14.0 | 22.6 | 0.0 | 0.5 | 0.7 |
| 9 | 137.9 | 113.1 | 1.5 | 4.8 | 0.0 | 4.1 | 2.4 |
| 11 | 1414.6 | 692.4 | 107.5 | 403.6 | 9.2 | 39.9 | 14.8 |
| 16 | 2029.1 | 934.2 | 134.8 | 608.5 | 9.2 | 29.0 | 5.9 |

# 2.3 Calculating the near-real time EWRS

## 2.3.1 Methodology

In line with accepted practice in South Africa, the ecological Reserve has been expressed as a function of the natural flow. This approach does however pose difficulties in estimating the ecological requirement at any point in time since it requires an estimate of the natural flow. There are three methods for estimating natural flow in real-time:

- Extrapolation from a gauge which is measuring flow in a catchment which is considered to be natural;
- The use of a rainfall/runoff model; and
- Estimating natural flow based on observed flow and a knowledge of water use in the catchment, referred to as real-time naturalisation.

The method used for compliance monitoring of the Olifants River Basin is that of real-time naturalisation which is described in Pollard et al, (2011). The compliance monitoring of flow model is based on the Water Resources Modelling Platform (WReMP) setup of the Olifants River Basin (Appendix A). This model setup was developed as part of an earlier phase of the RESILIM-O program in order to evaluate the impact of climate change in the Olifants River catchment. In order to adapt this model for compliance monitoring it was necessary to identify infrastructure and water use upstream of each EWR site. Generic input files have been used for this purpose so that the model user can add new monitoring sites in future if necessary.

There are two models that are a part of the DSS incorporated into WReMP which are to be used in the proposed methodology for emergency augmentation in the lower Olifants, namely:

- monthly catchment model
- daily De-Hoop release model

## 2.3.2 Selection of sites at which to monitor flow compliance

The process of Real-time naturalisation simply entails adding back water use in the catchment to the observed flow. To apply this concept successfully requires a reliable real-time flow gauge and a good knowledge of water use upstream of the gauge. These criteria are largely met in the Olifants River Basin although real time gauges are not always located at or near EWR sites. Hence it is not possible to monitor

flow and compliance at all EWR sites. Table 2.2 indicates the selected sites and the closest flow gauge which will be used for monitoring. While there is currently no real-time capability at the EWR 11 site it is understood that the AWARD data loggers and flow probes are to be installed shortly.

The EWRs were determined in 2002 (DWA, 2001) but updated as part of the Olifants Reconciliation Strategy (DWA, 2011). The update entailed estimating the EWR without freshet releases since the outlet of existing dams are too small to release the required freshets. The revised EWRs were accepted during the Classification of the Water Resources (DWS, 2011b) and the gazetted numerical RQOs (2016) are used in this study. The class of the EWR and the EWR as a percentage of the natural flow is indicated in Table 2.3. The numerical representation of the EWRs as duration curves are attached as Appendix B.

*Table 2. 2 EWR sites and related real-time gauges*

| EWR Site | Real time Gauge | Description | Quaternary catchment | River | Long | Lat |
|---|---|---|---|---|---|---|
| 1 | B1H010 | Olifants River @ Witbank | B11J | Olifants | 29.304 | -25.892 |
| 5 | B3H017 | Olifants River @ Loskop | B32C | Olifants | 29.358 | -25.417 |
| 6 | B3H020 | Elands River @ Rhenosterkop | B31G | Elands | 28.921 | -25.101 |
| 9 | B4H023 | De Hoop Dam Releases | B41H | Steelpoort | 29.957 | -24.954 |
| 10 | B4H025 | Taung | B41K | Steelpoort | 30.400 | -24.483 |
| 11 | B7H009 | Finale (Liverpool) | B71H | Olifants | 30.742 | -24.331 |
| 13 | B7H015 | Mamba | B73C | Olifants | 31.243 | -24.066 |
| 16 | B7H026 | Balule | B73H | Olifants | 31.721 | -24.057 |

*Table 2. 3: Ecological water requirements based on the gazetted RQOs (March 2016)*

| EWR Site | Category | Mean requirement | |
|---|---|---|---|
| | | million $m^3$/annum under Normal Conditions | million $m^3$/annum under Drought Conditions |
| 1 | D | 8.69 | 7.72 |
| 5 | C | 56.97 | 31.41 |
| 6 | D | 3.75 | 3.78 |
| 9 | D | 13.41 | 12.96 |
| 10 | D | 30.13 | 30.13 |
| 11 | D | 155.33 | 82.71 |
| 13 | C | 210.22 | 110.73 |
| 16 | C | 205.44 | 92.24 |

## 2.3.3 Storage of water in dams

A significant factor affecting river flow is the impoundment of water in dams. As described in the real-time naturalisation methodology (Pollard, et al, 2011), water that would have contributed to natural flow is stored in impoundments and hence this stored water needs to be added to the observed flow as part of the real-time naturalisation process. Since it is not possible to monitor all the dams in the catchment, only the larger dams with real-time or near real-time storage data have been included in the naturalisation process. These dams are listed in Table 2.4.

*Table 2. 4 Significant Dams in the Olifants River catchment*

| Dam name | Full supply capacity (million $m^3$) | Catchment | Flow at EWR sites influenced by dam | Storage on 15 August 2016 (% of FSC) | Storage on 1 Sept 2016 (% of FSC) |
|---|---|---|---|---|---|
| Bronkhorstspruit | 57.0 | B20C | 5, 11, 16 | 68.9 | 67.1 |
| Witbank | 104.1 | B12C | 1, 5, 11, 16 | 51.2 | 49.6 |
| Middelburg | 48.1 | B11G | 5, 11, 16 | 43.5 | 40.9 |
| Loskop | 361.6 | B32A | 5, 11, 16 | 54.8 | 52.5 |
| Rust de Winter | 28.2 | B31C | 6, 11, 16 | 51.2 | 50.1 |
| Mkombo | 204.6 | B31F | 6, 11, 16 | 20.5 | 19.5 |
| Flag Boshielo | 185.2 | B51B | 11, 16 | 25.0 | 22.8 |
| De Hoop | 348.7 | B41E | 9, 11, 16 | 86.4 | 85.4 |
| Buffelspoort | 5.3 | B42F | 11, 16 | 34.3 | 30.8 |
| Origstad | 13.5 | B60E | 16 | 5.1 | 4.4 |
| Blyderivierpoort | 54.4 | B60D | 16 | 59.6 | 54.4 |
| Klaserie | 5.7 | B73A | 16 | 40.9 | 36.1 |

## 2.3.4 Examples of EWR compliance monitoring

The EWR compliance model has been tested using near real-time flows and are presented in the table below (Table 2.5) as an example of a typical result. This does not however constitute comprehensive testing of the model which will need to be carried out over a longer period of time.

In addition to the dam storage information the following near real-time flows are needed to carry out the naturalisation calculation every week.

*Table 2. 5: Observed flows observed at real-time gauges associated with an EWR site*

| EWR Site | Real time gauge | Flow on 15 August 2016 ($m^3/s$) | Flow on 1 Sept 2016 ($m^3/s$) |
|---|---|---|---|
| 1 | B1H010 | 0.01 | 0.02 |
| 5 | B3H017 | 1.17 | 1.17 |
| 6 | B3H020 | 0.68 | 0.66 |
| 9 | B4H023 | 2.08 | 2.09 |
| 10 | B4H025 | | 1.95 |
| 11 | B7H009 | 4.18* | Reading unreliable |
| 13 | B7H015 | 1.76 | 1.76 |
| 16 | B7H026 | | 0.52 |

* Note that gauge B7H009 is not yet fitted with telemetry so flow was estimated from the downstream gauge.

Furthermore, scaling factors are applied to bring EWR site requirements in line with the gauged hydrology for example: EWR 9 (Steelpoort)

B4H023 catchment area = 2 388 $km^2$
EWR9 catchment area = 3 050 $km^2$
Scaling factor = 3 050/2 388
= 1.277

As noted, water use/ demand is added to the EWR to determine a flow requirement. The monthly water demand for key EWR sites is shown in Table 2.6.

*Table 2. 6: Consumptive bulk water demand upstream of Lower Olifants EWR sites*

| **Month** | **Requirement (million $m^3$) above EWR 9** | **Requirement (million $m^3$) above EWR 10** | **Requirement (million $m^3$) above EWR 11** | **Requirement (million $m^3$) above EWR 13** |
|---|---|---|---|---|
| October | 0.84 | 1.11 | 45.50 | 66.03 |
| November | 0.79 | 1.03 | 41.39 | 59.79 |
| January | 0.86 | 1.15 | 47.55 | 69.15 |
| February | 0.98 | 1.35 | 57.41 | 84.12 |
| March | 1.18 | 1.72 | 75.47 | 111.57 |
| April | 0.91 | 1.24 | 51.66 | 75.39 |
| May | 0.87 | 1.17 | 48.37 | 70.40 |
| June | 0.66 | 0.81 | 30.31 | 42.95 |
| July | 0.70 | 0.86 | 33.18 | 47.32 |
| August | 0.94 | 1.29 | 54.12 | 79.13 |
| September | 0.86 | 1.15 | 47.55 | 69.15 |
| **Total** | **10.36** | **13.88** | **572.25** | **832.31** |

# 2.4 Determination of near-real time target flows for the drought period

## 2.4.1 Principles for shifting industrial and urban allocation for LNW

The principles held with the presented scenario is to create a temporary shift of LNWs demand from Blyderivierspoort Dam to De Hoop Dam during emergency situations. Furthermore, the scenario assumes that the EWR is implemented for the Steelpoort River from De Hoop[7] whilst the EWR for the Olifants River below the Blyde River confluence is maintained by baseflow releases from Blyderivierspoort Dam. According to DWA (2011), the entire Lepelle water demand is being met not just by the Blyde alone, but also with a good proportion from the Olifants River as well through incremental catchment runoff. Therefore, in the current emergency situation we suggest shifting Lepelle's demand to De-Hoop dam as incremental runoff in the lower Olifants main stem becomes insufficient as was the case during early 2016.

## 2.4.2 General Principles

Releases from the De-Hoop Dam should coincide with an early warning system, which signifies an 'emergency situation'. The trigger for this are based on near-real time flows at the Oxford Weir (B7H007). This is the gauge that LNW uses to monitor inflows to the Phalaborwa barrage. This will use the following rule which gives the target flow in $m^3/s$ at B7H007 to meet the requirements at Mamba weir (B7H015) in the KNP:

B7H007 Target flow = LNW Requirement[8]) + EWR13 Requirement + 10% loss[9]

Therefore, a threshold is required to trigger a management action based on Observed flow at target gauge B7H007, when:

B7H007 Observed flow < (B7H007 Target flow * 1.25)

The above scenario uses 25% as an early warning excess to account for the lag time between a pulse release from the de Hoop Dam and observation at the target gauge (B7H007). There are no appropriate gauges in the system currently therefore we use a 5-7 day lag as learnt from experiences in the Crocodile River Catchment over a transfer distance of approximately 200 kms. This can be adapted in the future

[7] Noting that the full EWR from De Hoop dam for the lower Olifants will only be implemented on completion of the ORWRDP
[8] Daily requirement expressed as constant of the instantaneous flow
[9] DWA 2011 operating rules reassessed losses below the Blydepoort dam towards the barrage at 6.8%, we use a conservative estimate of 10 (predominantly quoted in literature at 30%)

after observation of gauges (B4H025, B7H007 and the soon to be completed B7H009), and will be one of the immediate required calibration exercises for the proposed emergency releases.

Once this threshold flow is triggered this would invoke a management action by LNW. With the response to run the WReMP De Hoop daily model and request DWS Infrastructure branch initiate the required release from de Hoop Dam.

### 2.4.3 Scenario of early warning system against stochastic hydrology

The results of the compliance analysis carried out on 15 August 2016 is given in Table 2.7. Although the following flows have been determined for this drought period, we suggest that this system can be used until De Hoop Dam integrated operating rules have been developed.

*Table 2. 7: EWR requirements under scenarios*

| EWR Site | Observed flow on 15 August 2016 ($m^3/s$) | Estimated natural flow ($m^3/s$) | Estimated ecological water requirement ($m^3/s$) |
|---|---|---|---|
| 1 | 0.01 | 2.29 | 0.22 |
| 5 | 1.17 | 5.31 | 1.32 |
| 6 | 0.68 | 2.63 | 0.14 |
| 9 | 2.08 | 2.89 | 1.28 |
| 11 | 4.18* | 12.33 | 5.10 |
| 16 | 1.76 | 15.56 | 5.38 |

# 3. Quantifying recommended releases from De Hoop Dam

## 3.1 Current scenario

The following scenario demonstrates when a trigger is initiated, with a lag from De-Hoop to Oxford (B7H007) of 5-7 days (calculated on 1 $m^3/s$ over 150-200Km) and made using present catchment conditions (1 September 2016). It is recognised that it will not be possible to meet the full EWR at all sites in the lower Olifants River from the De Hoop Dam. As an interim measure the releases will be made to meet minimum EWR at B7H026. These minimum flows are given in Table 3.1. These flows can also be considered to be the minimum cross-border flows into Mozambique.

*Table 3. 1: Minimum flows at B7H026*

| Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2.02 | 2.84 | 3.14 | 4.19 | 5.03 | 4.36 | 3.35 | 2.94 | 2.53 | 2.23 | 2.12 | 2.02 |

There are two solutions to deal with the lag time, that is, the time required for flow released from the De Hoop Dam to reach the Phalaborwa Barrage. Either the drop in flow must be anticipated and released five days early, or the storage on the Phalaborwa Barrage must be used as an additional trigger and flow released when there is still at least 7 days storage remaining for LNW[10]. The latter method is preferred since this will obviate unnecessary releases.

*Table 3. 2: Recommended release as of the 5th of September 2016*

| Date | 5-Sep-16 | |
|---|---|---|
| **EWR 16** | Represented by flow at Gauge B7H026 | |
| Flow | 0.45 | m3/s |
| Minimum EWR for August | 1.67 | m3/s |
| Additional Flow Required | 1.22 | m3/s |
| | | |
| **Lepelle Water Abstraction from the Phalaborwa Barrage** | | |
| Inflow | Represented by the flow at Gauge B7H007 | |
| Flow | 3.43 | m3/s |
| Abstraction | 1.32[11] | m3/s |
| Additional Flow Required | 0 | m3/s |
| | | |
| **De Hoop Dam** | | |
| Outflow | Represented by the flow at Gauge B4H023 | |
| Flow | 2.08 | m3/s |
| Additional flow required plus 10% losses | 1.342 | m3/s |
| **Total release now required from De Hoop** | **3.422** | |

# 3.2 Sustainability for De Hoop Water Resources

An analysis is required in order to ascertain how the De Hoop Dam will operate if water is released from the dam to support Lepelle Northern Water. A so-called short term analysis has been carried out using 500 stochastic hydrology sequences. This gives a good indication of the probability of the De Hoop Dam being in a particular state of storage as time progresses.

The 1 in 50 year yield of the De Hoop Dam is estimated to be 66 $Mm^3/a$. Currently there is no supply to other users from the dam since the pipelines are still under construction. A release of about 2 $m^3/s$ is presently being made from the dam. It is assumed that this release is for the EWR but it is not clear how this flow rate was determined. The DSS that has been set up by AWARD as part of the RESILIM-O project can determine the required release on a day to day basis. The current abstraction by LNW is about 1.32 $m^3/s$ (or 41.6 $Mm^3/a$) which is well within the yield of the De Hoop Dam. Figure 3.1 shows the performances of the De Hoop Dam given the following scenario:

[10] Approximately ¾ of LNW storage in the barrage is held within the first 1.5kms of backwater from the barrage (Clean Stream, 2015), this represents approx. 800 000 $m^3$, or approximately 7 days supply at present demand.

[11] LNW is presently licensed at 64 $Mm^3$/annum, with use due drop in industrial demand to 43 $Mm^3$/annum. Average daily demand for 2015-16 financial year equates to 114 Ml/day.

- Supplement supply to LNW, including an assumed 10% loss of the releases from The De Hoop Dam
- Release water from the De Hoop Dam to meet the EWR at site 9 and 10.

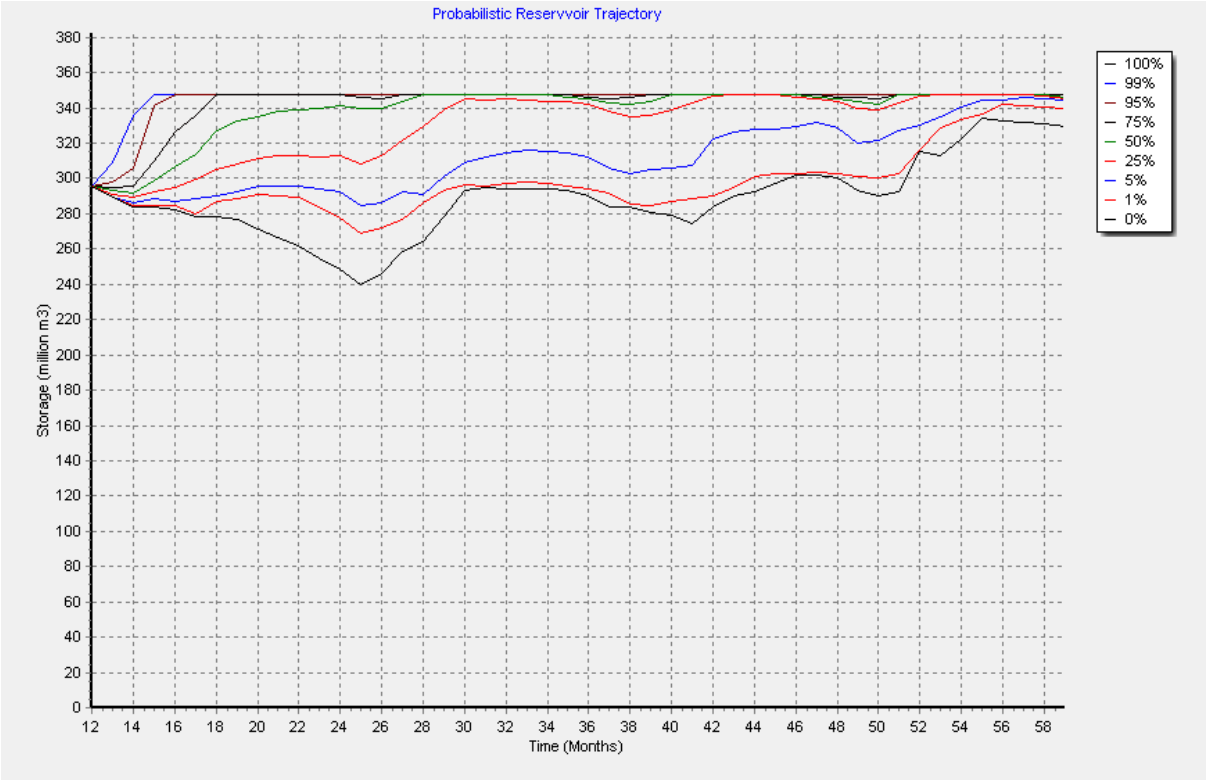


*Figure 3. 1: Scenario 1: Performance of De Hoop Dam with support to Lepelle Northern Water*

As a second scenario, the extent to which De Hoop Dam can meet all the EWRs along the lower Olifants River was modelled. This scenario assumes supplementary releases for LNW as well as EWR sites 9,10,11,13 and 16.

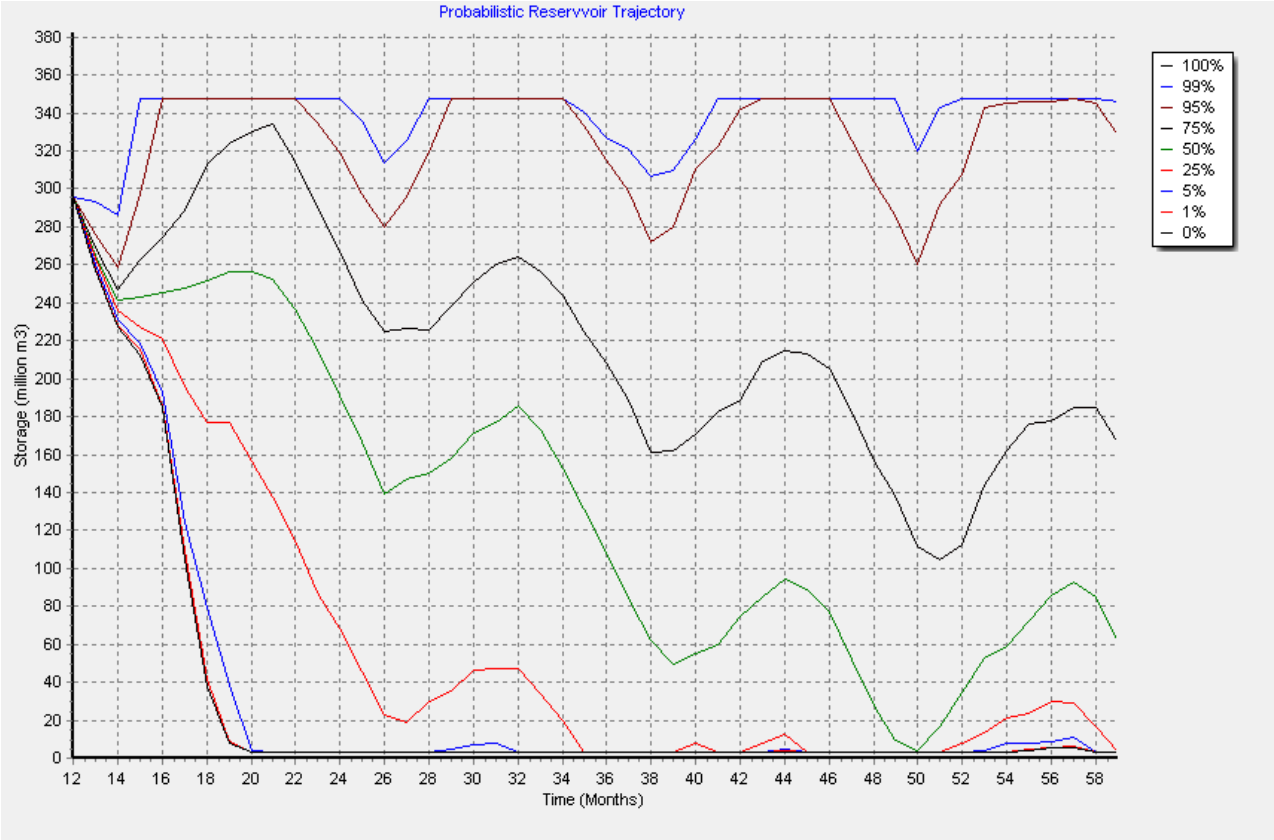


*Figure 3. 2: Scenario 2: Release from De Hoop to support LNW and all the EWRs on the lower Olifants River*

It can be concluded that the De Hoop Dam can used to support the water requirements of LNW as a temporary measure without imposing an undue risk on the mines and rural communities that will soon be supplied from this source. However, the De Hoop Dam cannot also meet all the EWR in the lower Olifants and an integrated solution to this is required (Figure 3.2). Support from the Blyderivier Dam and the Loskop Dam will most probably also be required.

# 4. Plan of Action

In order to initiate successful implementation of the proposed DSS the following actions will be required in a phased approach:

1. Initial briefing session with the following people (emergency situation during drought)
    a. Celiwe Ntuli (NtuliC@dws.gov.za) WRPS
    b. Johann van Aswegen (vanAswegenJ@dws.gov.za) OCMA
    c. Dr Beason Mwaka (mwakab@dws.gov.za) WRPS
    d. Tendani Nditwani (nditwani@dws.gov.za) NWRP
    e. Levy Modjadibodu (levym@lepelle.co.za) LNW
    f. Deon Joubert (joubertd@dws.gov.za) DWS Hydrology
    g. Kobus Pretorius (pretoriusk@dws.gov.za) DWS Infrastructure Branch
    h. Contact Olifants and Blyde river farmers(through Olifants proto CMA staff)

2. Priority to maintain B7H007 at Oxford on telemetric system (and utilise double up stations installed by RESILIM-O at B7H009, B7H007, B7H015, B7H026) – utilise manual readings of gauges where necessary (note LNW has photographic sensor of stage height at B7H007)
3. Document decisions – such as the KNP river management log (appendix e) which includes results of WReMP model runs, acknowledged releases (duration and volume by DWS Infrastructure Branch), hydrological response received (LNW & KNP)
4. Follow-up DSS technical training to include the following personnel: DWS System Operations (Head Office); Olifants-Letaba CMA River Operations Manager; DWS Infrastructure Branch (MP and LP); Lepelle Northern Water Phalaborwa Barrage Scheme Manager; Kruger National Park; Water User Associations; Maruleng municipality.
5. Concurrently with above will be the need to ensure Water User Associations provide validated water use and ensure users are compliant during release periods

# 5. Conclusion

In conclusion under the current situation: environmental flows will not be met downstream, the Blyde agricultural sector is at risk as well as the Maruleng Municipality water supply. Therefore, we recommend that the LNW demand be shifted to the De-Hoop dam based on what was shown in this report. The De-Hoop dam simulations have shown that shifting the water use can be sustained by the De-Hoop dam. We also suggest that this approach be used until the time comes that the integrated operating rules for the De-Hoop dam have been developed.

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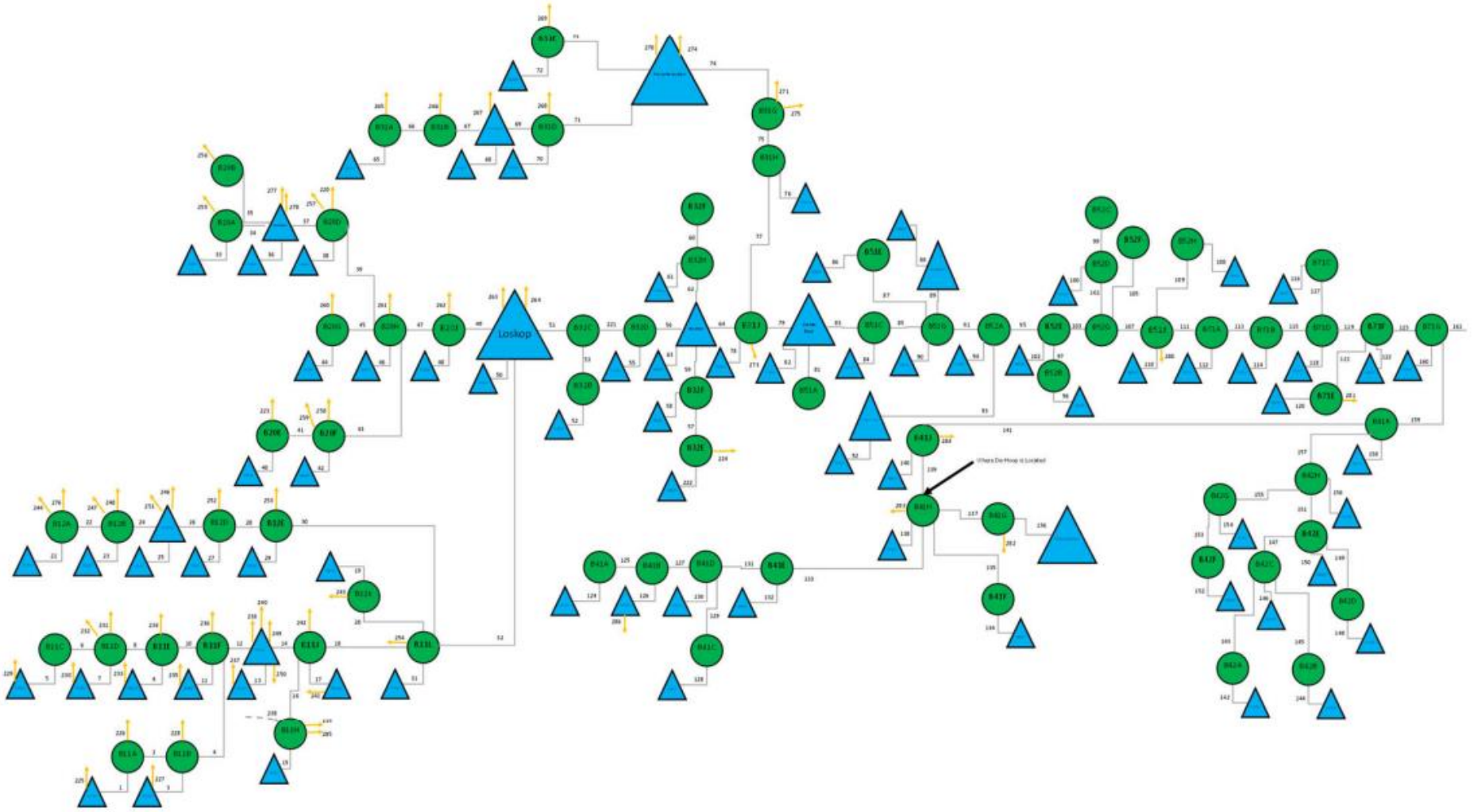
# APPENDIX A: WReMP Systems Diagram for Olifants Catchment



# APPENDIX B: ecological water requirements at selected sites in flow duration format

From DWA: RESOURCE QUALITY OBJECTIVES AND NUMERICAL LIMITS REPORT (Oct 2014)
REPORT NO.: RDM/WMA04/00/CON/RQO/0613 cross referenced against Gazetted Management Classes for the Olifants Water Management Area (Gazette No 39943, 22 April 2016)

## EWR 1

Olifants River
IUA 1
RU 11

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

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

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 0.588 | 0.584 | 0.576 | 0.557 | 0.524 | 0.468 | 0.389 | 0.298 | 0.221 | 0.185 |
| Nov | 1.648 | 1.638 | 1.616 | 1.574 | 1.494 | 1.355 | 1.134 | 0.826 | 0.484 | 0.268 |
| Dec | 2.594 | 2.577 | 2.541 | 2.470 | 2.337 | 2.104 | 1.734 | 1.220 | 0.647 | 0.286 |
| Jan | 4.286 | 3.831 | 3.441 | 3.096 | 2.766 | 2.216 | 1.904 | 1.470 | 0.986 | 0.682 |
| Feb | 1.807 | 1.710 | 1.623 | 1.539 | 1.448 | 1.293 | 1.163 | 0.982 | 0.781 | 0.654 |
| Mar | 2.148 | 1.975 | 1.822 | 1.678 | 1.528 | 1.276 | 1.084 | 0.818 | 0.521 | 0.269 |
| Apr | 0.980 | 0.973 | 0.957 | 0.923 | 0.860 | 0.756 | 0.610 | 0.442 | 0.298 | 0.228 |
| May | 0.461 | 0.458 | 0.451 | 0.438 | 0.413 | 0.373 | 0.315 | 0.249 | 0.192 | 0.166 |
| Jun | 0.317 | 0.315 | 0.311 | 0.302 | 0.287 | 0.261 | 0.224 | 0.181 | 0.145 | 0.129 |
| Jul | 0.240 | 0.239 | 0.237 | 0.232 | 0.223 | 0.208 | 0.187 | 0.162 | 0.141 | 0.131 |
| Aug | 0.191 | 0.190 | 0.189 | 0.185 | 0.179 | 0.168 | 0.153 | 0.136 | 0.121 | 0.114 |
| Sep | 0.168 | 0.167 | 0.165 | 0.161 | 0.153 | 0.140 | 0.122 | 0.100 | 0.082 | 0.074 |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 0.278 | 0.277 | 0.274 | 0.269 | 0.259 | 0.243 | 0.220 | 0.194 | 0.172 | 0.161 |
| Nov | 0.541 | 0.538 | 0.533 | 0.522 | 0.502 | 0.466 | 0.409 | 0.330 | 0.243 | 0.187 |
| Dec | 0.716 | 0.712 | 0.703 | 0.686 | 0.653 | 0.596 | 0.505 | 0.379 | 0.238 | 0.149 |
| Jan | 0.892 | 0.889 | 0.883 | 0.871 | 0.848 | 0.808 | 0.745 | 0.657 | 0.559 | 0.497 |
| Feb | 1.105 | 1.102 | 1.094 | 1.079 | 1.051 | 1.001 | 0.923 | 0.814 | 0.693 | 0.616 |
| Mar | 0.880 | 0.876 | 0.866 | 0.847 | 0.812 | 0.750 | 0.651 | 0.514 | 0.361 | 0.265 |
| Apr | 0.669 | 0.665 | 0.655 | 0.634 | 0.595 | 0.531 | 0.441 | 0.337 | 0.249 | 0.207 |
| May | 0.461 | 0.458 | 0.451 | 0.438 | 0.413 | 0.373 | 0.315 | 0.249 | 0.192 | 0.166 |
| Jun | 0.317 | 0.315 | 0.311 | 0.302 | 0.287 | 0.261 | 0.224 | 0.181 | 0.145 | 0.129 |
| Jul | 0.240 | 0.239 | 0.237 | 0.232 | 0.223 | 0.208 | 0.187 | 0.162 | 0.141 | 0.131 |
| Aug | 0.191 | 0.190 | 0.189 | 0.185 | 0.179 | 0.168 | 0.153 | 0.136 | 0.121 | 0.114 |
| Sep | 0.168 | 0.167 | 0.165 | 0.161 | 0.153 | 0.140 | 0.122 | 0.100 | 0.082 | 0.074 |
| Natural Duration curves | | | | | | | | | | |
| Oct | 8.673 | 2.546 | 1.665 | 1.060 | 0.877 | 0.650 | 0.500 | 0.392 | 0.295 | 0.187 |
| Nov | 21.177 | 14.267 | 9.236 | 7.373 | 5.189 | 3.468 | 2.126 | 1.215 | 0.525 | 0.305 |
| Dec | 27.356 | 21.871 | 14.068 | 12.063 | 7.687 | 5.313 | 3.293 | 2.352 | 1.139 | 0.392 |
| Jan | 36.178 | 23.738 | 15.476 | 10.902 | 8.419 | 6.635 | 3.610 | 2.528 | 1.684 | 0.918 |
| Feb | 33.767 | 18.155 | 13.079 | 7.841 | 5.076 | 3.952 | 3.146 | 2.079 | 1.224 | 0.711 |
| Mar | 30.358 | 9.827 | 6.291 | 5.100 | 3.648 | 2.729 | 1.781 | 1.135 | 0.687 | 0.269 |
| Apr | 12.369 | 6.107 | 4.109 | 2.840 | 2.068 | 1.682 | 1.211 | 0.880 | 0.467 | 0.228 |
| May | 6.033 | 3.510 | 2.065 | 1.520 | 1.072 | 0.911 | 0.709 | 0.575 | 0.396 | 0.190 |
| Jun | 2.928 | 1.674 | 1.292 | 1.061 | 0.756 | 0.629 | 0.579 | 0.471 | 0.309 | 0.177 |
| Jul | 1.885 | 1.176 | 0.956 | 0.777 | 0.638 | 0.571 | 0.493 | 0.444 | 0.336 | 0.205 |
| Aug | 1.150 | 0.933 | 0.698 | 0.594 | 0.549 | 0.463 | 0.429 | 0.392 | 0.302 | 0.190 |
| Sep | 1.111 | 0.752 | 0.583 | 0.529 | 0.490 | 0.409 | 0.367 | 0.313 | 0.216 | 0.147 |

## EWR 5

Olifants River

IUA 3

RU 40

Desktop Version 2, Printed on 9/2/2014

Summary of IFR rule curves for : Olifants_5 Generic Name

Determination based on site specific parameters from SPATSIM database.

Regional Type : Olifants ERC = C

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

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 2.374 | 2.358 | 2.322 | 2.248 | 2.109 | 1.880 | 1.558 | 1.186 | 0.868 | 0.720 |
| Nov | 5.558 | 5.526 | 5.458 | 5.325 | 5.076 | 4.640 | 3.947 | 2.985 | 1.912 | 1.237 |
| Dec | 8.078 | 8.030 | 7.929 | 7.729 | 7.356 | 6.704 | 5.666 | 4.225 | 2.619 | 1.608 |
| Jan | 16.296 | 14.568 | 13.082 | 11.758 | 10.476 | 8.335 | 7.059 | 5.287 | 3.311 | 2.068 |
| Feb | 7.205 | 6.796 | 6.425 | 6.058 | 5.645 | 4.944 | 4.315 | 3.441 | 2.467 | 1.854 |
| Mar | 9.001 | 8.280 | 7.648 | 7.060 | 6.453 | 5.433 | 4.685 | 3.647 | 2.490 | 1.761 |
| Apr | 4.290 | 4.261 | 4.196 | 4.060 | 3.807 | 3.391 | 2.803 | 2.126 | 1.547 | 1.278 |
| May | 2.496 | 2.482 | 2.450 | 2.384 | 2.261 | 2.059 | 1.773 | 1.445 | 1.163 | 1.033 |
| Jun | 1.996 | 1.985 | 1.960 | 1.907 | 1.810 | 1.650 | 1.424 | 1.163 | 0.941 | 0.837 |
| Jul | 1.670 | 1.661 | 1.640 | 1.597 | 1.516 | 1.383 | 1.195 | 0.978 | 0.793 | 0.707 |
| Aug | 1.367 | 1.360 | 1.343 | 1.308 | 1.242 | 1.134 | 0.982 | 0.807 | 0.657 | 0.587 |
| Sep | 1.187 | 1.180 | 1.166 | 1.136 | 1.079 | 0.987 | 0.856 | 0.706 | 0.577 | 0.518 |
| | | | | | | | | | | |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 1.504 | 1.496 | 1.477 | 1.438 | 1.366 | 1.246 | 1.078 | 0.884 | 0.718 | 0.641 |
| Nov | 2.347 | 2.336 | 2.315 | 2.271 | 2.191 | 2.050 | 1.826 | 1.515 | 1.168 | 0.949 |
| Dec | 2.846 | 2.833 | 2.807 | 2.754 | 2.655 | 2.483 | 2.210 | 1.830 | 1.406 | 1.139 |
| Jan | 3.446 | 3.431 | 3.399 | 3.335 | 3.215 | 3.005 | 2.672 | 2.210 | 1.694 | 1.370 |
| Feb | 4.281 | 4.261 | 4.221 | 4.141 | 3.992 | 3.731 | 3.317 | 2.741 | 2.099 | 1.695 |
| Mar | 3.719 | 3.702 | 3.667 | 3.598 | 3.468 | 3.242 | 2.882 | 2.382 | 1.825 | 1.474 |
| Apr | 3.146 | 3.127 | 3.084 | 2.996 | 2.830 | 2.557 | 2.172 | 1.729 | 1.350 | 1.174 |
| May | 2.496 | 2.482 | 2.450 | 2.384 | 2.261 | 2.059 | 1.773 | 1.445 | 1.163 | 1.033 |
| Jun | 1.996 | 1.985 | 1.960 | 1.907 | 1.810 | 1.650 | 1.424 | 1.163 | 0.941 | 0.837 |
| Jul | 1.670 | 1.661 | 1.640 | 1.597 | 1.516 | 1.383 | 1.195 | 0.978 | 0.793 | 0.707 |
| Aug | 1.367 | 1.360 | 1.343 | 1.308 | 1.242 | 1.134 | 0.982 | 0.807 | 0.657 | 0.587 |
| Sep | 1.187 | 1.180 | 1.166 | 1.136 | 1.079 | 0.987 | 0.856 | 0.706 | 0.577 | 0.518 |
| | | | | | | | | | | |
| Natural Duration curves | | | | | | | | | | |
| Oct | 18.134 | 9.614 | 6.425 | 5.025 | 3.995 | 3.230 | 2.666 | 2.397 | 1.594 | 1.187 |
| Nov | 55.475 | 39.954 | 26.258 | 21.146 | 15.733 | 11.481 | 7.851 | 5.799 | 2.867 | 2.002 |
| Dec | 76.538 | 51.359 | 38.471 | 34.076 | 25.616 | 17.380 | 11.630 | 8.023 | 5.238 | 2.733 |
| Jan | 101.747 | 62.862 | 39.546 | 30.645 | 22.189 | 17.103 | 13.852 | 10.230 | 7.463 | 4.342 |
| Feb | 83.201 | 48.636 | 33.296 | 23.752 | 15.960 | 13.000 | 11.442 | 9.082 | 7.031 | 4.233 |
| Mar | 74.843 | 42.880 | 23.055 | 18.164 | 14.322 | 10.723 | 8.658 | 6.575 | 4.376 | 2.057 |
| Apr | 31.254 | 23.927 | 14.834 | 12.137 | 10.779 | 8.603 | 6.539 | 4.938 | 3.835 | 1.917 |
| May | 19.971 | 13.030 | 9.954 | 7.575 | 6.037 | 5.570 | 4.465 | 3.476 | 2.584 | 1.553 |
| Jun | 12.353 | 9.209 | 6.813 | 5.752 | 4.807 | 4.113 | 3.526 | 2.596 | 2.157 | 1.300 |
| Jul | 10.122 | 7.206 | 5.335 | 4.981 | 4.002 | 3.741 | 2.856 | 2.464 | 1.983 | 1.228 |
| Aug | 6.209 | 5.570 | 4.465 | 3.969 | 3.274 | 2.759 | 2.382 | 2.102 | 1.781 | 1.561 |
| Sep | 6.933 | 4.390 | 3.704 | 3.094 | 2.704 | 2.230 | 1.983 | 1.671 | 1.451 | 1.073 |

# EWR 6

Elands River

IUA 4

RU 46

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

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

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 0.233 | 0.232 | 0.229 | 0.222 | 0.210 | 0.189 | 0.160 | 0.126 | 0.098 | 0.084 |
| Nov | 0.827 | 0.822 | 0.811 | 0.791 | 0.752 | 0.684 | 0.577 | 0.427 | 0.261 | 0.156 |
| Dec | 1.000 | 0.993 | 0.981 | 0.956 | 0.909 | 0.827 | 0.697 | 0.516 | 0.314 | 0.187 |
| Jan | 2.200 | 1.952 | 1.739 | 1.552 | 1.374 | 1.078 | 0.915 | 0.687 | 0.434 | 0.275 |
| Feb | 0.779 | 0.726 | 0.679 | 0.635 | 0.589 | 0.511 | 0.451 | 0.369 | 0.277 | 0.219 |
| Mar | 1.050 | 0.955 | 0.874 | 0.800 | 0.726 | 0.604 | 0.525 | 0.415 | 0.292 | 0.215 |
| Apr | 0.502 | 0.499 | 0.491 | 0.475 | 0.446 | 0.398 | 0.330 | 0.252 | 0.185 | 0.154 |
| May | 0.210 | 0.209 | 0.207 | 0.203 | 0.195 | 0.182 | 0.163 | 0.141 | 0.123 | 0.114 |
| Jun | 0.177 | 0.176 | 0.174 | 0.171 | 0.164 | 0.153 | 0.137 | 0.119 | 0.103 | 0.096 |
| Jul | 0.156 | 0.156 | 0.154 | 0.151 | 0.145 | 0.135 | 0.121 | 0.105 | 0.091 | 0.085 |
| Aug | 0.142 | 0.141 | 0.140 | 0.137 | 0.131 | 0.122 | 0.110 | 0.095 | 0.083 | 0.077 |
| Sep | 0.130 | 0.129 | 0.128 | 0.125 | 0.120 | 0.112 | 0.101 | 0.087 | 0.076 | 0.070 |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 0.143 | 0.142 | 0.141 | 0.138 | 0.133 | 0.124 | 0.111 | 0.096 | 0.083 | 0.078 |
| Nov | 0.241 | 0.241 | 0.239 | 0.235 | 0.227 | 0.214 | 0.194 | 0.165 | 0.133 | 0.113 |
| Dec | 0.265 | 0.264 | 0.262 | 0.258 | 0.251 | 0.237 | 0.216 | 0.187 | 0.154 | 0.134 |
| Jan | 0.344 | 0.343 | 0.341 | 0.335 | 0.325 | 0.308 | 0.281 | 0.243 | 0.201 | 0.174 |
| Feb | 0.392 | 0.390 | 0.387 | 0.381 | 0.370 | 0.350 | 0.319 | 0.276 | 0.228 | 0.198 |
| Mar | 0.351 | 0.349 | 0.347 | 0.341 | 0.331 | 0.314 | 0.286 | 0.247 | 0.204 | 0.177 |
| Apr | 0.274 | 0.272 | 0.269 | 0.263 | 0.252 | 0.233 | 0.206 | 0.176 | 0.149 | 0.137 |
| May | 0.210 | 0.209 | 0.207 | 0.203 | 0.195 | 0.182 | 0.163 | 0.141 | 0.123 | 0.114 |
| Jun | 0.177 | 0.176 | 0.174 | 0.171 | 0.164 | 0.153 | 0.137 | 0.119 | 0.103 | 0.096 |
| Jul | 0.156 | 0.156 | 0.154 | 0.151 | 0.145 | 0.135 | 0.121 | 0.105 | 0.091 | 0.085 |
| Aug | 0.142 | 0.141 | 0.140 | 0.137 | 0.131 | 0.122 | 0.110 | 0.095 | 0.083 | 0.077 |
| Sep | 0.130 | 0.129 | 0.128 | 0.125 | 0.120 | 0.112 | 0.101 | 0.087 | 0.076 | 0.070 |
| Natural Duration curves | | | | | | | | | | |
| Oct | 1.533 | 0.985 | 0.718 | 0.660 | 0.499 | 0.402 | 0.318 | 0.270 | 0.195 | 0.128 |
| Nov | 6.100 | 3.484 | 2.513 | 1.703 | 1.409 | 0.991 | 0.839 | 0.623 | 0.340 | 0.209 |
| Dec | 6.909 | 4.015 | 2.897 | 2.319 | 1.944 | 1.595 | 1.219 | 0.696 | 0.450 | 0.306 |
| Jan | 7.831 | 4.409 | 2.914 | 2.167 | 1.669 | 1.259 | 0.968 | 0.775 | 0.611 | 0.345 |
| Feb | 11.435 | 5.039 | 2.815 | 1.781 | 1.360 | 1.220 | 0.851 | 0.692 | 0.544 | 0.367 |
| Mar | 6.626 | 3.734 | 2.536 | 1.342 | 1.228 | 1.071 | 0.787 | 0.590 | 0.418 | 0.240 |
| Apr | 3.076 | 2.147 | 1.321 | 1.131 | 1.034 | 0.873 | 0.699 | 0.557 | 0.419 | 0.280 |
| May | 1.538 | 1.271 | 0.918 | 0.748 | 0.631 | 0.562 | 0.473 | 0.398 | 0.336 | 0.206 |
| Jun | 1.204 | 0.889 | 0.716 | 0.611 | 0.520 | 0.431 | 0.391 | 0.339 | 0.303 | 0.198 |
| Jul | 0.923 | 0.705 | 0.616 | 0.530 | 0.458 | 0.414 | 0.361 | 0.335 | 0.274 | 0.184 |
| Aug | 0.735 | 0.573 | 0.497 | 0.467 | 0.444 | 0.388 | 0.331 | 0.301 | 0.259 | 0.170 |
| Sep | 0.685 | 0.493 | 0.434 | 0.404 | 0.369 | 0.327 | 0.280 | 0.238 | 0.210 | 0.179 |

**EWR 9**

## EWR 10

Steelpoort River
IUA 6
RU 66

Desktop Version 2, Printed on 2008/07/03
Summary of IFR rule curves for : B41K Generic Name
Determination based on site specific parameters from SPATSIM database.
Regional Type : Olifants ERC = D

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

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

Reserve flows without High Flows

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

Natural Duration curves

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

# EWR 11

Olifants River

IUA 10

RU 96

Desktop Version 2, Printed on 9/2/2014

Summary of IFR rule curves for : Olifants_11 Generic Name

Determination based on site specific parameters from SPATSIM database.

Regional Type : Olifants ERC = D

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

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 5.963 | 5.921 | 5.827 | 5.632 | 5.269 | 4.671 | 3.827 | 2.854 | 2.023 | 1.637 |
| Nov | 11.353 | 11.288 | 11.151 | 10.881 | 10.374 | 9.490 | 8.083 | 6.129 | 3.951 | 2.580 |
| Dec | 14.783 | 14.696 | 14.516 | 14.159 | 13.490 | 12.323 | 10.466 | 7.887 | 5.011 | 3.202 |
| Jan | 15.647 | 15.207 | 14.748 | 14.188 | 13.396 | 12.034 | 10.329 | 7.958 | 5.316 | 3.654 |
| Feb | 26.483 | 25.063 | 23.748 | 22.399 | 20.803 | 18.091 | 15.433 | 11.740 | 7.623 | 5.033 |
| Mar | 17.392 | 16.943 | 16.464 | 15.865 | 15.000 | 13.510 | 11.601 | 8.947 | 5.989 | 4.129 |
| Apr | 12.940 | 12.850 | 12.646 | 12.223 | 11.436 | 10.140 | 8.310 | 6.203 | 4.401 | 3.564 |
| May | 9.435 | 9.371 | 9.225 | 8.924 | 8.364 | 7.440 | 6.136 | 4.635 | 3.352 | 2.755 |
| Jun | 7.664 | 7.612 | 7.494 | 7.250 | 6.794 | 6.044 | 4.985 | 3.765 | 2.723 | 2.238 |
| Jul | 6.288 | 6.245 | 6.148 | 5.947 | 5.574 | 4.958 | 4.089 | 3.089 | 2.234 | 1.836 |
| Aug | 5.344 | 5.307 | 5.225 | 5.054 | 4.737 | 4.214 | 3.475 | 2.625 | 1.898 | 1.560 |
| Sep | 4.857 | 4.824 | 4.749 | 4.594 | 4.305 | 3.830 | 3.159 | 2.386 | 1.725 | 1.418 |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 5.479 | 5.442 | 5.358 | 5.183 | 4.857 | 4.321 | 3.564 | 2.692 | 1.947 | 1.600 |
| Nov | 8.800 | 8.752 | 8.652 | 8.454 | 8.085 | 7.439 | 6.412 | 4.985 | 3.395 | 2.394 |
| Dec | 10.667 | 10.609 | 10.488 | 10.249 | 9.801 | 9.018 | 7.773 | 6.043 | 4.115 | 2.902 |
| Jan | 12.877 | 12.807 | 12.661 | 12.372 | 11.831 | 10.886 | 9.383 | 7.295 | 4.967 | 3.503 |
| Feb | 16.506 | 16.416 | 16.229 | 15.858 | 15.165 | 13.953 | 12.027 | 9.351 | 6.367 | 4.490 |
| Mar | 14.622 | 14.543 | 14.377 | 14.049 | 13.434 | 12.361 | 10.655 | 8.284 | 5.641 | 3.978 |
| Apr | 11.944 | 11.862 | 11.678 | 11.297 | 10.588 | 9.418 | 7.768 | 5.868 | 4.243 | 3.488 |
| May | 9.435 | 9.371 | 9.225 | 8.924 | 8.364 | 7.440 | 6.136 | 4.635 | 3.352 | 2.755 |
| Jun | 7.664 | 7.612 | 7.494 | 7.250 | 6.794 | 6.044 | 4.985 | 3.765 | 2.723 | 2.238 |
| Jul | 6.288 | 6.245 | 6.148 | 5.947 | 5.574 | 4.958 | 4.089 | 3.089 | 2.234 | 1.836 |
| Aug | 5.344 | 5.307 | 5.225 | 5.054 | 4.737 | 4.214 | 3.475 | 2.625 | 1.898 | 1.560 |
| Sep | 4.857 | 4.824 | 4.749 | 4.594 | 4.305 | 3.830 | 3.159 | 2.386 | 1.725 | 1.418 |
| Natural Duration curves | | | | | | | | | | |
| Oct | 34.155 | 21.024 | 14.527 | 12.407 | 11.003 | 8.535 | 6.978 | 6.411 | 5.462 | 3.741 |
| Nov | 129.340 | 89.815 | 59.460 | 42.091 | 35.104 | 27.207 | 20.629 | 15.845 | 10.096 | 5.972 |
| Dec | 133.404 | 108.580 | 88.153 | 77.106 | 54.126 | 43.078 | 32.658 | 24.335 | 16.540 | 8.737 |
| Jan | 201.803 | 147.711 | 94.915 | 69.601 | 56.041 | 46.195 | 36.376 | 30.514 | 22.364 | 14.303 |
| Feb | 309.020 | 154.398 | 82.866 | 64.922 | 48.582 | 35.884 | 33.027 | 27.468 | 21.615 | 14.563 |
| Mar | 150.653 | 100.455 | 73.167 | 55.417 | 38.564 | 30.208 | 23.600 | 20.228 | 15.901 | 9.229 |
| Apr | 81.944 | 55.328 | 40.517 | 33.546 | 29.398 | 24.205 | 18.839 | 14.039 | 12.014 | 7.045 |
| May | 42.496 | 32.919 | 22.849 | 20.023 | 16.551 | 14.863 | 12.616 | 10.697 | 8.550 | 5.305 |
| Jun | 26.759 | 20.752 | 17.400 | 14.653 | 12.168 | 11.389 | 9.846 | 8.299 | 6.647 | 4.591 |
| Jul | 18.911 | 15.722 | 12.634 | 12.018 | 10.088 | 8.972 | 8.147 | 7.527 | 5.903 | 4.114 |
| Aug | 14.598 | 12.582 | 10.335 | 9.685 | 8.266 | 7.374 | 6.859 | 6.392 | 5.175 | 4.555 |
| Sep | 15.968 | 10.509 | 8.912 | 7.870 | 7.311 | 6.701 | 6.057 | 5.351 | 4.441 | 3.947 |

# EWR 13

Olifants River

IUA 12

RU 105

Desktop Version 2, Printed on 9/2/2014

Summary of IFR rule curves for : Olifants_13 Generic Name

Determination based on site specific parameters from SPATSIM database.

Regional Type : Olifants ERC = C

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

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 6.039 | 6.003 | 5.920 | 5.749 | 5.429 | 4.903 | 4.160 | 3.305 | 2.573 | 2.233 |
| Nov | 11.488 | 11.427 | 11.300 | 11.049 | 10.579 | 9.757 | 8.451 | 6.636 | 4.612 | 3.339 |
| Dec | 15.829 | 15.742 | 15.560 | 15.201 | 14.529 | 13.354 | 11.487 | 8.892 | 6.000 | 4.181 |
| Jan | 17.747 | 16.879 | 16.076 | 15.254 | 14.284 | 12.635 | 11.025 | 8.788 | 6.294 | 4.725 |
| Feb | 38.032 | 34.952 | 32.250 | 29.739 | 27.140 | 22.772 | 19.566 | 15.111 | 10.145 | 7.021 |
| Mar | 20.220 | 19.340 | 18.513 | 17.642 | 16.581 | 14.773 | 12.910 | 10.320 | 7.434 | 5.618 |
| Apr | 14.289 | 14.199 | 13.996 | 13.575 | 12.792 | 11.501 | 9.679 | 7.582 | 5.788 | 4.955 |
| May | 9.766 | 9.709 | 9.579 | 9.311 | 8.812 | 7.989 | 6.827 | 5.490 | 4.347 | 3.816 |
| Jun | 7.939 | 7.893 | 7.788 | 7.572 | 7.170 | 6.507 | 5.570 | 4.493 | 3.571 | 3.142 |
| Jul | 6.412 | 6.375 | 6.291 | 6.118 | 5.795 | 5.264 | 4.514 | 3.650 | 2.912 | 2.568 |
| Aug | 5.417 | 5.386 | 5.316 | 5.171 | 4.901 | 4.456 | 3.828 | 3.104 | 2.486 | 2.199 |
| Sep | 4.912 | 4.884 | 4.821 | 4.691 | 4.448 | 4.048 | 3.482 | 2.832 | 2.276 | 2.017 |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 5.338 | 5.308 | 5.239 | 5.096 | 4.830 | 4.392 | 3.773 | 3.061 | 2.453 | 2.169 |
| Nov | 7.798 | 7.762 | 7.688 | 7.540 | 7.263 | 6.781 | 6.013 | 4.946 | 3.757 | 3.009 |
| Dec | 9.486 | 9.442 | 9.350 | 9.169 | 8.830 | 8.238 | 7.297 | 5.988 | 4.530 | 3.612 |
| Jan | 11.645 | 11.591 | 11.478 | 11.255 | 10.836 | 10.105 | 8.942 | 7.327 | 5.526 | 4.393 |
| Feb | 15.468 | 15.396 | 15.245 | 14.947 | 14.389 | 13.413 | 11.862 | 9.707 | 7.305 | 5.794 |
| Mar | 14.118 | 14.052 | 13.915 | 13.643 | 13.133 | 12.242 | 10.827 | 8.859 | 6.666 | 5.287 |
| Apr | 12.335 | 12.263 | 12.098 | 11.758 | 11.123 | 10.078 | 8.603 | 6.904 | 5.452 | 4.777 |
| May | 9.766 | 9.709 | 9.579 | 9.311 | 8.812 | 7.989 | 6.827 | 5.490 | 4.347 | 3.816 |
| Jun | 7.939 | 7.893 | 7.788 | 7.572 | 7.170 | 6.507 | 5.570 | 4.493 | 3.571 | 3.142 |
| Jul | 6.412 | 6.375 | 6.291 | 6.118 | 5.795 | 5.264 | 4.514 | 3.650 | 2.912 | 2.568 |
| Aug | 5.417 | 5.386 | 5.316 | 5.171 | 4.901 | 4.456 | 3.828 | 3.104 | 2.486 | 2.199 |
| Sep | 4.912 | 4.884 | 4.821 | 4.691 | 4.448 | 4.048 | 3.482 | 2.832 | 2.276 | 2.017 |
| Natural Duration curves | | | | | | | | | | |
| Oct | 38.986 | 26.997 | 20.968 | 17.600 | 15.576 | 12.698 | 10.353 | 9.681 | 8.180 | 6.776 |
| Nov | 135.664 | 100.667 | 69.591 | 52.118 | 43.958 | 35.305 | 27.643 | 21.053 | 14.379 | 9.140 |
| Dec | 159.226 | 121.393 | 103.136 | 94.105 | 74.395 | 52.628 | 42.552 | 32.583 | 25.243 | 14.049 |
| Jan | 250.168 | 172.678 | 119.762 | 89.169 | 74.817 | 61.302 | 49.884 | 42.716 | 31.075 | 23.111 |
| Feb | 342.101 | 221.970 | 109.433 | 83.180 | 69.887 | 59.131 | 48.223 | 42.617 | 35.417 | 25.781 |
| Mar | 206.541 | 161.772 | 109.711 | 82.855 | 55.052 | 44.153 | 37.392 | 32.919 | 26.154 | 18.022 |
| Apr | 109.815 | 75.741 | 57.785 | 51.786 | 42.215 | 36.412 | 31.308 | 23.322 | 20.988 | 14.394 |
| May | 53.913 | 42.593 | 35.559 | 30.279 | 25.680 | 23.581 | 20.046 | 17.089 | 15.095 | 9.909 |
| Jun | 36.292 | 28.360 | 24.880 | 21.825 | 19.383 | 17.963 | 15.567 | 14.016 | 11.863 | 8.765 |
| Jul | 27.845 | 21.935 | 18.922 | 17.398 | 14.639 | 13.908 | 12.907 | 11.604 | 9.901 | 7.680 |
| Aug | 20.214 | 17.507 | 15.222 | 14.027 | 12.287 | 11.481 | 10.794 | 10.338 | 8.610 | 7.056 |
| Sep | 22.029 | 16.150 | 13.962 | 12.191 | 11.038 | 10.177 | 9.425 | 8.461 | 7.230 | 6.478 |

## EWR 16

Olifants River

IUA 12

RU 116

Desktop Version 2, Printed on 9/2/2014
Summary of IFR rule curves for : Olifants_16 Generic Name
Determination based on site specific parameters from SPATSIM database.
Regional Type : Olifants ERC = C

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

| | % Points | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Month | 10% | 20% | 30% | 40% | 50% | 60% | 70% | 80% | 90% | 99% |
| Oct | 5.687 | 5.650 | 5.566 | 5.393 | 5.069 | 4.537 | 3.785 | 2.919 | 2.179 | 1.834 |
| Nov | 10.423 | 10.366 | 10.246 | 10.008 | 9.564 | 8.788 | 7.554 | 5.839 | 3.928 | 2.725 |
| Dec | 14.411 | 14.329 | 14.158 | 13.820 | 13.187 | 12.082 | 10.324 | 7.882 | 5.160 | 3.447 |
| Jan | 16.772 | 15.998 | 15.271 | 14.506 | 13.575 | 11.989 | 10.357 | 8.089 | 5.561 | 3.970 |
| Feb | 36.487 | 33.633 | 31.114 | 28.744 | 26.246 | 22.043 | 18.807 | 14.312 | 9.300 | 6.148 |
| Mar | 19.520 | 18.732 | 17.975 | 17.152 | 16.110 | 14.333 | 12.397 | 9.706 | 6.707 | 4.820 |
| Apr | 13.746 | 13.654 | 13.445 | 13.013 | 12.208 | 10.883 | 9.012 | 6.858 | 5.016 | 4.160 |
| May | 9.401 | 9.341 | 9.205 | 8.923 | 8.398 | 7.532 | 6.311 | 4.905 | 3.702 | 3.143 |
| Jun | 7.603 | 7.555 | 7.446 | 7.219 | 6.797 | 6.102 | 5.121 | 3.991 | 3.026 | 2.576 |
| Jul | 6.155 | 6.116 | 6.028 | 5.846 | 5.507 | 4.947 | 4.158 | 3.249 | 2.472 | 2.111 |
| Aug | 5.216 | 5.183 | 5.109 | 4.956 | 4.670 | 4.199 | 3.535 | 2.770 | 2.116 | 1.812 |
| Sep | 4.740 | 4.711 | 4.644 | 4.505 | 4.247 | 3.822 | 3.222 | 2.531 | 1.940 | 1.665 |
| Reserve flows without High Flows | | | | | | | | | | |
| Oct | 5.126 | 5.094 | 5.022 | 4.871 | 4.590 | 4.128 | 3.476 | 2.724 | 2.082 | 1.783 |
| Nov | 7.438 | 7.400 | 7.323 | 7.169 | 6.882 | 6.380 | 5.581 | 4.472 | 3.236 | 2.458 |
| Dec | 9.123 | 9.077 | 8.981 | 8.791 | 8.436 | 7.816 | 6.831 | 5.461 | 3.934 | 2.974 |
| Jan | 11.402 | 11.344 | 11.224 | 10.986 | 10.540 | 9.761 | 8.523 | 6.803 | 4.885 | 3.679 |
| Feb | 15.674 | 15.594 | 15.428 | 15.100 | 14.484 | 13.410 | 11.701 | 9.327 | 6.681 | 5.016 |
| Mar | 14.150 | 14.078 | 13.928 | 13.631 | 13.076 | 12.106 | 10.564 | 8.420 | 6.031 | 4.528 |
| Apr | 12.113 | 12.036 | 11.859 | 11.494 | 10.814 | 9.694 | 8.112 | 6.292 | 4.735 | 4.011 |
| May | 9.401 | 9.341 | 9.205 | 8.923 | 8.398 | 7.532 | 6.311 | 4.905 | 3.702 | 3.143 |
| Jun | 7.603 | 7.555 | 7.446 | 7.219 | 6.797 | 6.102 | 5.121 | 3.991 | 3.026 | 2.576 |
| Jul | 6.155 | 6.116 | 6.028 | 5.846 | 5.507 | 4.947 | 4.158 | 3.249 | 2.472 | 2.111 |
| Aug | 5.216 | 5.183 | 5.109 | 4.956 | 4.670 | 4.199 | 3.535 | 2.770 | 2.116 | 1.812 |
| Sep | 4.740 | 4.711 | 4.644 | 4.505 | 4.247 | 3.822 | 3.222 | 2.531 | 1.940 | 1.665 |
| Natural Duration curves | | | | | | | | | | |
| Oct | 40.005 | 27.834 | 21.569 | 18.257 | 16.110 | 13.269 | 10.745 | 10.226 | 8.509 | 7.030 |
| Nov | 139.209 | 101.204 | 70.351 | 53.329 | 44.518 | 35.745 | 28.318 | 21.852 | 14.649 | 9.549 |
| Dec | 169.310 | 127.901 | 108.094 | 95.654 | 77.292 | 58.744 | 46.464 | 33.281 | 26.355 | 14.423 |
| Jan | 301.721 | 185.447 | 123.536 | 95.520 | 76.079 | 66.906 | 53.211 | 44.751 | 33.610 | 24.108 |
| Feb | 403.100 | 261.698 | 120.304 | 94.808 | 77.402 | 61.996 | 50.128 | 45.176 | 35.962 | 26.608 |
| Mar | 241.614 | 177.102 | 122.950 | 86.081 | 56.369 | 49.776 | 39.083 | 34.636 | 27.684 | 18.690 |
| Apr | 116.346 | 83.009 | 63.522 | 53.160 | 44.066 | 38.449 | 32.639 | 24.649 | 21.601 | 15.154 |
| May | 55.526 | 44.702 | 36.820 | 31.119 | 27.233 | 25.034 | 21.158 | 17.790 | 15.834 | 10.353 |
| Jun | 37.901 | 29.383 | 26.308 | 22.411 | 20.482 | 18.858 | 16.138 | 14.637 | 12.508 | 9.140 |
| Jul | 29.245 | 23.656 | 19.866 | 18.272 | 15.539 | 14.636 | 13.964 | 12.093 | 10.323 | 7.997 |
| Aug | 21.382 | 18.720 | 15.681 | 14.729 | 13.071 | 12.130 | 11.473 | 10.898 | 8.931 | 7.273 |
| Sep | 22.928 | 17.226 | 14.703 | 12.731 | 11.952 | 10.787 | 9.950 | 9.093 | 7.585 | 6.725 |

# Appendix C: Letter of Response, DWS

water & sanitation

Department:
Water and Sanitation
**REPUBLIC OF SOUTH AFRICA**

Private Bag X313, Pretoria 0001 / Sedibeng Building, 185 Francis Baard Street, Pretoria
Tel: 012 336 7500 Fax: 012 323 4470 or 012 326 2715

**Enquiries**: Mr L Mabuda **Tel**: 012 336 8477 **Email**: MabudaL@dws.gov.za **Ref.**: 14/16/12/2

Mr Danie Pienaar
Acting Managing Executive
Kruger National Park
Private Bag X402
**SKUKUZA**
1350

Dear Mr Pienaar

**FOLLOW-UP ON THE IMPLEMENTATION OF THE ECOLOGICAL RESERVE AND AUGMENTATION FROM STORAGE FROM DAMS IN THE OLIFANTS RIVER SYSTEM**

I refer to your letter dated 14 June 2016, in which you were requesting the implementation of operating rules study for both the Blyderivierpoort and De Hoop Dams in an effort to meet bulk water requirements for Lepelle Northern Water (LNW) and the Environmental Water Requirements (EWRs) in the Kruger National Park.

Given that the water allocations from the De Hoop Dam are not currently utilized, the possibility to shift some or all of LNW's demand from the Blyde Dam to the De Hoop Dam in order to ensure adequate supply for agricultural sector during 2016-2017 growing season, as well as meet the water requirements for the Maruleng Local Municipality is acceptable, provided that the De Hoop Dam is not drained to a point that the dam starts with low storage after the rainy season. It is therefore recommended that 5 million $m^3/a$ allocation for Lepelle Northern Water from the Blyderivierpoort Dam be shifted to the De Hoop Dam and that the Integrated Olifants/Blyde operating rules should be implemented to impose restrictions on the remaining demands.

Implementing the Integrated Olifants operating rules and utilising RESLIM-O Decision Support System (DSS) to provide operations support for releases of water from the De Hoop Dam is supported. I would thus request you to share with my Department the results of the technical analysis and plans of the RESILIM-O DSS that you intend to implement to optimise releases from the De Hoop Dam. This will enable my technical staff to provide input and advice regarding implementation of this tool.

Issues raised regarding the hydraulic study to track and monitor slug/controlled releases from the De Hoop Dam down to meet the downstream water requirements for the Kruger National

Park, LNW and International Obligations will be addressed through the Integrated Olifants River System Operating Rule study which my Department has already completed the Terms of Reference (ToR) for. The main objectives of this study are to:

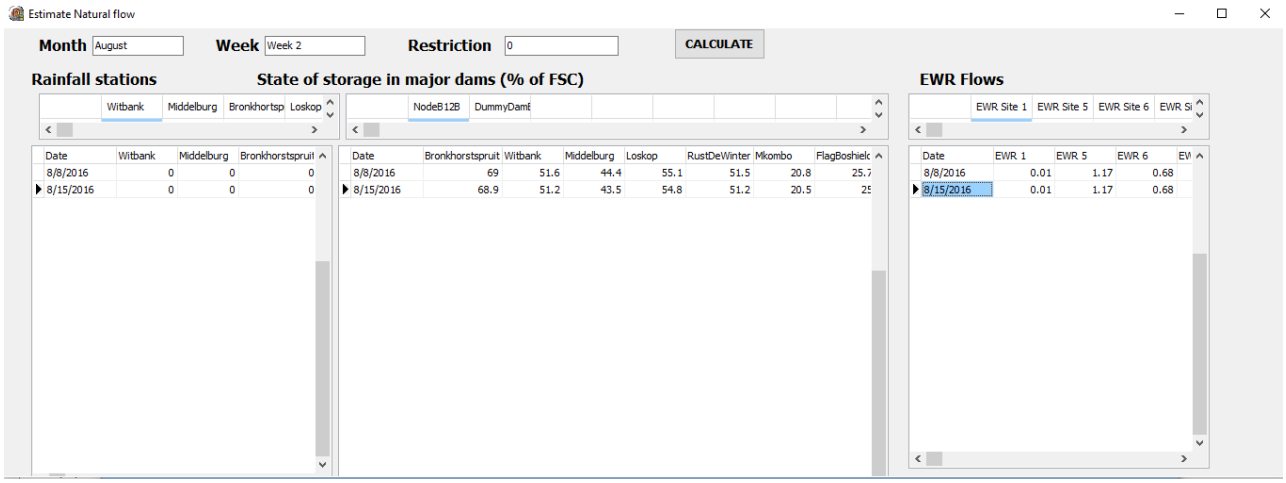
- develop the Integrated System Annual Operating Rules, which will be applied to regulate the systems' water availability so that its distribution can be reconciled with the water demand patterns on the systems;
- improve the efficiency of use of the available resource including the conjunctive use of all resources within a systems context, and detailed information on the timing and location of water requirements;
- Development/calibration of the Decision Support System (DSS); and
- Determination of the state of water resources availability and reconcile these with water demand patterns.

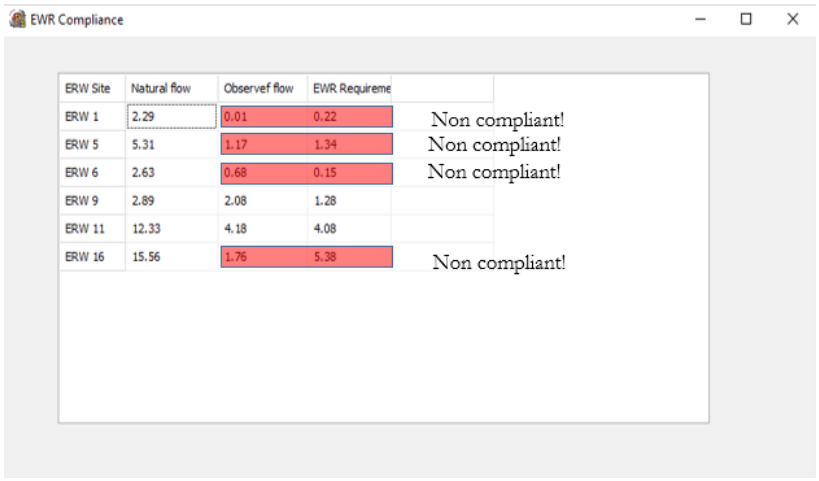
This study therefore aims to enable optimisation of system operation for the Olifants River System in an integrated manner. My Department thus supports the request and cooperation to achieve the implementation of EWR and the efforts by stakeholders to improve the situation particularly the implementation of water restrictions by the Agricultural sector and other key stakeholders is most welcome.

Yours sincerely

**Mr Sifiso Mkhize**
**ACTING DIRECTOR-GENERAL**
**DATE:** 15/7/16

# Appendix D: Example User Interface WReMP model for Olifants system



# Appendix E: River Management Log used by KNP to document river operations

**RIVER MANAGEMENT COMMUNICATION LOGSHEET**

**KNP**

| Management Problem | Management Options | Management Action | Result |
|---|---|---|---|
| 30 Aug 2016<br><br>Crocodile River Irrigation allocation and river flow reduction from Riverside to Mozambique border | 1. Inform DWS / IUCMA<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**IUCMA notice to all** | **Dawie van Rooy, TSB Sugar:**<br>Propose that the 20 hour/week irrigation is maintained and also that outlet from Kwena must be increased slightly<br><br>  <br>Fw 16 Kwena performance Aug Dav | |
| 30 Aug 2016<br>Luvuvhu River flow at Mhinga restored to Reserve level (0.7 cumec) | 1. Inform DWS<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**KNP RM informed DWS** | Meetings with the regional infrastructure branch manager of DWS and with the Nandoni Dam Operator to inform them of KNP River Management procedure seem to have improved the situation<br><br>  <br>WhatsApp Chat with Luvuvhu.txt<br>. | Flow recovered to 0.7 cumec |
| 22 Aug 2016<br>Sabie River at Phabeni<br><br>KNP need to do emergency excavation works at Phabeni abstraction works | 1. Inform DWS<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**KNP RM informed IUCMA** | **Eddie Riddell – KNP River Manager**:<br>Please be aware that the KNP has had to commence with some emergency excavation of sand around our abstraction points at Phabeni gate due to low flows<br><br>**Brian Jackson:**<br>**Specialist Manager: IUCMA**<br>We will increase outlet from Sept as the reserve is higher then | No action required from IUCMA yet, this is just to inform them. With the increase in temperature it might be necessary to increase outflow from Inyaka Dam soon |
| 19 Aug 2016<br>Luvuvhu River flow | 1. Inform DWS<br>2. Change dam | **Eddie Riddell – KNP River Manager**:<br>Solly, flows at Mhinga dropped to very low | Outflow from Nandoni was increased on 20 Aug from |

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| at Mhinga dropped to 0.5 cumec and below IFR of 0.7 cumec | releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**KNP RM informed DWS** | levels, is there still 1.6 cumec released from Nandoni?<br><br>Dear Sandra and Albert<br>Please note that releases from Nandoni dam were unexpectedly reduced over the past two days, such that flows at Mhinga reduced to 0.4 cumec. We were not informed | 190mm to 280mm and then to 200mm (1.3 cumec). |
| 15 Aug 2016<br><br>Crocodile river flow in Very High worry level<br><br>Flow – 0.36 cumec<br>Reserve – 1.53 cumec | 1. Inform DWS / IUCMA<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**KNP informed IUCMA and DWS** | Crocodile River at Ten Bosh is currently flowing below the Very High Worry zone and is currently 0.36 cumec instead of the 0.6 cumec interim minimum. Flow at Karino is 3.1 cumec but at Riverside is only 0.5 cumec instead of the 1.8 cumec target.<br><br>**Brian Jackson:**<br>**Specialist Manager: Water Resources Planning and Operations - IUCMA**<br>We have banned irrigation for 3 days as of yesterday and have released more from Kwena from Friday. We also made a pulse release from yesterday until this morning of 7 cumecs to get water down there quicker.<br>However, I am concerned for September and October. Without rains we will be under severe stress as we will no longer have enough | Flow increased to 0.8 cumec |
| 8 Aug 2016<br>Olifants river flow drops to 1 cumec. RQO = 2.18 cumec | 1. Inform DWS / Lepelle<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**Inform Lepelle** | **Eddie Riddell – KNP River Manager**: Flow dropped and then recovered. What is the present status at Barrage?<br><br>**Levy Majadibodu : Scheme Manager Lepele:**<br>We had increased flow from Blyde Dam | Flow back to 2.5 cumec at Mamba<br><br>WhatsApp Chat with Lower Olifants.txt |
| 26 Jul 2016<br><br>Olifants River flow drops to 1.2 cumec. Reserve 2.5 cumec | 1. Inform DWS / Lepelle<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br><br>**Inform Lepelle** | **Eddie Riddell – KNP River Manager**: Levy – Flow at Mamba very low, what is the present status at Barrage?<br><br>**Levy Majadibodu : Scheme Manager Lepele:**<br>Will look into it and inform | 16mm rain received on 27 July<br><br>Flow increased and stayed above Reserve for rest of the month. |
| 21 Jul 2016 | 1. Inform DWS | **Eddie Riddell – KNP River Manager**: Augmentation from Inyaka will be required | Flow in Sabie increased to 3.5 cumec |

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| Sabie river flow drop to 1.5 cumec<br>Reserve = 4 cumec | 2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br>**KNP RM informed DWS** | to improve flow<br>**Mr Sipho Magagule – IUCMA**<br>Confirmed that release was made – 25 Jul | |
| 23 June 2016<br>Luvuvhu River flow at Mhinga dropped to 0.6 cumec and below IFR of 0.9 cumec | 1. Inform DWS<br>2. Change dam releases<br>3. Water Restrictions<br>4. Verify flow readings<br>**KNP RM informed DWS** | **Eddie Riddell – KNP River Manager**: Please inform if the release from Nandoni was made as requested?<br>**Mr. Solly Thantsha' Area Manager Department of Water & Sanitation:** Sorted out today, the Water control officer forgot to adjust | Flow at Mhinga increased to 1.2 cumec |