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OLIFANTS RIVER WATER SUPPLY SYSTEM RECONCILIATION STRATEGY (CONTINUATION PHASE 1): (WP 10575)

Olifants River Water Supply System Reconciliation Strategy 2015

September 2015
FINAL

Title:	**OLIFANTS RIVER WATER SUPPLY SYSTEM RECONCILIATION STRATEGY 2015**
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EXECUTIVE SUMMARY

The Department of Water and Sanitation (DWS) completed a project for the "Development of a Reconciliation Strategy for the Olifants River Water Supply System" [4][5]*in 2012 (referred to as the 2012 Strategy). The Reconciliation Strategy recommended the most cost effective interventions to reconcile the growing water requirements and possible supply augmentation options. Now that the Strategy is developed, it needs to be implemented to ensure sustainable water use in the water supply system. Custodians for the recommended interventions of the Strategy needed to be identified and their initiatives needed to be tracked in terms of progress and success over time. In this way the Strategy can be updated to determine if the recommended interventions are effective and sufficient to obtain a positive water balance in future. This is mainly achieved by the establishment of an Olifants River Reconciliation Strategy Steering Committee (SSC), supported by DWS and an appointed PSP.*

To support the implementation of the Olifants River Reconciliation Strategy, the DWS commissioned the Olifants River Water Supply System Reconciliation Strategy – Continuation Phase 1 Study. The proposed scope of work for the study can be summarized as follows:

- *Support the implementation of the Strategy by providing the administrative and technical support to the SSC.*
- *Systematically maintain and improve the Water Resource Reconciliation Strategy so that remains relevant, technically sound, economically viable, socially acceptable and sustainable; therefore enabling its implementation.*
- *Ensure that the reconciliation scenario assumptions are tracked against observed data and that the strategies are updated accordingly.*
- *Track and co-ordinate the implementation progress of quantity and quality interventions as well as related actions proposed in the Strategy.*
- *Recommend planning activities that will ensure future reconciliation of requirements and available supply in the Olifants River System supply area.*

The 2012 Strategy was reassessed by formulating a "Full Balance" scenario to meet high water requirement growth scenarios and individual dam balances were developed to assess the transfer infrastructure constraints on the full balance scenario.

The current and projected water requirements (urban, industrial and irrigation water use sectors) were firstly adopted from the 2012 Strategy and the urban and mining water use sector water requirement information was updated where information was available from the following studies:

- *City of Tshwane Water Resources Masterplan (CoT, 2014)*[1] *where the water requirement projections for the City of Tshwane supply area in the Upper Olifants Catchment were updated.*
- *Continuation of the Northern Planning Region All Town Reconciliation Strategies where the strategies and hence water requirement information were updated for certain towns in the study area (DWS, 2015c)*[10]*.*
- *Olifants River Water Resources Development Project (Phase 2) Bulk Distribution System (ORWRDP-2 BDS) study (Municipal and Mining Water Requirements Approval report (DWS, 2015a)*[8] *where the water requirement projections of the mining and urban sector, to be supplied from the Olifants River Water Resource Development Project (ORWRDP), were updated. The noticeable shift in the intended planned mining developments from the Sekhukhune DM area to the Mogalakwena LM area had an impact on the projected mining as well as the municipal water requirements in the affected areas (Sekhukhune DM, Capricorn DM, Polokwane LM, Mogalakwena LM) which were as updated as a result.*

The existing DWSWater Resources Planning Model (WRPM) configuration for the Olifants River System was obtained and used as the base for this study. The main updates included the updated water requirement projections obtained from the study. The other main changes that were incorporated are summarised below:

- *The inclusion of the latest EWRs as from the Classification Study;*
- *The water requirement projections and future infrastructure changes relating to the Flag Boshielo and De Hoop area were carefully configured;*
- *The existing operating rule of the Loskop Irrigation Board was included;*
- *The updating of selected mine modules.*

T*he WRPMwas initially configured with updated information to assess the risks associated with the "Full balance" Scenario for each of the individual dam balances.*

Individual water balance projections were also prepared for the main dams in the Olifants River System covering the planning period until 2035. In all cases the High growth water requirement projections were applied to provide a conservative planning schedule for intervention options. Appropriate assurance of supply yield information (related to the type of water users supplied from each dam) formed the basis of the water availability shown in the water balances. The water balances also included the Ecological Water Requirements (EWRs) as determined in the recently completed Classification Study.

Updated information on the planned interventions and revised water requirement information from the ORWRDP Phase 2 investigations were incorporated into the De Hoop and Flag Boshielo Dams' individual Dam Balances in subsequent Scenarios. Full implementation of the ORWRDP is required to augment the system deficit at Flag Boshielo Dam through the utilisation of all De Hoop Dam's available yield.

The De Hoop dam water balance is presented in ***Figure 1****. De Hoop Dam's 1:100 year assured yield, after allowances for in catchment downstream users and EWR requirements can be utilised by implementing all the ORWRDP phases (conveyance infrastructure) and indirectly augmenting Flag Boshielo Dam subsystem over the medium term. From the* ***Figure 1*** *it can be seen that all the ORWRDP Phases 2C, 2D, 2E and 2F are required to fully utilise De Hoop, and hence reduce the water requirements imposed on Flag Boshielo Dam.*

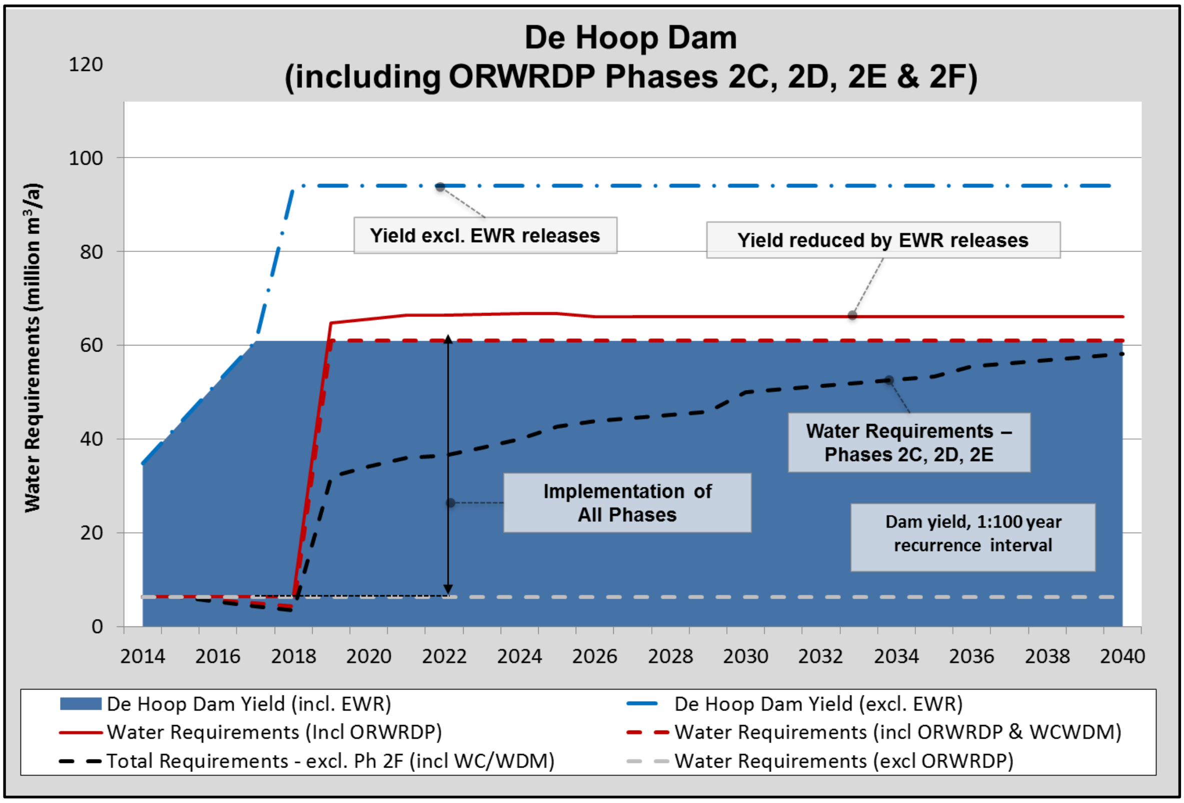

Figure 1: Water Balance Projection for De Hoop Dam

*The projected water balance of Flag Boshielo Dam is presented in **Figure 2**. The reduction in water use prior to 2019 is due to the removal of compensation releases (the implementation of EWR releases are accounted for in the Flag Boshielo Dam yield), support from De Hoop Dam as well as due to the implementation of WC/WDM measures. It is interesting to note how much higher the water requirement projection would have been if the ORWRDP conveyance infrastructure Phases were not implemented (grey dashed line).*

***Figure 2** shows that there will be deficits over the short term until the ORWRDP phases are implemented in full by 2019. This deficit can be mitigated since the actual current irrigation use from the dam is less than the total allocations, which was included in the balance diagram. The graph shows that due to the favourable current storage conditions and through the implementation of the following interventions listed below, augmentation is needed from 2026 onwards:*

- *Full implementation of WC/WDM*
- *AIP removal in the Flag Boshielo Dam Catchment*
- *Re-use of urban/municipal waste water (Polokwane, Mokopane and Lebowakgomo)*

The impact of the favourable storage conditions on the required augmentation date (blue shaded area, referred to as "Reliable supply due to favourable storage conditions") was confirmed through sophisticated water resource system risk analysis undertaken by the ORWRDP Phase 2 investigations (DWS 2015b)[9]. The augmentation requirements grow to 45 million m^3 per annum by 2030 and 66 million m^3 per annum by 2040.

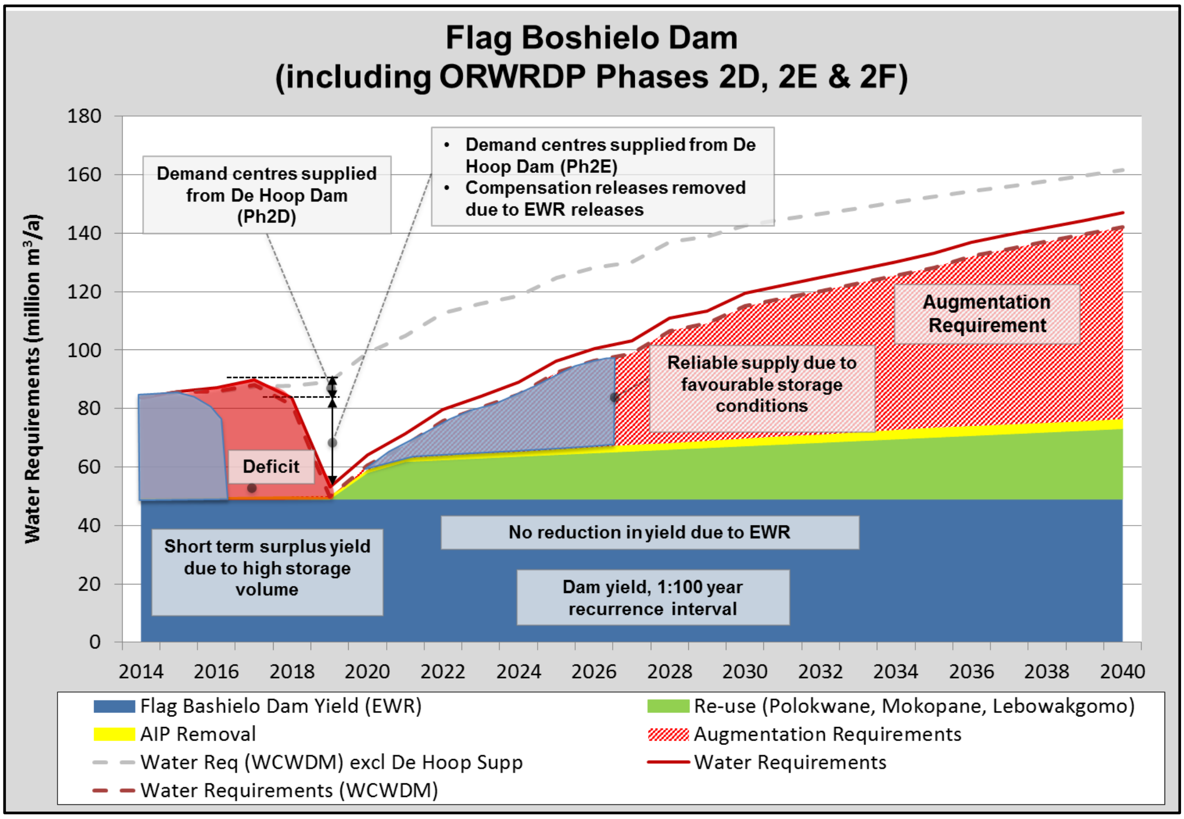

Figure 2: Water Balance Projection for Flag Boshielo Dam

*The water balance projections for the dams Middleburg Dam, Witbank Dam and Loskop Dams (Upper Olifants River Catchment) and the Phalaborwa Barrage (Lower Olifants River Catchment) with the intervention required to ensure there are sufficient water resources available to meet the projected water requirements throughout the planning period are presented in the document (**Section 0**). The projected water balance for the City of Tshwane supply area in the Upper Olifants Catchment (Premier Mine Dam and Bronkhorstspruit Dam) was investigated as part of the City of Tshwane Water Resources Masterplan (CoT, 2014)[1] which is also discussed in the document.*

Perspectives from the final water balances can be summarised as follows:

- *The implementation of EWR releases downstream of Loskop and Flag Boshielo dams will have to be made gradually to maintain the assurance of supply at acceptable levels. The EWR releases from Loskop Dam will have to occur in unison with the implementation of intervention measures such as savings in water requirements through WC/WDM, relocation of water use entitlements and/or accepting a reduced assurance of supply (higher risk or drought restrictions). The June 2015 scenario made provision for the full EWR release to be implemented by 2025. The EWR downstream of De Hoop Dam should be implemented in full once the dam has been commissioned*
- *Reuse of treated effluent is required for Middelburg, eMalahleni while Polokwane, Mokopane and Lebowakgomo need to continue and expand their reuse activities.*
- *Deficits are projected for both Witbank and Loskop dams (with gradual implementation of the EWR at Loskop Dam) by the year 2025.*
- *The Western Highveld area requires full implementation of WC/WDM, direct support from the total surplus yield from Rust de Winter Dam (based on the assumption that the current downstream irrigation will remain constant and not increase irrigation water use has decreased historically)) and additional augmentation from Rand Water.*

- *The Flag Boshielo Dam water users' assurance of supply is at risk from 2016 to 2019, pending the implementation of all the ORWRDP Phases. After the full implementation of the ORWRDP, deficits are projected only from 2026 for Flag Boshielo Dam, due to the dams being relatively full at the start of the simulation period (May 2014). ORWRDP Phases 2C, 2D, 2E and 2F are therefore essential to prevent water shortages before 2026 at Flag Boshielo Dam by the utilisation of De Hoop Dam yield.*
- *The overall Olifants River Water Supply System therefore needs augmentation as soon as 2025 in certain parts of the systems, and augmentation requirements are estimated to be as much as 59 million m^3/a in 2035 and 69 million m^3/a in 2040.*

*A Strategy Intervention Implementation Plan (SIP) was developed (**Appendix D**) which provides the following detail:*

- *Elements of the plan, include the current Strategy Interventions as well as Supporting Infrastructure and Operational Projects to give effect to the Strategy.*
- *The main custodians for each element (Note that the listed custodians are not inclusive of all role players that that need to be involved in the implementation of the interventions or projects)*
- *Organisations involved with each element.*
- *The total volume and projected cumulative volumes per year for each intervention for the current dated Scenario.*
- *Duration of interventions or supporting projects that gives effect to the Strategy.*

A description of the status of the following different interventions and supporting projects is provided:

- *Interventions:*
  - *WC/WDM (Irrigation, Urban and Mining Sectors)*
  - *Eliminate Unlawful Use*
  - *Development of Groundwater Resources*
  - *Removal of Invasive Alien Plants*
  - *Treatment of mine water*
  - *Municipal effluent re-use*
- *Supporting Infrastructure Development and Operational Projects:*
  - *Olifants River Water Resources Development Project*
  - *Determination, Review and Implementation of the Reserve in the Olifants/Letaba System*
  - *Integrated Olifants River Supply System Operating rules*

Although the tracking and updating of all the listed Strategy Interventions is important for the successful implementation of the Olifants River Reconciliation Strategy, the need for large scale interventions by 2026 are however more pressing. It is therefore recommended that:

- *Groundwater augmentation investigations should be initiated as soon as possible.*
- *The 2012 Strategy options for lower priority large scale augmentation need to be re-evaluated and potentially taken to a pre-feasibility stage as soon as possible.*
- *The SSC recommended that compulsory licensing, or similar reallocation initiatives, may have to be initiated for the Olifants River catchment to ensure a positive water balance over the long term future. It was recognised that clear policy and well thought out processes need to be established to avoid any unintended consequences should this fall-back option be considered in future.*

- *An Integrated Olifants River Operating Rule Study needs to be initiated as soon as possible to ensure that all the planning of the Reconciliation Strategy is given effect, thereby avoiding uncontrolled water supply shortages.*

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1. INTRODUCTION

1.1 Background

The water requirements in the Olifants Water Management Area (WMA) and its adjacent supply areas have increased substantially over the last number of years due to increases in a range of activities including power generation, mining, the steel industry, urban development and agriculture. The mining industry in particular has grown significantly. Since the water requirements in the area have increased substantially there are indications that the recently commissioned De Hoop Dam's firm yield will soon be exceeded. The Department of Water and Sanitation (DWS) completed a project for the "Development of a Reconciliation Strategy for the Olifants River System"[4]in 2012. This project recommended the most cost effective interventions to reconcile the growing water requirements and possible supply augmentation options. The Strategy assessed water requirements, water use efficiency options, schemes to provide supplementary water, implementation of the Reserve, groundwater utilisation, decision making, funding, stakeholder commitment, and a host of other options.

Once the Strategy was developed, it needed to be implemented to ensure sustainable water use in the water supply system. Custodians for the recommended interventions of the Strategy needed to be identified and their initiatives needed to be tracked in terms of progress and success over time. In this way the Strategy can be updated to determine if the recommended interventions are effective and sufficient to obtain a positive water balance in future. This is mainly achieved by the establishment of an Olifants River Reconciliation Strategy Steering Committee (SSC), supported by DWS and an appointed PSP.

To support the implementation of the Olifants River Reconciliation Strategy, the DWS commissioned the *Continuation of the Olifants River Water Supply System Water Reconciliation Strategy – Phase 1* Study. The proposed scope of work for the study can be summarized as follows:

- Support the implementation of the Strategy by providing the administrative and technical support to a SSC.
- Systematically maintain and improve the Water Resource Reconciliation Strategy so that it remains relevant, technically sound, economically viable, socially acceptable and sustainable; therefore enabling its implementation.
- Ensure that the reconciliation scenario assumptions are tracked against observed data and that the Strategies are updated accordingly.
- Track and co-ordinate the implementation progress of quantity and quality interventions as well as related actions proposed in the Strategy.
- Recommend planning activities that will ensure future reconciliation of requirements and available supply in the Olifants River System supply area.
- Identify water quality related planning activities that are necessary to improve and sustain the water quality in the Olifants River System supply area.

The 2012 Strategy was reassessed by formulating a "Full Balance" scenario to meet high water requirement growth scenarios and individual dam balances were developed to assess the individual water balance situation and required interventions. The Water Resources Planning Model (WRPM) was configured with updated information to assess the risks associated with the "Full balance" scenario for each of the individual dam balances.

Four Olifants River Reconciliation Strategy Steering Committee (SSC) meetings were held during the course of the study on the following dates:

- SSC 1: March 2013
- SSC 2: October 2013
- SSC 3: June 2014
- SSC 4: June 2015

A flow diagram of the study process and the various study linkages is presented in **Figure 1.1**.

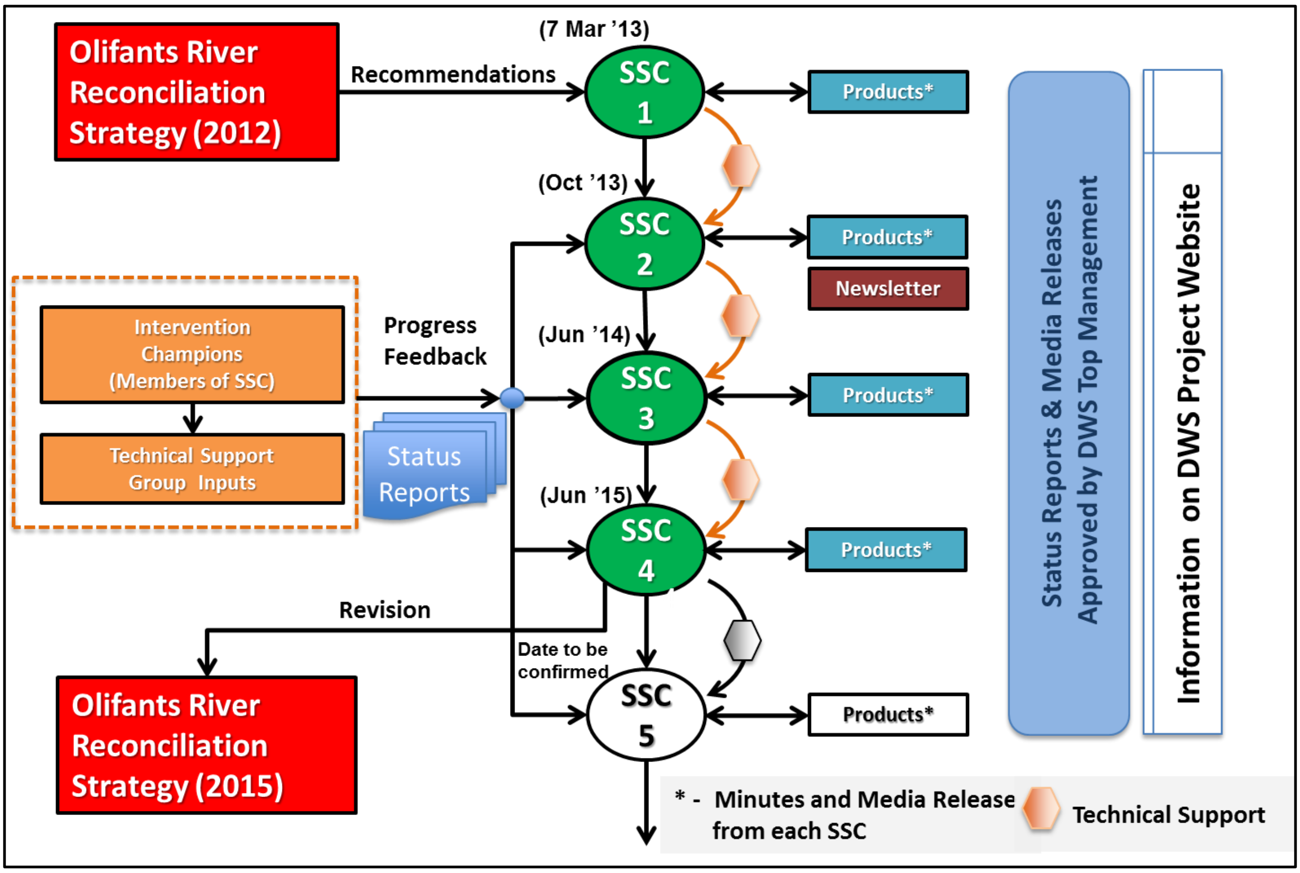

Figure 1.1: Study process

The status of the Reconciliation Strategy Implementation was reported in a status reports which were drafted and distributed after each of the SSC meetings. The main objectives of the SSC meetings, an overview of the updated information, the updated individual large dam water balances and progress on the Strategy Interventions were provided in each of the status reports.

This consolidated report provides the updated Reconciliation Strategy (2015 Strategy), based on the latest updated water balances and also presented the latest Strategy Implementation Plan and associated actions.

1.2 Study Area

The location of the sub-catchments and individual dams in the study area is illustrated in **Figure 1.2**.The major dams in each sub-catchment can be summarised as follows:

- Upper Olifants Catchment: Middelburg, Witbank and Loskop dams.
- Middle Olifants Catchment: Flag Boshielo Dam, newly constructed De Hoop Dam
- Lower Olifants Catchment: Blyderivierpoort Dam and Phalaborwa Barrage.

Water is also supplied from the Olifants River Catchment to Polokwane and Mokopane, and as a result this supply area has been included in **Figure 1.2**(red dotted line).

Figure 1.2: Study Area

1.3 Purpose and Layout of this Report

The purpose of this report is to present the Reconciliation Strategy which is the primary deliverable of the study and a synthesis of all the available information collected as well as investigations carried out during the study period. The report contains water balances for individual large dams with intervention scenarios that provided possible solutions to make sufficient water available for the planning period up to the year 2035.

The report is structured as follows:

- **Chapter 1** describes the rationale for the study, the study area, gives general background information and an overview of the study procedure.
- The methodology applied for updating the Reconciliation Strategy as well as the reconciled water balances for each of the large individual with relevant commentary are presented in **Chapter 2**.
- **Chapter 3** presents the Reconciliation Strategy Implementation Plan.
- The conclusions and recommendations are presented in **Chapter 4**.
- **Chapter 5** contains the references for information used in the study.

2. RECONCILIATION STRATEGY UPDATE

The main purpose of updating the Reconciliation Strategy was to ensure that the Strategy remains relevant, technically sound and socially acceptable and sustainable. The 2012 Strategy was reassessed by formulating a "Full Balance" scenario to meet high water requirement growth scenarios and individual dam balances were developed to assess the individual water balance situation and required interventions. The Water Resources Planning Model (WRPM) was configured with updated information to assess the risks associated with the "Full balance" scenario for each of the individual dam balances.

The water requirements and interventions from the 2012 Strategy were revised, where updated information was available from DWS studies that were being undertaken in the study area over the study period, and incorporated into the individual balances. An important infrastructural intervention that links the Flag Boshielo and De Hoop System and as a results influences the Flag Boshielo Dam and De Hoop Dam water balances is the Olifants River Water Resources Development Project (ORWRDP). It was thus imperative that the latest ORWRDP planning is incorporated into the Strategy for alignment.

The latest ORWRDP planning information, updated water requirements, water resource availability, reconciliation interventions as well as the WRPM risk analysis results used to develop the projected water balances for the large individual dams is presented in this section.

2.1 Olifants River Water Resources Development Project (ORWRDP)

2.1.1 Overview

The purpose of the Olifants River Water Resources Development Project (ORWRDP) is to supply the needs for water (both domestic and mining) in the middle part of the Olifants River catchment, and the adjacent Mogalakwena and Polokwane Municipal areas. The project will facilitate improving social conditions in the area as well as enabling much needed economic development. With mining as the main economic stimulant and major user of water, the opportunity arises to share in the economies of scale to also enable the improved supply of water to urban and rural domestic users, in particular to impoverished communities in the area (DWS 2015b).

The ORWRDP comprises two main phases:

- *Phase 1* involves the raising of the Flag Boshielo Dam on the Olifants River by 5 m (ORWRDP-1) which was completed in 2005; and
- *Phase 2* involves the development of additional water resource infrastructure (the De Hoop Dam on the Steelpoort River and bulk raw water distribution infrastructure) in the middle Olifants catchment (ORWRDP-2). Phase 2 includes nine sub-phases namely:
  - Phase 2A: De Hoop Dam which started in 2007 and is nearing completion
  - Phase 2B: Bulk distribution system from Flag Boshielo to Mokopane.
  - Phase 2C: Bulk distribution system from De Hoop to Steelpoort (which is under construction) including:
    - Jane Furse off-take
    - Spitskop pump station link to supply water in the Dwars River Valley
    - Steelpoort pump station
    - Flow reversal in section of Lebalelo Scheme from Steelpoort town to Groothoek balancing dam and Mooihoek WTW (2D(H))
  - Phase 2D: Bulk distribution system from Steelpoort to Groothoek including:
    - Parallel pipeline
    - Groothoek balancing dam
    - Mooihoek WTW Link

    - Flow reversal in section of Lebalelo Scheme from Groothoek balancing dam to the Havercroft Junction (2E(H))
  - 2E: Possible parallel pipeline Groothoek balancing dam to Havercroft junction
  - 2F: Possible pipeline to OlifantspoortWTW

A simplified schematic of the ORWRDP infrastructure layoutis presented in **Figure 2.1**.

2.1.2 ORWRDP Phase 2 Investigation

The ORWRDP Phase 2 is currently under construction. A Record of Implementing Decisions (RID) report has been issued by the Chief Directorate Integrated Water Resources Planning of the Department of Water and Sanitation (DWS) to the National Water Resources Infrastructure (NWRI) Branch of the DWS in 2008 and designs for the project infrastructure are based on this RID.

The project faces a number of challenges as a result of changing water requirements and difficulty to reconcile these new water requirements with the available water resources. A substantial portion of the mining water requirements have also shifted from the Sekhukhune District Municipality (DM) area to the Mogalakwena Local Municipality (LM) area since the start of the project. The configuration of the project infrastructure required changes and augmentation to water resources which needed to be investigated. It was therefore decided to do a technical review of the planning and design work done so far and where necessary recommend changes in a Technical Review Report that would be used to inform the due diligence process embarked upon by the National Treasury (NT) to consider issuing an explicit guarantee by government or fiscal funding. The current RID report will also be revised to accommodate the changes.

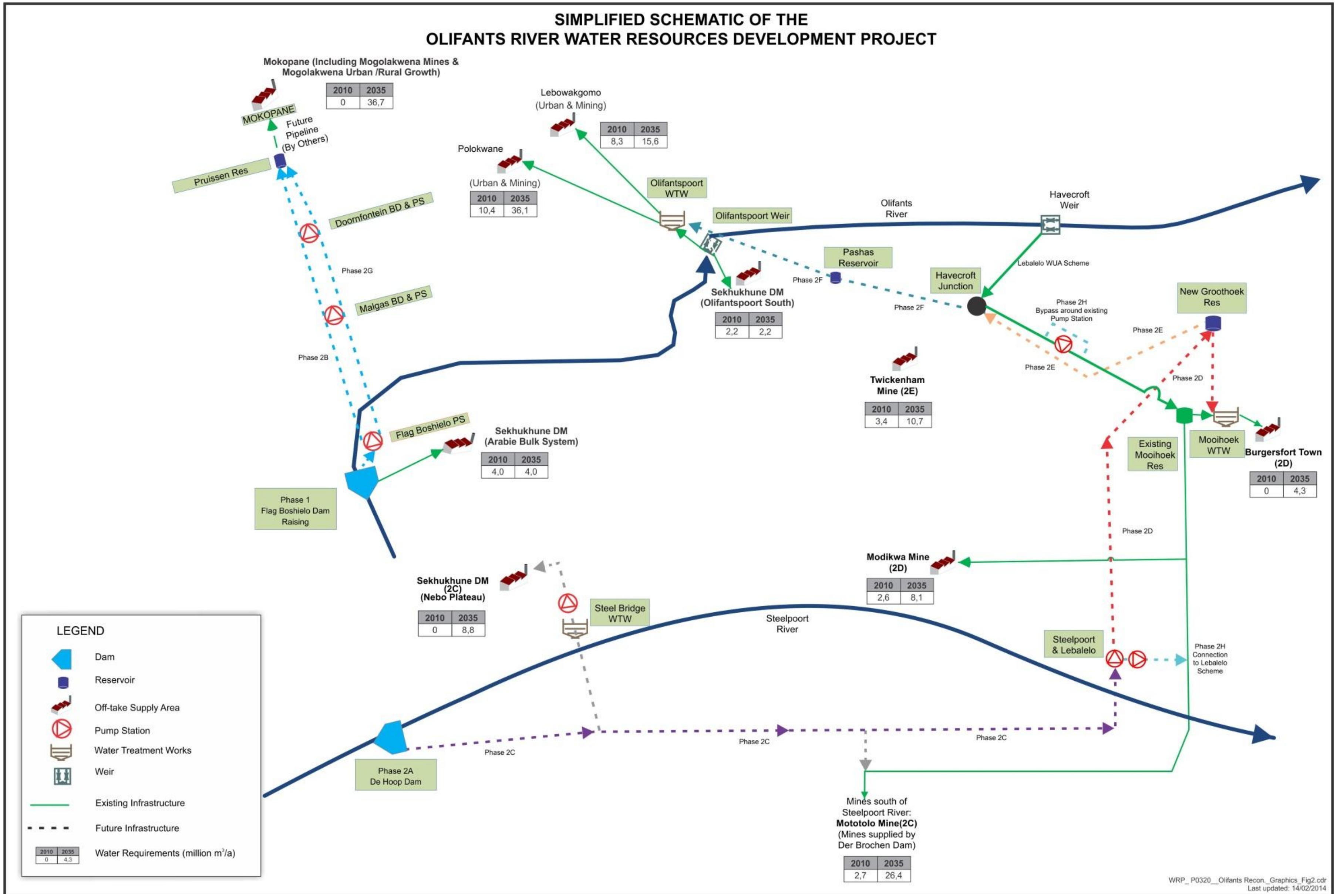

Figure 2.1: ORWRDP simplified schematic

The Trans-Caledon Tunnel Authority (TCTA) offered support to the DWS by preparing a Technical Review report and a revised RID for DWS as part of the Olifants River Water Resources Development Project (Phase 2) Bulk Distribution System (ORWRDP-2 BDS) Project. The objectives of this report were to:

- Review the water requirements of the mining and municipal sectors in the ORWRDP bulk water supply area namely Mogalakwena and Polokwane Local Municipalities (LMs) as well as Capricorn and Sekhukhune District Municipalities (DMs).
- Investigate the water availability in Flag Boshielo and De Hoop Dams as well as possible groundwater augmentation from the Malmani Dolomitic Area.
- Do a simulation risk analysis using the Water Resources Planning Model (WRPM) to determine the required transfer volumes through Sub-phases 2D, 2E and 2F using the projected water requirements, installed conveyance capacities as well as the water resource availability in Flag Boshielo and De Hoop Dams.
- Update the water balances for Flag Boshielo and De Hoop Dams using the 1 in 100-year recurrence interval yield (99% assurance) together with the updated projected water requirements (domestic, mining, irrigation) and Ecological Water Requirements (EWRs). Management interventions identified to improve the water balance including water conservation and water demand management (WC/WDM) initiatives, re-use of treated effluent and eradication of invasive alien plants (IAPs) must be included.
- Update the proposed infrastructure layout, configuration, phasing and sizing of the ORWRDP-2 based on the results of the risk analysis and updated water balances;
- Update capital cost estimates of sub-phases using the Vaal Augmentation Planning Study (VAPS) model.
- Update the programme of implementation and project cash flows for Sub-phases 2B, 2D, 2E and 2F.
- Investigate/comment on the institutional arrangement regarding the future ownership and operations and maintenance (O&M) of the BDS. The BDS beyond Sub-phase 2B (Pruisen to Sekuruwe) currently being implemented through RBIG funding must be investigated to determine whether the 47 km bulk raw water pipeline qualifies as national water resource infrastructure (NWRI).
- Make recommendations in terms of the implementation of further sub-phases of the ORWRDP-2 BDS as well as recommendation on future studies to be initiated by the Department of Water and Sanitation (DWS).

The noticeable shift in the intended planned mining developments from the Sekhukhune DM area to the Mogalakwena LM area had an impact on the projected municipal water requirements in the affected areas and the water services authorities (Sekhukhune DM, Capricorn DM, Polokwane LM, Mogalakwena LM) were thus requested to review and submit their latest water requirement projections.

As a result of the shift in mining developments, the project also conducted an updated demographics assessment for the Sekhukhune DM (Burgersfort and Steelpoort growth nodes) and the total Mogalakwena LM. Updated water requirement projections were derived based on the revised demographics and an assumed increase in Levels of Service (LOS). The Capricorn DM indicated that the Aganang LM also required augmentation from the ORWRDP and updated water requirement projections were also derived for the LM in order to confirm the augmentation requirements.

A Municipal Water Requirements Workshop was held on the 13 October 2014 where the water requirement projections from the various information sources were presented for each of the WSA's and the water requirement projections to be adopted for planning purposes were agreed upon (the water requirement projections to be adopted for the Sekhukhune DM were agreed at a follow up meeting held on 14 October 2014). The re-use of treated effluent for municipal use for Polokwane, Mokopane and Lebowakgomo were also updated according to the latest municipal planning as confirmed at the workshop.

This work was undertaken during in the last quarter of 2014 and information from both the Municipal and Mining Water Requirements Approval report (DWS, 2015a) and the Technical Review Report (DWS, 2015b) were incorporated into updated water requirement projections, risk analysis results and water balance during this study. An annual time series of the updated water requirement projections for the municipal and mining sectors are presented in **Appendix A** and **Appendix B** respectively.

2.2 Water Requirements

The current and projected water requirements for the urban, industrial and irrigation water use sectors were adopted from the 2012 Strategy (DWS, 2011a). The urban and mining water use sector water requirement information was superseded where updated water requirement information was available from the following studies:

- City of Tshwane Water Resources Masterplan (CoT, 2014) where the water requirement projections for the City of Tshwane supply area in the Upper Olifants Catchment were updated.
- Continuation of the Northern Planning Region All Town Reconciliation Strategies where the water requirement projections for certain towns in the Olifants River Catchment were updated based on the latest recorded water use and the Statistics South Africa Census 2011 demographic data from which the demographic projections were derived.
- Olifants River Water Resources Development Project (Phase 2) Bulk Distribution System (ORWRDP-2 BDS) study (Municipal and Mining Water Requirements Approval report (DWS, 2015a)) where the water requirement projections of the mining and urban sector, to be supplied from the Olifants River Water Resource Development Project (ORWRDP), were updated. The noticeable shift in the intended planned mining developments from the Sekhukhune DM area to the Mogalakwena LM area had an impact on the projected mining as well as the municipal water requirements in the affected areas (Sekhukhune DM, Capricorn DM, Polokwane LM, Mogalakwena LM), which were then updated as a result.

The updated water requirement projections of the various water use sectors from the major dams in the Upper, Middle and Lower Olifants Catchments are presented in **Table 2.1**, **Table 2.2**and **Table 2.3**respectively.

Table 2.1: Upper Olifants Water Requirements

Sector	Description	2012	2015	2020	2025	2030	2035	Information Source
		(million m^3/a)						
Bronkhorstspruit Dam&Mkhombo Dam (Weltevreden Weir)								
Urban	Bronkhorstspruit and surrounding area[1]	9.6	11.1	13.7	16.2	18.7	21.3	CoT, 2014
Urban	Western Highveld (North)[2]	22.0	22.0	22.0	22.0	22.0	22.0	CoT, 2014
Urban	Western Highveld (South)[3]	20.2	20.2	20.3	20.3	20.4	20.4	CoT, 2014
Premier Mine Dam (Wilge Dam)								
Urban	Cullinan (Town & Mine)	4.6	5.2	6.2	7.2	8.2	9.2	CoT, 2014
Witbank Dam								
Urban	Emalahleni (incl. Highveld Steel)	48.3	52.4	59.1	63.6	67.7	71. 7	DWS 2015c
Middelburg Dam								
Urban	Middelburg Town	16.1	16.6	17.3	18.1	19.0	19.8	DWS 2015c
Industrial	Columbus Steel	0.4	0.4	0.4	0.4	0.4	0.4	DWA 2011a
Industrial	Middelburg Ferrochrome	0.2	0.2	0.2	0.2	0.2	0.2	DWA 2011a
Industrial	Kanhym	0.2	0.2	0.2	0.2	0.2	0.2	DWA 2011a
Loskop Dam								
Urban	Marble Hall	0.9	1.0	1.0	1.0	1.1	1.1	DWA 2011a
Urban	Groblersdal	3.4	3.5	3.6	3.8	3.9	4.1	DWA 2011a
Urban	Western Highveld Allocation (Northern (Siyabuswa))	2.5	2.5	2.5	2.5	2.5	2.5	DWA 2011a
Irrigation	Herford	26.4	26.4	26.4	26.4	26.4	26.4	DWA 2011a
Irrigation	Loskop	159.9	159.9	159.9	159.9	159.9	159.9	DWA 2011a
Irrigation	Olifants River	2.4	2.4	2.4	2.4	2.4	2.4	DWA 2011a

[1] Supplied from Bronkhorstspruit Dam

[2] Supplied from Weltevreden Weir (Mkhombo Dam) and partially from Bronkhorstspruit Dam

[3] Supplied from Bronkhorstspruit Dam with augmentation from the Rand Water Mamelodi-Bronkhorstpruit pipeline

Table 2.2: MiddleOlifants Water Requirements

Sector	Description	2012	2015	2020	2025	2030	2035	2040	Information Source
		(million m^3/a)							
Flag Boshielo Dam									
Urban	Polokwane (Olifantspoort Weir)		23.8	28.7	33.3	37.7	42.1	46.5	DWS 2015a
Urban	Lebowakgoma (Olifantspoort Weir)	9.8	10.4	11.2	11.9	12.7	13.4	14.1	DWA 2011a
Urban	Phase 2B: Mogalakwena LM -Mokopane	-	-	11.4	16.8	21.3	26.0	29.8	DWS 2015a
Mining	Phase 2B: Mines 1	-	-	16.3	26.8	32.8	32.8	32.8	DWS 2015a
Urban	Phase 2B: Mogalakwena (Growth-Flag Boshielo)	-	-	0.0	0.0	0.0	0.0	0.0	DWS 2015a
Urban	Phase 2B: Aganang LM	-	-	0.0	2.2	2.2	2.2	2.2	DWS 2015a
Urban	Sekhukhune DM (Olifantspoort South)	1.6	2.9	3.6	3.8	4.0	4.2	4.4	DWA 2011a
Urban	SekhukhuneDM (Flag Boshielo Dam)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	DWA 2011a
Irrigation	Central Olifants	15.8	15.8	15.8	15.8	15.8	15.8	15.8	DWA 2011a
Mining	Mine 2 (Havercroft Weir)[1]	1.7	-	-	-	-	-	-	DWA 2011a
Mining	Mine 3 (Havercroft Weir)[1]	2.4	3.4	-	-	-	-	-	DWA 2011a
Mining	Mine 4 (Havercroft Weir)[1]	3.2	2.3	-	-	-	-	-	DWA 2011a
Enviro	Compensation Release	19.0	19.0	-	-	-	-	-	DWA 2011a
De Hoop Dam									
Urban	PraktiseerWTW	0.8	0.8	0.8	0.9	0.9	0.9	0.9	DWS2015a
Irrigation	Central Steelpoort	1.8	1.8	1.8	1.8	1.8	1.8	1.8	DWS2015a
Irrigation	Groot Dwars Irrigation Board	3.8	3.8	3.8	3.8	3.8	3.8	3.8	DWA2011a
Mining	Phase 2C: Mines 5[1]	-	4.1	4.6	5.9	5.9	5.9	5.9	DWS2015a
Urban	Phase 2C: Sekhukhune DM Nebo Plateau (Steel Bridge)	-	2.1	3.7	5.2	6.2	7.2	8.2	DWS2015a
Mining	Phase 2C: Mine 6	-	-	2.1	2.1	2.2	2.2	2.2	DWS2015a
Mining	Phase 2C: Mine 7	-		0.6	0.6	0.6	0.6	0.6	DWS2015a
Mining	Phase 2C: Mine Growth	-	2.1	3.8	3.8	3.8	3.8	3.8	DWS2015a
Mining	Phase 2D: Mines 8[1]	-	-	3.4	3.4	3.4	3.4	3.4	DWS2015a
Urban	Phase 2D: Mooihoek Burgersfort	-	-	1.5	3.2	4.5	5.9	7.3	DWS2015a
Urban	Phase 2D:Tubatse (excl. Burgersfort)	-	-	1.0	2.2	2.8	3.3	3.8	DWS2015a
Urban	Phase 2D:Lower Steelpoort, North East, Prakitseer	-	-	0.6	1.6	2.1	2.5	2.8	DWS2015a
Urban	Phase 2D:Mooikhoek (LebaleloNorth, Central& South)	-	-	2.7	2.7	2.7	2.7	2.7	DWS2015a
Urban	Phase 2D:Steelpoort	-	-	0.2	0.3	0.4	0.4	0.5	DWS2015a
Mining	Phase 2D: Mine Growth	-	-	2.3	2.8	2.8	2.8	2.8	DWS2015a
Mining	Phase 2E: Mines 9[1]	-	-	4.9	6.3	8.2	8.2	8.2	DWS2015a
Mining	Phase 2E: Mine Growth	-	-	1.1	1.8	3.3	3.3	4.7	DWS2015a
Mining	Phase 2E:Mine 10	-	-	4.9	6.3	8.2	8.2	8.2	DWS2015a
Mining	Phase 2E: Mine Growth	-	-	1.1	1.8	3.3	3.3	4.7	DWS2015a

[1]Flag Boshielo Dam demand centres to be supported from De Hoop Dam once the relevant ORWRDP Phases are commissioned.

Table 2.3: Lower Olifants Water Requirements

Sector	Description	2012	2015	2020	2025	2030	2035	Information Source
		(million m^3/a)						
Blyderivierpoort Dam								
Urban	Hoedspruit (Allocation from Blyde River IB)	2.5	2.6	2.8	2.9	3.1	3.3	DWA 2011a
Irrigation	Blyde River IB	89.9	89.9	89.9	89.9	89.9	89.9	DWA 2011a
Phalaborwa Barrage								
Urban	Phalaborwa	25.6	27.2	30.0	32.7	35.5	38.2	DWS 2015c
Mining	Mine 11	10.0	10.0	10.0	10.0	10.0	10.0	DWS 2015c
Mining	Mine 12	19.0	19.0	19.0	19.0	19.0	19.0	DWS 2015c

2.3 Water Resource Availability

The water resources of the Upper, Middle and Lower Olifants River sub-catchments have been harnessed by the construction of several large dams. The yields of the dams in the Upper, Middle and Lower Olifants catchments are presented in **Table 2.4**, **Table 2.5**and **Table 2.6** respectively.

Table 2.4: Yields of major dam in the Upper Olifants Catchment

Dam	Historic Firm Yield (million m^3/a)	Long Term Stochastic Yield as Specified Assurance (million m^3/a)			Information Source
		Excl. EWR	Incl. EWR	Assurance	
Witbank	29.5	28.1	28.1	1:100 year (99%)	DWAF 2010
Middelburg	12.6	12.5	12.5	1:100 year (99%)	DWAF 2010
Loskop	153.6	167.6	127.6	1:50 year (98%)	DWA 2011b

Table 2.5: Yields of major dam in the Middle Olifants Catchment

Dam	Historic Firm Yield (million m^3/a)	Long Term Stochastic Yield as Specified Assurance (million m^3/a)			Information Source
		Excl. EWR	Incl. EWR	Assurance	
Flag Boshielo	53	49	49*	1:100 year (99%)	DWA 2011b
De Hoop	65	94	61	1:100 year (99%)	DWA 2011b

* No yield reduction duo to increase inflow from Loskop Dam EWR releases

Table 2.6: Yields of major dam in the Lower Olifants Catchment

Dam	Historic Firm Yield (million m^3/a)	Long Term Stochastic Yield as Specified Assurance (million m^3/a)			Information Source
		Excl. EWR	Incl. EWR	Assurance	
Blyderivierpoort	110	130	87.6	1:50 year (98%)	DWA 2011b
Phalaborwa Barrage	-	-	53.2*	1:100 year (98%)	This study

* Yield was interpreted from the results of the sophisticated water resource system risk analysis (WRPM) that was conducted based on the following conditions:

- The EWR from the Classification Study was included
- Upstream support was provided as per the following sequence order:
    1. Utilised incremental runoff
    2. Support provided from Blyderivierpoort Dam
    3. Support from Flag Boshielo/ De Hoop Dam

The yield assurance selected for each of the dams was based on the water use sector supported by the dams i.e. for dams predominantly supporting urban and industrial water use sectors the high 1 in 100-year yield (99% assurance) was adopted while the 1 in 50-year yield (98% assurance) was adopted for dams predominantly supporting irrigation. The yields with the Ecological Water Requirements, adopted from the DWA Classification of Significant Water Resources in the Olifants Water Management Area (DWA, 2012), included are also illustrated.

2.4 Reconciliation Interventions

The 2012 Olifants River Reconciliation Strategy indicated that the total Olifants River Catchment 2012 Low Growth water requirement projection can be met by implementing the 50% Intervention Scenario (50% success rate for selected measures) while the High Growth water requirement projection required additional intervention measures to achieve a balance throughout the planning period. This resulted in the formulation of the Full Balance Scenario (Full Balance 2012). **Table 2.7**provides an overview of the Strategy Interventions along with the volume of water each intervention will contribute by either reducing the water requirements or making more water available by increasing the system yield. For comparison purposes the Full Balance Scenario from the 2012 Reconciliation Strategy, updated June 2014 Scenarios (SSC Meeting 3) and the revised final June 2015 Scenario is listed (changes from previous Scenarios are indicated in red text).

Table 2.7: Overview of the Strategy Intervention volumes per Scenario.

Interventions	Intervention Scenarios Requirements (million m^3 per annum)		
	Full Balance 2012	June 2014	June 2015
Reduction in water requirements			
WC/WDM Irrigation	21.0	21.0	21.0
WC/WDM Urban	32.0	22.7	22.7
WC/WDM Mining	5.0	5.0	5.0
Eliminating unlawful water use	10.0	14.0	14.0
Sub-Total	**68.0**	**62.7**	**62.7**
Increase in system yield			
Removal of Invasive Alien Plants	13.0	20.4	20.4
Development of groundwater	70.0	70.0	To be determined
Treatment of mine water	22.0	27.0	27.0
Municipal effluent re-use: Polokwane, Mokopane&eMalahleni	11.0	11.0	34.5
Sub-Total	**115.0**	**128.4**	**81.9**
TOTAL	**183.0**	**191.1**	**144.6**

The two changes from the June 2014 Scenario interventions are as a result of an increased volume of municipal effluent re-use (as discussed in **Section 2.1.2**), and reduced availability from groundwater developments. A desktop assessment of the groundwater development potential in the Olifants River Catchment was undertaken as part of this study (**Appendix C**), which confirmed that the groundwater development potential is noticeably less than 70 million m^3/a. Further groundwater assessments of the Mohlapitse catchment area (B71A-D), and the Penge area (B71F and G) were conducted by the ORWRDP Phase 2 study (DWS, 2014). The assessments found that approximately 9.3 million m^3/a of groundwater could be abstracted from the Mohlapitse area, which could potentially be increased up to 13.4 million m^3/a if the base flow is not protected as part of the groundwater reserve. In the Penge area approximately 7.1 million m^3/a could be abstracted from the dolomites and up to 20 million m^3/a if the entire aquifer recharge is utilised and base flow not protected. The above results are however based on preliminary desktop assessments and as a result, the DWS is planning a detailed groundwater feasibility study that will focus on the dolomitic areas of the Middle and Lower Olifants River Catchment.It is for this reason that the development of groundwater for the June 2015 scenario has been indicated as "to be determined" in **Table 2.7**.

2.5 Updating of the WRPM

The WRPM as configured and used in the "Development of an Integrated Water Resource Management Plan for the Upper and Middle Olifants Catchment Study" (DWAF, 2008) and the "Assessment of Water Availability in the Olifants WMA by means of Water Resource Related Models" (DWAF, 2010)was obtained and used as the base for this study. The main updates included the updated water requirement projections obtained from the study (**Section 2.2**). The simulation time period was extended to include the full projected time period for the study i.e. up till 2035. The other main changes that were incorporated are summarised in the bullets below:

- The inclusion of the latest EWRs as from the Classification Study;
- The water requirement projections and future infrastructure changes relating to the Flag Boshielo and De Hoop area were carefully configured (**Section 2.1.2**);
- The existing operating rule of the Loskop Irrigation Board was included;
- The updating of selected mine modules as described in the following section.

Prior to the start of this study, the WRPM included 33 mine modules in the Upper Olifants catchment. These modules had originally been configured as part of the "*Development of an Integrated Water Resources Model of the Upper Olifants River (Loskop Dam) Catchment"* study *(Coleman, 2001)*. A few updates had been included when the hydrology was recalibrated as part of the "Development of an Integrated Water Resource Management Plan for the Upper and Middle Olifants Catchment Study" (WRP, 2008). Due to the time period between the previous updates and this study, it was deemed necessary to look at further updates as a result of the constant changes taking place with the mining activities in the area.

In addition to updates to the mines, further enhancements were included into the WRPM in order to simulate the possible mine outflows that could be reused in the system. **Table 2.8** provides a complete summary of the mining updates and subsequent results. The attempted reuse was generally calculated as the "area of the coal reserves" (for open cast sections) multiplied by the "mean annual precipitation" multiplied by the "Recharge factor for the disturbed rehabilitated area". This was the maximum value that was included into the WRPM as a reuse demand from each mine, however it was not necessarily supplied all the time due to the workings of the mine module. An average simulated value has therefore also been included into the table in order to present the model results. The point of reuse in terms of the relevant Dams that could benefit have also been included in the Table.The updated WRPM was used to assess the risks associated with the "Full balance" scenario for each of the individual dam balances.

Table 2.8: Mining Module updates and results

Mine Name	Catchment	WRPM number	Updated	Attempted Reuse	Simulated avg. reuse	Place of Reuse
Syferfontein	MU1	495	No			
Matla	MU2	479	No			
Koornfontein/Blinkpan	MU3	220	No			
Goedehoop House	MU3	229	No			
Goedehoop	MU3	234	No			
MMS South	MU4	381	Yes	2.78	2.78	eMalahleni
Witbank Cons	MU5	340	No			
Tavistock	MU5	343	No			
Phoenix	MU5	346	No			
Boschmans	MU5	349	No			
Landau 1&2	MU6	296	No			
Greenside	MU6	365	Yes	1.46	1.45	Witbank
Kriel	MU7b	470	No			
Albion	MU7c	216	Yes	0.06	0.06	Witbank
Atcom	MU7c	214	No			
Rietspruit	MU7c	211	No			
TNC	MU8b	272	No			
NNC	MU8b	356	No			
Gloria	MU8b	219	No			
Goedehoop/Spring	MU9a	376	No			
Douglas	MU9b	378	Yes	2.60	2.27	Witbank
Kleinkopje	MU9b	362	Yes	2.92	2.69	Witbank
ArnotUG	MU11	201	Yes	1.10	0.92	Middelburg
Arnot OC	MU12	203	Yes	0.99	0.11	Middelburg
Eikeboom	MU13	206	Yes	0.79	0.67	Middelburg
Zevenfontein	MU13	406	Yes	5.99	5.58	Middelburg
Optimum	MU13	300	Yes			
Woestalleen	MU13	410	Yes			
T & DB	MU16	484	No			
Kromdraai	MU19	501	Yes	4.06	3.74	Witbank
Anon	MU22b	385	No			
MMS North	MU26ab	453	Yes	6.13	6.02	Loskop
Bank	MU26ab	450	No			
Kwagga	MU12	6002	New	2.69	1.87	Middleburg
Kwagga	MU11	6000	New	1.33	1.23	Middleburg
Arnot OC	MU12	6004	New	0.50	0.84	Middleburg
Mafube	MU12	6007	New	3.57	1.07	Middleburg

2.6 Projected Water Balances for Individual Large Dams

Individual water balance projections were prepared for the main dams in the Olifants River System covering the planning period until 2035. Due to the upstream-downstream orientation of the dams in the river system any excess yield in Middelburg and Witbank Dams is cascaded to Loskop and Flag Boshielo reservoirs with allowance of 10% conveyance losses. In all cases the High growth water requirement projections were applied to provide a conservative planning schedule for intervention options. Appropriate assurance of supply yield information (related to the type of water users supplied from each dam) formed the basis of the water availability shown in the water balances. The water balances for the dams were prepared by giving effect to the Ecological Water Requirements (EWRs) as determined in the recently completed Classification Study.

The projected water balance graphs presented in the subsequent paragraphs applied the revised water requirement projections as discussed in **Section 2.2** and provides an overview of the Strategy Interventions along with the volume of water each intervention will contribute by either reducing the water requirements or making more water available by increasing the system yield (**Table 2.7**).

Figures 2.2, 2.3, 2.4and **2.5**present the projected water balances for Middelburg, Witbank and Loskop Dams respectively.

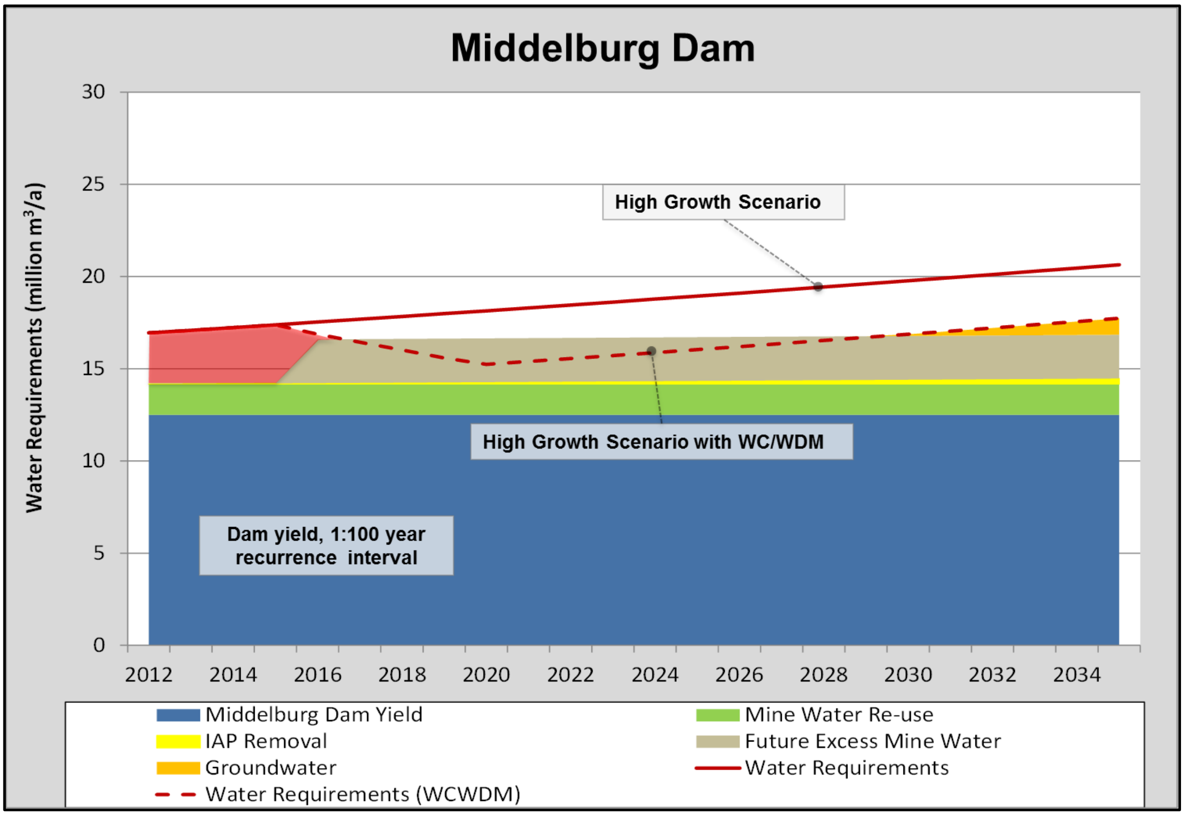

Figure 2.2: Projected Water Balance for Middelburg Dam

From **Figure 2.2**it can be seen that Middelburg Dam can supply the high growth water requirements throughout the projection period, provided that the following interventions are implemented:

- Continuous re-use of mine water from the Optimum Coal reclamation works
- Full implementation of Water Conservation/Water Demand Management (WC/WDM)
- Invasive alien plan (AIP) removal in the Middelburg Dam Catchment
- Future excess mine water re-use
- Small contribution from groundwater required from 2030 onwards

Figure 2.3shows the projected water balance for Witbank Dam which illustrates that the projected water requirements exceed the currently available resources throughout the projection period.

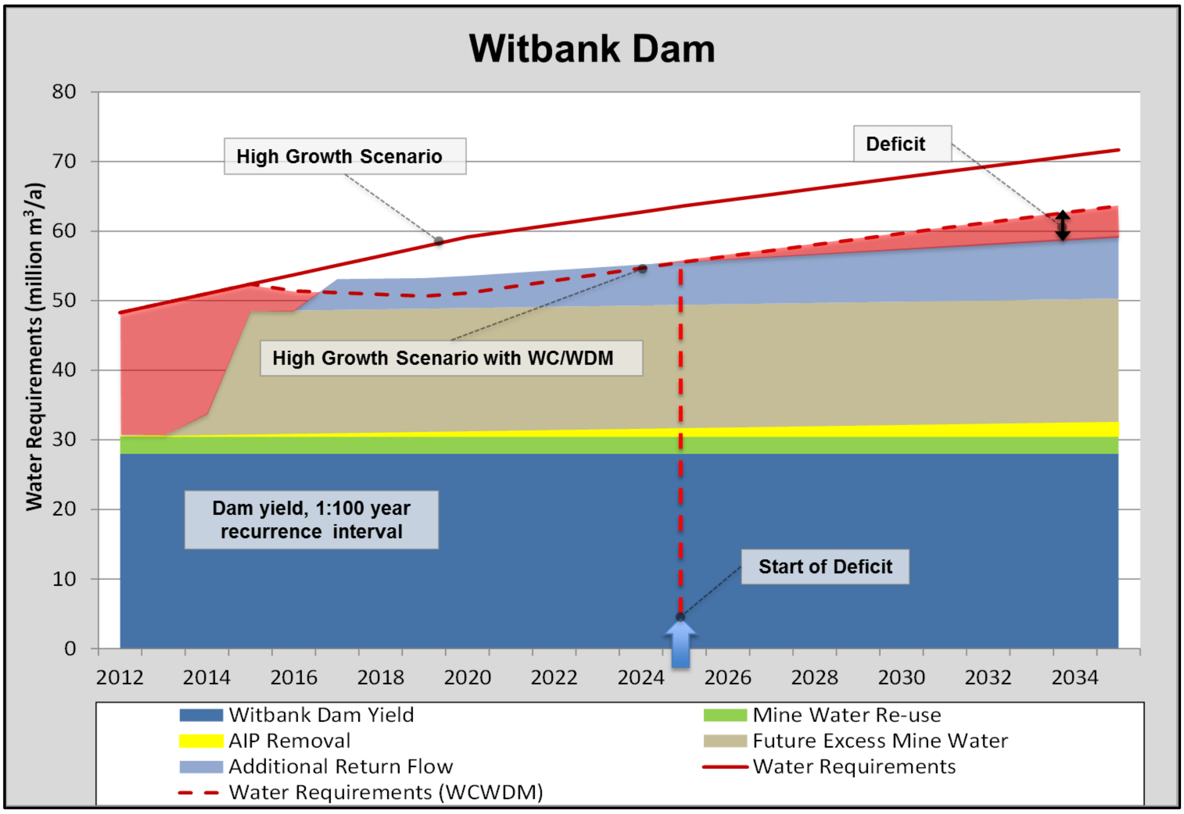

Figure 2.3: Projected Water Balance for Witbank Dam

The high growth water requirements can only be met up to 2025, after which additional augmentation is required, if the following intervention are implemented:

- Continuous re-use of mine water from the Anglo Coal reclamation works
- Full implementation of WC/WDM
- AIP removal in the Witbank Dam Catchment
- Re-use of treated urban/municipal wastewater
- Further excess mine water re-use

Potential options that could be considered to defer the indicated deficit are the transfer of water from Grootdraai Dam (Vaal River System),applying an integrated operation rule where transfers are only implemented during drought periods and/or the reallocation of water use entitlements of users abstracting water from the river system upstream of Witbank Dam. These alternatives require further investigation before they are incorporated as Strategy Interventions and after monitoring confirms that the actual water use is following the high growth projection trend.

Figure 2.4 shows the Loskop Dam balance situation where releases for the EWR are implemented in 2017.

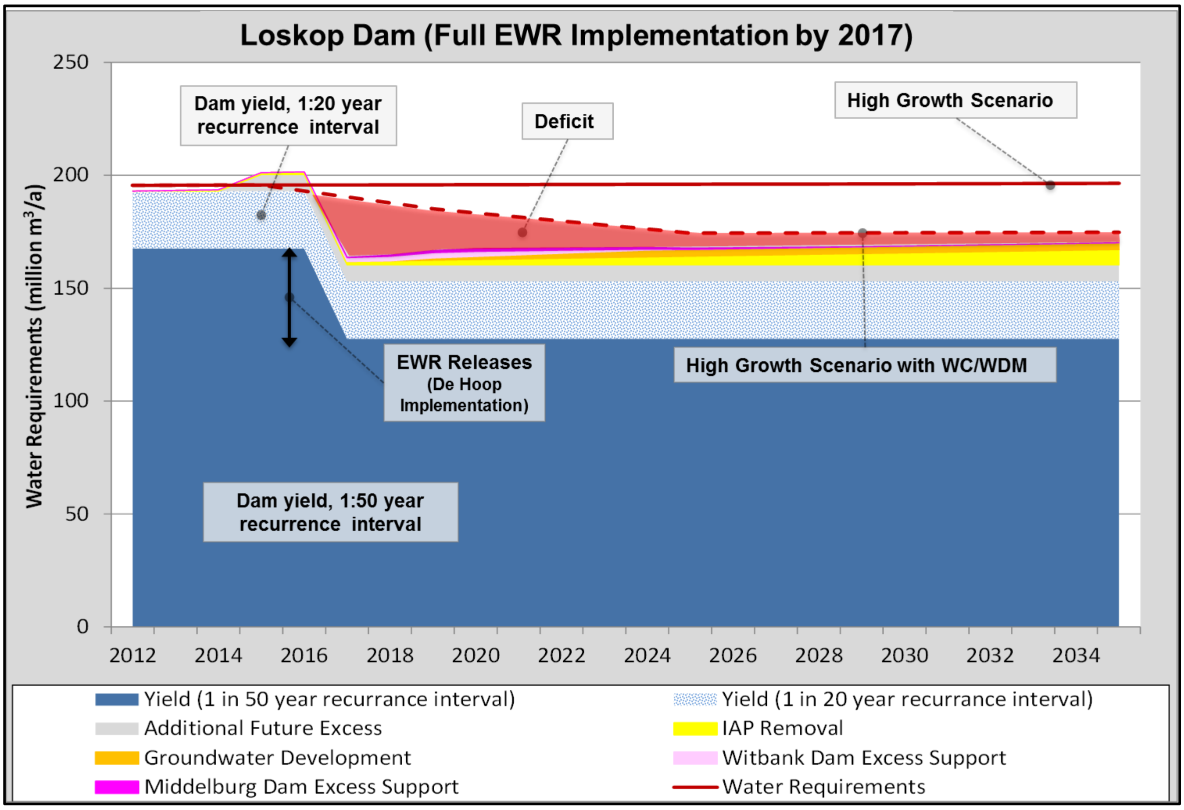

Figure 2.4: Projected Water Balance for Loskop Dam, with full EWR implementation by 2017

The Figure indicates that there will be deficits in the water balance with the following interventions included:

- Full implementation of WC/WDM
- AIP removal in the Loskop Dam Catchment
- Small contribution from groundwater development

The lower assurance yield (1:20 year recurrence interval) is also illustrated as the over 95% of the water use supported by the dam is the irrigation sector. The deficit reduces over time through the implementation of WC/WDM measures. To prevent negative socio-economic implications it is proposed that the EWR releases be gradually implemented as illustrated in **Figure 2.5,** to maintain a positive water balance until 2025 as illustrated. The deficit after 2025 can be managed by water users accepting a lower assurance of supply or reallocation of water use entitlements.

The updated information on the planned interventions and revised water requirement information from the recent ORWRDP Phase 2 investigations (**Section 2.1.2**) were incorporated into the De Hoop and Flag Boshielo Dams' individual Dam Balances. Full implementation of the ORWRDP is required to augment the system deficit at Flag Boshielo Dam through the utilisation of all De Hoop Dam's available yield.

The projected water balance for the City of Tshwane supply area in the Upper Olifants Catchment (Premier Mine Dam and Bronkhorstspruit Dam)was investigated as part of the City of Tshwane Water Resources Masterplan (CoT, 2014). The Premier Mine Dam supplies water to Cullinan, Rayton, Refilwe and the Zonderwater prison while the Bronkhorstspruit Dam supplies water to Bronkhorstspruit, Ekangala, Ekandustria, Rethabiseng and also to the Western Highveld area in the Thembisile Hani Local Municipality, which is also augmented by the Rand Water Mamelodi-Bronkhorstpruit pipeline.The

Western Highveld area can be grouped into the southern, central and northern Western Highveld areas. The southern area is supplied by the Bronkhorstspruit WTP, the northern by the Weltevreden WTP (abstracts water from the Weltevreden Weir which is supported by Mkombo Dam) and the central area by both the Bronkhorstspruit and Weltevreden WTP's. Limited support can also be provided to the Weltevreden WTP from Loskop Dam.

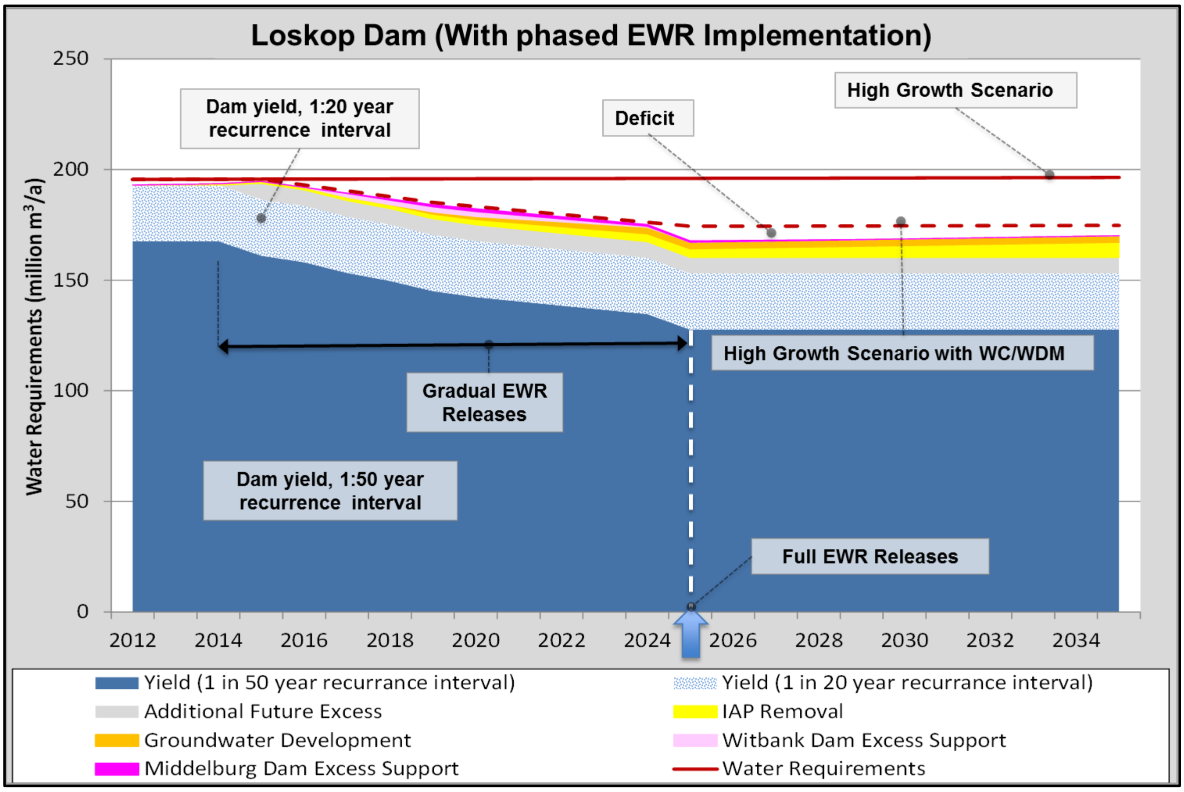

Figure 2.5: Projected Water Balance for Loskop Dam, with phased implementation of EWR

The total Western Highveld area with the supporting water resources was included in the City of Tshwane Water Resources Masterplan WRPM water resource analysis. The results of the WRPM analysis showed that the users cannot be supplied according to their required assurance criteria and the following interventions will be required to ensure sufficient water resource availability (CoT, 2014):

- Full implementation of WC/WDM initiatives (target savings of 12.8 million m^3/a).
- Total surplus yield from Rust de Winter Dam required as support (surplus yield is based on the assumption that the current downstream irrigation will remain constant and not increase to the scheduled area as the irrigation water use has decreased historically (irrigation farms being converted to game farms))
- Additional augmentation of approximately 14 million m^3/a.It is envisaged that the feasible option for the required support will most likely be additional supply from Rand Water.

Figure 2.6 presents De Hoop Dam's projected water balance for the June 2015 Scenario.

De Hoop Dam's 1:100 year assured yield, after allowances for in catchment downstream users and EWR requirements can be utilised by implementing all the ORWRDP phases (conveyance infrastructure) and indirectly augmenting Flag Boshielo Dam subsystem over the medium term. From the Figure it can be seen that all the ORWRDP Phases 2C, 2D, 2E and 2F are required to fully utilise De Hoop, and hence reduce the water requirements imposed on Flag Boshielo Dam.

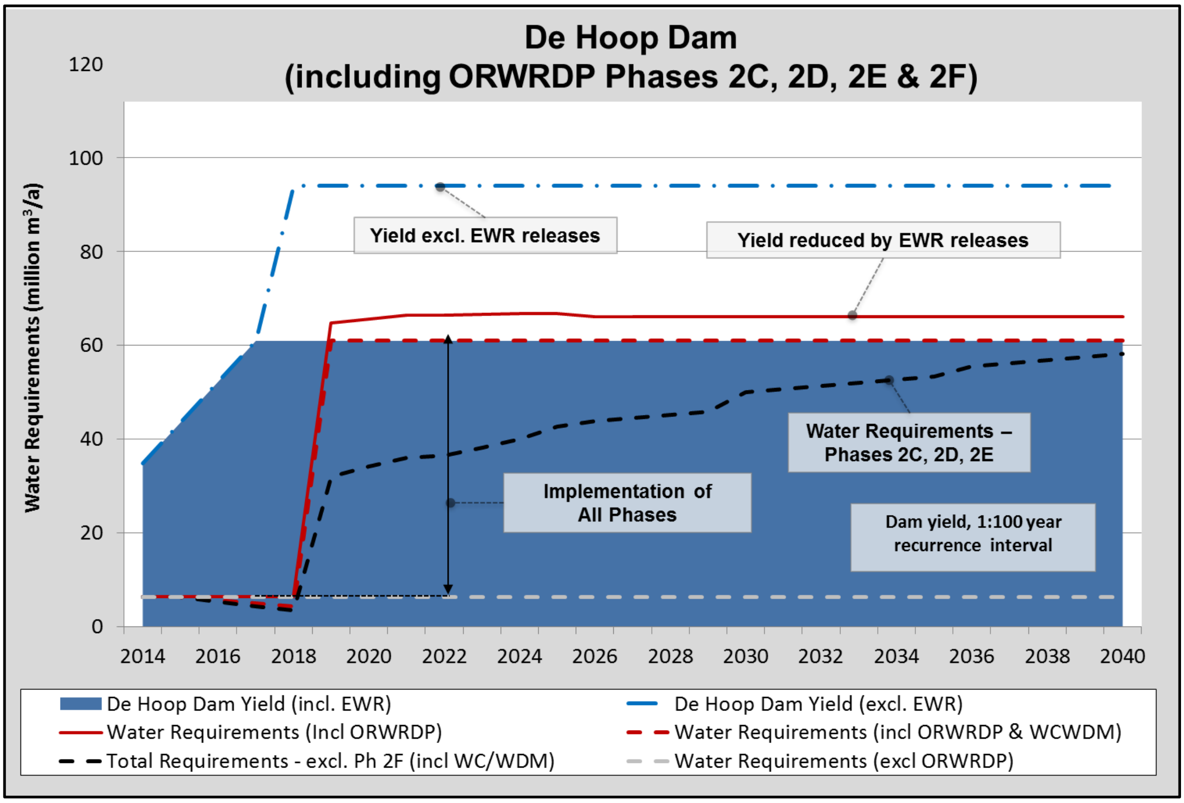

Figure 2.6: 2015 Scenario Water Balance Projection for De Hoop Dam

Figure 2.7shows the difference in the Flag Boshielo Dam water requirements between the June 2014 Scenario (black dotted line) and the June 2015 Scenario (red dashed line).

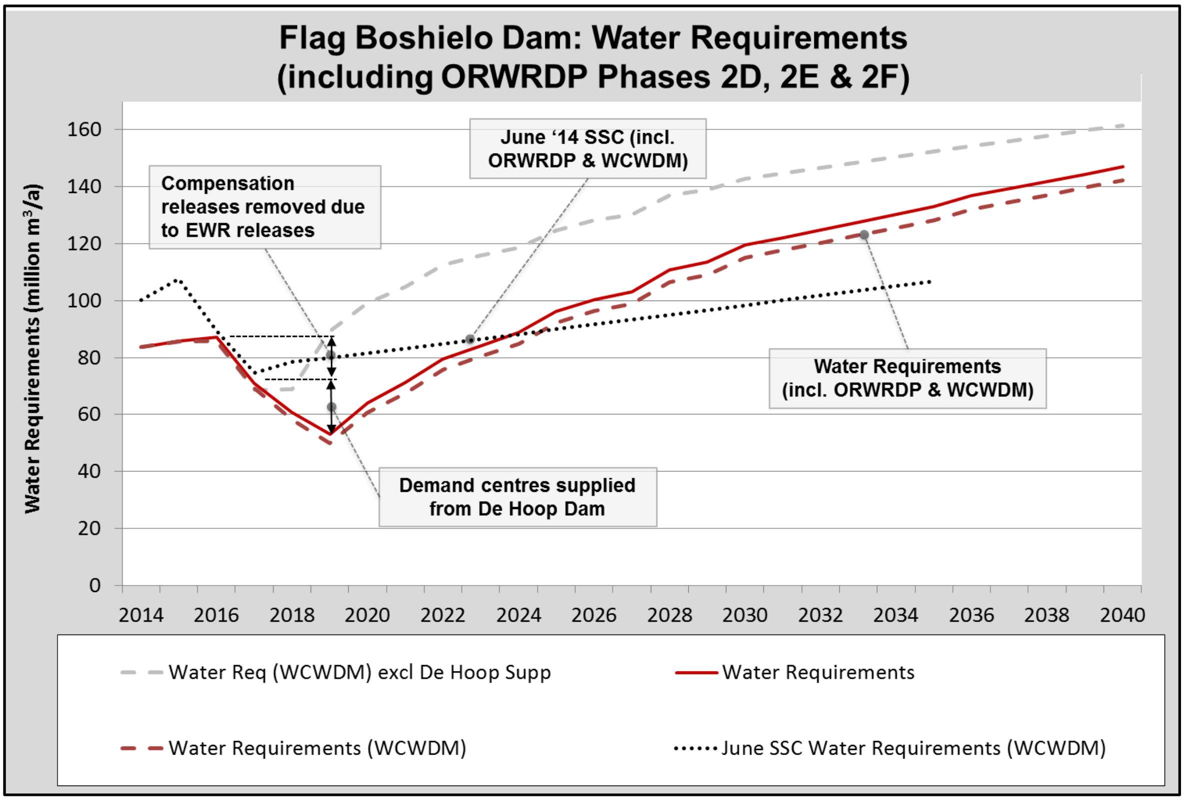

Figure 2.7: Comparison of the Flag Boshielo Dam water requirements between the June 2014 and June 2015 scenarios

The reduction in water use prior to 2019 is due to the removal of compensation releases (the implementation of EWR releases are accounted for in the Flag Boshielo Dam yield), support from De Hoop Dam as well as due to the implementation of WC/WDM measures.

The delay in the projected mining water requirements can clearly be seen in the June 2015 Scenario water requirements being lower than the June 2014 Scenario requirements up to 2023. It is interesting to note how much higher the water requirement projection would have been if the ORWRDP conveyance infrastructure Phases were not implemented (grey dashed line).

Figure 2.8 shows the projected water balance of Flag Boshielo Dam, which indicates that over the short term there will be deficits until the ORWRDP phases are implemented. This deficit can be mitigated since the actual current irrigation use from the dam is less than the total allocations, which was included in the balance diagram.

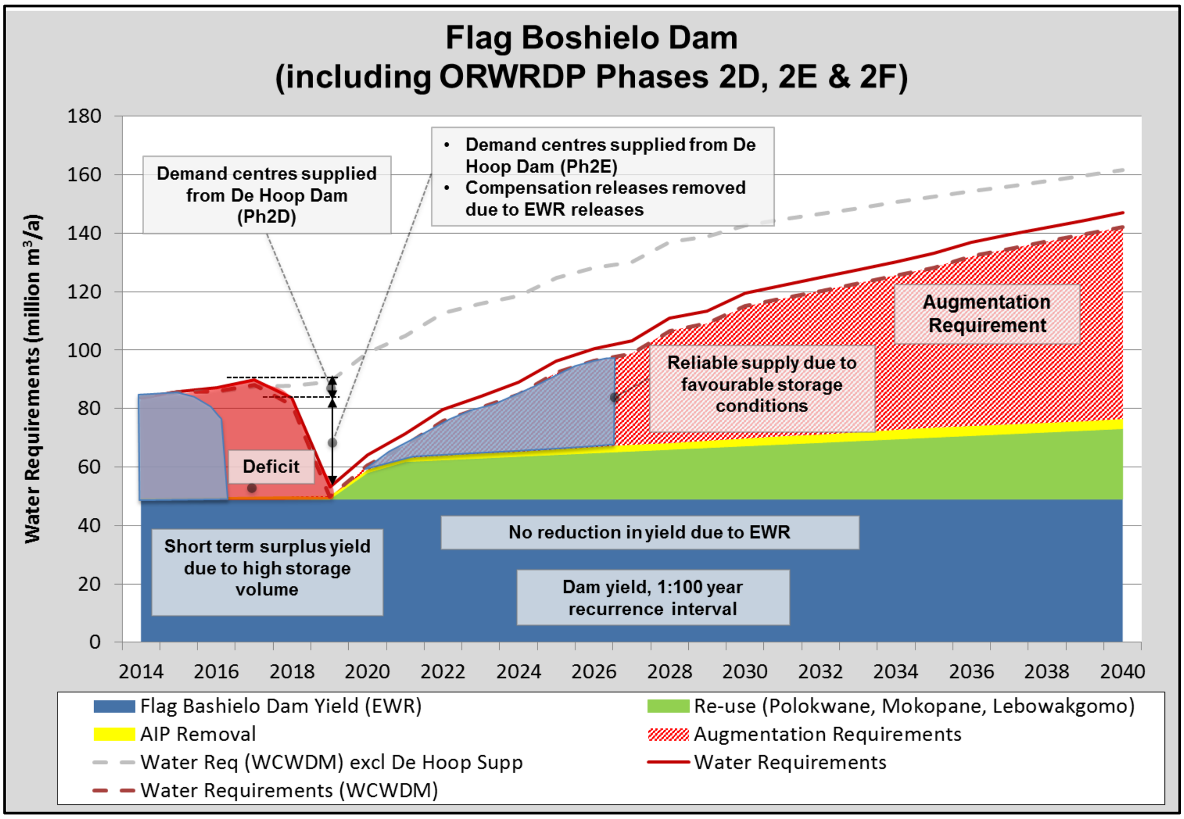

Figure 2.8: 2015 Scenario Water Balance Projection for Flag Boshielo Dam

The graph shows that due to the favourable current storage conditions and through the implementation of the following interventions listed below, augmentation is needed from 2026 onwards:

- Full implementation of WC/WDM
- AIP removal in the Flag Boshielo Dam Catchment
- Re-use of urban/municipal waste water (Polokwane, Mokopane and Lebowakgomo)

The impact of the favourable storage conditions on the required augmentation date (blue shaded area, referred to as “Reliable supply due to favourable storage conditions”)was confirmed through sophisticated water resource system risk analysis undertaken by the ORWRDP Phase 2 investigations

(DWS 2015b). The augmentation requirements grow to 45 million m^3 per annum by 2030 and 66 million m^3 per annum by 2040.

The water balance for Phalaborwa Barrage was revised based on updated water use information (DWS, 2015c). There has been a substantial reduction in the projected water requirement due to reduced mining activity as well as substantial savings in water use through various water saving initiatives implement by Phalaborwa Mining in recent years. **Figure 2.9**shows the projected water balance for the Phalaborwa Barrage, which indicates that the high growth requirements for the Barrage can be met for the entire planning horizon.

The Phalaborwa Barrage yield was assessed with sophisticated water resource system risk analysis based on the following conditions:

- The EWR from the Classification Study was included
- Upstream support was provided as per the following sequence order:
  1. Utilised incremental runoff
  2. Support provided from Blyderivierpoort Dam
  3. Support from Flag Boshielo/ De Hoop Dam

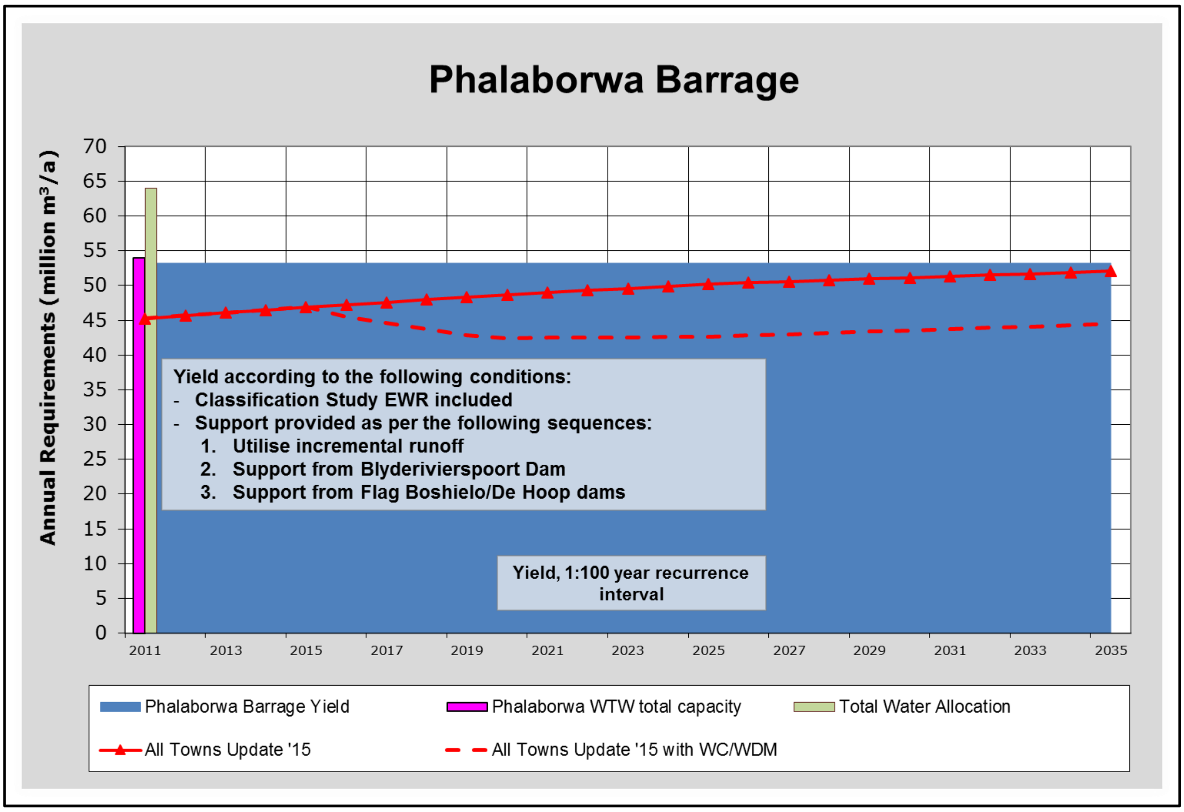

Figure 2.9: 2015 Scenario Water Balance Projection for Phalaborwa Barrage

2.6.1 Perspectives on Water Balances

In summary, the following observations can be made from the final June 2015 Scenario water balances that were presented in **Section 0**.

- The implementation of EWR releases downstream of Loskop and Flag Boshielo dams will have to be made gradually to maintain the assurance of supply at acceptable levels. The EWR releases from Loskop Dam will have to occur in unison with the implementation of intervention measures such as savings in water requirements through WC/WDM, relocation of water use entitlements and/or accepting a reduced assurance of supply (higher risk or drought restrictions). The June 2015 scenario made provision for the full EWR release to be implemented by 2025.The EWR downstream of De Hoop Dam should be implemented in full once the dam has been commissioned

- Reuse of treated effluent is required for Middelburg, eMalahleni while Polokwane, Mokopane and Lebowakgomo need to continue and expand their reuse activities.
- Deficits are projected for both Witbank and Loskop dams (with gradual implementation of the EWR at Loskop Dam) by the year 2025.
- The Western Highveld area requires full implementation of WC/WDM, direct support from the total surplus yield from Rust de Winter Dam (based on the assumption that the current downstream irrigation will remain constant and not increase (irrigation water use has decreased historically)) and additional augmentation from Rand Water.
- The Flag Boshielo Dam water users' assurance of supply is at risk from 2016 to 2019, pending the implementation of all the ORWRDP Phases. After the full implementation of the ORWRDP, deficits are projected only from 2026 for Flag Boshielo Dam, due to the dams being relatively full at the start of the simulation period (May 2014). ORWRDP Phases 2C, 2D, 2E and 2F are therefore essential to prevent water shortages before 2026 at Flag Boshielo Dam by the utilisation of De Hoop Dam yield.
- The overall Olifants River Water Supply System therefore needs augmentation as soon as 2025 in certain parts of the systems, and augmentation requirements are estimated to be as much as 59 million m^3/a in 2035 and 69 million m^3/a in 2040.

3. RECONCILIATION STRATEGY IMPLEMENTATION PLAN

Appendix D provides the overall Strategy Intervention Implementation Plan (SIP). The Implementation Plan provides the following detail:

- Elements of the plan, include the current Strategy Interventions as well as Supporting Infrastructure and Operational Projects to give effect to the Strategy.
- The main custodians for each element (Note that the listed custodians are not inclusive of all role players that that need to be involved in the implementation of the interventions or projects)
- Organisations involved with each element.
- The total volume and projected cumulative volumes per year for each intervention for the current dated Scenario.
- Duration of interventions or supporting projects that gives effect to the Strategy.

The following section provides a description of the status of the different interventions and supporting projects.

3.1 Interventions and Status

3.1.1 WC/WDM - Irrigation

Water Management Plans (WMPs) for the Loskop and Hereford Irrigation Boards showed that there are approximately 13 million m^3/a of avoidable losses in their distributions systems. The 21 million m^3/a currently in the water balances will have to be reduced accordingly and the implications on the water resource supply risks need to be assessed in as part of future analysis. This intervention needs to be investigated as soon as possible and savings should already start in 2016 and is scheduled over a 10-year period.

3.1.2 WC/WDM - Urban

Although some of the Local Municipalities do have successful WC/WDM initiatives underway (such as Steve Tshwete, City of Tshwane and others), many of the large municipalities are not actively involved at the Strategy Steering Committee, which leaves a knowledge gap. Phalaborwa and eMalahleni will have to be approached by DWS to obtain information regarding any initiatives and to track success with those initiatives. The successes already achieved need to be translated into benefits to the Supply System and tracked against the IP targets. First savings are required in 2016 over a 5-year period.

3.1.3 WC/WDM - Mining

The target for this intervention has most probably already been reached through activities undertaken by Palabora Copper. The company is working towards reducing all raw water inputs through a number of reuse interventions at the mine. Additional sources of information on this might increase the target for this water use sector.

3.1.4 Eliminate Unlawful Use

Some validation and verification work has started on an ad hoc basis by DWS: Mpumalanga Regional Operation and directives have been given to offenders where water use transgressions occurred. The Validation and Verification process is now a DWS: Head Office Function and PSP’s are being appointed currently. Some enforcement of obvious illegal users has taken place upstream from Middelburg Dam and in the Ogies area. The current water balances assume the first reductions in unlawful use will commence in 2016 and will reach the expected maximum savings over a 10-year period.

3.1.5 Development of Groundwater Resources

Groundwater development was seen as the largest contributor to make more water available in the 2012 Strategy. However recent desktop investigations showed that the amount of groundwater estimated in the 2012 Strategy might be substantially less and further detailed investigation into this intervention is now underway by DWS.

3.1.6 Removal of Invasive Alien Plants

The Working for Water Programme of the Department of Environment and Tourism has cleared a total of 359 km^2 of the potential of 1990 km2 (2012 Strategy) AIP's. This achievement has to be translated into estimated volumes and tracked against the intervention targets. This intervention spans the complete planning horizon of the current Strategy.

3.1.7 Treatment of mine water

There are several mining companies that already constructed or who are planning to construct mine water treatment plants in the areas of the Upper Olifants River Catchment. The SSC maintains a list of the structures already in place as well as planned for the future on a six monthly basis and adapt the Strategy accordingly. This intervention is therefore on schedule, but the current full implementation target in 2016 might have to be revised due to delays in the implementation of some of the schemes.

3.1.8 Municipal effluent re-use

Polokwane and Mokopane have historically treated their municipal effluent and sold the treated water to mining and industrial water users. eMalahleni has the biggest potential for effluent reuse but it is unclear if the LM has started any such initiative. This intervention will have to be monitored on an ongoing basis and treatment capacity needs to be upgraded as effluent grows in accordance with the water requirement projections, spanning over the whole planning horizon. The current planned treatment works and adjusted projections of water requirements might affect the current projected targets and might have to be revised in future.

3.2 Supporting Infrastructure Development and Operational Projects

3.2.1 Olifants River Water Resources Development Project

As shown by the water balances, the ORWRDP is crucial to prevent large potential deficits over the short term. Currently the project is scheduled to be completed by 2019. It was however reported at the June 2015 SSC Meeting that some of the phases are not scheduled to be implemented concurrently pending realisation of future mining projects.

3.2.2 Determination, Review and Implementation of the Reserve in the Olifants/Letaba System

This study is underway and is scheduled to be completed by 2017. This study will provide key inputs into how the EWRs should be implemented in the catchment.

3.2.3 Integrated Olifants River Supply System Operating rules

Internal processes in DWS have commenced for the development of water resource system operating rules that will give effect to all the planning as outlined in this document and will ensure appropriate drought preparedness plans are developed and implemented.

4. CONCLUSIONS AND RECOMMENDATIONS

Although the tracking and updating of all the listed Strategy Interventions (as discussed in **Section 3.1**) is important for the successful implementation of the Olifants River Reconciliation Strategy, the need for large scale interventions by 2026 are however more pressing. It is therefore recommended that:

- Groundwater augmentation investigations should be initiated as soon as possible.
- The 2012 Strategy options for lower priority large scale augmentation need to be re-evaluated and potentially taken to a pre-feasibility stage as soon as possible.
- The SSC recommended that compulsory licensing, or similar reallocation initiatives, may have to be initiated for the Olifants River catchment to ensure a positive water balance over the long term future. It was recognised that clear policy and well thought out processes need to be established to avoid any unintended consequences should this fall-back option be considered in future.(A brought framework for what to consider to implement water use entitlement exchange mechanisms is described in **Appendix E**)
- An Integrated Olifants River Operating Rule Study needs to be initiated as soon as possible to ensure that all the planning of the Reconciliation Strategy is given effect, thereby avoiding uncontrolled water supply shortages.

5. REFERENCES

[1]	CoT, 2010	**City of Tshwane Water Resources Masterplan.** Prepared by GLS Consulting in association with WRP Consulting Engineers and CSVwater Consulting Engineers on behalf of the Water & Sanitation Planning Section of the City of Tshwane. 2014.
[2]	DWAF 2008	**Development of an Integrated Water Resource Management Plan for the Upper and Middle Olifants Catchment: WRYM Report.** Prepared by Golder Associates in association with WRP Consulting Engineers on behalf of the Department of Water Affairs and Forestry, Directorate: National Water Resources Planning. 2008.
[3]	DWAF 2010	**Assessment of Water Availability in the Olifants WMA by Means of Water Resource Related Model: Water Resources Yield Model Analysis (WRYM). P WMA 04/000/00/5507.**Prepared by SSI and Knight Piesold on behalf of the Department of Water Affairs and Forestry, Directorate: National Water Resources Planning. May 2010.
[4]	DWA (2011a)	**Development of a Reconciliation Strategy for the Olifants River Water Supply System: Final Reconciliation Strategy Report. Report Number: P WMA 04/B50/00/8310/14.** Prepared by Aurecon on behalf of the Department of Water and Sanitation, Directorate: National Water Resources Planning. December 2011
[5]	DWA (2011b)	**Development of a Reconciliation Strategy for the Olifants River Water Supply System: Water Requirements and Water Resources Report: P WMA 04/B50/00/8310/6.** Prepared by Aurecon on behalf of the Department of Water and Sanitation, Directorate: National Water Resources Planning. December 2011
[6]	DWA (2012)	**Classification of significant water resources in the Olifants Water Management Area. Prepared by Golder Associates on behalf of the Department of Water Affairs** Directorate: Resource Directed Measures. 2012
[7]	DWS (2014)	**Olifants River Water Resources Development Project (Phase 2) Bulk Distribution System (ORWRDP-2 BDS): Review of Data for the Groundwater Options.** Prepared by WSM Leshika in association with the Aurecon Ndodana Joint Venture on behalf of the Department of Water and Sanitation. October 2014.
[8]	DWS (2015a)	**Olifants River Water Resources Development Project (Phase 2) Bulk Distribution System (ORWRDP-2 BDS): Municipal and Mining Water Requirements Approval.**Prepared by WRP Consulting Engineers in association with the Aurecon Ndodana Joint Venture on behalf of the Department of Water and Sanitation. 2015.
[9]	DWS (2015b)	**Olifants River Water Resources Development Project (Phase 2) Bulk Distribution System (ORWRDP-2 BDS): Technical Review Report.** Prepared by the Aurecon Ndodana Joint Venture on behalf of the Department of Water and Sanitation. 2015.
[10]	DWS (2015c)	**Continuation and Maintenance of Reconciliation Strategies for All Towns in the Northern Planning Region.** Prepared by UWP Consulting and WRP Consulting Engineers on behalf of the Department of Water and Sanitation. September 2015.

Appendix A: Municipal Sector Water Requirement Projections

USER	SOURCE	ORWRDP: SUB PHASE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
MOGOLAKWENA LM																												
Total Mogalakwena LM	Flag Boshielo	2B	5.500	10.640	15.780	20.920	26.060	31.200	34.180	37.160	40.140	43.120	46.100	48.520	50.940	53.360	55.780	58.200	60.820	63.440	66.060	68.680	71.300	73.360	75.420	77.480	79.540	81.600
CAPRICORN DM																												
LEPELLE NKUMPI LM																												
Lepelle-Nkumpi LM	Olifantspoort	Olifantspoort	28.364	28.802	29.240	29.678	30.116	30.554	30.938	31.321	31.704	32.088	32.471	32.909	33.347	33.785	34.223	34.661	35.044	35.428	35.811	36.194	36.578	36.961	37.344	37.728	38.111	38.494
Lepelle-Nkumpi LM (WCWDM)	Olifantspoort	Olifantspoort	28.364	28.145	28.145	28.145	28.145	28.364	28.747	29.131	29.514	29.897	30.281	30.719	31.157	31.595	32.033	32.471	32.854	33.238	33.621	34.004	34.387	34.771	35.154	35.537	35.921	36.304
AGANANG LM																												
Aganang LM	Flag Boshielo	2B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
POLOKWANE LM																												
Total Polokwane LM	Olifantspoort	Olifantspoort	65.281	67.941	70.601	73.261	75.921	78.581	81.112	83.644	86.175	88.706	91.238	93.635	96.032	98.429	100.827	103.224	105.646	108.067	110.489	112.911	115.333	117.755	120.177	122.599	125.020	127.442
Total Polokwane LM (WCWDM)	Olifantspoort	Olifantspoort	65.281	65.258	66.130	67.002	67.873	69.639	72.170	74.702	77.233	79.765	82.296	84.693	87.090	89.488	91.885	94.282	96.704	99.126	101.547	103.969	106.391	108.813	111.235	113.657	116.079	118.500
SEKHUKHUNE DM																												
Flag Basheilo RWS	Flag Boshielo Dam	Flag Boshielo Dam	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951	10.951
Olifantspoort South	Olifantspoort	Olifantspoort	7.900	8.300	8.700	9.100	9.500	9.900	10.010	10.120	10.230	10.340	10.450	10.560	10.670	10.780	10.890	11.000	11.110	11.220	11.330	11.440	11.550	11.660	11.770	11.880	11.990	12.100
Mooihoek Burgersfort	Mooihoek/Burgersfort	2D	0.588	1.208	1.877	2.600	3.381	4.225	5.021	5.873	6.785	7.762	8.807	9.446	10.111	10.802	11.522	12.270	12.978	13.712	14.473	15.262	16.080	16.848	17.617	18.386	19.154	19.923
Mooihoek Tubatse (excl Burgersfort)	Mooihoek	2D	0.071	0.502	0.978	1.501	2.077	2.712	3.265	3.862	4.507	5.204	5.957	6.258	6.568	6.887	7.215	7.553	7.841	8.136	8.438	8.748	9.065	9.343	9.621	9.899	10.177	10.456
Lower Steelpoort North & East, Prakitseer	Mooihoek/Praktiseer	2D	1.341	1.760	2.222	2.730	3.290	3.907	4.424	4.981	5.581	6.228	6.925	7.150	7.381	7.617	7.859	8.106	8.317	8.531	8.750	8.974	9.201	9.387	9.573	9.759	9.945	10.131
Mooikhoek Lebalelo North,Central & South)	Mooihoek	2D	5.638	6.554	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469	7.469
Steelpoort	Mooihoek/Steelpoort	2D	0.543	0.566	0.589	0.614	0.639	0.666	0.694	0.724	0.754	0.786	0.818	0.854	0.891	0.930	0.970	1.011	1.050	1.091	1.133	1.176	1.221	1.266	1.310	1.355	1.399	1.444
Nebo Plateau / Steelpoort valley	Steel Bridge	2C	5.859	6.703	7.546	8.390	9.233	10.077	10.921	11.764	12.608	13.451	14.295	14.842	15.390	15.937	16.484	17.032	17.579	18.126	18.674	19.221	19.768	20.316	20.863	21.410	21.958	22.505
Total			**32.892**	**36.544**	**40.332**	**43.355**	**46.541**	**49.907**	**52.755**	**55.745**	**58.886**	**62.191**	**65.672**	**67.530**	**69.430**	**71.373**	**73.360**	**75.393**	**77.296**	**79.238**	**81.219**	**83.241**	**85.306**	**87.240**	**89.175**	**91.109**	**93.044**	**94.979**
Total (incl. Burgersfort WCWDM)			**32.822**	**36.474**	**40.262**	**43.285**	**46.471**	**49.837**	**52.685**	**55.675**	**58.816**	**62.121**	**65.572**	**67.430**	**69.330**	**71.273**	**73.260**	**75.293**	**77.196**	**79.138**	**81.119**	**83.141**	**85.206**	**87.140**	**89.075**	**91.009**	**92.944**	**94.879**
Total Municipal Demand			**132.037**	**143.927**	**155.953**	**167.214**	**178.638**	**190.242**	**198.985**	**213.869**	**222.906**	**232.105**	**241.480**	**248.594**	**255.750**	**262.947**	**270.190**	**277.478**	**284.806**	**292.173**	**299.579**	**307.027**	**314.516**	**321.316**	**328.116**	**334.916**	**341.715**	**348.515**
Total Municipal Demand (incl. WCWDM)			**131.967**	**140.517**	**150.317**	**159.351**	**168.549**	**179.040**	**187.783**	**202.667**	**211.703**	**220.903**	**230.248**	**237.362**	**244.517**	**251.715**	**258.958**	**266.245**	**273.574**	**280.941**	**288.347**	**295.795**	**303.284**	**310.084**	**316.884**	**323.683**	**330.483**	**337.283**

Appendix B: Mining Sector Water Requirement Projection

	JWF MINES	SOURCE	ORWRDP: SUB PHASE	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Phase 2B																													
1	Mine 1	Flag Boshielo	2B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.000	5.000	7.000	9.000	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500	11.500
1a	Mine 1 Local Resources	Local Resources		0.000	0.000	0.000	0.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
2	Mine 2	Flag Boshielo	2B	0.000	4.000	6.000	8.000	8.000	11.000	11.000	11.000	11.000	11.000	16.000	16.000	16.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000	30.000
2a	Mine 2 Local Resources	Local Resources		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	Mine 3	Flag Boshielo	2B	0.000	0.000	0.000	0.000	8.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000	16.000
3a	Mine 3 Effluent reuse	Local Resources		20.000	20.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000	24.000
4	Mine 4	Flag Boshielo	2B	0.000	0.000	0.000	0.000	3.500	3.500	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
5	Mine 5	Flag Boshielo	2B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300	6.300
5a	Mine 5 Local Resources	Local Resources		5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
6	Mine 6	Flag Boshielo	2B	0.000	0.000	0.000	0.000	5.000	10.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000	15.000
7	Mine 7	Flag Boshielo	2B	0.000	0.000	0.000	0.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
	Total Mininng Demand			**25.000**	**29.000**	**35.000**	**37.000**	**63.500**	**79.500**	**88.000**	**97.300**	**99.300**	**101.300**	**108.300**	**110.800**	**110.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**	**124.800**
	Total Mining Demand ORWRDP		**2B**	**0.000**	**4.000**	**6.000**	**8.000**	**28.500**	**44.500**	**53.000**	**62.300**	**64.300**	**66.300**	**73.300**	**75.800**	**75.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**	**89.800**
Phase 2C																													
1	Mine 8	De Hoop	2C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	Mine 9	De Hoop	2C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2a	Mine 9 - LWUA	Flag Boshielo	LWUA	3.500	3.500	3.500	3.500	3.500	3.500	3.500	3.500	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
3	Mine 10	De Hoop	2C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3a	Mine 10 - LWUA	Flag Boshielo	LWUA	3.500	3.500	3.500	3.500	3.500	5.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000	7.000
4	Mine 11	De Hoop	2C	0.000	0.000	0.000	0.000	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200	1.200
4a	Mine 11 Existing Resources	Local Resources		6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000	6.000
5	Mine 12	De Hoop	2C	0.000	0.000	0.000	0.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
5a	Mine 12 - Existing Resources	De Hoop	2C	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6	Mine 13	De Hoop	2C	0.000	0.000	0.000	0.000	1.200	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500	1.500
6a	Mine 13 - LWUA	Flag Boshielo	LWUA	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200	4.200
7	Mine 14	De Hoop	2C	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700	5.700
7a	Mine 14 Existing Resources	Local Resources		1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900
	Total Mininng Demand			**24.800**	**24.800**	**24.800**	**24.800**	**29.200**	**31.000**	**33.000**	**33.000**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**	**34.500**
	Total Mininng LWUA		**LWUA**	**11.200**	**11.200**	**11.200**	**11.200**	**11.200**	**12.700**	**14.700**	**14.700**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**	**16.200**
	Total Mining Demand ORWRDP		**2C**	**5.700**	**5.700**	**5.700**	**5.700**	**10.100**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**	**10.400**
	Total Flag Boshielo/De Hoop			**16.900**	**16.900**	**16.900**	**16.900**	**21.300**	**23.100**	**25.100**	**25.100**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**	**26.600**
Phase 2D																													
1	Mine 15	De Hoop	2D	0.000	0.000	0.000	0.000	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100	1.100
1a	Mine 15 - LWUA	Flag Boshielo	LWUA	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
2	Mine 16	De Hoop	2D	0.000	0.000	0.000	0.000	1.700	2.200	2.600	3.100	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600	3.600
2a	Mine 16 - LWUA	Flag Boshielo	LWUA	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000
3	Mine 17	De Hoop	2D	2.000	2.000	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900	2.900
3a	Mine 17 - LWUA	Flag Boshielo	LWUA	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800	0.800
	Total Mininng Demand			**11.200**	**11.200**	**12.100**	**12.100**	**14.900**	**15.400**	**15.800**	**16.300**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**	**16.800**
	Total Mininng LWUA		**LWUA**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**	**9.2**
	Total Mining Demand ORWRDP		**2D**	**2**	**2**	**2.9**	**2.9**	**5.7**	**6.2**	**6.6**	**7.1**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**	**7.6**
	Total Flag Boshielo/De Hoop			**11.2**	**11.2**	**12.1**	**12.1**	**14.9**	**15.4**	**15.8**	**16.3**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**	**16.8**
Phase 2E																													
1	Mine 18	De Hoop	2E	0.000	0.000	0.000	0.000	0.000	0.000	2.000	0.000	0.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000	2.000
2	Mine 19	De Hoop	2E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000	4.000	4.000	4.000	4.000	4.000	8.000	8.000	8.000	8.000	8.000
2a	Mine 19 - LWUA	Flag Boshielo	LWUA	0.700	1.100	5.200	5.200	5.200	7.000	7.000	7.000	7.000	7.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000	11.000
3	Mine 20	De Hoop	2E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3a	Mine 20 - LWUA	Flag Boshielo	LWUA	3.800	3.800	3.800	3.800	3.800	4.500	4.500	4.500	4.500	4.500	4.500	4.500	4.500	4.500	4.500	9.700	9.700	9.700	9.700	9.700	9.700	9.700	9.700	9.700	9.700	9.700
4	Mine 21	De Hoop	2E	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4a	Mine 21 - LWUA	Flag Boshielo	LWUA	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800	1.800
5	Mine 22	De Hoop	2E	1.400	1.800	1.800	1.800	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000	3.000
	Total Mining Demand			**7.700**	**8.500**	**12.600**	**12.600**	**13.800**	**16.300**	**18.300**	**16.300**	**16.300**	**18.300**	**22.300**	**22.300**	**22.300**	**22.300**	**22.300**	**31.500**	**31.500**	**31.500**	**31.500**	**31.500**	**31.500**	**35.500**	**35.500**	**35.500**	**35.500**	**35.500**
	Total Mininng LWUA		**LWUA**	**6.300**	**6.700**	**10.800**	**10.800**	**10.800**	**13.300**	**13.300**	**13.300**	**13.300**	**13.300**	**17.300**	**17.300**	**17.300**	**17.300**	**17.300**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**	**22.500**
	Total Mining Demand ORWRDP		**2E**	**1.400**	**1.800**	**1.800**	**1.800**	**3.000**	**3.000**	**5.000**	**3.000**	**3.000**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	**9.000**	**9.000**	**9.000**	**9.000**	**9.000**	**9.000**	**13.000**	**13.000**	**13.000**	**13.000**	**13.000**
	Total Flag Boshielo/De Hoop			**7.700**	**8.500**	**12.600**	**12.600**	**13.800**	**16.300**	**18.300**	**16.300**	**16.300**	**18.300**	**22.300**	**22.300**	**22.300**	**22.300**	**22.300**	**31.500**	**31.500**	**31.500**	**31.500**	**31.500**	**31.500**	**35.500**	**35.500**	**35.500**	**35.500**	**35.500**
	Total Mining Demand			**68.700**	**73.500**	**84.500**	**86.500**	**121.400**	**142.200**	**155.100**	**162.900**	**166.900**	**170.900**	**181.900**	**184.400**	**184.400**	**198.400**	**198.400**	**207.600**	**207.600**	**207.600**	**207.600**	**207.600**	**207.600**	**211.600**	**211.600**	**211.600**	**211.600**	**211.600**
	Total Mining Demand from LWUA			**26.700**	**27.100**	**31.200**	**31.200**	**31.200**	**35.200**	**37.200**	**37.200**	**38.700**	**38.700**	**42.700**	**42.700**	**42.700**	**42.700**	**42.700**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**	**47.900**
	Total Mining Demand from ORWRDP			**9.100**	**13.500**	**16.400**	**18.400**	**47.300**	**64.100**	**75.000**	**82.800**	**85.300**	**89.300**	**96.300**	**98.800**	**98.800**	**112.800**	**112.800**	**116.800**	**116.800**	**116.800**	**116.800**	**116.800**	**116.800**	**120.800**	**120.800**	**120.800**	**120.800**	**120.800**
	Total Mining Demand from Flag Boshileo & De Hoop			**35.800**	**40.600**	**47.600**	**49.600**	**78.500**	**99.300**	**112.200**	**120.000**	**124.000**	**128.000**	**139.000**	**141.500**	**141.500**	**155.500**	**155.500**	**164.700**	**164.700**	**164.700**	**164.700**	**164.700**	**164.700**	**168.700**	**168.700**	**168.700**	**168.700**	**168.700**

Appendix C:

REVIEW OF THE GROUNDWATER OPTIONS FOR RECONCILIATION STRATEGY OF THE OLIFANTS RIVER

WATER SUPPLY STRATEGY: JUNE 2013

REVIEW OF THE GROUNDWATER OPTIONS FOR RECONCILIATION STRATEGY OF THE OLIFANTS RIVER WATER SUPPLY STRATEGY

June 2013

K. Sami

REVIEW OF THE GROUNDWATER OPTIONS FOR RECONCILIATION STRATEGY OF THE OLIFANTS RIVER WATER SUPPLY STRATEGY

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1 INTRODUCTION

1.1 TERMS OF REFERENCE

WSM Leshika was appointed by Bennie Haasbroek of Hydrosol regarding a review of the Groundwater Reserve done by SRK, currently under revision, and a study done by AGES (AGES (2009) Olifants River Water Management Area: Groundwater Assessment. Final Report prepared for SATAC, Report AS-R-2009-05-20.

1.2 BACKGROUND

Hydrosol is currently undertaking the Olifants Reconciliations Strategy Maintenance project. The largest contribution to the water balance will be the development of groundwater. A report undertaken by Aurecon, Development of a Reconciliation Strategy for the Olifants River Water Supply System WP10197 Groundwater Options Report (Report No P WMA 04/B50/00/8310/10), compared two existing groundwater studies for the basin. The SRK report concluded that 1250 MCM/a of groundwater is available. The AGES report concluded that an amount of 70 MCM/a is available as potential diffuse groundwater development. There is also a significant dolomitic aquifer that that will potentially provide additional 60 – 90 MCM/a, however, the combined total of the dolomites and diffuse groundwater is uncertain and a large variation exists between the 2 reports.

The specific objective of the AGES report was to formulate a detailed strategy for water resource management in the Olifants River Water Management Area (WMA) in terms of water quantity and future groundwater allocations for application in the water use licensing process. The water balance was based on a regional assessment and review of existing information, an evaluation of the groundwater component of the Olifants River, and the development of a groundwater flow balance model.

SRK (2009) was appointed by DWA: Chief Directorate Resource Directed Measures to determine the groundwater component of the Reserve for the Olifants River catchment at an Intermediate Level. This level of determination can be defined as yielding results of medium to high confidence which is required for assessing individual licenses for moderate impacts in relatively stressed catchments.

1.3 SCOPE OF WORK

WSM was appointed to address the following questions:

- Are the Reconciliation Strategy's groundwater estimates an accurate reflection of the available groundwater and what is the spatial distribution of the available groundwater? Do these estimates include Groundwater Reserve?
- Is the Strategy's dolomitic allocable groundwater a representative reflection of availability of water?
- Does If the Strategy's allocable groundwater estimates results take into account the effects of surface water reductions due to groundwater depletions, i.e. therefore is the 70 Mm^3/a additional yield to the system?

2 SITE DESCRIPTION

2.1 LOCATION

The Olifants River Catchment is located within the provinces of Gauteng, Mpumalanga and Limpopo and covers an area of approximately 54 550 km2. It consists of tertiary catchments B10-B70 (figure 1).

Figure 1 Location of the study area

2.2 PHYSIOGRAPHY AND DRAINAGE

The Olifants River is fed by a number of tributaries of which the most significant on the left bank are the Wilge, Elands and Ga-Selati Rivers and the Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank. The Olifants River flows directly from South Africa into Moçambique where it joins the Limpopo River. Developments in South Africa directly impact upon the water quality and quantity flowing across the border into Moçambique.

The catchment is divided into three sub-catchments, namely the Upper Olifants, Middle Olifants (incorporates the Steelpoort River), and the Lower Olifants. In the western part of the catchment the topography is characterised by gently sloped hills before the Olifants River cuts through the Drakensberg mountains to enter the relatively featureless Lowveld region.

The Olifants catchment WMA covers a total area of 54 550 km^2. The catchment has been sub-divided into 3 sub-areas as follows:

- The Upper Olifants, covering an area of 12 250 km^2, and incorporating quaternary catchments B11A – K, B21A – E, B20A – J, and B32A
- The Middle Olifants, covering an area of 22 550 km^2, and incorporating quaternary catchments B31A – J, B32A – J, B41A – K, B42A – H, B51A – J, B71A – F
- The Lower Olifants, covering an area of 12 600 km^2, incorporating quaternary catchments B60A – J, B72A – K, B73A – J.

2.3 CLIMATE

As a consequence of the topography, the climate experienced differs distinctly throughout the catchment, varying from cool in the Highveld region of the catchment, through temperate in the central parts to sub-tropical east of the escarpment and lowveld region. The mean annual precipitation falls within the range of 700 mm in the Highveld region, reaching 1 000 mm in the mountains and reducing to 500 mm in the lowveld region. The potential evaporation is well in excess of the rainfall.

3 GROUNDWATER RESOURCES EVALUATION

3.1 GROUNDWATER USE

Groundwater is available throughout the Olifants WMA only varying in quantity depending upon the hydrogeological characteristics of the underlying formations. The groundwater use in the various sub-catchments therefore varies very much with the groundwater availability.

Groundwater in high yielding areas is mainly used for irrigation, whereas in low yielding areas it is mainly for domestic purposes and livestock watering.

AGES (2009) reported that yield information is available from 5690 boreholes on the DWA NGA. The average yield data was used to get a broad estimation of the annual abstraction across the Olifants WMA by assuming a 2 to 6 hour pumping per day. This gave a usage of between 30 million m^3/a and 90 million m^3 /a. This was taken as farming water use, excluding irrigation.

The Groundwater Component of the Reserve Determination Study for the Olifants River Catchment, undertaken by SRK Consulting (Pty) Ltd determined that the groundwater usage is approximately 269.3 million m_3/a, of which only 168.87 is registered.

GRAII lists the registered groundwater use is 145 Mm^3/a, however, the water use data in GRAII is dated. Estimated water use from the various sources is shown in table 1.

This study utilised the groundwater use tabulated by SRK.

Table 1 Estimated water use

Study	Use (Mm^3/a)
AGES	229
SRK	269
GRAII	145

3.2 GROUNDWATER RESOURCES

3.2.1 Comparison of water balances

AGES utilised The Groundwater Yield Model (GYM) to quantify the groundwater balance on quaternary catchment scale based on assurance levels. In the steady state system, the inputs to the groundwater from recharge will equate the outputs from the groundwater to surface water system in the form of base flow and losses to evapotranspiration. The overall results of the GYM indicated that there is a surplus of groundwater in the four sub-areas due to inflow exceeding outflow. The total volume of groundwater recharge was calculated to be in the order of 864 million m_3/a and the groundwater component of base flow was given as 45 million m_3/a for the Olifants WMA (table 2).

AGES calculated that evapotranspiration losses account for up to 646 million m^3/a of the groundwater flow losses (70%). The biggest water users are the community water supply at 80 million m^3/a (10%), and irrigation at 83 million m^3/a (8%). They estimate the inflow from dam seepage as high as 47 million m_3/a, which is more than baseflow. After subtracting abstraction, they tabulated the available groundwater resources as 70 Mm^3/a

SRK utilised GRAII data to tabulate recharge as 2015 Mm^3/a and baseflow as 614 Mm3/a, and calculated that 1250 Mm^3/a remains to be abstracted.

Using data in GRAII, this study found recharge to 1119 Mm^3/a, of which 708 Mm^3/a recharges the regional aquifer, while the balance contributes to the interflow component of baseflow. Under present day conditions, aquifer recharge is 720 Mm^3/a, and transmission losses from surface water, another 14 Mm^3/a.

The large discrepancies seem to be the recharge calculated by SRK, 2015 Mm^3/a; and the low baseflow calculated by AGES, 45 Mm^3/a. The baseflow calculated by the Sami model in GRAII is 808 Mm^3/a, of which 414 is from the regional groundwater. In comparison the Hughes figures for baseflow are 853 Mm^3/a, and the Pitman figures are 651 Mm^3/a. Hence the baseflow calculated by AGES do not reconcile with existing data utilised and accepted by surface water hydrologists.

The SRK figures on available groundwater don't consider evapotranspiration, hence the excessive recharge and no evapotranspiration losses from shallow groundwater result in a large surplus groundwater figure of 1250 Mm3/a. The SRK figures also don't consider that not all the recharge enters the regional aquifers. AGES have a low recharge rate of 864

Mm^3/a and high ET loses of 646 Mm^3, but cannot account for the far larger baseflow recorded by other studies and calibrated against observed flow data. Calibrated baseflow figures by the Pitman and Hughes methods range from 651-853 Mm^3/a, consequently, the ET figures in AGES cannot be correct, as baseflow is less than an order of magnitude below observed volumes.

Table 2 Comparison of water balances

	SRK	AGES	GRAII-virgin[1]	GRAII- Present[1]
Recharge (aquifer recharge)	2015	864	1119 (708)	1119 (720)
Transmission losses-virgin		47	13	14
TOTAL	2015	911	1132 (721)	1133 (734)
Abstraction	267	229	0	145
Baseflow (groundwater baseflow)	614	45	808 (414)	798 (404)
Evapotranspiration		646	305	187
AVAILABLE	1250	70		

[1] – Values in brackets provide the contribution to the regional aquifer, excluding interflow losses.

3.3 AVAILABLE GROUNDWATER RESOURCES

Available resources were tabulated according to DWA data on Harvest Potential, Exploitation Potential, GRAII utilisable Exploitation Potential, Groundwater recharge in GRAII, and aquifer recharge in GRAII, which excludes recharge lost to interflow, and not available to boreholes from the regional groundwater (table 3). Estimates of the total available groundwater range from 600 Mm^3/a from the Exploitation Potential data, to 900 Mm^3/a from the Harvest Potential data.

Table 3 Available groundwater resources

Quaternary	Harvest Potential Mm^3/a	Exploitation Potential Mm^3/a	Recharge	Aquifer Recharge Mm^3/a	Utilisable groundwater Exploitation Potential
B11A	20.60	12.36	16.55	15.45	7.94
B11B	9.48	6.64	7.22	6.84	5.27
B11C	8.39	5.04	6.01	5.71	2.62
B11D	12.01	7.21	7.92	7.66	4.21
B11E	10.18	5.09	7.04	6.80	4.46
B11F	9.33	5.60	6.75	6.44	4.99
B11G	8.02	4.81	5.88	5.61	4.65
B11H	5.33	3.73	3.97	3.78	3.29
B11J	4.70	3.29	8.61	7.08	2.28
B11K	7.13	4.28	11.54	9.84	3.13
B11L	3.82	1.91	7.28	6.05	2.13
B12A	8.83	5.30	4.72	4.72	4.60
B12B	14.68	7.34	8.62	8.62	9.53
B12C	12.73	8.91	7.20	7.20	7.25
B12D	8.47	5.93	5.18	5.16	4.72
B12E	7.33	5.13	14.32	11.49	3.71
B20A	16.64	11.65	13.99	10.26	7.22
B20B	11.51	8.06	7.59	5.72	7.70
B20C	3.08	2.16	8.87	6.53	10.72
B20D	5.43	3.80	11.12	8.52	12.41
B20E	13.52	8.11	12.55	9.81	6.38
B20F	7.29	5.10	11.34	9.05	9.49
B20G	10.07	7.05	15.36	13.15	4.78
B20H	10.60	6.36	15.81	13.70	4.74
B20J	10.57	7.40	11.84	10.03	3.40
B31A	5.49	3.84	7.20	6.09	7.00
B31B	9.09	5.45	5.66	5.56	3.55
B31C	9.11	5.46	5.80	5.14	-1.87
B31D	13.18	9.23	8.39	7.58	-2.56
B31E	25.60	17.92	9.00	8.34	11.47
B31F	13.64	9.55	3.80	3.69	5.41
B31G	12.70	8.89	6.78	4.67	3.96
B31H	14.44	10.11	9.06	6.85	4.35
B31J	19.96	13.97	7.94	7.84	8.47
B32A	14.95	8.97	25.74	21.18	6.61
B32B	15.01	9.01	18.37	13.40	6.28
B32C	6.56	4.60	7.86	3.19	4.18
B32D	9.95	6.96	5.16	4.95	5.99
B32E	2.78	1.95	2.88	2.43	2.82
B32F	11.44	8.01	8.28	3.71	8.64

Quaternary	Harvest Potential Mm^3/a	Exploitation Potential Mm^3/a	Recharge	Aquifer Recharge Mm^3/a	Utilisable groundwater Exploitation Potential
B32G	27.72	19.41	17.26	8.89	12.66
B32H	14.12	9.88	11.04	10.21	6.25
B32J	6.44	4.51	1.17	1.17	3.52
B41A	13.65	9.56	23.27	18.28	9.23
B41B	10.14	7.10	22.82	18.51	8.10
B41C	3.50	2.45	8.70	7.19	2.32
B41D	4.84	3.39	9.38	4.97	4.93
B41E	2.84	1.71	1.18	1.17	2.89
B41F	4.49	3.14	12.99	10.88	3.41
B41G	5.24	3.67	13.72	11.41	4.38
B41H	4.92	3.44	3.31	2.57	6.08
B41J	8.12	5.68	5.51	4.31	8.77
B41K	9.23	6.46	4.20	3.53	9.41
B42A	3.57	2.50	20.71	10.64	4.54
B42B	2.40	1.68	17.93	7.65	4.71
B42C	1.84	1.10	2.92	2.66	2.82
B42D	1.74	1.22	16.76	6.33	4.95
B42E	2.49	1.49	2.16	2.04	3.26
B42F	3.12	2.19	16.14	9.39	3.12
B42G	3.66	2.56	4.15	3.86	5.55
B42H	4.63	3.24	3.06	2.31	6.55
B51A	3.65	2.56	2.92	2.24	2.66
B51B	7.64	4.59	6.19	4.82	4.60
B51C	6.32	3.16	5.00	4.52	4.18
B51E	41.44	29.01	6.31	6.31	10.99
B51F	4.79	2.87	3.30	2.71	5.59
B51G	7.07	4.95	4.24	3.79	1.30
B51H	7.62	4.57	5.80	4.90	5.85
B52A	6.36	4.45	2.65	2.58	2.17
B52B	6.50	4.55	7.76	7.09	5.78
B52C	2.38	1.66	1.11	0.96	3.06
B52D	4.76	3.33	2.09	2.09	1.94
B52E	4.33	3.03	4.77	4.66	4.03
B52F	1.39	0.84	0.68	0.58	1.88
B52G	3.40	2.38	1.50	1.35	2.67
B52H	8.16	5.71	5.27	3.38	10.54
B52J	5.68	3.41	2.56	2.09	4.72
B60A	5.15	3.61	57.79	12.93	20.29
B60B	7.17	5.02	70.94	20.22	24.23
B60C	1.97	1.38	29.94	5.33	9.42
B60D	6.18	4.32	30.30	15.98	7.21
B60E	0.93	0.65	9.59	1.73	3.26

Quaternary	Harvest Potential Mm^3/a	Exploitation Potential Mm^3/a	Recharge	Aquifer Recharge Mm^3/a	Utilisable groundwater Exploitation Potential
B60F	4.48	3.14	8.53	7.68	8.56
B60G	5.14	3.60	9.16	4.52	10.04
B60H	8.70	6.09	8.75	7.58	6.26
B60J	10.84	7.59	20.22	13.05	6.11
B71A	6.63	4.64	4.06	3.37	3.81
B71B	3.33	2.00	2.44	2.11	1.83
B71C	4.89	1.47	26.64	5.87	8.53
B71D	3.73	2.61	10.80	4.03	2.74
B71E	8.34	5.84	7.87	6.25	7.83
B71F	9.34	6.54	32.59	12.68	11.07
B71G	5.75	4.03	19.42	6.94	5.62
B71H	4.99	3.49	1.82	1.56	6.24
B71J	1.00	0.30	0.18	0.18	0.57
B72A	8.66	6.07	31.01	12.53	7.21
B72B	4.66	3.26	1.45	1.37	1.50
B72C	4.67	1.87	2.14	1.88	2.15
B72D	11.93	8.35	7.21	6.54	2.58
B72E	6.22	4.36	21.95	8.54	5.79
B72F	1.51	0.75	7.05	2.27	2.23
B72G	0.77	0.31	0.12	0.12	0.98
B72H	5.53	3.32	2.35	1.94	5.30
B72J	6.86	4.80	3.04	2.91	6.18
B72K	11.60	8.12	3.45	3.45	4.19
B73A	2.78	1.95	16.99	2.20	7.12
B73B	8.46	5.92	2.19	2.19	2.47
B73C	10.57	7.40	3.19	3.19	4.57
B73D	8.26	5.78	2.34	2.34	3.97
B73E	6.90	4.83	2.81	2.51	3.66
B73F	5.94	4.16	3.58	3.37	4.14
B73G	8.23	5.76	4.41	4.31	4.26
B73H	2.77	1.94	1.51	1.50	0.82
B73J	2.27	1.59	1.58	1.55	0.64
	901.01	600.44	1119.09	708.61	618.71

3.4 BASEFLOW AND THE RESERVE

Baseflow figures were obtained from GRAII to calculate the groundwater reserve. The Basic Human Need component was obtained from the SRK study, and the Reserve calculated as the sum of the Basic Human Need and groundwater baseflow (table 4). The groundwater reserve is 442 Mm^3/a, in comparison to the 495 Mm3/a calculated by SRK.

Table 4 baseflow and the groundwater reserve

Quaternary	Baseflow Mm^3/a	Groundwater Baseflow Mm^3/a	Basic Human Need Mm^3/a	Ground Water Reserve Mm^3/a
B11A	13.54	12.20	0.1	12.30
B11B	5.91	5.37	0.12	5.49
B11C	4.91	4.85	0.04	4.89
B11D	6.48	6.50	0.18	6.68
B11E	5.76	5.36	0.11	5.47
B11F	5.52	5.07	0.08	5.15
B11G	4.81	4.42	0.07	4.49
B11H	3.25	2.97	0.04	3.01
B11J	6.88	5.60	1.88	7.48
B11K	9.23	7.59	0.03	7.62
B11L	6.06	4.95	0.01	4.96
B12A	4.25	4.31	0.18	4.49
B12B	7.76	7.81	0.08	7.89
B12C	6.48	6.54	0.04	6.58
B12D	4.66	4.72	0.98	5.70
B12E	11.45	9.15	0.04	9.19
B20A	9.88	6.60	1.86	8.46
B20B	5.35	3.62	1.1	4.72
B20C	6.26	4.13	0.03	4.16
B20D	7.85	5.30	0.26	5.56
B20E	10.04	7.27	0.37	7.64
B20F	8.00	5.71	0.05	5.76
B20G	12.28	10.28	0.3	10.58
B20H	12.65	11.03	0.36	11.39
B20J	9.47	8.03	0.05	8.08
B31A	5.08	3.77	0.04	3.81
B31B	3.95	3.45	0.19	3.64
B31C	3.31	2.75	0	2.75
B31D	4.80	4.06	0.42	4.48
B31E	0.11	0.00	0.14	0.14
B31F	0.04	0.00	0.43	0.43
B31G	3.54	1.40	0.31	1.71
B31H	4.18	1.96	1.64	3.60
B31J	0.08	0.00	0.1	0.10
B32A	20.59	16.26	0.05	16.31
B32B	14.50	9.70	0.04	9.74
B32C	5.61	1.09	0.01	1.10
B32D	3.44	3.15	0.07	3.22
B32E	1.92	1.59	0.01	1.60
B32F	5.52	0.71	0.34	1.05
B32G	10.35	1.35	1.83	3.18

Quaternary	Baseflow Mm^3/a	Groundwater Baseflow Mm^3/a	Basic Human Need Mm^3/a	Ground Water Reserve Mm^3/a
B32H	6.37	5.77	0.06	5.83
B32J	0.23	0.00	0.44	0.44
B41A	19.39	14.79	0.14	14.93
B41B	19.02	14.96	0.04	15.00
B41C	7.25	5.79	0.02	5.81
B41D	7.22	2.61	0.09	2.70
B41E	0.17	0.00	0.23	0.23
B41F	11.81	9.99	0.01	10.00
B41G	12.47	10.34	0.01	10.35
B41H	0.37	0.00	0.35	0.35
B41J	0.73	0.00	0.41	0.41
B41K	0.82	0.00	0.47	0.47
B42A	19.73	9.81	0.02	9.83
B42B	16.30	6.28	0.17	6.45
B42C	2.66	2.57	0	2.57
B42D	15.88	5.72	0	5.72
B42E	2.16	1.99	0.01	2.00
B42F	15.37	8.55	0.01	8.56
B42G	3.77	3.59	0.01	3.60
B42H	0.37	0.00	0.07	0.07
B51A	0.21	0.00	0.4	0.40
B51B	0.41	0.00	0.46	0.46
B51C	0.25	0.00	0.45	0.45
B51E	0.20	0.00	0.34	0.34
B51F	0.23	0.00	0.01	0.01
B51G	0.26	0.00	0.97	0.97
B51H	0.37	0.00	0.98	0.98
B52A	0.11	0.00	0.48	0.48
B52B	0.44	0.00	1.07	1.07
B52C	0.03	0.00	0.16	0.16
B52D	0.03	0.00	0.73	0.73
B52E	0.21	0.00	0.34	0.34
B52F	0.02	0.00	0.09	0.09
B52G	0.04	0.00	0.22	0.22
B52H	0.80	0.00	0.66	0.66
B52J	0.17	0.00	0.22	0.22
B60A	55.03	11.46	0.02	11.48
B60B	66.30	17.18	0.01	17.19
B60C	28.79	4.93	0	4.93
B60D	27.44	14.00	0.15	14.15
B60E	8.53	0.76	0	0.76
B60F	7.11	5.43	0.01	5.44
B60G	5.39	1.32	0.03	1.35

Quaternary	Baseflow Mm^3/a	Groundwater Baseflow Mm^3/a	Basic Human Need Mm^3/a	Ground Water Reserve Mm^3/a
B60H	6.95	6.15	0.14	6.29
B60J	13.48	6.46	0.05	6.51
B71A	0.66	0.00	0.03	0.03
B71B	0.13	0.00	0.07	0.07
B71C	22.84	2.17	0.03	2.20
B71D	8.84	1.98	0.1	2.08
B71E	1.08	0.00	0.8	0.80
B71F	29.33	9.11	0.07	9.18
B71G	16.26	3.97	0.13	4.10
B71H	0.11	0.00	0.2	0.20
B71J	0.01	0.00	0.01	0.01
B72A	27.23	8.64	0.54	9.18
B72B	0.04	0.00	0	0.00
B72C	0.04	0.00	0.05	0.05
B72D	0.05	0.00	0.01	0.01
B72E	18.38	4.90	0.45	5.35
B72F	6.04	1.30	0	1.30
B72G	0.00	0.00	0.01	0.01
B72H	0.12	0.00	0.01	0.01
B72J	0.10	0.00	0.03	0.03
B72K	0.07	0.00	0.52	0.52
B73A	15.99	1.29	0	1.29
B73B	0.04	0.00	0.01	0.01
B73C	0.06	0.00	0.65	0.65
B73D	0.05	0.00	0	0.00
B73E	0.08	0.00	0	0.00
B73F	0.06	0.00	0	0.00
B73G	0.06	0.00	0	0.00
B73H	0.01	0.00	0	0.00
B73J	0.02	0.00	0	0.00
	808.37	414.43	**28.25**	442.68

3.5 GROUNDWATER USE

Table 5 shows groundwater use, and use (according to the SRK report) expressed as a percentage of the available groundwater resources, tabulated by various methods, allowing stressed quaternaries to be identified. Catchments shown in red are overexploited. Catchments shown in orange can be considered stressed and severely impacted.

(red)	> potential
(orange)	>0.75 potential
(yellow)	>0.5 potential
(green)	< 0.5 potential

Table 5 Groundwater use

Quaternary	Total Use Mm^3/a	% of Harvest Potential	% of Exploitation Potential	% of aquifer recharge	% of recharge
B11A	0.57	2.77	4.61	3.69	3.44
B11B	0.2	2.11	3.01	2.93	2.77
B11C	4.37	52.07	86.78	76.59	72.77
B11D	2.34	19.48	32.47	30.53	29.53
B11E	3.53	34.67	69.35	51.94	50.13
B11F	0.37	3.97	6.61	5.75	5.48
B11G	0.1	1.25	2.08	1.78	1.70
B11H	0.46	8.62	12.32	12.17	11.58
B11J	0.42	8.93	12.76	5.93	4.88
B11K	0.22	3.09	5.14	2.24	1.91
B11L	0.06	1.57	3.14	0.99	0.82
B12A	0.16	1.81	3.02	3.39	3.39
B12B	3.84	26.17	52.33	44.54	44.54
B12C	0.21	1.65	2.36	2.92	2.92
B12D	0.24	2.83	4.05	4.65	4.64
B12E	0.45	6.14	8.77	3.92	3.14
B20A	20.57	123.64	176.63	200.44	147.01
B20B	57.31	497.89	711.27	1001.20	755.45
B20C	0.91	29.52	42.18	13.93	10.26
B20D	1.43	26.32	37.60	16.79	12.86
B20E	3.58	26.49	44.15	36.48	28.53
B20F	0.8	10.97	15.67	8.84	7.05
B20G	1.87	18.56	26.52	14.22	12.18
B20H	1.77	16.70	27.83	12.92	11.20
B20J	1.09	10.31	14.73	10.87	9.21
B31A	4.81	87.60	125.14	79.00	66.84
B31B	1.22	13.42	22.37	21.95	21.55
B31C	0.82	9.01	15.01	15.94	14.14
B31D	1.96	14.87	21.24	25.86	23.36
B31E	9.24	36.09	51.56	110.75	102.69
B31F	2.31	16.94	24.20	62.65	60.73
B31G	1.42	11.18	15.97	30.40	20.94
B31H	4.36	30.19	43.13	63.62	48.14
B31J	30.84	154.54	220.76	393.19	388.52
B32A	0.54	3.61	6.02	2.55	2.10
B32B	0.25	1.67	2.78	1.87	1.36

Quaternary	Total Use Mm^3/a	% of Harvest Potential	% of Exploitation Potential	% of aquifer recharge	% of recharge
B32C	3.47	52.86	75.51	108.68	44.14
B32D	3.14	31.57	45.10	63.40	60.81
B32E	0.19	6.84	9.77	7.83	6.60
B32F	4.3	37.58	53.69	115.87	51.93
B32G	5.85	21.10	30.14	65.79	33.90
B32H	2.9	20.54	29.34	28.39	26.27
B32J	1.01	15.68	22.40	86.23	86.23
B41A	0.06	0.44	0.63	0.33	0.26
B41B	1.23	12.13	17.33	6.65	5.39
B41C	0.54	15.44	22.06	7.51	6.21
B41D	1.72	35.57	50.81	34.64	18.33
B41E	0.11	3.87	6.45	9.39	9.35
B41F	0	0.00	0.00	0.00	0.00
B41G	0.38	7.25	10.36	3.33	2.77
B41H	0.16	3.25	4.65	6.22	4.84
B41J	0.64	7.88	11.26	14.86	11.62
B41K	1.99	21.57	30.81	56.32	47.38
B42A	3.46	96.84	138.35	32.52	16.71
B42B	0.06	2.50	3.58	0.78	0.33
B42C	0	0.00	0.00	0.00	0.00
B42D	0	0.00	0.00	0.00	0.00
B42E	0.22	8.85	14.75	10.76	10.20
B42F	0.22	7.04	10.06	2.34	1.36
B42G	3.26	89.01	127.16	84.40	78.63
B42H	0.99	21.40	30.57	42.89	32.38
B51A	0.08	2.19	3.13	3.58	2.74
B51B	0.33	4.32	7.20	6.85	5.33
B51C	0.22	3.48	6.96	4.87	4.40
B51E	8.56	20.65	29.51	135.76	135.76
B51F	3.02	63.08	105.13	111.57	91.39
B51G	12.43	175.84	251.19	327.94	293.46
B51H	0.57	7.48	12.46	11.63	9.82
B52A	0.28	4.40	6.29	10.86	10.56
B52B	2.08	32.00	45.72	29.36	26.80
B52C	0.22	9.25	13.22	22.82	19.87
B52D	1.19	25.01	35.73	56.93	56.93
B52E	0.51	11.79	16.84	10.95	10.69
B52F	0.47	33.69	56.16	81.41	68.89
B52G	0.84	24.70	35.28	62.24	55.85
B52H	0.77	9.44	13.48	22.81	14.61
B52J	0.14	2.46	4.10	6.70	5.47
B60A	0.13	2.52	3.60	1.01	0.22
B60B	0	0.00	0.00	0.00	0.00

Quaternary	Total Use Mm^3/a	% of Harvest Potential	% of Exploitation Potential	% of aquifer recharge	% of recharge
B60C	0	0.00	0.00	0.00	0.00
B60D	0	0.00	0.00	0.00	0.00
B60E	0	0.00	0.00	0.00	0.00
B60F	2.71	60.49	86.42	35.29	31.75
B60G	3.71	72.12	103.03	82.06	40.51
B60H	5.34	61.35	87.64	70.46	61.02
B60J	1.37	12.64	18.05	10.50	6.78
B71A	0.23	3.47	4.95	6.83	5.67
B71B	0.19	5.70	9.51	9.01	7.78
B71C	0	0.00	0.00	0.00	0.00
B71D	0.22	5.90	8.43	5.46	2.04
B71E	1.55	18.59	26.55	24.80	19.70
B71F	0.03	0.32	0.46	0.24	0.09
B71G	0.22	3.82	5.46	3.17	1.13
B71H	2.52	50.52	72.18	161.08	138.65
B71J	0	0.00	0.00	0.00	0.00
B72A	3.01	34.74	49.63	24.01	9.71
B72B	0.06	1.29	1.84	4.38	4.14
B72C	0.07	1.50	3.75	3.71	3.28
B72D	4.49	37.64	53.77	68.61	62.27
B72E	0.9	14.46	20.66	10.53	4.10
B72F	0	0.00	0.00	0.00	0.00
B72G	0.43	55.99	139.97	345.02	345.02
B72H	0.92	16.65	27.75	47.41	39.21
B72J	0.16	2.33	3.33	5.50	5.26
B72K	0.61	5.26	7.51	17.67	17.67
B73A	0	0.00	0.00	0.00	0.00
B73B	2.75	32.51	46.44	125.64	125.64
B73C	1.01	9.55	13.65	31.63	31.63
B73D	1.2	14.53	20.76	51.28	51.28
B73E	0.35	5.08	7.25	13.92	12.47
B73F	0	0.00	0.00	0.00	0.00
B73G	0	0.00	0.00	0.00	0.00
B73H	0	0.00	0.00	0.00	0.00
B73J	0	0.00	0.00	0.00	0.00
	266.43				

3.6 POTENTIAL GROUNDWATER ALLOCATION

Potential additional groundwater allocations were calculated by several means:

1. Harvest Potential allocation: this figure represents the available allocation as the difference between Harvest Potential and current use, hence is a measure of currently available diffuse groundwater resources.

2. Exploitation Potential allocation: this figure represents the available allocation as the difference between Exploitation Potential and current use, hence is a measure of the economically exploitable diffuse groundwater.

3. Aquifer recharge allocation: this figure represents the available allocation as the difference between recharge to the regional aquifers and current use. Aquifer recharge is recharge available to boreholes, after interflow from perched aquifers and localised high lying aquifers has been accounted for. Groundwater baseflow is not accounted for, hence this values represents an upper abstraction limit.

4. Groundwater Reserve allocation (a). This is the groundwater allocation as calculated according to the GRDM Manual; however, all of baseflow (including interflow) is included in the reserve. The allocation is calculated by: Recharge + transmission losses – Basic Human Needs – baseflow - current use. Since some of the use already meets basic human needs, this results in double accounting. In addition, abstraction has an impact on baseflow, depending on the location of the abstraction, the hydraulic properties of the aquifer, and the duration of pumping, hence the baseflow component cannot be strictly reserved. In addition, groundwater losses to evapotranspiration are not considered.

5. Groundwater Reserve allocation (b). This is the groundwater allocation as calculated according to the GRDM Manual. Only the groundwater contribution to baseflow is included in the reserve as the maintenance low flow. The allocation is calculated by: Recharge + transmission losses – Basic Human Needs – groundwater baseflow- current use. Not all of the recharge is accessible via the regional aquifer, and some is lost as interflow

before recharging the aquifer, hence this method is an overestimate of available resources.

6. Groundwater Reserve allocation (c). This is the groundwater allocation as calculated according to the GRDM Manual, however, only recharge to the regional aquifer is considered. Only the groundwater contribution to baseflow is included in the reserve as the maintenance low flow. The allocation is calculated by: Aquifer Recharge + transmission losses – Basic Human Needs – groundwater baseflow- current use.

Catchments where existing use results in a negative water balance for allocation were considered to have a zero allocation. The results of the different allocation methods are shown in table 6. If the Reserve is not considered, the Harvest Potential allocation suggests 700 Mm^3/a of groundwater remain to be allocated from diffuse recharge. The Exploitation Potential allocation suggests 420 Mm^3/a can be economically exploited. Of the recharge to the regional aquifer, 541 Mm^3/a is currently not utilised. However, these methods do not consider the groundwater reserve and baseflow.

If the GRDM methodology is utilised, and the groundwater reserve is considered, the suggested methodology results in 546 Mm^3/a being available, however, this method assumes all the recharge can be tapped. If only aquifer recharge is considered, or interflow is subtracted from recharge, 155-170 Mm^3/a remain to be allocated.

The dolomitic aquifers are generally already utilised, except for the escarpment dolomites stretching in a NW arc from B60A-D, B71A-D, F and G, and B52J. These form the Blyde river catchment and the lower part of the Mid-Olifants

Table 6 Potential remaining Groundwater allocation. Quaternaries containing dolomites are shaded

Quaternary	HP allocation Mm³/a Method 1	EP allocation Mm³/a Method 2	Aquifer Recharge allocation Mm³/a Method 3	Ground Water Reserve allocation (a) Mm³/a Method 4	Groundwater reserve allocation (b) Mm³/a Method 5	Groundwater Reserve allocation (c) Mm³/a Method 6
B11A	20.03	11.79	14.88	2.74	4.08	2.98
B11B	9.28	6.44	6.64	1.17	1.71	1.32
B11C	4.02	0.67	1.34	0.00	0.00	0.00
B11D	9.67	4.87	5.32	0.00	0.00	0.00
B11E	6.65	1.56	3.27	0.00	0.00	0.00
B11F	8.96	5.23	6.07	0.94	1.39	1.08
B11G	7.92	4.71	5.51	1.05	1.44	1.17
B11H	4.87	3.27	3.32	0.32	0.60	0.41
B11J	4.28	2.87	6.66	0.00	0.89	0.00
B11K	6.91	4.06	9.62	2.31	3.95	2.25
B11L	3.76	1.85	5.99	1.32	2.44	1.21
B12A	8.67	5.14	4.56	0.32	0.26	0.26
B12B	10.84	3.50	4.78	0.00	0.00	0.00
B12C	12.52	8.70	6.99	0.76	0.70	0.70
B12D	8.23	5.69	4.92	0.00	0.00	0.00
B12E	6.88	4.68	11.04	2.73	5.03	2.21
B20A	0.00	0.00	0.00	0.00	0.00	0.00
B20B	0.00	0.00	0.00	0.00	0.00	0.00
B20C	2.17	1.25	5.62	1.81	3.93	1.59
B20D	4.00	2.37	7.09	1.75	4.30	1.70
B20E	9.94	4.53	6.23	0.00	1.49	0.00
B20F	6.49	4.30	8.25	2.62	4.92	2.62
B20G	8.20	5.18	11.28	1.24	3.24	1.04
B20H	8.83	4.59	11.93	1.36	2.98	0.87
B20J	9.48	6.31	8.94	1.51	2.95	1.14
B31A	0.68	0.00	1.28	0.00	0.00	0.00
B31B	7.87	4.23	4.34	0.32	0.82	0.71
B31C	8.29	4.64	4.32	1.68	2.25	1.59
B31D	11.22	7.27	5.62	1.24	1.97	1.16
B31E	16.36	8.68	0.00	0.00	0.00	0.00
B31F	11.33	7.24	1.38	1.02	1.06	0.95
B31G	11.28	7.47	3.25	1.56	3.70	1.59
B31H	10.08	5.75	2.49	0.00	1.13	0.00
B31J	0.00	0.00	0.00	0.00	0.00	0.00
B32A	14.41	8.43	20.64	4.59	8.92	4.36
B32B	14.76	8.76	13.15	3.75	8.56	3.59
B32C	3.09	1.13	0.00	0.00	3.35	0.00
B32D	6.81	3.82	1.81	0.00	0.00	0.00
B32E	2.59	1.76	2.24	0.79	1.12	0.67
B32F	7.14	3.71	0.00	0.00	3.22	0.00
B32G	21.87	13.56	3.04	0.00	8.43	0.07
B32H	11.22	6.98	7.31	1.72	2.32	1.49
B32J	5.43	3.50	0.16	0.00	0.00	0.00
B41A	13.59	9.50	18.22	3.86	8.45	3.47
B41B	8.91	5.87	17.28	2.71	6.76	2.45
B41C	2.96	1.91	6.65	0.95	2.41	0.90
B41D	3.12	1.67	3.25	0.40	5.01	0.59
B41E	2.73	1.60	1.06	0.66	0.84	0.83
B41F	4.49	3.14	10.88	1.32	3.14	1.03
B41G	4.86	3.29	11.03	1.05	3.19	0.88
B41H	4.76	3.28	2.41	2.43	2.80	2.06

Quaternary	HP allocation Mm^3/a Method 1	EP allocation Mm^3/a Method 2	Aquifer Recharge allocation Mm^3/a Method 3	Ground Water Reserve allocation (a) Mm^3/a Method 4	Groundwater reserve allocation (b) Mm^3/a Method 5	Groundwater Reserve allocation (c) Mm^3/a Method 6
B41J	7.48	5.04	3.67	3.73	4.46	3.26
B41K	7.24	4.47	1.54	0.92	1.74	1.07
B42A	0.11	0.00	7.18	0.00	7.48	0.00
B42B	2.34	1.62	7.59	1.55	11.57	1.29
B42C	1.84	1.10	2.66	0.45	0.53	0.28
B42D	1.74	1.22	6.33	1.24	11.41	0.99
B42E	2.27	1.27	1.82	0.00	0.07	0.00
B42F	2.90	1.97	9.17	0.59	7.42	0.67
B42G	0.40	0.00	0.60	0.00	0.00	0.00
B42H	3.64	2.25	1.32	1.63	2.00	1.25
B51A	3.57	2.48	2.16	2.22	2.44	1.76
B51B	7.31	4.26	4.49	4.99	5.40	4.03
B51C	6.10	2.94	4.30	4.08	4.33	3.85
B51E	32.88	20.45	0.00	0.00	0.00	0.00
B51F	1.77	0.00	0.00	0.04	0.27	0.00
B51G	0.00	0.00	0.00	0.00	0.00	0.00
B51H	7.05	4.00	4.33	3.89	4.25	3.35
B52A	6.08	4.17	2.30	1.78	1.89	1.82
B52B	4.42	2.47	5.01	4.17	4.61	3.94
B52C	2.16	1.44	0.74	0.70	0.73	0.58
B52D	3.57	2.14	0.90	0.14	0.17	0.17
B52E	3.82	2.52	4.15	3.71	3.92	3.81
B52F	0.92	0.37	0.11	0.10	0.12	0.02
B52G	2.56	1.54	0.51	0.40	0.44	0.29
B52H	7.39	4.94	2.61	3.04	3.84	1.95
B52J	5.54	3.27	1.95	2.03	2.20	1.73
B60A	5.02	3.48	12.80	3.51	47.09	2.23
B60B	7.17	5.02	20.22	5.43	54.55	3.83
B60C	1.97	1.38	5.33	1.72	25.58	0.97
B60D	6.18	4.32	15.98	3.40	16.84	2.52
B60E	0.93	0.65	1.73	1.10	8.87	1.00
B60F	1.77	0.43	4.97	0.00	0.51	0.00
B60G	1.43	0.00	0.81	0.21	4.27	0.00
B60H	3.36	0.75	2.24	0.00	0.00	0.00
B60J	9.47	6.22	11.68	5.36	12.38	5.21
B71A	6.40	4.41	3.14	3.14	3.80	3.11
B71B	3.14	1.81	1.92	2.05	2.18	1.85
B71C	4.89	1.47	5.87	3.89	24.55	3.78
B71D	3.51	2.39	3.81	1.68	8.54	1.77
B71E	6.79	4.29	4.70	4.43	5.52	3.90
B71F	9.31	6.51	12.65	3.53	23.75	3.84
B71G	5.53	3.81	6.72	3.06	15.35	2.87
B71H	2.47	0.97	0.00	0.00	0.00	0.00
B71J	1.00	0.30	0.18	0.16	0.17	0.17
B72A	5.65	3.06	9.52	0.44	19.03	0.56
B72B	4.60	3.20	1.31	1.35	1.39	1.31
B72C	4.60	1.80	1.81	1.98	2.02	1.76
B72D	7.44	3.86	2.05	2.66	2.71	2.04
B72E	5.32	3.46	7.64	2.41	15.88	2.48
B72F	1.51	0.75	2.27	1.10	5.85	1.07
B72G	0.34	0.00	0.00	0.00	0.00	0.00
B72H	4.61	2.40	1.02	1.30	1.42	1.01
B72J	6.70	4.64	2.75	2.75	2.85	2.72
B72K	10.99	7.51	2.84	2.26	2.32	2.32
B73A	2.78	1.95	2.20	1.12	15.83	1.04

Quaternary	HP allocation Mm³/a Method 1	EP allocation Mm³/a Method 2	Aquifer Recharge allocation Mm³/a Method 3	Ground Water Reserve allocation (a) Mm³/a Method 4	Groundwater reserve allocation (b) Mm³/a Method 5	Groundwater Reserve allocation (c) Mm³/a Method 6
B73B	5.71	3.17	0.00	0.00	0.00	0.00
B73C	9.56	6.39	2.18	1.47	1.53	1.53
B73D	7.06	4.58	1.14	1.09	1.14	1.14
B73E	6.55	4.48	2.16	2.37	2.46	2.16
B73F	5.94	4.16	3.37	3.52	3.58	3.37
B73G	8.23	5.76	4.31	4.35	4.41	4.31
B73H	2.77	1.94	1.50	1.50	1.51	1.50
B73J	2.27	1.59	1.55	1.56	1.58	1.55
	700.56	419.54	541.87	171.32	546.51	155.95

4 CONCLUSIONS

Please note: References to the “AGES Report” is equivalent to the recommended groundwater availability as adopted in the Reconciliation Strategy.

In conclusion, the following comments are made to address the required scope of work:

Are the Reconciliation Strategy’s allocable groundwater estimates an accurate reflection of the available groundwater and what is the spatial distribution of the available groundwater? Do these estimates include Groundwater Reserve?

Estimates of the total available groundwater for the WMA range from 600 Mm^3/a from the Exploitation Potential data, to 900 Mm^3/a from the Harvest Potential data. The groundwater reserve is 442 Mm^3/a.

In Section 3.6 it is explained that there are significant variations in calculating the available groundwater according to which methodology is followed and whether the reserve is considered. According to the Groundwater Reserve Determination Methodology, 546 Mm^3/a can be allocated, however, this methodology does not consider that much of the recharge is lost to interflow and is not available to boreholes.

Both the AGES and SRK reports utilised significantly different recharge values, 2015 Mm^3/a in the SRK report, 864 Mm^3/a in the AGES report. This report utilised a recharge of 1119 Mm^3, as per GRA II project 3B, which lists the groundwater balance of recharge, evapotranspiration, and baseflow per catchment. The AGES analysis also included a significant loss due to ET and almost no baseflow, which is over an order of magnitude smaller than other sources and established figures.

After making use of the existing water use as provided in the SRK Report, the remaining allocation was calculated to be 156 Mm^3/a according to Method 6C in this analysis which was selected as the most representative result. The distribution of the allocable groundwater resources, according to different methods of calculation, is presented in **Table 6** and the selected Scenario 6C (as described in **Section 3.6**) is illustrated in **Figure 2**. **Figure 2** illustrates that more diffuse allocable water is available than in dolomitic areas.

The result from Method 6C (156 Mm^3/a) is in the same range than the Strategy’s 70 Mm^3/a diffuse groundwater availability and 60 – 90 Mm^3/a estimated dolomitic availability combined as for the Strategy. The AGES analysis however did not take into account the Groundwater Reserve, where Method 6C took a revised Reserve estimate into account.

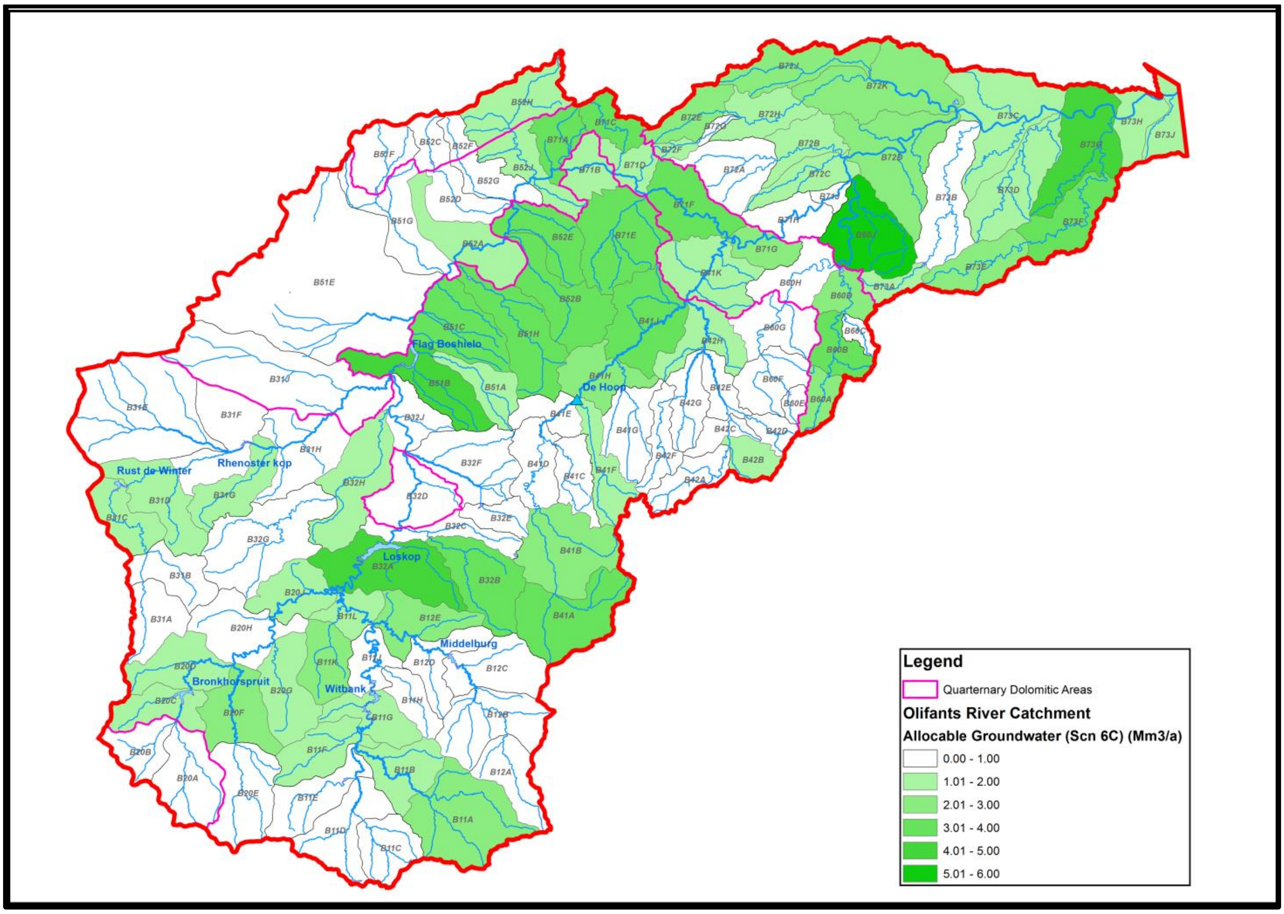

Figure 2 Allocable groundwater according to Method 6, indicating quaternaries with Dolomitic Aquifers.

Is the Strategy's dolomitic allocable groundwater a representative reflection of availability of water?

Many Quaternaries are already over exploited in the Olifants River, especially those in the upper and mid Olifants with dolomitic geology. As can be seen from **Figure 2**, the dolomitic areas are however already extensively used. The remaining allocable groundwater estimates from this analysis for quaternaries with dolomitic aquifers are in total 30 Mm^3/a, half of what was estimated by the AGES report. A current scenario in the Strategy is looking at abstracting 30 Mm^3/a from the B71C,D F and G quaternary catchments, while this analysis only estimates 12 Mm^3/a allocable groundwater in this area. More than 12 Mm^3/a could possibly be abstracted, but this would start negatively affecting the baseflow. This should however be investigated in more detail since significant impacts can be expected due to increase transmission losses and baseflow depletion for that section of the Olifants River, upstream from the KNP and Phalaborwa Weir. Therefore more detailed investigation are required on the availability of dolomitic groundwater and the effects on transmission losses on the Olifants River.

Does the Strategy's allocable groundwater estimates results take into account the effects of surface water reductions due to groundwater depletions, i.e. therefore is the 70 Mm^3*/a additional yield to the system?*

Neither this analysis nor the SRK or AGES analyses took into account the effects of baseflow depletion due to groundwater abstraction on surface water availability. Taking into account the Groundwater Reserve in allocable groundwater estimates does attempt to preserve baseflows, but the AGES report did not take into account any Reserve requirements. Also the effects of proposed groundwater use should be modelled in a surface-groundwater interaction hydrological model to assess the actual impact on surface water availability.

The Sami-method was implemented during the generation of the hydrology that in turn was used during the Reconciliation Strategy Development. Groundwater abstractions were taken in account during the calibration of the WRSM2000 for the Upper Olifants. Unfortunately no groundwater use were included for the rest of the Olifants Catchment. It will therefore be very difficult to assess the effects of further groundwater use in the Middle and Lower Olifants without an updating of the hydrological models with estimated historic groundwater figures, adjusting the calibrations and simulating the present day groundwater use effects on long term yield of the reservoirs in these areas. Only then additional groundwater use can be added to the simulations to determine the impact on yields.


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K. SAMI M.Sc, Pr Sci. Nat

Appendix D: Olifants River Reconciliation Strategy – Implementation Plan

Intervention/Supporting Project	Main Custodian	Organisations	June 2015 Scenario Totals	Cumulative Savings in Requirements/Increase in Resources (million m^3/a)																					
				2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
A) INTERVENTIONS FOR REDUCING REQUIREMENTS				x	= Duration of intervention with x amount of cumulative savings/increase in resources for particular year																				
A.1) WC/WDM - Irrigation																									
Investigate Loskop and Hereford WMP avoidable losses.	J. Van Stryp, D. Ferreira	Loskop & Hereford IB																							
Implement actions to reduce avoidable losses.																									
Monitor Implementation Progress	Olifants Recon SSC	All	**21.0**	0.0	0.0	2.1	4.2	6.3	8.4	10.5	12.6	14.7	16.8	18.9	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0
A.2) WC/WDM - Urban																									
Involve municipalities and initiate projects	Olifants Recon SSC	All																							
Implementation of WC/WDM Projects	Various (See Strategy for Targets)	LMs, COT, LepelleNorthern Water, Rand Water																							
Monitor Implementation Progress	Olifants Recon SSC	All	**22.7**	0.0	0.0	4.5	9.1	13.6	18.2	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7	22.7
A.3) WC/WDM - Mining																									
Identify mining operators with WC/WDM initiatives	Olifants Recon SSC	All																							
Mining reuse of water	M. Surmon	Palaborwa Mining																							
Monitor Implementation Progress	Olifants Recon SSC	All	**5.0**	0.0	0.0	1.0	2.0	3.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
A.4) Eliminate Unlawful use																									
Validation and Verification	J. van Aswegen	DWS: Mpumalanga																							
Directives to unlawful water users	To be decided	DWS: Legal Services																							
Legal action where needed	To be decided	DWS: Legal Services																							
Maintenance of lawful water use in controlled areas	J. van Aswegen	DWS: Mpumalanga																							
Track implementation Progress	Olifants Recon SSC	All	**14.0**	0.0	0.0	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Sub-Total: Reduction in Requirements (million m^3/a)			**62.7**	0.0	0.0	9.0	18.1	27.1	36.2	45.2	48.7	52.2	55.7	59.2	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7	62.7
B) INTERVENTIONS FOR INCREASING RESOURCES																									
B.1) Development of Groundwater																									
Project Approval	S. Mndaweni& O. vd Berg	DWS: WRPS& OA	**To be determined in feasibility study**																						
Feasibility Study																									
Implementation																									
Track implementation Progress	Olifants Recon SSC	All		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
B.2) Removal of IAPs																									
Implement IAP clearance projects and follow-ups	K. Saunders, W. Roux, D. Strydom	Working for Water																							
Track implementation success	Olifants Recon SSC	All	**20.4**	0.9	1.9	2.8	3.7	4.6	5.6	6.5	7.4	8.3	9.3	10.2	11.1	12.1	13.0	13.9	14.8	15.8	16.7	17.6	18.5	19.5	20.4
B.3) Treatment of mine water																									
Implement and maintain Water Treatment Plants	V. Cogho, T. Naidu, C. Linstrom, W. Mey	Glencore, Anglo Coal, Exarro, Besca/BHP																							
Track implementation success	Olifants Recon SSC	All	**27.0**	3.0	25.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0
B.4) Municipal effluent re-use at Polokwane, Mokopane and Emalahleni																									
Improvement of treatment capacity	R. Mushai, S. Abass, M. Letsoalo	Polokwane, Mokopane, EmalahleniLMs																							
Track implementation success and maintenance	Olifants Recon SSC	All	**34.5**	0.0	0.0	0.0	4.4	4.4	4.4	13.7	17.8	18.7	19.6	20.5	21.4	22.3	23.2	24.1	25.0	25.8	26.7	27.6	28.4	29.3	30.2
Sub-Total: Increase in Resources (million m^3/a)			**81.9**	3.9	26.9	29.8	35.1	36.1	37.0	47.2	52.2	54.0	55.9	57.7	59.6	61.4	63.2	65.0	66.8	68.6	70.4	72.2	74.0	75.8	77.6
TOTAL INTERVENTIONS (million m^3/a)			**144.6**	3.9	26.9	38.8	53.2	63.2	73.1	92.4	100.9	106.2	111.6	116.9	122.3	124.1	125.9	127.7	129.5	131.3	133.1	134.9	136.7	138.5	140.3
C) SUPPORTING INFRASTRUCTURE DEVELOPMENT AND OPERATIONAL PROJECTS																									
C.1) Olifants River Water Resources Development Project(Summarised from detail project implementation plan)																									
Phase 2b	O. vd Berg, D. vd Boon	DWS: OA, DWS: Infrastr																							
Phase 2d																									
Phase 2e&f																									

Intervention/Supporting Project	Main Custodian	Organisations	June 2015 Scenario Totals	Cumulative Savings in Requirements/Increase in Resources (million m^3/a)																					
				2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
C.2) Determination, Review and Implementation of the Reserve in the Olifants/Letaba System																									
PSP Approval	G. Makhado, B. Weston	DWS: Water Ecosystem																							
Reserve Determination Study																									
Model operational scenarios of the EWR																									
C.3) Integrated Olifants River Supply System Operating rules (Project Name to be determined)																									
PSP Approval	C. Ntuli, B. Mwaka	DWS: WRPS																							
Study on operating rule for integrated system																									
Implementation of operating rules		System Operators Forum, DWS: WRPS																							
Annual operating rules		System Operators Forum, DWS: WRPS																							

Appendix E:

BROAD FRAMEWORK FOR WATER USE ENTITLEMENT EXCHANGE AS A MEASURE TO ACHIEVE RECONCILIATION OVER THE LONG TERM.

BROAD FRAMEWORK FOR WATER USE ENTITLEMENT EXCHANGE AS A MEASURE TO ACHIEVE RECONCILIATION OVER THE LONG TERM

Introduction

This appendix provides a broad description of aspects that need to be considered to regulate and facilitate the exchange of water use entitlements amongst water users from different sectors, as a measure to achieve a reconciled water balance over the long term in the Olifants River System. The intention is to provide seeding ideas of how water use entitlement exchange could be undertaken, especially in river systems where both measures to save water and make more water available have been fully exploited, while there is still a need for additional water to support socio-economic developments.

In the 2012 Olifants River Reconciliation Strategy the exchange of water use entitlements was identified as a "fall back" measure that could be considered in the event where the measures proposed at the time are insufficient to maintain a positive system water balance. Given the water balances presented in the main body of this report, which show that additional augmentation is needed the "fall-back" measure should now be investigated as a primary strategic option.

Background

Limited exchanges of water use entitlement have taken place in South Africa in the recent past and in most cases these exchanges occurred on a localised scale and within the confines of an irrigation scheme (intra-sectorial exchanges) or in tributary river systems located far from a larger river system where some inter-sectorial exchange occurred. Although these historical cases are evidence that exchanges are possible within the current legislative and institutional environment, the magnitude (volume of entitlements exchanged) remained small compared to what is required in the Olifants River System, which needs to be augmented by between 60 and 70 million m^3/annum (see **Section 2.6.1**).

It would therefore be prudent to formulate and set in motion a well-researched and structured process that will avoid any unintended consequences especially when considering the potential socio-economic and ecological implications. When considering that there are many other water resource systems in the country where water entitlement exchanges could be a further solution to achieve reconciliation, the scope of this framework is also to inform national policies and procedures.

A brief review of the literature shows that much can be learned from other countries such as Australia, Chile and the Western United States where different forms of water use entitlement exchanges are operational and formed the basis for a wealth of documented experiences of their successes and pitfalls. **(A list of all the references cited can be made available electronically on request)**. Note that the cited information sources were not studied in detail, however, key pointers, ideas and guiding principles from these documents informed this broad framework.)

In particular, the United Nations Report: *Principles and Practices of Water Allocation Among Water-Use Sectors* (New York, 2000) is highlighted as an informative document where interpreted information and experiences have been put together as a practical guide on water allocation and how water use entitlement exchange could be facilitated.

Another report: *Prices, Property and Markets in Water Allocation* compiled for the United Nations Economic Commission for Latin America and the Caribbean, Santiago, Chile. (Authors; Lee and Jouravlev, published in 1998) provides a comprehensive "review of a vast body of recent literature on tradable resource use and rights as well as actual experiences with tradable water rights programmes both in Latin America and in the rest of the world".

In most countries or water resource systems where the exchange of water use entitlements is practiced, **all available resources have been allocated** (in some cases even over allocated). The motivations for selecting an exchange systems are divers, ranging from moving water from low to higher economic efficient uses as well as to make water available for providing ecological functions. In each case the institutional framework, water right legislation and prevailing policies largely shape the form and mechanisms of the implemented exchange systems. A universal characteristic is that it takes many years for the exchange systems to mature into an efficient method of water use management.

Another widely cited cautionary aspect to consider is the need to put mechanisms in place to manage the external or "third party" implications that may materialise when implementing a water use entitlement exchange system. In general, the solution is to formulate an appropriate regulatory structure to frame how approval is granted for any water use entitlement exchange to take place.

Many of the founding principles listed in the literature as prerequisites for viable water entitlement exchanges are already embedded in the South African water legislation and the time consuming reforms that other countries had to go through are thus already behind us.

Water use entitlement exchange in context of the Olifants River System

The Olifants River System's Reconciliation Strategy has as a key element that water users, including the Ecological Water Requirements, will have to be supplied from the systems own water resources. One of the reasons for this approach is that further infrastructural augmentation, in particular the transfer of water from adjacent systems is very expensive and will not be affordable. It should be noted that such transfer options are however possible and that the costs of the proposed water use entitlements should continuously be compared to ensure economic efficiencies.

Recommended framework and processes:

As the custodian of the water resources of the country, DWS should play an active role in the exchange of water use from low value irrigation activities to make water available to supply water to the high value urban, industrial and mining sectors. As the regulator, it would be prudent for DWS to formulate clear policy and procedural guidelines to achieve the intended outcomes of such a process while also making sure appropriate preventive measures are put in place to eliminate negative and unintentional consequences.

Such a policy and regulations will have to the formulated from a national perspective and the Olifants River System could serve as a pilot application.

The most important first step in reallocation is to complete the water use Validation and Verification processes, which will ensure certainty when existing lawful water use is exchanged from current license holders to a new licence holder.

A well-structured and transparent process needs to be designed and implemented and the following steps should be considered:

Step 1: Draft a framework document for internal discussion and deliberation within DWS.A first activity of this step would be a comprehensive literature review to ensure DWS benefits from the lessons learned from other countries.
Step 2: Prepare policy guidelines and operational procedures and solicit comments from all DWS directorates.
Step 3: Discuss the refined guidelines with leading sectorial institutions.
Step 4: Prepare policy guidelines and procedures for public comment and inputs.
Step 5: Apply the procedures in the Olifants River System as a pilot (first) implementation.
Step 6: Record the lessons learnt from the Olifants application and amend the procedures where required.

An incomplete list of aspects to consider in the formulation of the policies and procedures is provided below:

- Define different methods of how allocation exchanges can take place where Compulsory Licensing (according to the Act) will serve as a method of “last resort” for DWS to affect allocation exchange.
- The conditions under which each method is applicable should be described and clarified.
- A key aspect would be to ensure socio-economic stability is achieved in the economic activities (value chain) dependant on irrigation agriculture.
- The boundaries of target water user licence holders and new users’ needs to also be considered in the context of future infrastructure developments.
- Evaluate the continuous viability of irrigation schemes when only a portion of the irrigation volume is exchanged.
- Obtain an understanding of all the socio-economic influences and consequences and implement measures to prevent negative consequences.
- Consider the dynamics that mining activities will eventually (30 to 40 years from now) reduce at which time the water can again be made available for irrigation or other purposes.
- Consideration should be given for the pricing policy to guide the exchange of water use entitlements between “willing buyer” and “willing seller”.