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

WP10197

Final Reconciliation Strategy Report

Original

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Final Reconciliation Strategy

Report no.: P WMA 04/B50/00/8310/14

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LIST OF REPORTS

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Inception Report	P WMA 04/B50/00/8310/1
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Extent of Invasive Alien Plants and Removal Options	P WMA 04/B50/00/8310/3
Future Water Reuse and other Marginal Water Use Possibilities	P WMA 04/B50/00/8310/4
Possible Water Conservation and Demand Management Measures	P WMA 04/B50/00/8310/5
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Glossary of Terms

Allocatable Water
Water available to allocate for consumptive use.

Acid Mine Drainage
Polluted and acidic water decanting from mines and reaching the resource supply system.

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

Environmental Water Requirement
The quantity, quality and seasonal patterns of water needed to maintain aquatic ecosystems within a particular ecological condition (management category), excluding operational and management considerations.

Eutrophic
Ecology lacking oxygen: used to describe a body of water whose oxygen content is depleted by organic nutrients (eutrophication).

Existing Lawful Use
An existing lawful water use means a water use which has taking place at any time during a period of two years immediately before the date of commencement of the National Water Act or which has been declared an existing lawful water use under Section 33 of the National Water Act.

Hypertrophic indicates a water body that is extremely eutrophic.

Integrated Water Resource Management (IWRM) Objectives
The objectives and priorities for water resource management, for a given time frame, which have been agreed by the parties as those which will best support the agreed socio economic development plans for the basin.

Internal Strategic Perspective
A DWA status quo report of the catchment outlining the current situation and how the catchment will be managed in the interim until a Catchment Management Strategy of a CMA is established.

Intervention Scenarios
An intervention scenario is a combination of reconciliation options which have to be implemented together over the planning period in order to achieve a water balance.

IWRM Plans
A set of agreed activities with expected outcomes, time frames, responsibilities and resource requirements that underpin the objectives of IWRM.

Level of Assurance
The probability that water will be supplied without any curtailments. The opposite of Level of Assurance is the risk of failure.

Management Options
A management option is maintenance, administrative or regulatory intervention that is implemented to improve the water use efficiency. Such intervention can either reduce the water requirements or increase the water supply.

Oligotrophic
Nutrient poor and oxygen rich, i.e. containing very little plant life and nutrients in its water, but rich in dissolved oxygen.

Reconciliation option
A reconciliation option can be a management option or a development option and is an intervention to either reduce the water requirements or increase the water supply.

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

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

Validation and Verification
Validation is the process for verifying that the water use registrations on the Water Authorisation and Registration Management System (WARMS) were correctly done, and, Verification is the process for verifying that the water uses, registered in WARMS and in other data sources are lawful.

Diffuse irrigators
Irrigators who are not scheduled under any one of the Irrigation Boards or Water User Associations and who take their water directly from a river, i.e. from the run-of-river flows or from a farm dam in that particular river.

List of Abbreviations & Acronyms

AEC	Alternative Ecological Category
AMD	Acid Mine Drainage
ARC	Agricultural Research Council
BHN	Basic Human Needs
CMA	Catchment Management Agency
CME	Compliance Monitoring and Enforcement
DWA	Department of Water Affairs
EC	Ecological Category
E.Cond	Electrical Conductivity
EIS	Ecological Importance and Sensitivity
ER	Ecological Reserve
EWR	Ecological Water Requirements (Ecological Component of the Reserve)
GRDM	Groundwater Resource Determination Management
IB	Irrigation Board
IAP	Invasive Alien Plants (vegetation)
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resources Management
KNP	Kruger National Park
LHWP	Lesotho Highlands Water Project
LHWP2	Lesotho Highlands Water Project – Phase 2
MAR	Mean Annual Runoff
NGDB	National Groundwater Data Base
NPV	Nett Present Value
NSDF	National Spatial Development Framework
NWA	National Water Act (Act 36 of 1998)
NWRS	National Water Resource Strategy
OWAAS	Olifants Water Assessment and Availability Study
PES	Present Ecological State
REC	Recommended Ecological Category
ROD	Record of Decisions
SADC	Southern African Development Community
SANP	South African National Parks
SSC	Study Steering Committee
SH	Stakeholder
UN	United Nations
URV	Unit Reference Value
V & V	Validation and Verification
VRESAP	Vaal River Eastern Sub-system Augmentation Project
WC/WDM	Water Conservation / Water Demand Management
WC	Water Conservation
WDM	Water Demand Management
WfW	Working for Water
WMA	Water Management Area
WRC	Water Research Commission
WUA	Water User Association
WWTW	Waste Water Treatment Works

The Olifants Reconciliation Strategy in a Nutshell

The following is envisaged for the Olifants catchment for the next 25 years:

i. The Reserve needs to be operationalized as soon as practical. It is expected that this will be achieved in 2016 as De Hoop Dam reaches its full yield potential.
ii. Water required to supply the current and future social and economic activities in the Olifants catchment will have to come from the catchment's local resources, except for the power stations within the catchment.
iii. Water to power stations will continue to be supplied from the Usuthu, Komati and Vaal systems.
iv. Water required by the Polokwane and Mokopane supply areas will be augmented from the Olifants catchment.
v. Water requirements can be balanced by availability through the implementation of the following measures:
   - Eliminating unlawful water use. The target date for the majority of transgressions to be addressed is 2018, after which compliance monitoring and enforcement will remain an on-going activity.
   - Introducing water conservation and water demand management (WC/WDM) in all sectors. Full water savings need to be achieved within five years in the irrigation and urban water use sectors, and within 10 years in the mining sector.
   - The introduction of a mechanism whereby water saved through water use efficiency (WUE) measures, especially in agriculture, can be traded back into the market. This means that water users will be in a position to sell their water savings, and not necessarily use this water to expand horizontally.
   - The treatment of acid mine drainage water to an acceptable standard, either for immediate direct use or before it is allowed to decant into the river system.
   - Invasive alien plants must be removed. Working for Water programmes must be accelerated to ensure that at least 50% of infested areas, plus all new growth, is eradicated by 2035.
   - Groundwater resources must be developed as a priority. The Malmani dolomites must be investigated as a possible resource for a regional water supply scheme.
   - Return flows from Polokwane and Mokopane should be reused by the urban or mining sector.
vi. All above measures lean more towards management interventions rather than development interventions. An orchestrated effort is necessary to ensure that objectives are achieved. If these implementation measures are not successful as assumed, in spite of the fact that the assumed measures are conservative, the water will have to be reallocated to other use by means of compulsory licensing or by buying out water entitlements in respect of low value irrigation.

EXECUTIVE SUMMARY

INTRODUCTION

The water requirements in the Olifants Water Management Area (WMA) and the adjacent areas of Polokwane and Mogalakwena, which are supplied from the Olifants, have increased substantially over the last number of years due to increased water use in a range of sectors, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture.

A reconciliation strategy, aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future, is required for the basin and its water users.

A preliminary reconciliation strategy was completed in November 2010. That preliminary strategy contains a water balance based on the best information available at that time.

The preliminary strategy identified a number of information gaps which had to be filled for this final strategy.

This final reconciliation strategy is an improved version of the preliminary reconciliation strategy, based on the improved information obtained.

Key elements of this reconciliation strategy are summarised below.

THE RESERVE

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

An Olifants Comprehensive Reserve Study was undertaken during 1999.

As part of the current study, the Eco-Classification was repeated in 2010. The main objective of redoing the Eco-Classification was to check how the Ecological Water Requirements (EWRs) would be affected by the new classification. It should be noted that the EWRs themselves (i.e. the flow pattern associated with an ecological category at a specific site) were not reassessed and are still the same as determined in the 1999 study.

The rule tables that were developed for the Reserve as part of the 1999 study make provision to release small floods (called freshets) from the dams during the spawning season for fish.

The existing dams do not have sufficient release capacity to release these small floods, and in most cases they can be generated downstream of the dams from the tributaries and the catchment below the dam. These small floods were therefore removed from the rule tables.

Provision has therefore only been made for that portion of the Reserve that is practically implementable. This will reduce the available yield of the whole system by 157 million m^3/a in order to maintain the ecological categories at their recommended levels. The full Reserve with the flood component would have reduced the available yield by 221 million m^3/a.

CURRENT WATER USE

*For the analysis of the surface water and groundwater requirements and availability, the Olifants Catchment has been divided into three management zones as illustrated in **Figure E1**.*

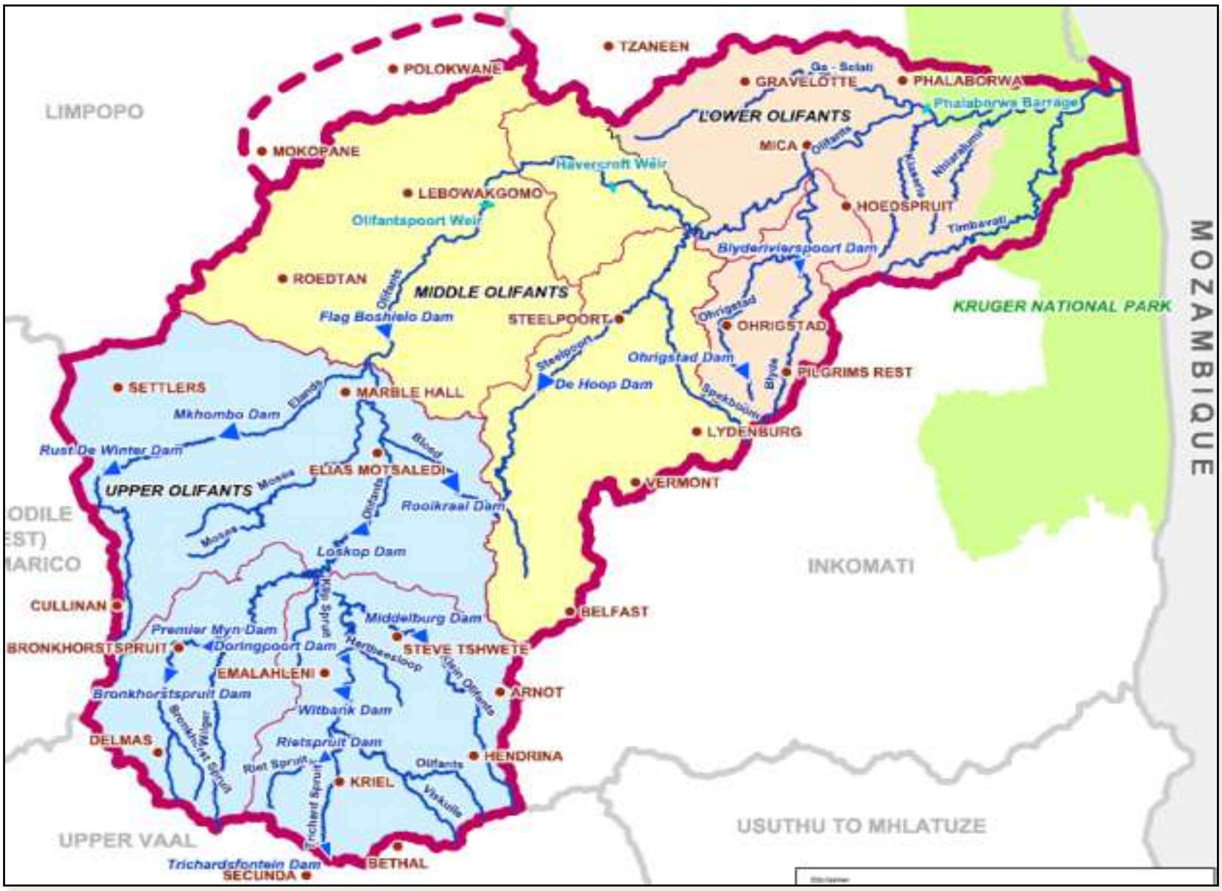

***Figure E1:** Management Zones of the Olifants Catchment*

*The current water use in the irrigation, domestic and industrial, mining, power generation and forestry sectors is summarised in **Table E1**.*

***Table E1:** Summary of Water Requirements (Units: million m^3/a)*

Management Zone	*Irrigation*	*Urban*	*Rural*	*Industrial*	*Mining*	*Power Generation*	*Total*
Upper Olifants	*249*	*93*	*4*	*9*	*26*	*228*	***609***
Middle Olifants	*81*	*56*	*22*	*0*	*28*	*0*	***187***
Lower Olifants	*156*	*29*	*3*	*0*	*32*	*0*	***220***
TOTAL	***486***	***178***	***29***	***9***	***86***	***228***	***1016***

Note: The requirements are at different assurances of supply. They have all been converted to a 1:50 year assurance of supply in this table.

PROJECTED FUTURE WATER REQUIREMENTS

*The estimated projected high growth scenario for the Olifants River Basin is shown graphically in **Figure E2.***

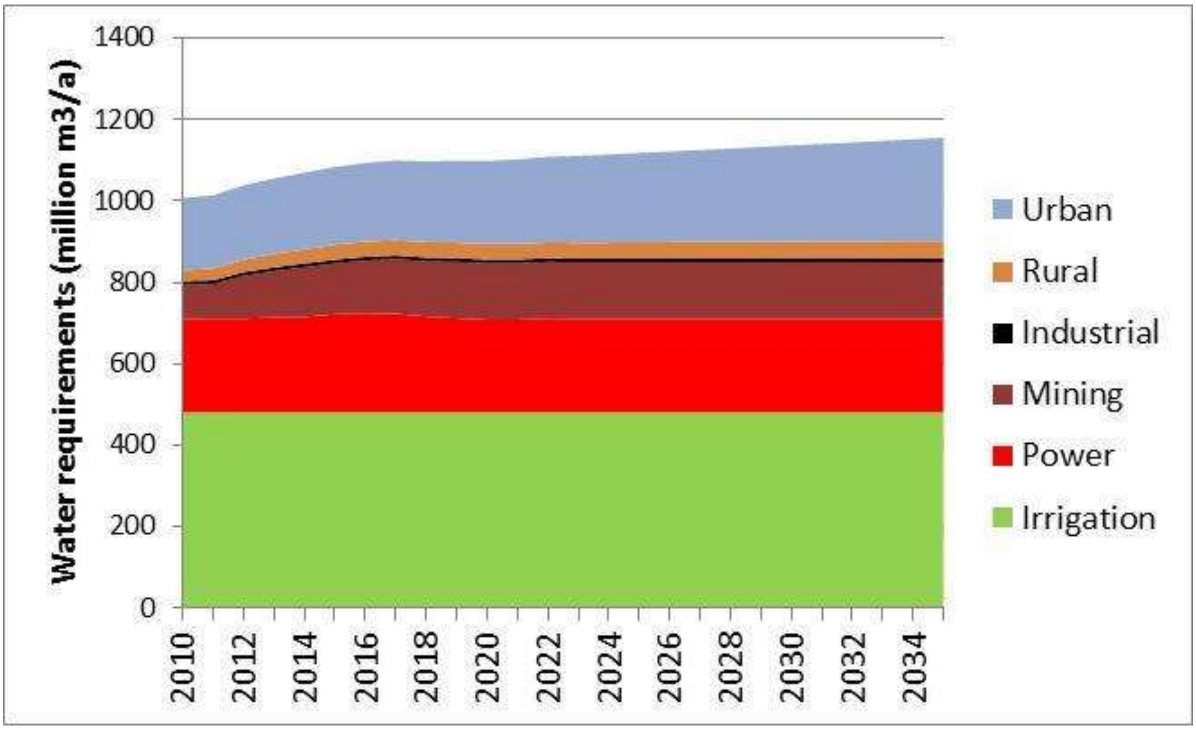

Figure E2: *High Growth Scenario*

*The projected total high and low growth water requirement figures for 2035 are shown in **Table E2.** These high and low growth water requirement figures have been used for the reconciliation scenarios described in Section 9.*

Table E2: *Total high and low growth water requirements*

Sector	***Current requirement (2010)***	***Future requirement (2035)***	
		High growth	***Low growth***
Irrigation	*486*	*486*	*486*
Urban	*178*	*255*	*221*
Rural	*29*	*51*	*39*
Industrial	*9*	*9*	*9*
Mining	*86*	*140*	*128*
Power Generation	*228*	*229*	*229*
TOTAL	***1 016***	***1 170***	***1 112***

It should be noted that low growth scenario is only 5% less than the high growth scenario

WATER AVAILABILITY

- ***Groundwater***

  Groundwater is available throughout the Olifants WMA, although varying in quantities depending upon the hydrogeological characteristics of the underlying formations.

  The overall results of the Groundwater Yield Model (AGES, 2008) indicated that there is a surplus of groundwater in the order of 70 million m^3/a.

  *A hydrogeological yield map of the Olifants WMA is shown in **Figure E3**.*

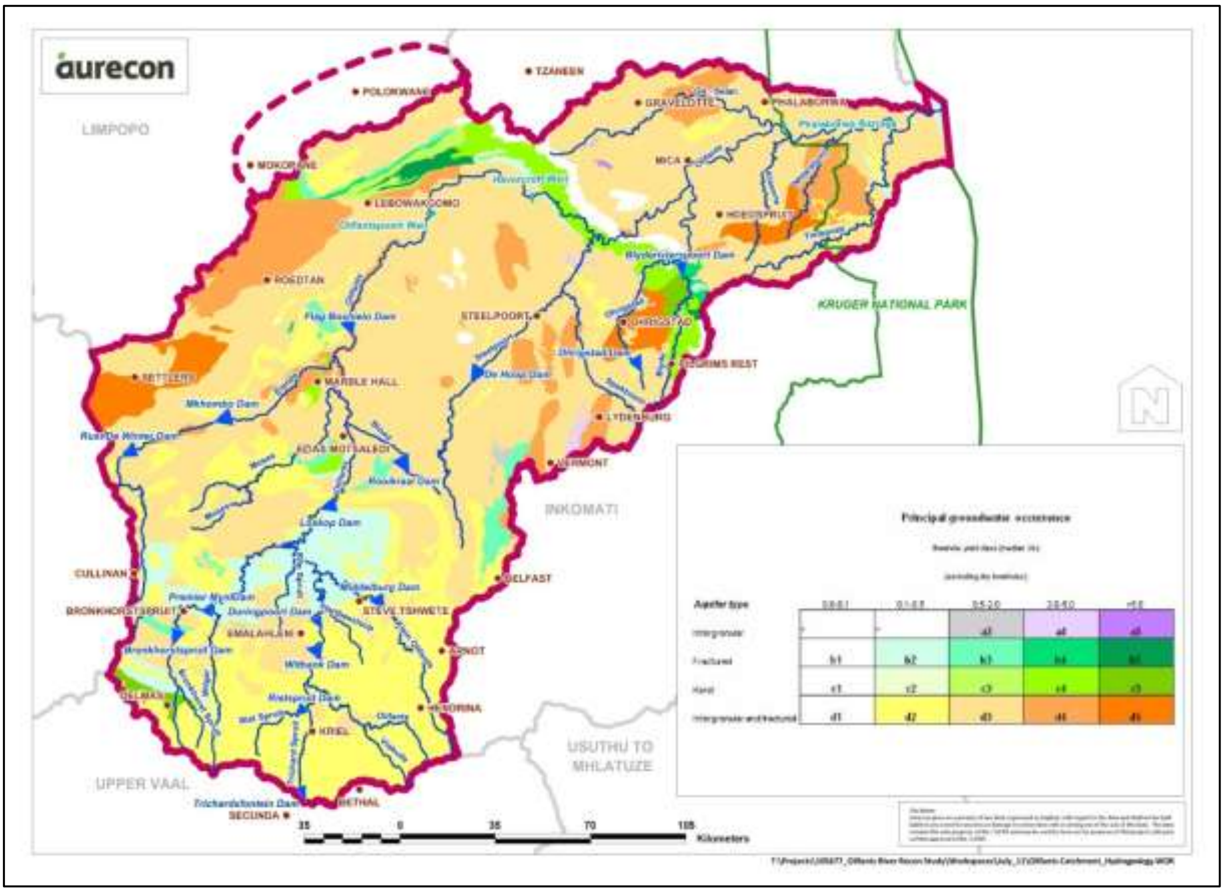

***Figure E3**: Groundwater availability map for the Olifants Basin*

  Groundwater development in unstressed aquifers must be encouraged. A possible regional water scheme with the Malmani dolomites as resource should be investigated. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River.

- ***Surface Water***

  *The significant dams with their historical and 1:50 year yields are listed in **Table E4.***

  *Polokwane and Mogalakwena are currently supplied by dams that are outside of the study area. These dams and the allocated water to the towns are listed in **Table E3**.*

Table E3: *Large dams outside the study area supplying Polokwane and Mogalakwena*

Dam	Town supplied	1:50 year yield allocation (million m^3/a)
Dap Naude Dam	Polokwane	6.2
Ebenezer Dam	Polokwane	12.0
Doorndraai Dam	Mogalakwena	4.4
	TOTAL	**22.6**

*In addition to the yield of the major dams listed in **Table E4** there are a large number of farm dams in the Olifants River catchment that contribute to the yield of the system. There are also many water users, mostly irrigators, that abstract water directly from the river and these run-of-river supplies also form part of the water resource equations. The yield related to farm dams and run-of-river abstractions are referred to further as diffuse sources.*

***Table E5** summarises the diffuse water resources of the study area.*

There are several large water transfers from the Upper Komati, Usuthu and the Vaal Systems to supply the six power stations located in the Upper Olifants catchment. These transfers are estimated at 228 million m^3/a.

The incremental future decant also known as Acid Mine Drainage (AMD) from the coal mines in the Upper Olifants Management Zone can be regarded as direct additional yield. In the case of the Witbank Dam catchment this value is approximately 12 million m^3/a and that of the Middelburg Dam catchment 10 million m^3/a, i.e. approximately 22 million m^3/a in total which will become available over a period of 20 years. However this water will require treatment since the river system does not have the capacity to dilute the AMD to an acceptable quality.

Table E4: *Large Dams in the Olifants River Catchment*

Dam	Management Zone	Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
Bronkhorstspruit	Upper	58.9	16.9	23.5
Middelburg	Upper	48.4	12.6	14.0
Wilge	Upper	1.6	6.7	8.0
Witbank	Upper	104.0	29.5	33.0
Loskop	Upper	374.3	161	168
Rust de Winter	Upper	27.3	9.8	11.7
Mkombo with Weltevreden weir	Upper	205.8	11.7	14.0
Flag Boshielo	Middle	1788	53.0	56.0
De Hoop (under construction)	Middle	347.4	65.0	66.0*
Ohrigstad	Lower	13.2	18.9	19.8

Dam	Management Zone	Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
Buffelskloof	*Middle*	*5.4*	*14.7*	*14.7*
Der Bruchen	*Middle*	*9.0*	*8.3*	*8.3*
Belfast	*Middle*	*5.5*	*5.7*	*5.7*
Lydenburg	*Middle*	*1.1*	*2.5*	*2.5*
Blyderivierspoort	*Lower*	*54.6*	*110*	*130*
Phalaborwa Barrage	*Lower*	*5.7*	*42*	*49*

*** *After meeting the EWR water requirements. The yield of De Hoop Dam reduces from 99 million m^3/a to 66 million m^3/a as a result of the EWR requirements*

Table E5: *Diffuse Water Resources (Units: million m^3/a)*

Management Zone	Full Supply Capacity of Minor Dams	Yield of Farm Dams and Run-of-River
Upper Olifants	*327*	*128*
Middle Olifants	*60*	*71*
Lower Olifants	*40*	*49*
TOTAL	***427***	***248***

The projected growth in available yield is shown in ***Figure E4****.*

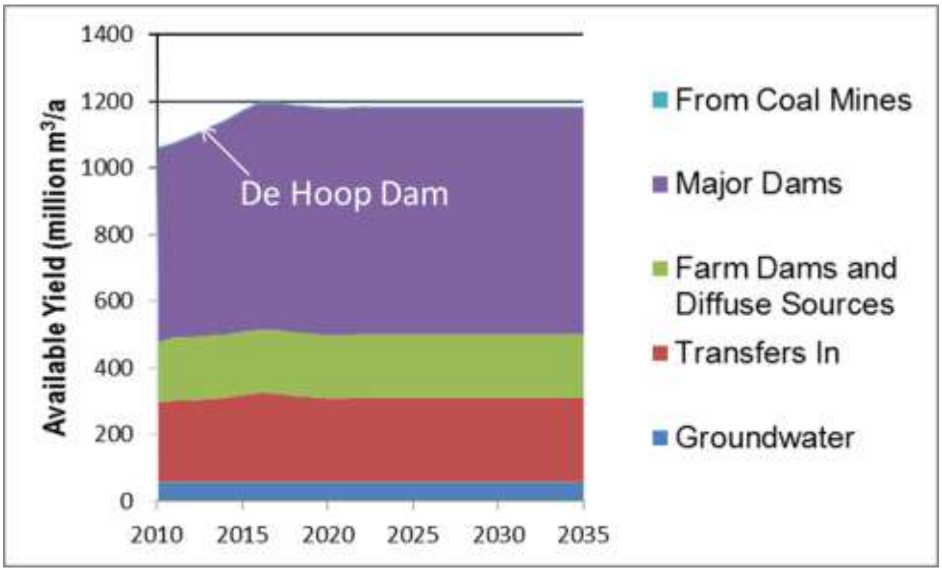

Figure E4: *Projected growth in system yield*

WATER QUALITY

A separate water quality management strategy is being envisaged to address the water quality management issues. It is recommended that this study commences as soon as possible.

The water quality in the study area does not affect the management or availability of the resource (i.e. dilution is not required as yet) although there are limited locations where the water quality is only tolerable and is unacceptable at two sampling points. At many stations however, there is an upward trend in pollution.

Localised water quality problems must be addressed by intensified compliance monitoring and enforcement and by reducing pollution at source.

*Despite the fact that the water quality in the system will not influence the water availability (**Table 6.3**), immediate attention should be given to the upward trends shown in **Table 6.4** so that the sustainability of the resource is ensured.*

An issue that will require specific attention is the increasing decant of acid mine drainage. On the one hand it represents a potential source of water if treated properly, while on the other hand it represents a threat to future water quality if uncontrolled decanting is allowed to occur.

THE WATER BALANCE

*The water balance, based on estimated 2010 water requirements, all at equivalent 1:50 year assurances of supply, is shown in **Table E6**. Water deficits are shown in brackets.*

Table E6: *2010 Water Balance (Units: million m^3/a)*

Management Zone	*Water Requirement*	*Total Water Resource*	*Minimum Flow Rule*	*Losses*	*Water Balance*
Upper Olifants	*609*	*630*	*0*	*0*	*21*
Middle Olifants	*187*	*185*	*(19)*	*0*	*(21)*
Lower Olifants	*220*	*248*	*(19)*	*(5)*	*4*
TOTAL	***1 016***	***1 063***	***(38)***	***(5)***	***4***

Note: *Excluding De Hoop Dam*

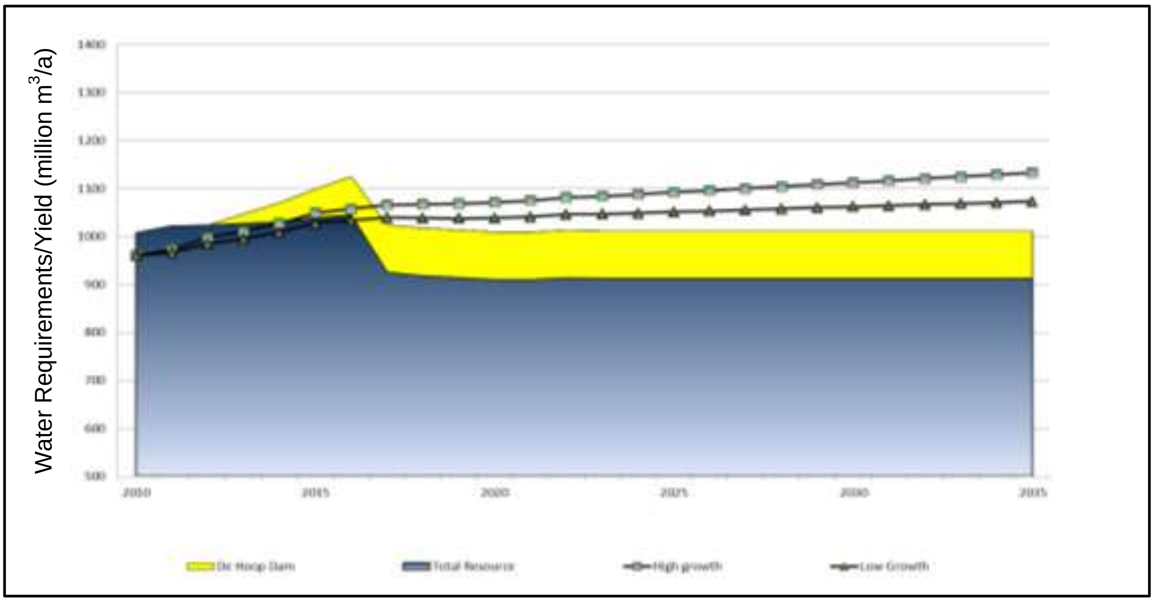

Figure E5: *Projected Future Water Balance*

*The projected future water balance is shown graphically in **Figure E5** and represents the situation if water requirements are allowed to increase and there is no further water resources development. The increase in the water resource is due to the construction of the De Hoop Dam, phased in over 5 years to allow for filling. The ecological Reserve that reduces the system yield by 157 million m^3/a, was assumed to be operationalized from 2016. This is illustrated by the drop in available yield.*

The conclusion can therefore be drawn that the system runs into deficit by 2017, and that by then interventions be required to have been implemented and to be effective.

POSSIBLE INTERVENTION SCENARIOS

Intervention scenarios comprise combinations of reconciliation options, which can be divided into two main categories, i.e.:

- *Reconciliation options which reduces the water requirements*
- *Reconciliation options which increases the system yield*

The following reconciliation options were considered during the study:

- ***Reconciliation options that can reduce water requirements***
  - *Eliminating unlawful water use*
  - *Water Conservation and Water Demand Management (WC/WDM) in the irrigation sector*
  - *WC/WDM in the domestic water use sector*
  - *WC/WDM in the mining sector*
  - *Reducing assurances of supply*
  - *Compulsory licensing*
  - *Water trading*

- ***Reconciliation options that can increase water supply***
  - *Removal of invasive alien plants (IAPs)*
  - *Refinements to System operating rules*
  - *Rainfall enhancement through Cloud Seeding*
  - *Groundwater development*
  - *Water Transfers*
    - *Transferring treated effluent from the East Rand*
    - *Transferring more water from Vaal Dam*
    - *Water transfer from the Crocodile (West) River System*

  - *Dam Options*
    - *Raising of the Blyderivierspoort Dam*
    - *New dam downstream of Rooipoort*
    - *New dam on the farm Godwinton in the Olifants River Gorge*
    - *New dam on the farm Chedle in the Olifants River Gorge*
    - *New dam on the farm Epsom in the Lower Olifants River*
    - *New dam on the farm Mica in the Lower Olifants River*
    - *New dam on the farm Madrid in the Lower Olifants River*

- *Utilising the acid mine drainage (AMD) in the Upper Olifants*
- *Reusing sewage effluent from towns*
- *Desalination and transfer of seawater*

Basis For Water Reconciliation

The following aspects were taken into account and formed the basis for water reconciliation:

- *South Africa will meet its international obligations.*
- *The water for basic human needs (BHN) will be supplied.*
- *The Reserve is a priority – ecological Water Requirements to meet the recommended ecologic category (REC) will be maintained.*
- *All unlawful water use will be eliminated.*
- *Water for strategic users for the benefit of the country must receive priority before any other economic development.*
- *Water for socio-economic development within the policy parameters of the government will be provided.*
- *There will be no increase in total water allocations for irrigation.*
- *There will be no increase in forestry areas*

- ***Yield and cost information of the reconciliation options***

  Table E7 *and* ***Table E8*** *summarise the yields, costs and unit reference values (URVs) of the different options*

Table E7: *Reconciliation options that will reduce water requirements*

Option	Yield/Water Saving (million m^3/a)	Cost as NPV (R million)	URV (R/m^3)
Eliminating Unlawful Irrigation use	*8.7*	*12*	*0.12*
WC/WDM: Urban	*20*	*285*	*1.48*
Compulsory Licensing	*35*	*32*	*0.07*
Water Trading – Partial Water Entitlements	*35*	*32*	*0.07*

Table E8: *Reconciliation options that will increase system yield*

Option	Yield (million m^3/a)	Capital Cost (R million)	URV (R/m^3)
Removal of Invasive Alien Plants	*15*	*120*	*0.76*
Dams:			
Rooipoort Dam	*59*	*1 140*	*2.14*
Dam in Olifants Gorge: *Godwinton* *Chedle*	 *100* *100*	 *132* *200*	 *0.14* *0.20*
Dam in Lower Olifants: *Epsom* *Madrid*	 *286* *440*	 *4 820* *8 800*	 *1.58* *1.71*
Raising of Blyderivierspoort Dam	*110*	*2 977*	*2.77*

Option	*Yield (million m^3/a)*	*Capital Cost (R million)*	*URV (R/m^3)*
Water Transfers:			
Transfer from ERWAT ⁎	*38.3*	*1 123*	*7.31*
Transfer from Vaal Dam ⁎	*160*	*3 500*	*3.60*
Transfer from Crocodile (West):			
Pienaars – Flag Boshielo Dam	*30*	*1 268*	*3.82*
Crocodile – Flag Boshielo Dam	*60*	*3 926*	*6.43*
*Crocodile – Mogalakwena ***	*25*	*3 728*	*14.51*
Transfer from Massingir Dam	*50*	*2 000*	*4.85*
Desalination and transfer of Sea Water	*100*	*12 970*	*44.45*

⁎ Excludes cost of early augmentation of the Vaal System (LHFP2 (URV R6.14/m^3))
⁎⁎ This option could replace the currently planned ORWRDP-Phase 2B
All cost estimates based on 2010 prices.

- ***Environmental screening of options***
  Environmental screening was focused on the possible schemes considered in the strategy and aims to:

  - *summarise any key environmental or social issues that should be taken into account when considering and comparing options;*
  - *identify any environmental or social "fatal flaws" or "red flags" associated with any of the projects; and*
  - *identify environmental authorisations that will be required for any of the projects.*

RECONCILING THE WATER REQUIREMENTS WITH THE WATER RESOURCE

***Table E9** lists the selected reconciliation options that will reduce water requirements and that are recommended for implementation for the entire Olifants WMA.*

***Table E9:** Management Options*

Option	*Starting Year*	*Duration (Years)*	*% Saving*	*Estimated Saving (million m^3/a)*	*Comments*
WC/WDM Irrigation	*2013*	*5*	*3.3%*	*17*	*Two focus areas:* • *Improved Irrigation Systems is 19 million m^3/a* • *Improved conveyances (reducing canal/pipe leaks) is 16 million m^3/a* *Need to be linked to water trading in order to get the savings back into the system instead of horizontal expansion by the irrigation farmers.* *Expected savings is 35 million m^3/a, but it is assumed*

Option	Starting Year	Duration (Years)	% Saving	Estimated Saving (million m^3/a)	Comments
					that only 50% of the irrigation farmers will put their savings on offer for purchase.
WC/WDM Urban	2013	5	18.8%	19.8	This saving is regarded as achievable.
WC/WDM Mining	2015	10	6.8%	5	This saving will necessitate transformation from existing processes to alternative processes which will be costly and more time was consequently allowed. Regarded as achievable by the mining industry.
Unlawful Water Use	2012	4	2.1%	8.5	The yield impact as a result of the increased irrigation is 17.4 million m^3/a. This irrigation expansion is not all unlawful as part of it could have expanded through water savings. It was assumed that 50% of this is unlawful. This assumption can only be verified after the completion of the validation and verification processes, but is regarded as a fairly conservative assumption.
			TOTAL SAVING / YIELD	**50.3**	

Table E10 *lists the selected reconciliation options that will increase the system yield. These options are recommended for implementation.*

Table E10: *The most promising and selected reconciliation options that will increase the system yield*

Option	Starting year	Duration (years) to full yield	Estimated Yield (million m^3/a)	Comments
Removal of IAPs	2012	23	10.5	Half of the estimated water use by IAPs, i.e. 0.5 x 21 million m^3/a.
Development of Groundwater Schemes	2012	23	35	Half of availability as modelled by AGES. Not all areas are accessible and half of the availability is regarded as exploitable.
Treatment of decanting water from the coal mines in the Witbank Dam Catchment	2015	1	12	Graph in **Figure 5.4** shows the results of a model estimating the future decant from mines in the Witbank Dam Catchment. The additional decant from 2011 – 2015 is 12 million m^3/a.
Treatment of decanting water from the coal mines in the Middelburg	2030	1	10	Graph in **Figure 5.5** shows the result of a model estimating the future decants from mines in the Middelburg

Option	*Starting year*	*Duration (years) to full yield*	*Estimated Yield (million m^3/a)*	*Comments*
Dam Catchment				*Dam Catchment. The additional decant from approximately 2020 – 2030 is 10 million m^3/a.*
Sewage water reuse Polokwane and Mogalakwena	*2012*	*23*	*11*	*Treatment will be necessary. Water can be reused by the mines.*
		TOTAL YIELD	***78.5***	

*A water balance can be achieved with the selected reconciliation options , which reduce the water requirements in both growth scenarios by about 50 million m^3/a and increase the system yield by approximately 68 million m^3/a. The treatment of decanting mine water has to be done in any event since the owners of the mines are under legal obligation to do this. The development of groundwater schemes is done by various role players on a wide-spread basis. The water balance is illustrated in **Figure E6**.*

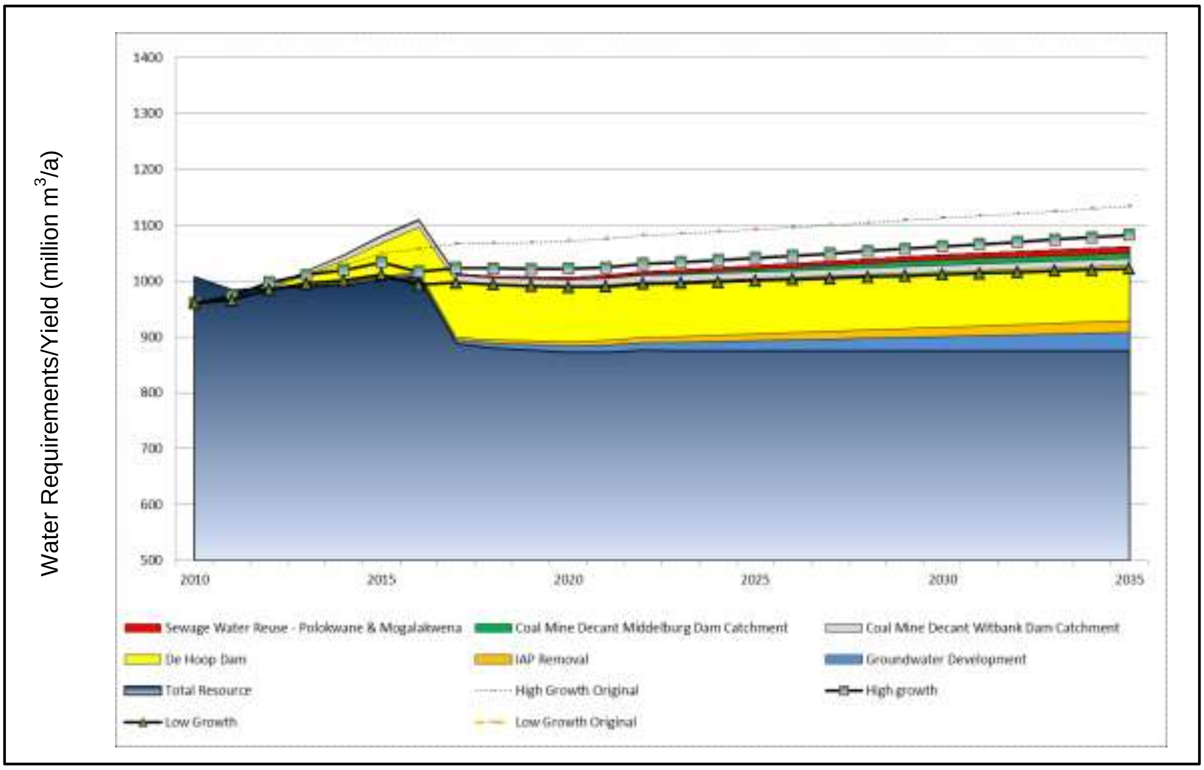

***Figure E6:** Water reconciliation graph for the entire Olifants with management and development interventions*

A water balance is achieved with the selected reconciliation options applied. It was assumed that the Reserve will be operationalized in 2016 after De Hoop Dam has filled. Although a water balance is achieved on the catchment as a whole, temporary water shortages might occur within management zones or smaller sub-catchments.

RISKS AND UNCERTAINTIES

The following risks and uncertainties have been identified:

- *The extent of unlawful water use is unknown. Until the V&V processes are complete, the water reconciliation strategy will have to rely on the best estimates.*

- *The possible additional yield which could become available as a result of additional infiltration into existing and decommissioned coal mines is based on the best information available. A study is currently being conducted to improve the confidence in this information but the results of this study were not ready for the purpose of this strategy.*

- *The results of the Agricultural Research Council (ARC) survey on Invasive Alien Plants (IAPs) need to be verified. It appears as if there could be an over-estimation of IAPs in the Upper Olifants Management Zone, but if correct, it will affect the current water balance negatively in this zone.*

- *The success of the purchasing of water entitlements (WC/WDM savings) as an option is difficult to predict. It is not clear how many water users would, in the longer term, offer water entitlements or parts thereof for sale and how much water will eventually be freed up. Care must be taken that irrigation farmers don't cause social upheaval by selling their water entitlements. There must therefore be a well-structured policy in place that will prevent interested sellers from going overboard.*

- *The cooperation of District and Local Municipalities is of utmost importance for achieving the WC/WDM targets in the urban water use sector.*

- *The postponement of the establishment of the Olifants Catchment Management Agency is seen as a core fundamental stumbling block in implementing the strategy successfully. If the establishment of the CMA cannot be accelerated, the successful implementation of this strategy holds a significant risk.*

- *Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc. This may not necessarily materialise to the extent, or within the time frames that has been assumed in this study.*

- *The outcome of the Resource Classification process that has now started as a separate study can have a significant impact on the setting of the resource quality objectives and therefore the EWRs. This in turn may have an impact on the assured yield of the system.*

- *The impact of operationalising the ecological Reserve over a longer period of say four years is uncertain. Such a measure can resolve the short term shortages if the impact is tolerable.*

- *Tshwane Metro provided new water requirements for Bronkhorstspruit Town and Thembisile right at the end of the study of approximately 73 million m^3/a, which is significantly higher than documented in this study. It is however suspected that*

Tshwane is referring to the water treated at Bronkhorstspruit Town and that their figure represents peak water demands and not yearly average water demands. These uncertainties could not be resolved as part of this study as the inputs were only provided at the close of the study, but it should be taken further in the envisaged Maintenance Study. Detail of the Tshwane inputs are documented in Appendix B of this report.

- *The Olifants River Joint Water Forum and Anglo American Platinum commented that they are concerned about relying too much on the water management interventions (e.g. WC/WDM, eradication of unlawful water use end removal of alien invasive plants) and that development options such as the transfer of treated sewage water from Ekurhuleni should have been allocated a higher priority. The water management options require huge amounts of energy from various role players and failure in coordinating these activities effectively holds a risk of not achieving the future water balance.*

IMPLEMENTATION ARRANGEMENTS

It must be realised from the outset that DWA, as trustee of the country's water resources, is only facilitating the process of water reconciliation planning and that implementation is the responsibility of many more institutions.

- ***Institutional Responsibilities***

  The following entities will play a crucial role in all aspects of implementation of the strategy:

  - *DWA Regional Office;*
  - *CMA;*
  - *ESKOM;*
  - *Mines;*
  - *Industries*
  - *Municipalities;*
  - *Water Boards;*
  - *Irrigation Boards and Water User Associations;*
  - *Organised Agriculture; and*
  - *Nature Conservation Institutions (e.g. Parks Board).*

  It is recommended that the Department reviews the priority of this catchment in terms of CMA establishment and put all measures in place to accelerate this process.

- ***Funding***

  Capital will be required for recycling / treating AMD and to refurbish water supply infrastructure as part of WC/WDM. No other capital expenditure is required to implement the proposed short-term actions. Operational funding from the DWA will be required for some of the other actions.

  Capital investment will be required if any one of the structural development options is pursued. A capital project such as a water transfer scheme can be funded from either the fiscus or it can be undertaken by an institution such as the TCTA which also can *obtain funds from international financial markets or funding agencies, e.g. the World Bank. Normally the purpose of the project will determine whether the project should be DWA funded or funded from elsewhere. Should the project for example be needed for the water supply to resource poor communities, funding out of the fiscus could be considered by Parliament. Water supply to enterprises that can redeem the capital expenditure themselves would normally be funded off-budget, outside DWA.*

RECOMMENDATIONS TOWARDS IMPLEMENTATION

- *The ecological categories and Reserve quantum adopted in this final reconciliation strategy must be compared with the results of the current Departmental Water Resource Classification study, once the study is complete.*
- *All management options (except compulsory licensing) to reduce the water requirements must be implemented as soon as possible.*
- *The WC/WDM in the irrigation sector should be linked to water trading.*
- *A policy and guideline document on the purchase of partial water entitlements (save water through WC/WDM measures) are urgently required and should be produced by DWA during the first year of implementation 2012.*
- *The validation and verification process must be resumed and accelerated. Various interventions are dependent on this process, e.g. purchase of water entitlements, water trading, compulsory licensing and eliminating unlawful water use.*
- *The establishment of a catchment management agency for the Olifants River should be accelerated.*
- *Groundwater development in unstressed aquifers must be encouraged. Groundwater in stressed aquifers must be managed and regulated better.*
- *The impacts of all interventions must be continuously monitored. Given the many uncertainties it is essential to stay ahead, respond rapidly, and to manage the system as indicated by successes or failures in measures applied.*
- *The intended Water Quality Management strategy must commence and be completed and water pollution must be addressed at source.*

RECOMMENDATIONS FOR FURTHER WORK

The following further work is recommended:

- *A possible regional water scheme with the Malmani dolomites as resource should be investigated. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River. The possibility of artificial recharge of the Malmani dolomites with surface water should also be investigated.*

- *Operating rules for operating Middelburg Dam, Witbank Dam, Loskop Dam, De Hoop Dam and Flag Boshielo Dam as a system must be developed and implemented, including management of river losses.*

- *The accuracy of the Agricultural Research Council Study on the Invasive Alien Plants infestation should be determined.*

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Appendix A

Tables A-1 to A-11 (1999 results of Eco-Classification in terms of the PES and the Recommended Ecological Category (REC) and the 2010 results per reach of the Olifants River)

Appendix B

1. INTRODUCTION

1.1 PURPOSE OF THIS STUDY

The water requirements in the Olifants Water Management Area (WMA) and the adjacent areas of Polokwane and Mogalakwena, which are supplied from the Olifants, have increased substantially over the last number of years due to increased water use in a range of sectors, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture.

The Olifants River Catchment is currently perceived to be one of South Africa's most stressed catchments as far as water quantity and water quality is concerned.

A reconciliation strategy, aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future, is required for the basin and its water users.

Figure 1.1 shows the Olifants River Basin and the Study Area.

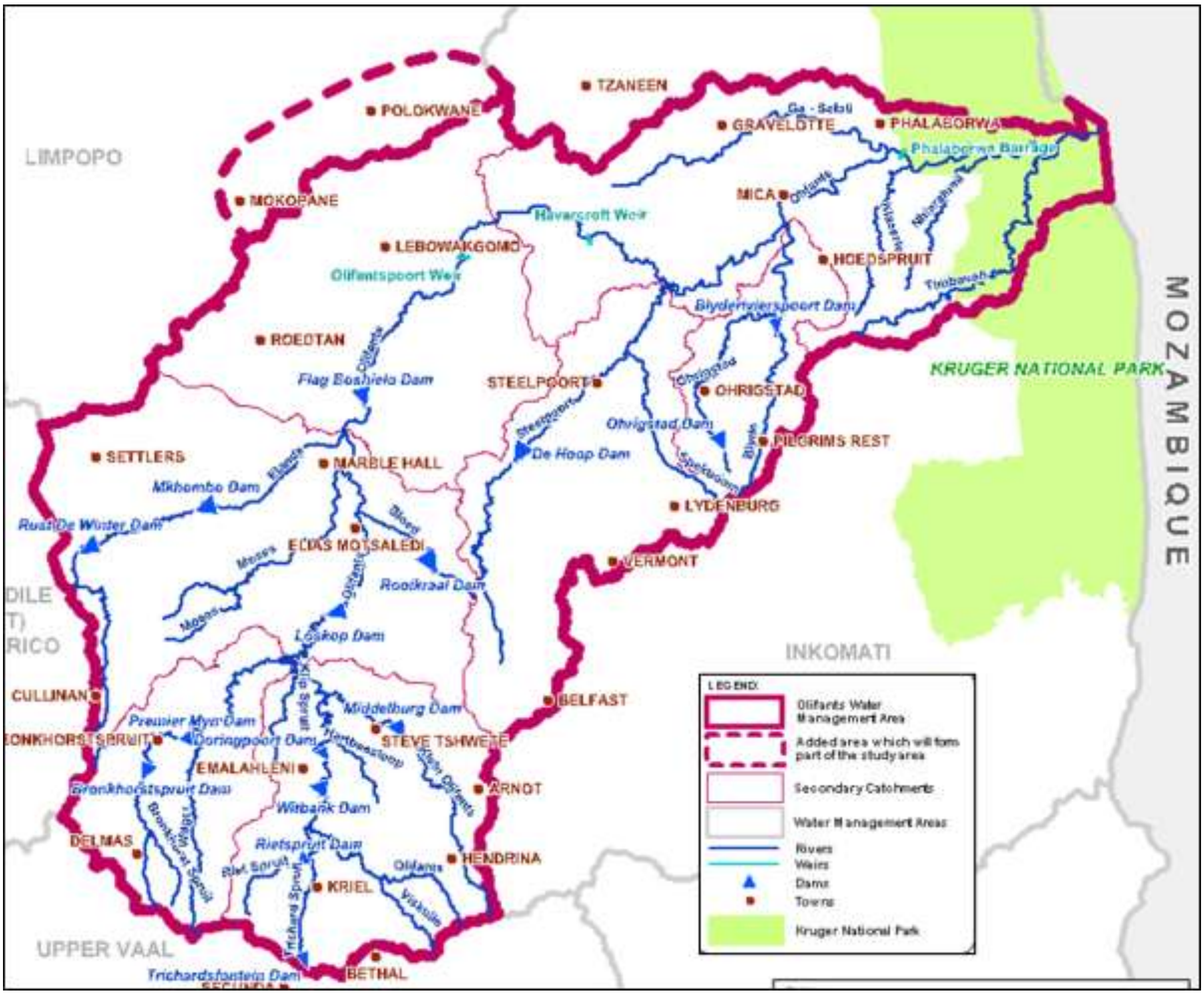


Figure 1.1: Olifants River Basin and Study Area

1.2 OBJECTIVES OF THE OLIFANTS RECONCILIATION STRATEGY

The objectives of the Olifants Reconciliation Strategy are:

- To meet legitimate current and future water requirements
- To recommend the most suitable interventions to balance the water requirements and water resources
- To identify responsible institutions and provide target dates for implementation of the strategy.

1.3 RELATION BETWEEN THE PRELIMINARY AND FINAL RECONCILIATION STRATEGIES

A preliminary reconciliation strategy was completed in November 2010. That preliminary strategy contained a water balance which was based on the best information available at that time.

The strategy identified a number of information gaps which had to be filled for this final strategy. The focus areas for which more information was needed were:

- Impact on the yield of the system as a result of the Reserve,
- Groundwater availability,
- Additional yield as a result of decant water from the coal mines,
- Urban and rural water requirements,
- Mining water requirements,
- Extent of unlawful water use,
- A more accurate estimate for Water conservation and water demand management savings in the irrigation sector,
- A further reconciliation option, i.e. to transfer water into the Olifants Catchment from the Crocodile (West) System.

These focus areas have been studied and this final reconciliation strategy is thus an improved version of the preliminary reconciliation strategy, based on the additional information obtained.

The purpose of this report is to present the Final Reconciliation Strategy.

1.4 REPORT STRUCTURE

After this introduction, this report starts with describing the study area and the study procedure.

The report then leads the reader into the ingredients for deriving the water balance for the system, i.e. the Reserve, current water use, projected water requirements, available water resources and water quality.

The water shortages emerging from this water balance are then addressed by identifying intervention measures and reviewing these.

The strategy for reconciling the future water requirements with the available water and the optimum scenario of intervention options are then described.

The report concludes with lists of risks and uncertainties, implementation arrangements and recommendations.

2. OVERVIEW OF THE STUDY AREA AND STUDY PROCEDURE

2.1 SYSTEM DESCRIPTION

The study area consists of the Olifants River Catchment and its adjacent supply zones, i.e. the urban areas of Polokwane and Mogalakwena to the north west of the basin. The Olifants River catchment has several large dams located in the upper and middle reaches. The earlier dams were constructed to supply large irrigation schemes, while later dams were constructed to meet growing domestic, industrial and mining water requirements. All the dams are operated independently of each other. However water court orders require releases from Middelburg Dam, Witbank Dam and Loskop Dam but these orders do not seem to have been upheld in recent times.

While the majority of water users obtain their water from the major dams, there are also a large number of water users who obtain their water from farm dams, and run-of-river abstraction, referred to in this report as diffuse water use. There is also a significant supply to irrigators and mines from groundwater. The reconciliation strategies developed as part of this study do not address water shortages of these diffuse water users.

In the upper part of the catchment, water use is mainly for power generation, mining and urban use, although run-of-river irrigation is also practised. In the upper parts of the Wilge River and Bronkhorstspruit there is significant abstraction for irrigation from groundwater (dolomite). In the middle part of the catchment most water is used for irrigation, while at the lower end of the catchment the Kruger National Park (KNP) requires that there is sufficient flow in the river to maintain the ecological integrity of the system. These conflicting requirements pose a significant challenge in the reconciliation process.

2.2 STUDY PROCEDURE

The study is anchored by technical and stakeholder engagement processes that are intertwined. **Figure 2.1** illustrates the flow of the processes.

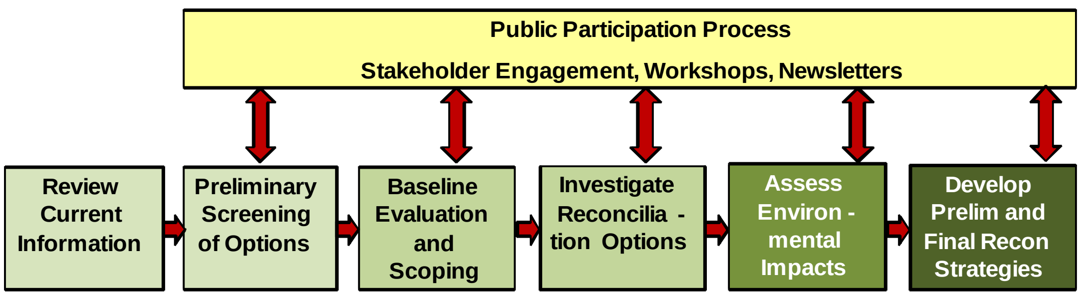


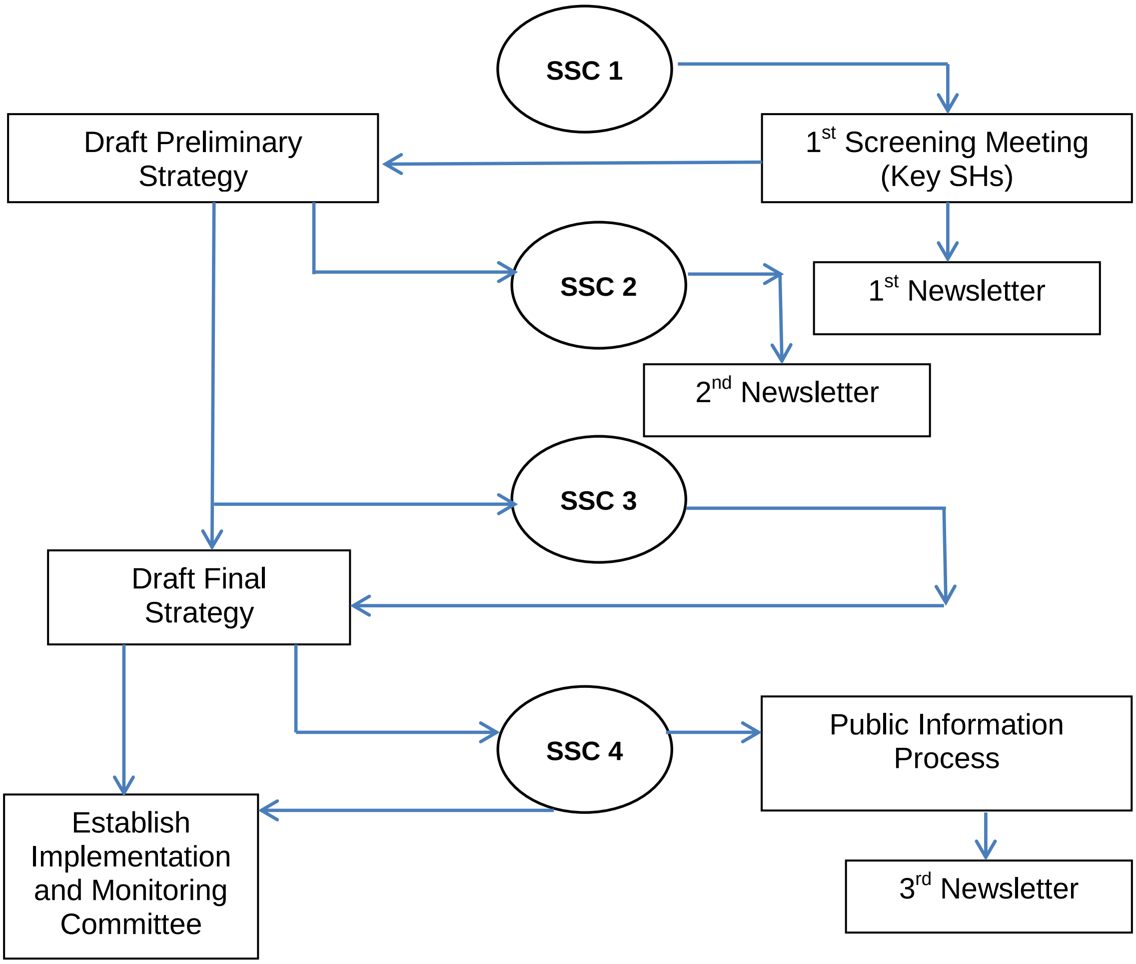
Figure 2.1: Technical and Public Participation Process

The technical process which is complete has followed the steps of **Figure 2.1**. The Review of Current Information concluded with the Summary Report (*Report No P WMA 04/B50/00/8310/2)* which summarised all relevant recent and current reports on the study area.

The Preliminary Screening of Options was performed at a preliminary screening workshop which was held on 7 July 2010 where a list of possible reconciliation options were evaluated by a group of key stakeholders who had to decide which options should be investigated further.

The further steps of the technical process, i.e. baseline evaluation and scoping, investigation of reconciliation options and assessment of environmental impacts all led to the development of the strategies – first a preliminary strategy which was developed halfway through the study to obtain an understanding of the reconciliation possibilities and to address the immediate needs and now this final strategy which has been developed with the improved information which has been obtained since the preliminary strategy.

To achieve the objectives of this study, all possible stakeholders were, and are still, consulted through workshops and information sessions. The diagram in **Figure 2.2** depicts the process which was followed in the engagements.



Note: **SSC = Study Steering Committee**

Figure 2.2: Process for Stakeholder Engagement

3. THE RESERVE

3.1 BASIC HUMAN NEEDS COMPONENT

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

The intention of the basic human needs component is to ensure that enough water is left in the resources for those communities that rely on them. The basic human needs can however be, and usually are, met from bigger supply systems. The Olifants Comprehensive Reserve Study which was undertaken during 1999 only focused on the ecological component of the Reserve. Most domestic water supply in the Olifants River catchment is supplied via water supply infrastructure while rural communities rely mostly on groundwater and hence the Basic Human Needs are already largely catered for in the water requirement estimates. In order to allow for riparian run-of-river abstraction to supply basic human need, an additional 3 million m^3/a, was included as a water requirement. It is recommended however that this estimate be reviewed during the next Reserve study in the Olifants River catchment.

3.2 ECOLOGICAL COMPONENT

3.2.1 Previous Ecological Water Requirements (EWRs) Study done for the System

The BHN component of the Reserve has largely been catered for in the total water requirements for domestic water use (See paragraph 3.1) and the focus of the description below is entirely on the ecological component of the Reserve

It should be kept in mind that the quantities that are reported in this study as being required for the Reserve, represent the impact of implementing the Reserve on the assured yield of the system and not the quantity that is left in the system to cater for the Reserve.

The Olifants Comprehensive Reserve Study was undertaken during 1999 and was only the second Comprehensive Reserve Study in South Africa. Eighteen ecological water requirement (EWR) sites were selected and the approaches used were the following:

- A qualitative assessment of the ecological state to determine the Ecological Categories (ECs) was done. The Present Ecological State (PES), the Ecological Importance and Sensitivity (EIS) the Recommended Ecological Category (REC) and the Alternative Ecological Category (AEC) were determined at each site.

- Environmental Water Requirements (EWRs) were set. The Building Block Methodology was followed to determine the ECs and the EWRs for a range of ecological states or categories at each of the 18 chosen sites.

The 18 sites are shown in **Figure 3.1**.

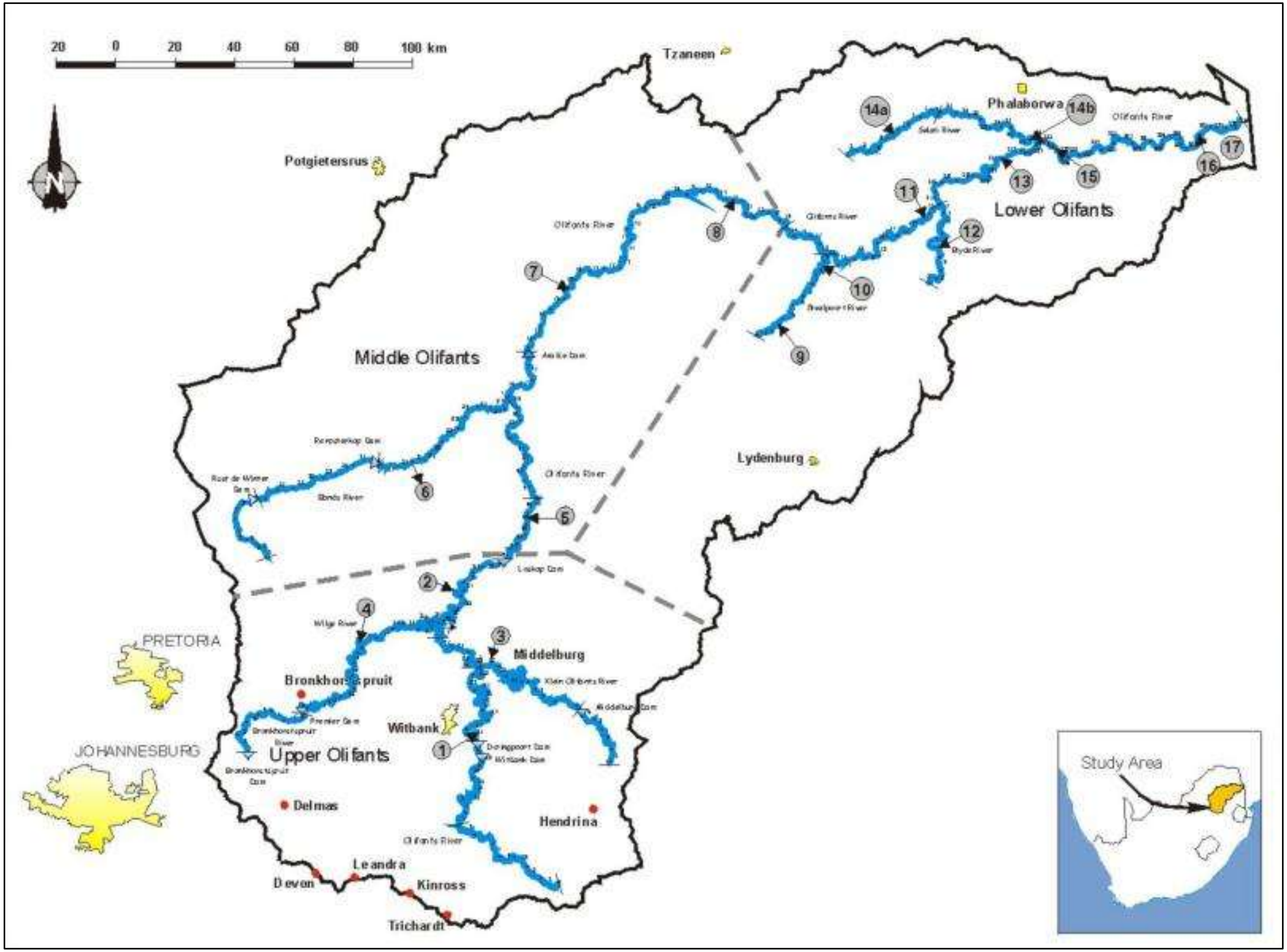


Figure 3.1: Olifants IFR Sites from the Ecological Reserve Report [by BKS, dated July 2001]

3.2.2 Ecological Changes since Previous EWR Determinations

As part of the current study, the Eco-Classification (i.e. the process to determine PES, EIS, REC and AEC) was repeated in 2010. This was done in accordance with the Eco-Classification models and the process developed by the Department of Water Affairs (DWA), Resource Quality Services. These models and processes were developed after 1999 and the manuals were published in 2007.

The main objective of redoing the Eco-Classification was to check how the EWRs would be affected by the new classification. It should be noted that the EWRs themselves (i.e. the flow pattern associated with an ecological category at a specific site) were not redone and are still the same as determined in the 1999 study.

Tables A-1 to A-11 in **Appendix A** provide the 1999 results of Eco-Classification in terms of the PES and the REC and the 2010 results per reach of the Olifants River.

Table 3.1 summarises the information in **Tables A-1 to A-11** of **Appendix A** and illustrates how the RECs, based on the revised Eco-Classification, changed for the whole Olifants River Catchment from 1999 to 2010. A "=" symbol indicates no change in REC, whereas a "+" and "-" symbol respectively indicate an higher or a lower REC.

Note that the Eco-classification work could not be redone for all the 18 sites used in the 1999 study as some of the sites have changed as a result of floods or were inaccessible.

Table 3.1: Overall 1999 and 2010 Results

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

3.2.3 Flood Component of the Ecological Reserve

The rule tables for each EC that were developed for the Reserve specify the water that has to be left in the river based on the "natural" flow conditions, which in turn depend on the rainfall. In simple terms, this generally means that a higher percentage of water can be abstracted during periods of average and above average flows, while this percentage reduces during periods of low flow. The rule tables also make provision to release small floods (called freshets) from the dams during the spawning season for fish.

The existing dams do not have sufficient release capacity to release these small floods, and in most cases they are in any case generated downstream of the dams from the tributaries and the catchment below the dam. These small floods were therefore removed from the rule tables.

Larger floods occur naturally and are generally not significantly affected by the presence of dams, while the abstraction capacity from users along the river is only a fraction of these floods. Larger floods are therefore not modelled as a requirement from the dams, but occur when the dams spill under high flow conditions.

3.3 RECOMMENDED RESERVE SCENARIO

The recommended operation of the Olifants River to meet ecological flow requirements is summarised in **Table 3.2**. It is essential that the EWR for the REC (Class B) be provided at EWR 4 (Wilge River) where the recommended categories in 1999 and in 2010 was a B but the PES has deteriorated from a B in 1999 to a C in 2010, and at EWR 16/17 (Kruger Park) because of its ecological and conservation importance. Note that EWR 16/17 is the driver site for the catchment and this will also result in the EWR for the REC (Class B) being met at EWR 15. Changes to the operation of the Blyderivierspoort and Mkhombo Dams are recommended as these could, with minimal impact on yield, achieve the ecological objectives. This is especially important for the Blyde River, EWR 12, which has a HIGH EIS and as it has now shown to be degrading. Note that in all cases the flooding requirements have been removed from the EWR Rules.

Table 3.2: Summary of ecological consequences of various flow scenarios and recommendations regarding an optimised scenario

EWR Site	Location	Recommended Class	Recommendations of Optimised Reserve Scenarios	EWRs Rule used for Yield Modelling
1	Olifants River d/s of Witbank Dam	D	Maintain “present” operation according to the revised more realistic hydrology. Present in this context does not include court order releases from Witbank Dam. These releases will have a slight negative impact on the ecological status of the river due to a reversal of seasonality.	D Class, no floods
3	Klein Olifants River	D	Maintain present operation.	D Class, no floods
4	Wilge river	B	Improve to a B Class	B Class, no floods
5	Downstream of Loskop dam	N/A	As invertebrates have degraded and the fish are 1 % away from degradation, it would be necessary to at least never have zero flows from Loskop. Maintain a minimum flow of at least 0.5 m^3/s.	No EWR Rule. Model a minimum flow of 0.5 m^3/s.
6	Downstream of Mkhombo Dam	N/A	Address operation from dam.	No EWR
8	Downstream of the Mohlapitse tributary	N/A	Maintain present day flow and operation according to the revised hydrology.	No EWR
9	Downstream of the De Hoop Dam	D	Implement the approved EWR in terms of the ROD	EWR as determined as part of the ORWRDP
12	Downstream of the Blyderivier-poort Dam	B	Address operation from Blyderivierspoort Dam	No EWR
13 & 15		B	See 16	
16/17	Olifants River in Kruger Park	B	Maintain the flows to meet a Class B Reserve.	B Class, no floods

Provision has only been made for that portion of the Reserve that is practically implementable (without freshets) and this will reduce the available yield of the whole system by 157 million m^3/a including the flows to be released from De Hoop Dam in order to maintain the ecological categories at their recommended levels. The full Reserve with the flood component would have reduced the available yield by 221 million m^3/a.

The DWA is currently doing the Water Resource Classification for the Olifants catchment, which may lead to different Reserve values than those recommended above. The Water Resource Classification will, however, only be completed after the completion of this study. The above recommended Reserve value will therefore provisionally be used for the purpose of the Reconciliation Strategy. Should the Water Resources Classification Study, however, later show different Reserve values, the Reserve values of the Water Resource Classification study will be used and the strategy will have to be amended accordingly.

4. CURRENT WATER USE AND PROJECTED WATER REQUIREMENTS

For the analysis of the surface water and groundwater requirements and availability, the Olifants Catchment has been divided into three management zones as illustrated in **Figure 4.1**.

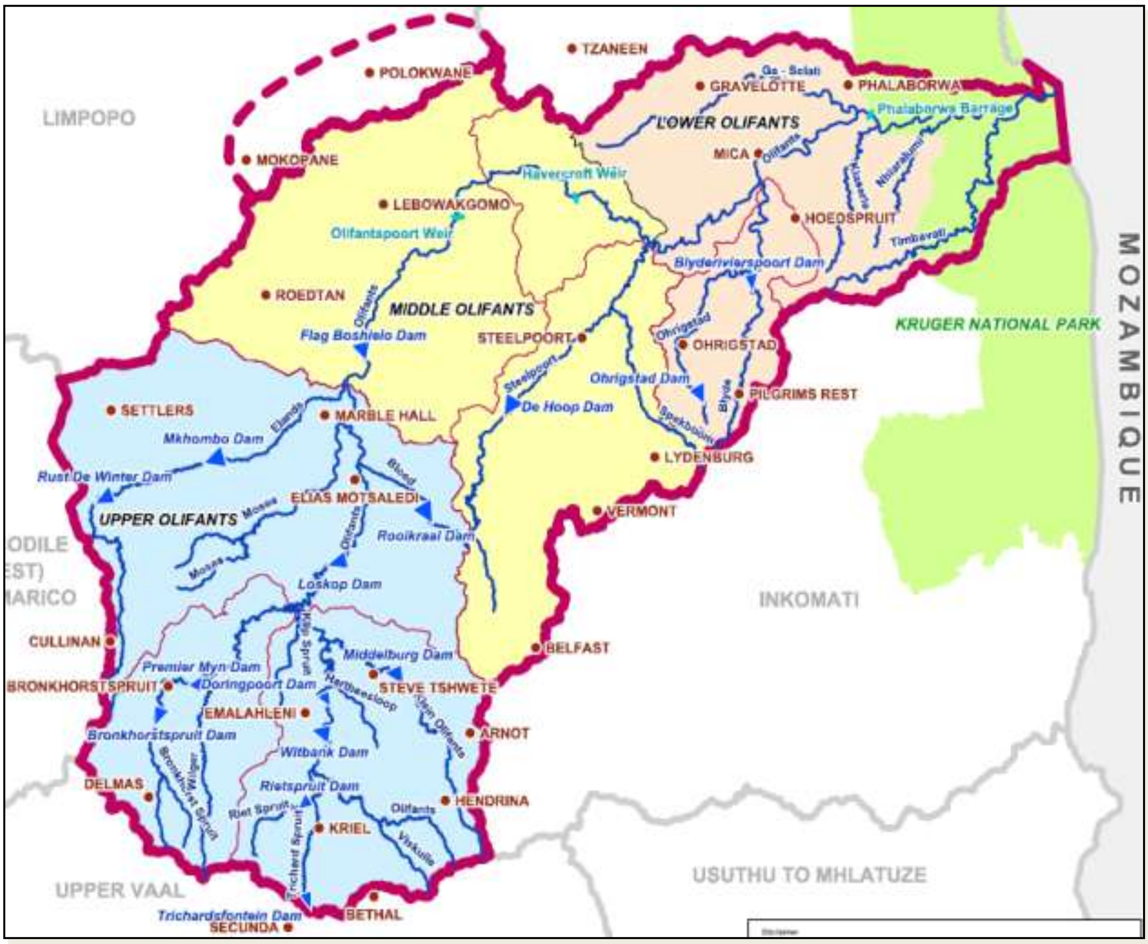


Figure 4.1: Management Zones of the Olifants Catchment

The assurances of supply differ for the one water use sector to the other. For example irrigation water on schemes is normally supplied at 80% assurance while urban water at 98%. For the purpose of comparison all water use was converted to 98% assurance of supply.

4.1 CURRENT WATER USE

The current water use in the irrigation, domestic and industrial, mining, power generation and forestry sectors is described below.

4.1.1 Irrigation Sector

Irrigation is the largest water user in the Olifants River catchment, with the two largest schemes situated downstream of the Loskop and Blyderivierspoort Dams. The total estimated irrigation requirement (estimated with the use of irrigation models) is 681 million m^3/a. However, it appears as if much of this requirement is not met at a high level of assurance, and the actual supply to irrigators is estimated at only 486 million m^3/a at a 98% assurance, with actual assurances of supply varying from as little as 10% to 100%, depending on the location in the catchment. This means that a significant amount of irrigation in the catchment is in real fact opportunistic irrigation and such irrigators won't have water all the time. The volume water use at 98% assurance of supply will then be much less for such irrigators.

Table 4.1 lists the estimated water demands and current supply to the irrigators in the Olifants River Catchment.

Table 4.1: Estimated Water Requirements and Supply to the Irrigators in the Olifants River Catchment

Management Zone	Controlled Irrigation (million m^3/a)		Diffuse Irrigation (million m^3/a)		Requirements Adjusted to 1:50 Year (million m^3/a)
	Require-ments	Supply	Require-ments	Supply	
Upper Olifants	174	152	154	97	249
Middle Olifants	56	50	68	31	81
Lower Olifants	118	109	111	47	156
TOTAL	**348**	**311**	**333**	**175**	**486**

The full validation and verification process has not yet been completed by DWA so it is difficult to ascertain what portion of this irrigation water use might be illegal. However, since no (or very few) irrigation water use licences have been issued since 1998, an analysis of the increase in irrigated areas from 1998 to 2004 will give an indication of the unlawful expansion of irrigation. This increase is indicated in **Table 4.2**. Note that increased irrigated area within irrigation boards were assumed to be lawful if they fell within the scheduled irrigation area for that board.

Table 4.2: Increased irrigation areas from 1998 to 2004

Catchment	Irrigated area (km^2)		
	1998	2004	Increase
Bronkhorstspruit	42.6	75.5	32.9
Middelburg	34.1	45.7	11.6
Witbank	41.7	55.6	13.9
Loskop	1.6	3.0	1.4
Flag Boshielo	177.7	192.2	14.5
De Hoop	13.7	22.8	9.1
B41&B42 (remainder)	52.1	53.4	1.3
Blyderivier	74.3	75.1	0.8
Phalaborwa Barrage (B50&B70)	50.6	70.0	19.4
TOTAL	**488.4**	**593.3**	**104.9**

A yield analysis was carried out to estimate the impact of the expanded irrigation on the existing system yield. **Table 4.3** gives the results of this yield analysis.

Table 4.3: Reduction in system yield as a result of irrigation expansion

Catchment	Yield (million m^3/a)		
	Base Scenario (2010) yield	Impact of Irrigation expansion on yield	Yield without recent irrigation expansion
Bronkhorstspruit	11.0	7.3	18.3
Middelburg	5.8	2.1	7.9
Witbank	23.0	1.0	24.0
Loskop	110	3.0	113
De Hoop	65.0	4.0	69.0
TOTAL	**214.8**	**17.4**	**232.2**

Note that in the above table only dams which showed a significant decrease in yield are shown.

The above result means that if the expanded irrigation were to be unlawful, and had to be eradicated, an increased yield of 17.4 million m^3/a can be expected. However not all of the irrigation expansion will necessarily be unlawful. The unlawful component can only be confirmed once the validation and verification process is complete.

4.1.2 Urban and Rural water requirements

Urban and rural water requirements within the Olifants River catchment including Polokwane and Mogalakwena in the Limpopo WMA, are summarised in **Table 4.4.** The urban water requirements were sourced mainly from the All Towns Study (DWA, 2011) although these estimates were confirmed through actual water use records of the major towns. The rural water requirements were estimated from the Water Services database (DWA, 2011). The distinction between urban and rural was derived from the Water Service Database and relates to the level of service. Levels A and B were accepted as Urban while all other levels of service were classified as rural.

Domestic and industrial water users usually receive their water at a high level of assurance. However, the Western Highveld area, i.e. the rural area in the north-western part of the Upper Olifants Management Zone, which is supplied from the Mkhombo and Bronkhorstspruit Dams and more recently through transfers from the Vaal System, receive its water at a lower assurance of supply than 98%. The reason for this is the high water demand and inefficient water use. This is one of the areas that need to be targeted for a WC/WDM intervention and for an increase in water supply if the water demand can still not be met.

Table 4.4: Urban and rural water requirements

Management zone	Urban (million m^3/a)	Rural (million m^3/a)
Upper Olifants	93	4
Middle Olifants	56	22
Lower Olifants	29	3
TOTAL	**178**	**29**

4.1.3 Industrial sector

It is often difficult to quantify industrial water requirements because industries are generally supplied from municipalities and are not separately licensed. The industries identified within the Olifants River catchment with clearly defined water requirements are listed in **Table 4.5**. These industries are all located in the Upper Olifants River management zone. By far the largest of these is Highveld Steel, which obtains its water from Witbank Dam via the Emalahleni Municipality.

Table 4.5: Industrial demands in the Upper Olifants Management Zone

Industry	Water requirement (million m^3/a)
Highveld Steel	8.0
Columbus Steel	0.4
Middelburg Ferrochrome	0.2
Kanhym	0.2
Gouda/Festival Farms	0.4
TOTAL	**9.2**

4.1.4 Mining Sector

The water requirements of the mining sector are summarised in **Table 4.6**. Many of the mines, and especially the coal mines located in the Upper Olifants, make use of groundwater obtained through their mine dewatering activities.

Table 4.6: Mining Requirements (million m^3/a)

Management Zone	Surface Water Mining Requirements (million m^3/a)	Groundwater Mining Requirements (million m^3/a)	Total (million m^3/a)
Upper Olifants	9	17	26
Middle Olifants	17	11	28
Lower Olifants	32	0	32
TOTAL	**58**	**28**	**86**

4.1.5 Power Generation

There are several large power stations located in the Upper Olifants which have large water requirements for their wet cooling process. All of these power stations are supplied from either the upper Komati or the Vaal Systems. The estimated transfer of water into the Olifants Catchment to supply to these power stations is 228 million m^3/a.

The Kendal power station utilises a dry cooling process requiring only 7% of the water used in the wet cooled process for the same amount of power generated. The new Kusile Power Station, near eMalahleni, which will also be supplied from the Vaal System, is under construction and this power station is also based on a dry-cooling process with limited water requirements. See **Table 4.7.**

Table 4.7: Power Stations in the Olifants River Catchment

Power Station	Cooling Process	Water Requirement (million m^3/a)
Arnot	Wet	36.5
Duvha	Wet	51.6
Hendrina	Wet	32.5
Kriel	Wet	45.6
Matla	Wet	53.8
Kendal	Dry	3.4
Komati	Wet	4.4
Kusile (under construction)	Dry	

4.1.6 Streamflow Reduction

There is limited afforestation, mainly in the higher rainfall areas of the Olifants River catchment. This results in a reduction in streamflow and ultimately a reduction in the yield available from the various dams in the system. This streamflow reduction, summarised in **Table 4.8**, has already been factored in when calculating the yields of major dams and the diffuse water resources.

Table 4.8: Streamflow Reduction due to Afforestation

Sub-area	Area (km2)	Streamflow reduction (million m^3/a)
Middle Olifants	91	3.5
Lower Olifants	186	18.9
TOTAL	**277**	**22.4**

There are no plans to expand or reduce forestry in the Olifants catchment.

4.1.7 Invasive Alien Plants

There are also significant areas of the catchment that have been invaded by alien vegetation, and this also results in a reduction in streamflow. Estimates of the invaded areas, as provided in the Olifants Water Availability Assessment Study (OWAAS) are summarised in **Table 4.9.** More recently, the Agricultural Research Council [ARC, 2010] carried out an intensive study to update estimates of Invasive Alien Plants (IAPs) across South Africa, and therefore also the Olifants Catchment. This study indicates areas of IAPs in the Upper Olifants that are significantly greater than those estimates used in previous studies but less in the Middle and Lower Olifants. These areas are shown in **Table 4.9.**

Table 4.9: Summary of Areas of IAPs (Units: Km^2)

Management Zone	OWAAS (2010)	ARC (2010)
Upper Olifants	459	1540
Middle Olifants	929	728
Lower Olifants	529	358
TOTAL	**1 917**	**2 676**

The streamflow reduction due to IAPs based on the areas from the OWAAS is given in **Table 4.10.** This was calculated using duration curves based on the known impacts of commercial afforestation in South Africa [Gush, et al, 2002].

Table 4.10: Summary of Streamflow Reduction due to IAPs

Management Zone	OWAAS (2010) (million m^3/a)	ARC (2010) (million m^3/a)
Upper Olifants	Not stated	33,3
Middle Olifants	Not stated	23,5
Lower Olifants	Not stated	25,0
TOTAL		**81,8**

The estimated available surface water resource took account of Invasive Alien Plants to the extent estimated and used in the OWAAS, although the ARC study suggests significantly greater areas of IAPs and hence a greater streamflow reduction in the upper catchment meaning that there could be less water available in the upper system than stated in the OWAAS. However, there are doubts as to the accuracy of the ARC study, which seems to consistently overestimate the areas of IAPs. The large area (301 km^2) of IAPs that the ARC report lists upstream of the De Hoop Dam, is especially a cause for concern. This catchment seems to be only very sparsely invaded by IAPs and hence this large area has not been accepted. The accuracy of the ARC study however, needs to be verified and a meeting was held with key role players in the IAP field at which it was decided that a workshop needs to be held in due course to debate these issues and agree on a way forward.

The impact on yield for removing these IAPs is shown in **Table 4.11**.

Table 4.11: Impact of IAPs on the Yield of Dams

Sub-catchment	Yield million m³/a		
	Without IAPs	With IAPs	Impact
Bronkhorstspruit	23.3	22.5	0.8
Middelburg	24.5	24.2	0.3
Witbank	57.5	55.4	2.1
Loskop	158.7	151.9	6.8
Rust de Winter	14.5	13.8	0.7
Mkombo	14.6	13.5	1.1
Flag Boshielo	67.1	63.9	3.2
Blyde River	178.5	172.5	6
		TOTAL	**21.0**

Table 4.12 provides a summary of all the water use requirements in the Olifants Catchment. The table excludes the water requirements of forestry as the later yield estimates already include the reductions caused by the forestry plantations.

Table 4.12: Summary of Water Requirements (Units: million m^3/a)

Management Zone	Irrigation	Urban	Rural	Indus-trial	Mining	Power Gene-ration	Total
Upper Olifants	249	93	4	9	26	228	**609**
Middle Olifants	81	56	22	0	28	0	**187**
Lower Olifants	156	29	3	0	32	0	**220**
TOTAL	**486**	**178**	**29**	**9**	**86**	**228**	**1016**

Note: The requirements are at different assurances of supply. They have all been converted to a 1:50 year assurance of supply in this table.

4.2 PROJECTED FUTURE WATER REQUIREMENTS

The estimated high growth scenario within the Olifants River Basin is shown graphically in **Figure 4.2** and is discussed in detail in the following sections.

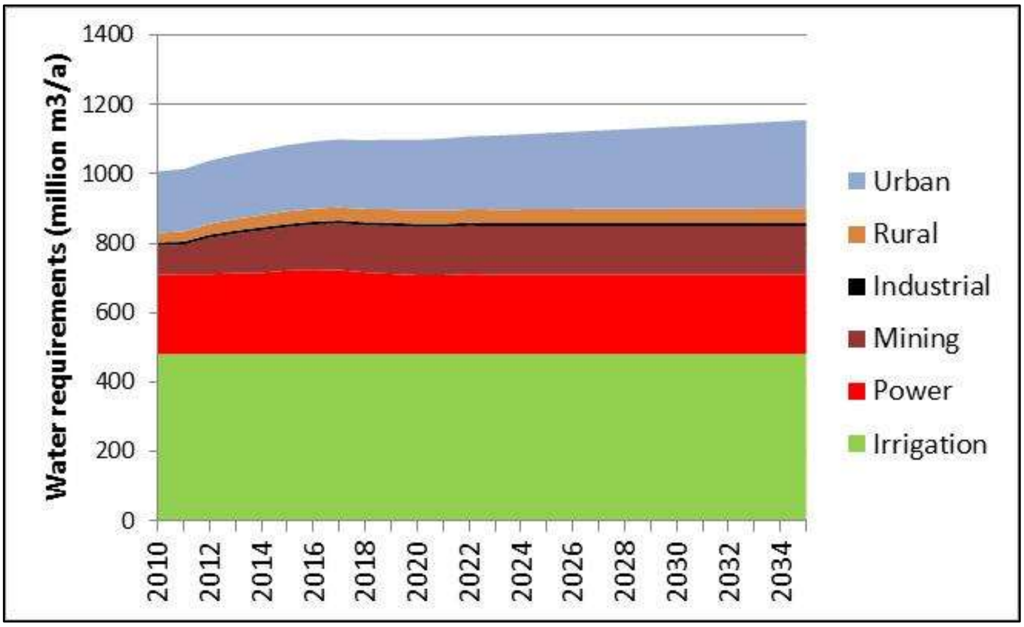


Figure 4.2: High Growth Scenario

4.2.1 Irrigation Sector

While there is a demand for additional irrigation, it is highly unlikely that new licences will be granted for irrigation due to the stressed nature of the catchment. The irrigation requirements are therefore assumed to remain constant for future years. Nevertheless, there is a considerable amount of irrigation that has fallen into disuse within the former homelands which the Department of Agriculture is attempting to revitalise. The present day estimated irrigation water requirements include these areas and the assumption has been made that the revitalisation projects will be successful.

Proposed augmentation schemes do not explicitly exclude irrigation development projects, but due to the very high cost of augmenting the water resources it is unlikely that any irrigation expansion will be economically viable.

4.2.2 Urban and rural water use

The growth estimates were obtained from numerous sources, the most comprehensive of which was the Development of Reconciliation Strategies for All Towns in the Northern Region (DWA, 2010), which contains the latest demographic analysis of the Olifants River catchment. The low population estimate derived from the All Towns study (DWA, 2010) '*was based on the future scenario compiled by Stats SA for DWA at a District Municipality level. The local municipality level figures were firstly derived from the district municipality figures and then to a sub place level based on the historical trends between the 1996 and 2001 Census data.*'

The high growth scenario (also from the All Towns study) '*provides a higher population growth rate based on lower HIV and AIDS infections and deaths,* *longer lifespan, lower international out migration, illegal immigration and brings into account the various growth scenarios of government, including the National Spatial Development Framework (NSDF), ASGISA, Presidential scenarios, etc. Each municipality was contacted and discussions were held with a number of officials regarding their perceptions with respect to past and future growth of each of the towns/groupings. This information was incorporated into the high scenario.'*

There has been rapid growth in the urban sector especially in the metropolitan area of EMalahleni and Middelburg, while the growth in more rural areas has been limited by the lack of water supply infrastructure. The estimated growth from 2010 to 2035 is shown in **Table 4.13.** An important principle applied in the All Towns studies is that growth in water requirements would be limited to acceptable levels of service, i.e. a minimum of 60 litres per capita per day. Implicit in this assumption is that unacceptable water losses are not escalated into the future and that some success in WC/WDM is assumed in the growth estimates. Previous studies escalated the water demand based on historical growth rates and hence implicitly accepted the high losses. It is suggested that the observed high growth rates in water use over the last 5 years are due to high and uncontrolled losses.

More recent studies carried out in Polokwane (DWA, 2011) and Mogalakwena (DWA, 2011) were used as a basis for the growth in these areas.

The growth in rural water demands assumed that all rural water supply schemes would be upgraded to a service level of 60 ℓ/person/day. Population estimates and levels of service for rural areas were obtained from the DWA Water Service Database (DWA, 2011). When the level of service in the rural areas is upgraded, it becomes imperative that proper WC/WDM in the rural areas is exercised.

For the purpose of this strategy, no estimates for WC/WDM savings for the rural water use were taken into account because of the many uncertainties but it remains important and urgent that WC/WDM in the rural areas receive the necessary attention.

Table 4.13: Growth in Requirements – Urban and Rural

Sub-area	Urban requirements (million m^3/a)			Rural requirements (million m^3/a)		
	2010	2035		2010	2035	
		High	Low		High	Low
Upper Olifants	93	113	107	4	6	5
Middle Olifants*	56	100	77	22	39	29
Lower Olifants	29	42	37	3	6	5
TOTAL	**178**	**255**	**221**	**29**	**51**	**39**

* *It should be noted that the water requirement figures for the Middle Olifants include the total urban and rural water requirements of Polokwane and Mogalakwena which will be partially met by the two towns' own water resources.*

As a result of the high irrigation water use and the water use for power generation, which remain almost constant over the future years, there is a very slight difference between the high and low growth scenarios. It will only be the urban, rural and mining water use sectors that will show significant growths.

Very late inputs from Tshwane Metro on the water requirements of Bronkhorstspruit and Thembisile might influence the water requirement projections in Table 4.13 for the Upper Olifants Management Zone. The inputs were received too late to amend this report and the Tshwane comments are only dealt with qualitatively here and should be studied in more detail in the envisaged follow-up Maintenance Study. The matter has been flagged as a risk under Chapter 10 – "Risks and Uncertainties" and the comments of Tshwane Metro are documented in Appendix B of this report.

4.2.3 Mining Sector

Water use in the mining sector grew very rapidly in the Middle Olifants in the last decade due to the surge in the platinum price; this prompted the raising of Flag Boshielo Dam and the construction of the De Hoop Dam. The economic downturn in 2008 put many new planned mining developments on hold and the future requirements of the mining sector have since been revised. The most likely growth remains in the Middle Olifants, with limited expansion of mining water demands in the remainder of the catchment.

The growth projection for the mining industry is shown on **Figure 4.3** and **Figure 4.4**. **Figure 4.3** indicates the high and low growth scenarios for the middle Olifants and are based on discussions with the mining sector (Bierman, 2010) which indicated a low growth scenario with annual water use less than their best estimate and a high growth rate of water use 15% above their best estimate. This growth is not only due to platinum mining, but also irons and chrome. Some of the larger mining groups active in this area and Anglo, Xstrata and Samancor.

According to the information received, the water requirements flatten off from 2025 to 2032.

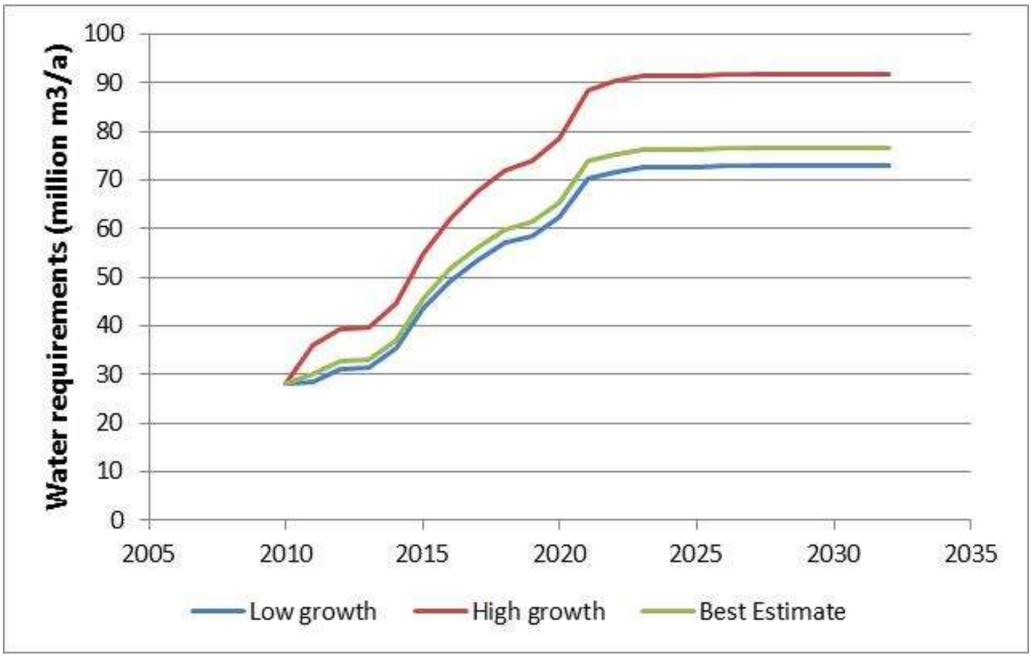


Figure 4.3: Growth projection of the Mining Industry in the Middle Olifants

Figure 4.4 shows the growth in water requirements for the entire mining sector, that is, including the Upper and Lower Olifants. There is no indication that the mining water requirements in the Upper and Lower Olifants are going to increase. Although the coal mining activities in the Upper Olifants continue to expand, these mines make use of groundwater and there have been no new applications for water use licences from mines in this area. There are also no plans to expand the mining activities in the Phalaborwa region (Lower Olifants).

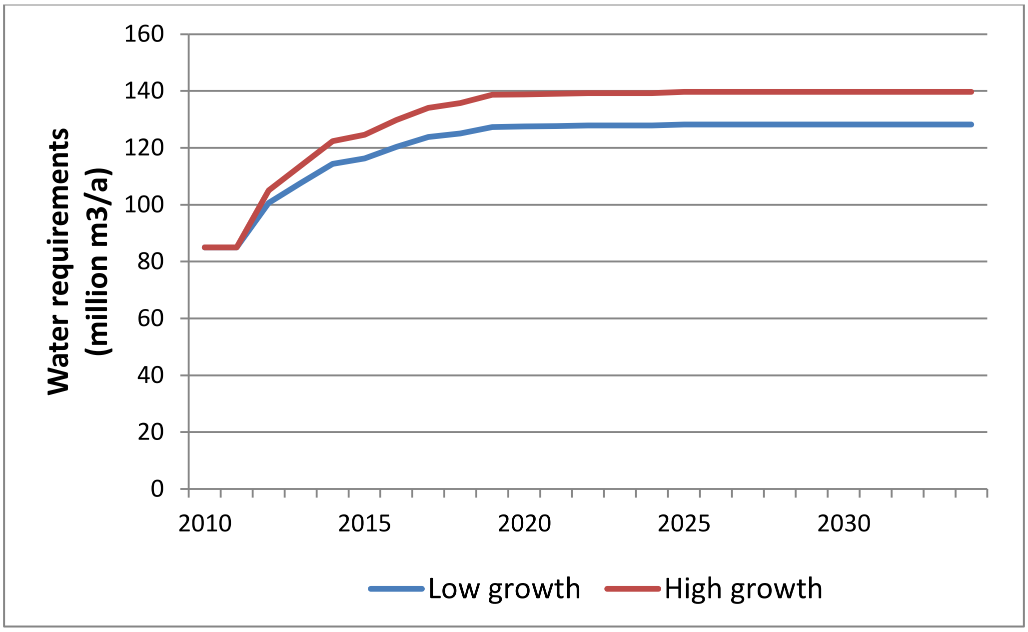


Figure 4.4: Growth projection from Mining Industry in whole Olifants Study Area

4.2.4 Power Generation

The water requirements of the six operational power stations located within the Olifants River catchment will increase until approximately 2016 but all of this water will be sourced from outside the Olifants Catchment. The new Kusile Power Station is being constructed near eMalahleni, within the Olifants River catchment, but will obtain its water from Vaal System. Kusile power station will utilise a dry-cooling process, so that the additional water requirements due to this plant are relatively low. The Komati Power Station is being re-commissioned and its water requirements, which will come from the Olifants basin, have been factored into the water requirements for power generation.

The water transfers from the Upper Komati and Vaal Systems will increase to meet the demands of these new power stations since the flow capacity of the pipeline infrastructure of the transfer schemes is adequate enough for the higher water demand. The water balance of the Olifants River catchment will therefore not be affected by this growth.

4.2.5 Other

Streamflow reduction due to afforestation will not increase as it is not the intention of the DWA to issue new licences for forestry in the Olifants River catchment. The on-going removal of IAPs in the catchment should result in an increase in stream flow although actual areas and water resource impacts must still be confirmed. Scenarios have been modelled to indicate the gain in yield with the reduction in IAPs. These are shown in section 4.1.6 and should not be seen as a growth scenario but rather as a management intervention.

4.3 TOTAL HIGH AND LOW SCENARIO WATER REQUIREMENT PROJECTIONS

The projected total high and low growth water requirement figures for 2035 are shown in **Table 4.14.** These high and low growth water requirement figures have been used for the reconciliation scenarios that will be described in Section 9.

Table 4.14: Total high and low growth water requirements

Sector	Current requirement (2010)	Future requirement (2035)	
		High growth	Low growth
Irrigation	486	486	486
Urban	178	255	221
Rural	29	51	39
Industrial	9	9	9
Mining	86	140	128
Power Generation	228	229	229
TOTAL	**1 016**	**1 170**	**1 112**

5. WATER RESOURCE AVAILABILITY

5.1 GROUNDWATER

5.1.1 Geology and Geohydrology of the catchment

The Olifants catchment is underlain by rocks varying in age from Archaean to Quaternary, with most lithologies having been subjected to varying degrees of metamorphism. The granite gneiss is the oldest formations covering the central and lower parts of the catchment. The Transvaal Supergroup consist of sedimentary rocks found along the escarpment and the Chuniespoort dolomite which appears along the Eastern Escarpment, Delmas and central part. The Bushveld Complex is the massive layered igneous complex overlying the older formations and consists of ultramafic rocks known as the Rustenburg Layered Suite, which is overlain by the acidic rocks that form the Lebowa Granite. Sandstone and quartzite belonging to the Waterberg Group outcrop in the Bronkhorstspruit and Middelburg areas. The Karoo Supergroup outcrops in the Witbank, Hendrina, Springbokflats and the Kruger National Park and consists of glacial tillite at the base overlain by shale and sandstone formations with basalt at the top. Intrusions and extrusions such as the Timbavati Gabbro, Phalaborwa Complex and Spitskop Complex occur in the Lower Olifants while dykes and sills are prevalent particularly in the central regions. Alluvial clayey silts, sands and gravels are present along most major rivers.

The availability of groundwater resources for abstraction is controlled by the aquifer characteristics of permeability and storage. The aquifers in the Olifants River Catchment can be divided into three main types namely, Intergranular and fractured, fractured and karst or only fractured [GMKS, Tlou and Matji and Wates, Meiring and Barnard, 2004]. The highest yields are available in the fractured karst (dolomite) aquifer with boreholes yielding 0.1-50 ℓ/s. Favourable resources are also available in the deep weathered Karoo basalt and valley areas underlain by norite and gabbro of the Bushveld Igneous Complex with boreholes yielding up to 5 ℓ/s. Low yields can be expected in the Karoo siltstone, shale and mudstones, the Nebo granite, as well as the Waterberg sandstone and quartzite with boreholes yielding in the order of 0.5 ℓ/s. A summary of the hydrogeological characteristics of the various formations is shown in **Table 5.2**.

DWA's classification of water quality and criteria of concern for drinking water purposes were applied to the data in order to establish the status of water quality as shown in **Table 5.2.** The classification is based on the content range of main inorganic substances and total coliforms in the water.

Table 5.1: DWA classification of water quality and criteria of concern for drinking water

Water quality class	Description	Drinking health effects
Class 0	Ideal water quality	No effect, suitable for many generations.
Class 1	Good water quality	Suitable for lifetime use. Rare instances of sub-clinical effects.
Class 2	Marginal water quality, water suitable for short-term use only	May be used without health effects by majority of users, but may cause effects in some sensitive groups. Some effects possible after lifetime use.
Class 3	Poor water quality	Poses a risk of chronic health effects, especially in babies, children and the elderly. May be used for short-term emergency supply with no alternative supplies available.
Class 4	Unacceptable water quality	Severe acute health effects, even with short-term use.

Table 5.2: Summary of Typical hydrogeological Characteristics (Source: Olifants River Internal Strategic Perspective)

Lithology	Area within Catchment (km^2)	Average Borehole Yield (ℓ/s)	Average Range of Depth of Water Level (mbgl)	Typical Borehole Depth (m)	Aquifer Type	Groundwater Quality DWA Class
Karoo age siltstone and sandstone	7 250	,0.5 0.5 – 2 along dyke contacts	5-20	30-60	Inter-granular and fractured	0-1 Occasionally 2
Delmas dolomite	210	0.1 - > 50	3-68	100-250	Fractured and karst	0 Pockets of NO_3 due to agriculture
Pretoria Group quartzite and shale (Bronkhorstspruit area)	1 230	< 0.5 – 2	20-30	40-100	Inter-granular and fractured (shale) Fractured (Quartzite)	0
Waterberg Sandstone and Quartzite	3 275	< 0.5 Occasionally > 3	<10 - > 40	40-120	Fractured	0
Nebo granite	6 630	< 0.5 Up to 2 in fracturing	10-20	40-100	Inter-granular and fractured	0-1 Isolated NO_3 in settlements Isolated F
Rhyolite and felsite	2 675	< 0.1 Occasionally < 0.5	10-50	70-150	Fractured	0
Basalt (Springbok flats) and KNP	2 730	2 – 5 Sometimes > 10	10-50	50- > 150	Inter-granular and fractured	NO_3 problem in Springbok Flats
Clarens SST	2 830	1-2	10-20	30-70	Inter-granular and fractured	0
Mudstone and shale (Irrigation) Sandstone (Ecca)Norite and gabbro		>0.5	10-20	802-120	Inter-granular and fractured	2 or 3
Norite and gabbro	5 800	0.5 – 2 Occasionally > 5	10-20	30-80	Inter-granular and fractured	0 or 1 Isolated NO_3 in settlements
Pretoria Group quartzite and shale Escarpment areas	6 200	0.5 – 2 Occasionally up to 5	<10 - > 40	40-150	Fractured	0

Lithology	Area within Catchment (km^2)	Average Borehole Yield (ℓ/s)	Average Range of Depth of Water Level (mbgl)	Typical Borehole Depth (m)	Aquifer Type	Groundwater Quality DWA Class
Dolomite	1 615	< 1 - > 5 Potentially > 20	0 - > 50	30-250	Fractured and karst	Pristine in many areas
Black reef quartzite	2 120	0.5 – 2 > 5 in dolomite	10-30	50-100	Fractured	0 Pristine in many areas
Granite (Low veld)	9 200	0.5 – 2	5-15	30-80	Inter-granular and fractured	1 Isolated NO_3 in settlements

5.1.2 Groundwater Use and Potential

Groundwater is available throughout the Olifants WMA but varying in quantities depending upon the hydrogeological characteristics of the underlying formations. The groundwater use in the various Management Zones varies significantly with the groundwater availability. Groundwater in high yielding areas is mainly used for irrigation, whereas in low yielding areas it is mainly for domestic and livestock watering.

AGES (2008) developed the Groundwater Yield Model (GYM) which aims 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 evapo-transpiration. The overall results of the GYM indicated that there is a surplus of groundwater in the order of 70 million m^3/a, with inflow exceeding outflow.

Areas were identified by AGES, 2008 as stressed aquifer units and termed “hotspots” and these are shown in **Figure 5.1**. At the following hotspots, groundwater is over-utilised on a local scale.

1. The Delmas Dolomite Aquifer (B20A and B20B), where irrigation in the order of 6 million m^3/a, is abstracted from a spatial limited aquifer. Sinkhole formation increased tremendously in the last number of years with loss of land use (Jasper Mulder and Associates, 2005).

2. The Zebediela Dolomite Aquifer (B51E and B51G), which is similar to the Delmas aquifer where 3 million m^3/a, are abstracted, also from a spatially limited aquifer.

3. The Springbok Flats Karoo Aquifer (B51E) where groundwater in the order of 10 – 12 million m^3/a, is abstracted for irrigation.

4. The Upper Olifants (Witbank-Middelburg-Kriel) Karoo Coal Aquifers (B11K, B11J, B11H and B12D) where water quality as result of acid mine drainage is more of concern than quantity.

5. The Steelpoort mining and community water supply aquifers (B41J and B41K) where groundwater quantity and quality are concerns as result of high sulphate from mining and nitrate from poor sanitation management.

6. Kruger National Park and Bushbuckridge Catchments (B73J, B73H and B73F) where groundwater sustains community water requirements and wildlife and riparian vegetation.

7. The Polokwane well fields are affected by their current management and it needs to be established what the safe yield is without seriously affecting the water quality of the resource.

Groundwater is also utilized in the supply areas of Polokwane and Mogalakwena. The groundwater balances in those areas are provided in **Table 5.3**.

Table 5.3: Groundwater Resources in the Polokwane and Mogalakwena areas

Resource	Current water use (million m^3/a)
Well fields near Mogalakwena for domestic use	9.6
Well fields near Mogalakwena used for mining	2.1
Polokwane Well fields	5.7*
TOTAL	**17.4**

* Maybe optimistic. See 7 above.

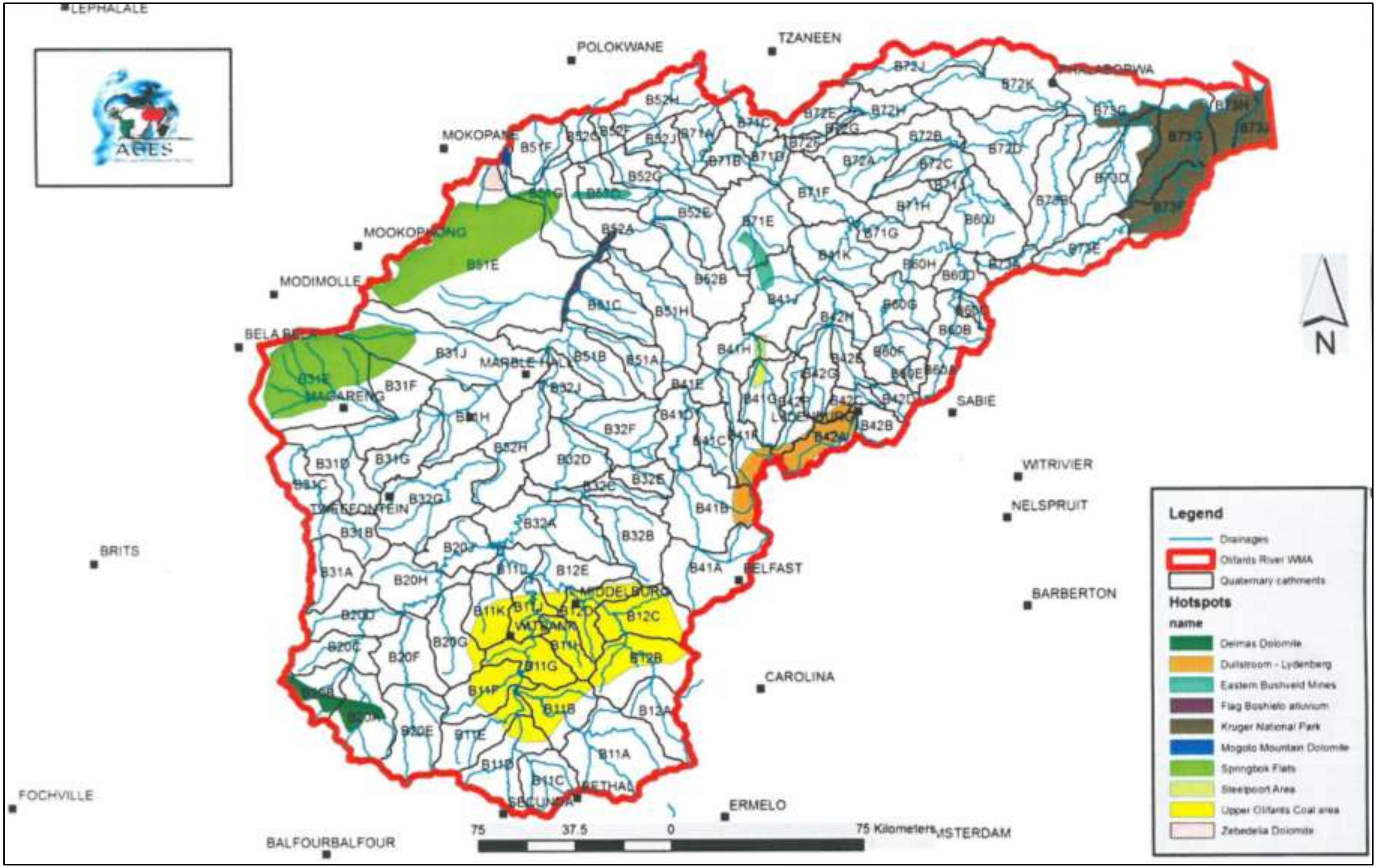


Figure 5.1: Hotspot quaternary catchments in the Olifants WMA (Source: AGES, 2009)

5.1.3 Further Groundwater Development Options

Groundwater is the only source of water supply in many places, especially rural areas, where it is used mainly for domestic and stock watering purposes. DWA published General Hydrogeological Maps at the scale of 1:500 000 covering the whole country. The four maps Johannesburg, Polokwane, Phalaborwa and Nelspruit were used to compile a hydrogeological yield map of the Olifants WMA shown in **Figure 5.2**. The map displays the principal groundwater occurrence in the various aquifer types across the basin calculated from the borehole yields on the National Groundwater Data Base (NGDB). It is clear from the map that almost 80 to 90% of boreholes in aquifers across the basin yield less than 2ℓ/s. The map confirm the previous conclusions that the higher yielding aquifers are the karst and fractured karst aquifers in the Delmas and Escarpment area and the Intergranular and Fractured aquifers in the Springbok Flats and Hoedspruit areas. Generally new groundwater development can only be used for domestic and stock watering and supply for small villages supplied by well fields. The high yielding aquifers in the Springbok Flats, Delmas and Zebediela areas are stressed and the only potential high yielding aquifer for development is the karst or dolomite aquifers of the Eastern Escarpment.

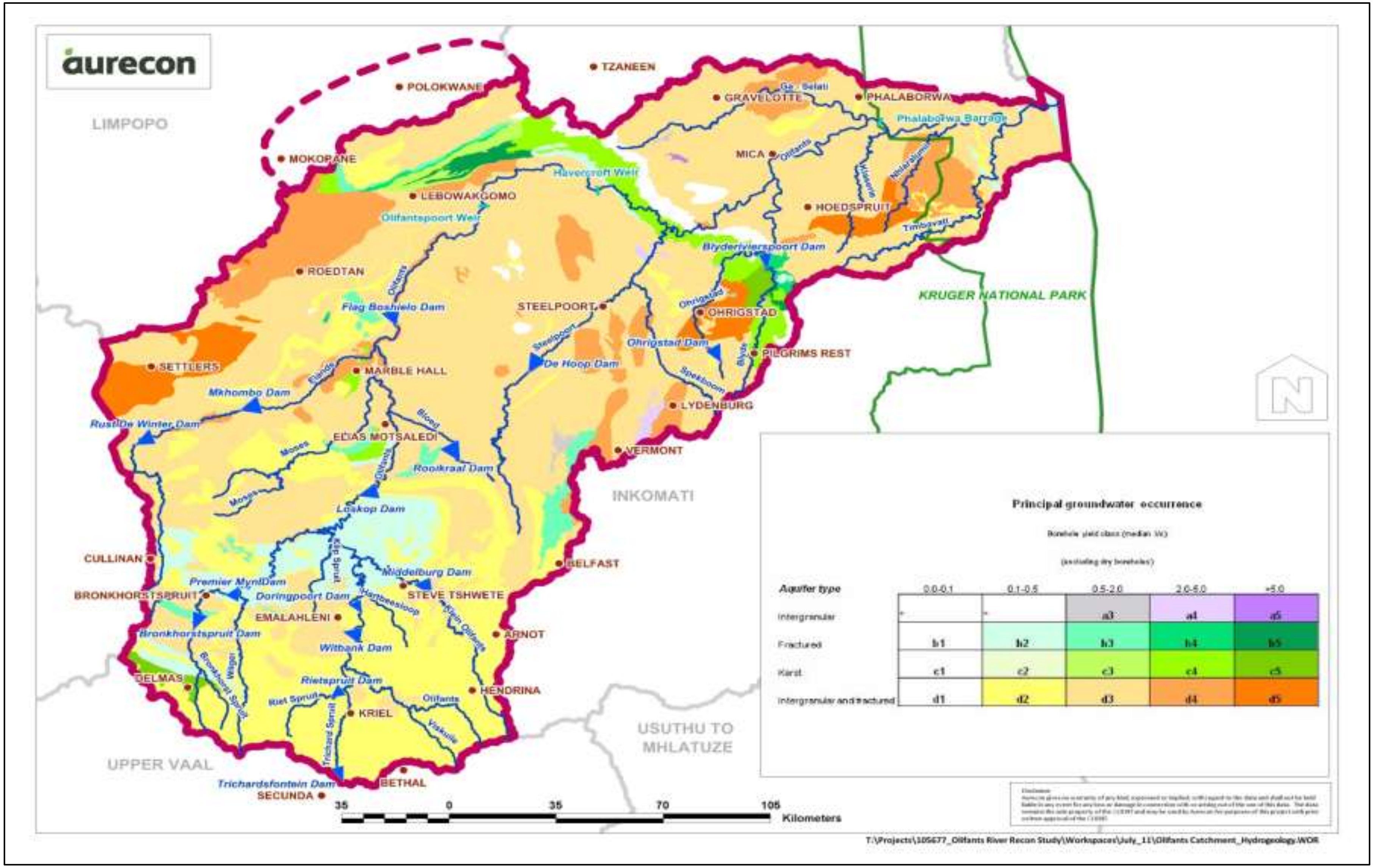


Figure 5.2: Groundwater availability map for the Olifants WMA

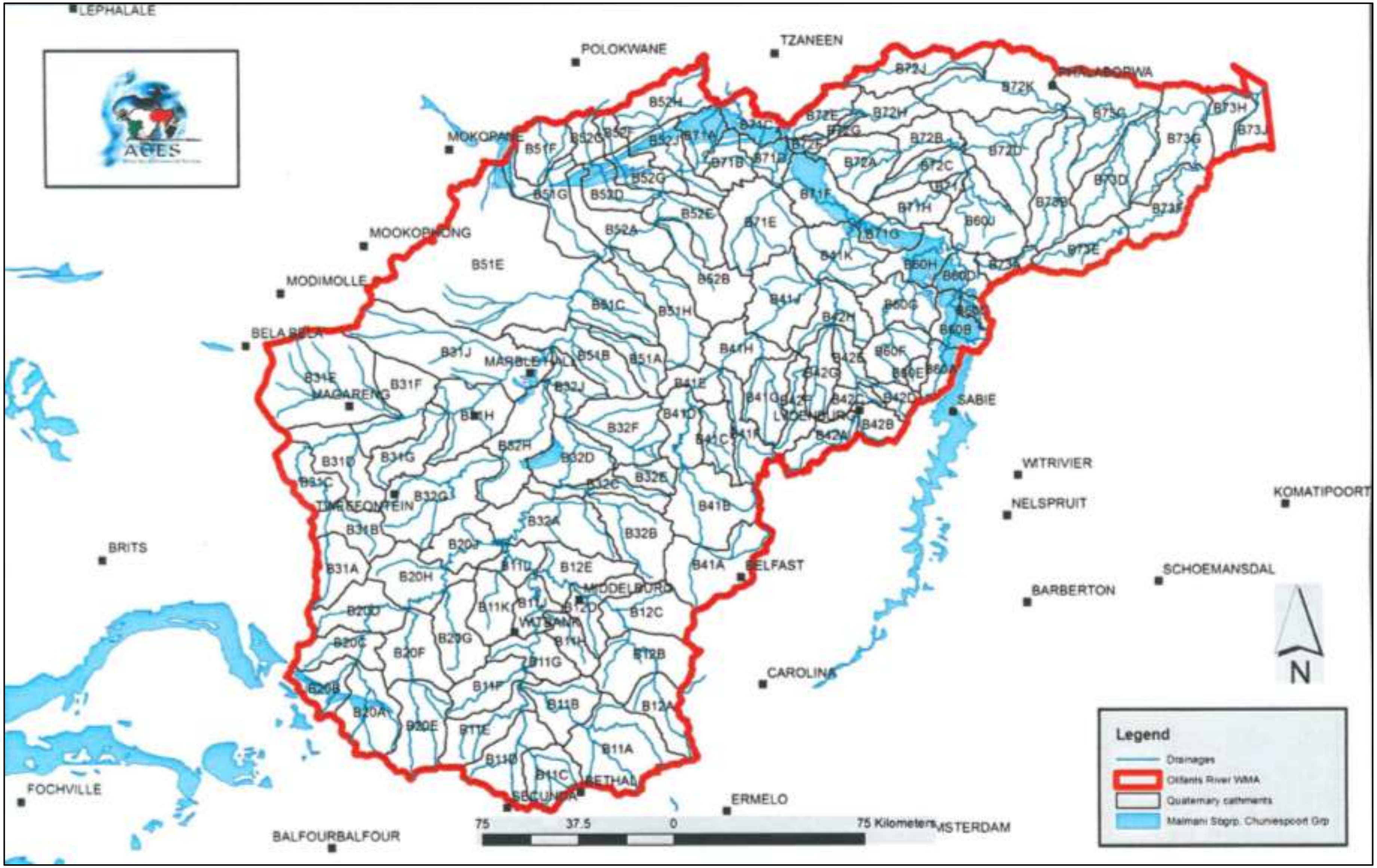


Figure 5.3: The Escarpment Dolomite Aquifer crossing the Olifants WMA

In the Olifants WMA Strategies (DWA ISP, 2004) it is stated that there is still further development potential of the groundwater resources. However, detailed studies will be required at the local level to determine the additional potential sustainable yield. Two general groundwater development options can be considered to improve the available water resources in the future. These are:

- The development of the under-exploited groundwater resource of the Escarpment Dolomite Aquifer;
- Conjunctive use of groundwater and surface water.

The exploitation potential of the Escarpment Dolomite Aquifer was investigated by Ages (2009). The water balance model they developed for this relatively-unexploited dolomite in the northern escarpment area of the Olifants River indicated that the groundwater balance in the dolomite aquifers is positive (60 – 90 million m^3/a) and can be used for future development as a regional groundwater resource. The topography, however, is mountainous and the population is sparse. A detailed study will be required to investigate the best localities for development and areas (communities) that will benefit from supply from this resource.

The Escarpment Dolomite Aquifer is shown in **Figure 5.3**. The study will also have to include the possible impact of groundwater abstraction from the dolomite aquifer on the surface water base flow in the Olifants River.

A possible regional water supply scheme could consider the construction of a weir on the farm Godwinton on the Olifants River as an option to recharge surface water back into the dolomite formation where it can be abstracted for bulk supply to areas with low water resources. The proposed weir will block the river flow and push water back upstream, providing an opportunity for recharge to take place into structural features in the dolomite. The locality of the weir is about 25 to 30 kilometres downstream from where the Olifants River enters the dolomite formation in the escarpment. The river bed level falls about 50 m over this distance, indicating the weir height required to inundate the full river reach which is on dolomite. This water could then be distributed to new users through new infrastructure.

Conjunctive groundwater/ surface water use is applicable to groundwater resources with unacceptable drinking water quality, e.g. where boreholes yield water which contains natural fluorides or nitrates. Poor quality groundwater can be used conjunctively (diluted) with surface water to reduce the parameters to acceptable levels. The conjunctive use with surface water can reduce the salinity of groundwater resources and reduce the cost of treatment for selected uses. Groundwater can replace surface water use in agricultural to make it available for domestic use. A detailed investigation is required to select the areas where conjunctive use with groundwater resources can be implemented.

For the purpose of this reconciliation strategy, it was assumed that only half of the estimated groundwater potential of 70 million m^3/a can be exploited since the catchment is not everywhere easily accessible. By studying the groundwater availability map of **Figure 5.2**, it was further assumed that the breakdown of the 35 million m^3/a, exploitable groundwater between the management zones will be as follows:

- Upper Olifants 5 million m^3/a
- Middle Olifants 15 million m^3/a,
- Lower Olifants 15 million m^3/a.

5.1.4 Management of Groundwater

Previous studies showed that the available groundwater resources within the Olifants catchment are over- exploited. However even weaker groundwater occurrence areas can often provide more than the BHN of 25 litres per head per day, for rural supplies. However boreholes are often misused or are used for other purposes (e.g. irrigation) as well. Where groundwater is the only resource for a community's BHN, the borehole should be sited outside the settlement and away from pollution sources, using the most modern geophysical exploration techniques.

Management and control of the six stressed areas previously mentioned needs immediate attention. If the groundwater resources in these areas are not protected and exploitation is not reduced, a point will be reached where the communities will demand import of water to solve imbalance. The implementation of full groundwater regulation and management actions are urgently required in these Management Zones. These management actions must be developed in co-operation with the local water users associations to ensure sustainability of the resources.

Implementation of the following groundwater regulation and management actions are urgently required:

- Comprehensive Groundwater Reserve determinations of all catchments to establish the maximum volume available for allocation.
- A Water User Licence Application is required from every groundwater user.
- Validation and accounting of the groundwater use in all catchments by detailed hydro census.
- Control drilling of boreholes for groundwater supply in all catchments by requiring registration of all new boreholes.
- Monitoring of over exploited aquifers.

5.2 SURFACE WATER

5.2.1 Yield of Large Dams

The surface water resources of the Olifants River are already well developed, especially the upper reaches, with several large dams which were constructed to supply water to large irrigation schemes as well as to domestic and industrial water users. The significant dams with their historical and 1:50 year yields are listed in **Table 5.4**.

Table 5.4: Large Dams in the Olifants River Catchment

Dam	Management Zone	Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
Bronkhorstspruit	Upper	58.9	16.9	23.5
Middelburg	Upper	48.4	12.6	14.0
Wilge	Upper	1.6	6.7	8.0
Witbank	Upper	104.0	29.5	33.0
Loskop	Upper	374.3	161	168
Rust de Winter	Upper	27.3	9.8	11.7
Mkombo with Weltevreden weir	Upper	205.8	11.7	14.0
Flag Boshielo	Middle	1788	53.0	56.0
De Hoop (under construction)	Middle	347.4	65.0	66.0*
Ohrigstad	Lower	13.2	18.9	19.8
Buffelskloof	Middle	5.4	14.7	14.7
Der Bruchen	Middle	9.0	8.3	8.3
Belfast	Middle	5.5	5.7	5.7
Lydenburg	Middle	1.1	2.5	2.5
Blyderivierspoort	Lower	54.6	110	130
Phalaborwa Barrage	Lower	5.7	42	49

***** *After meeting the EWR water requirements. The yield of De Hoop Dam reduces from 99 million m^3/a to 66 million m^3/a as a result of the EWR requirements*

The historic firm yield and the 1:50 yields of all the dams are lower than the storage capacity of most dams except for the Wilge, Buffelskloof, Belfast, Lydenburg and Phalaborwa Barrage, Ohrigstad and Blyderivierspoort Dams. The big difference in the Blyderivierspoort Dam is an indication that the Blyde River is currently not utilised to its full potential.

Polokwane and Mogalakwena are currently supplied by dams that are outside of the study area. These dams and the allocated water to the towns are listed in **Table 5.5**.

Table 5.5: Large dams outside the study area supplying Polokwane and Mogalakwena

Dam	Town Supplied	1:50 year yield allocation (million m^3/a)
Dap Naude Dam	Polokwane	6.2
Ebenezer Dam	Polokwane	12.0
Doorndraai Dam	Mogalakwena	4.4
	TOTAL	**22.6**

5.2.2 Diffuse Water Resources

In addition to the yield of the major dams listed in **Table 5.4** there are a large number of farm dams in the Olifants River catchment that contribute to the yield of the system. There are also many water users, mostly irrigators, that abstract water directly from the river and these run-of-river supplies also form part of the water resources. The yield related to farm dams and run-of-river abstractions (referred to further as diffuse sources) are much more difficult to quantify than the yields of large dams. The approach taken in this study was to quantify the actual water supply from farm dams and run-of-river through the use of a water resources model and to equate the resource with the modelled supply. The diffuse water use is therefore in balance with the diffuse water resources.

The assurance of supply to the users of diffuse sources varies throughout the catchment, but in general is high in the upper reaches of the Olifants and low in the middle and lower reaches. **Table 5.6** summarises the diffuse water resources of the study area.

Table 5.6: Diffuse Water Resources (Units: million m^3/a)

Management Zone	Full Supply Capacity of Minor Dams	Yield of Farm Dams and Run-of-River
Upper Olifants	327	128
Middle Olifants	60	71
Lower Olifants	40	49
TOTAL	**427**	**248**

5.2.3 Transfers In

There are several large water transfers from the Upper Komati and the Vaal Systems into the Upper Olifants River catchment to supply the six power stations located in the Upper Olifants catchment. These transfers are currently estimated to be in the order of 228 million m^3/a. The transfers are fully utilised in meeting the requirements of the power stations, and there are no return flows, so the effect on the water balance in the catchment is zero. There are also small transfers into the Upper Olifants from the Vaal system to supply the town of Delmas.

Although there are no transfers in the Middle Olifants catchment *per se,* effluent is transferred from Polokwane to mines near Mogalakwena. This represents an additional source which has been included as a transfer in since this effluent would otherwise have flowed out of the area. Approximately 2 million m^3/a, is supplied from the Tzaneen Dam to a mine near Gravellotte, while a further 1 million m^3/a is supplied from the Thabina Dam to villages in the north of Olifants catchment. Also, the pipeline from the Ebenezer Dam to Polokwane supplies water to villages *en route*, some of which are located in the Olifants River catchment.

5.2.4 Other sources

A recent initiative is to treat the effluent from several coal mines near EMalahleni to a potable standard and sell this water to EMalahleni. Currently the eMalahleni Water Reclamation Plant supplies 9.1 million m^3/a to EMalahleni while a new plant is being constructed by Optimum Coal to supply a further 5.5 million m^3/a. As far as the water balance for EMalahleni is concerned, this water is an additional resource, while if the Olifants River catchment is considered as a whole, it is argued that this water would have flowed into the Loskop Dam and become available as yield there and hence should not be considered as additional yield to the system as a whole. A detailed analysis carried out by Golder Associates (Coleman, 2010), suggested that because of the source used and operation of the plants approximately one third of this additional supply of 14.6 million m^3/a, is additional yield to the system as a whole. Hence the additional yield created by these reclamation works is approximately 5 million m^3/a.

5.2.5 Additional Yield from Decommissioned Coal Mines in the upper Olifants Management Zone

The question that has been addressed in this Reconciliation Strategy is how much additional water can be sourced from mine water decant in the future? Some work on this was carried out as part of the IWRMP study (DWA, 2009), and the conclusion is that as much as 45 million m^3/a will decant by 2035. See **Figure 5.4** and **Figure 5.5**. The WRC report No 1628/1/11 “Prediction Of How Different Management Options Will Affect Drainage Water Quality And Quantity In The Mpumalanga Coal Mines Up To 2080” by Coleman et al, April 2011 gives lower values up to 36.5 million m^3/a. The graphs of **Figure 5.4** and **Figure 5.5** show the latest information available.

Whether or not this water is additional yield or water that would have flowed down the river in any event is being widely debated. The groundwater specialists that carried out this work (Coleman, et al, 2011) are of the opinion that all new mine decants will be additional water and additional yield. The reason for the increase in MAR is the reduction in evapo-transpiration losses from soil moisture due to more rapid infiltration into underground storage in the mined areas.

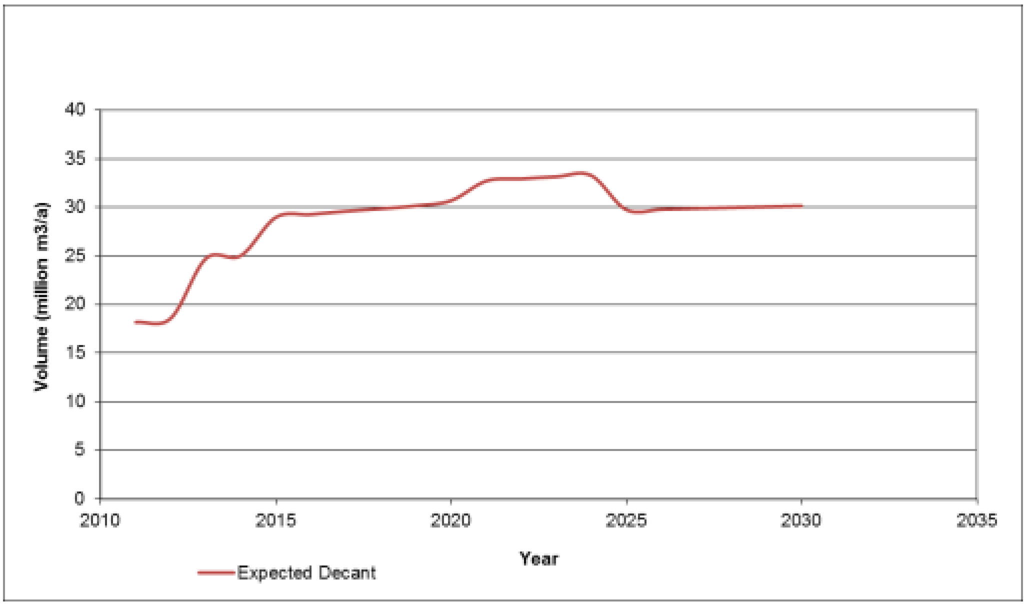


Figure 5.4: Decant water from coal mines in the Witbank Dam catchment
Source: Golder Associates, 2011

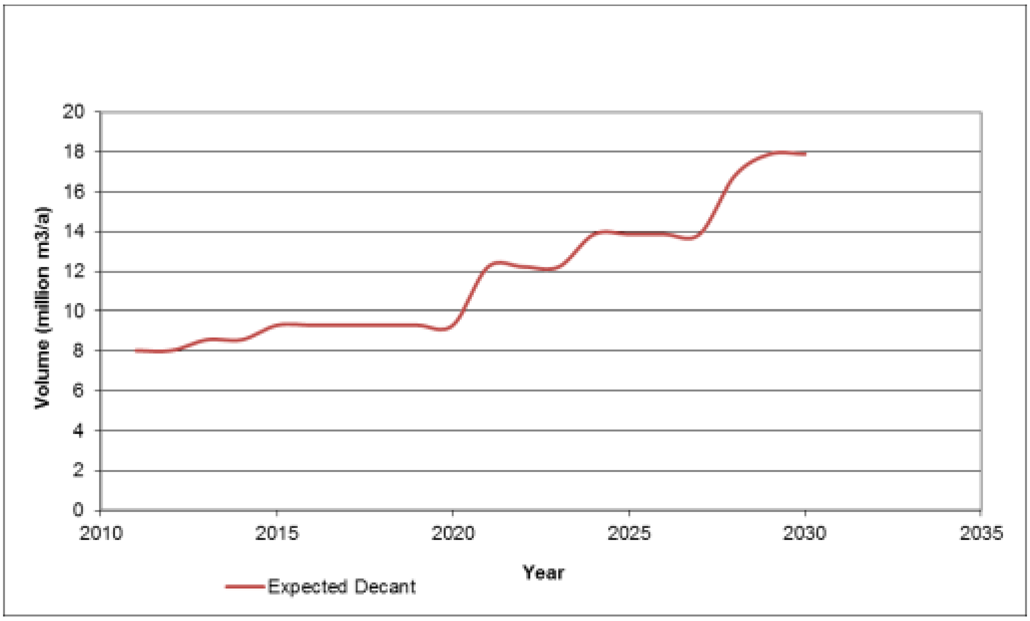


Figure 5.5: Decant water from coal mines in the Middelburg Dam Catchment
Source: Golder Associated, 2011

In July 2011 Anglo American Platinum appointed a consultant to look into this possible additional water resource in more detail. The results of this detailed analysis were not available at the time of compiling this Final Reconciliation Strategy report. For the purpose of this study therefore, the decant information of **Figure 5.4** and **Figure 5.5** has been used. This possible future water resource has been factored into this reconciliation strategy as a reconciliation option scenario (see report *P WMA 04/B50/00/8310/9* of this study). However because of the divergence of opinion on whether it will realise and also because this additional water is linked to expensive treatment costs it cannot be regarded as an unconditional additional yield.

The current excess water decant in the catchments of Witbank and Middelburg Dams can be read off the graphs of **Figure 5.4** and **Figure 5.5** as 18 million m^3/a and 8 million m^3/a respectively. It was assumed that the additional yield of 4.2 million m^3/a as a result of the EMalahleni Water Reclamation Plant and the Optimum plant comes from this excess water decant and that the rest (i.e. 21.8 million m^3/a) is part of the current system runoff in any event. The incremental future decant can then be regarded as direct additional yield. In the case of the Witbank Dam catchment this value is approximately 12 million m^3/a, and of the Middelburg Dam catchment 10 million m^3/a, i.e. approximately 22 million m^3/a, in total over a period of 20 years. This probable additional yield is included as an option in the water reconciliation model to determine the desired water balance scenario on which the reconciliation strategy is based.

It is critical that a monitoring system is put in place as soon as possible in order to remove the uncertainties about the yield from the use of the mine water. This is a recommendation of the reconciliation strategy.

5.2.6 Summary of current and future Water Resources

The total current surface water resource of the Olifants River catchment is summarised in **Table 5.7** while the future water resource, which includes the yield of the De Hoop Dam, is shown in **Table 5.8**. The growth in the yield can be seen in **Figure 5.6**. Note that there will be an increase in the transfer into the catchment from the Vaal system over time (up to 11 million m^3/a) to meet the growing water demands of the Western Highveld.

Table 5.7: Summary of 2010 Total Water Resources within the Olifants River Catchment (Units: million m^3/a)

Management Zone	Yield from Major Dams (1 in 50 year)	Yield from Farm Dams and Diffuse Sources	Transfers In	Other sources	Ground-water	Total
Upper Olifants	272	104	230	4	20	**630**
Middle Olifants	110	32	8	0	35	**185**
Lower Olifants	199	43	3	0	3	**248**
TOTAL	**581**	**179**	**241**	**4**	**58**	**1 063**

Note: *Yield from major dams exclude the yield of De Hoop Dam*

Table 5.8: Summary of Future (2035) Total Water Resources within the Olifants River Catchment (Units: million m^3/a)

Management Zone	Yield from Major Dams (1 in 50 year)	Yield from Farm Dams and Diffuse Sources	Transfers In	Other sources	Ground-water	Total
Upper Olifants	272	104	241	4	20	**641**
Middle Olifants	209	32	8	0	35	**284**
Lower Olifants	199	43	3	0	3	**248**
TOTAL	**680**	**179**	**252**	**4**	**58**	**1 173**

Note: *Yield of major dams include the full yield of De Hoop Dam (without EWRs)*

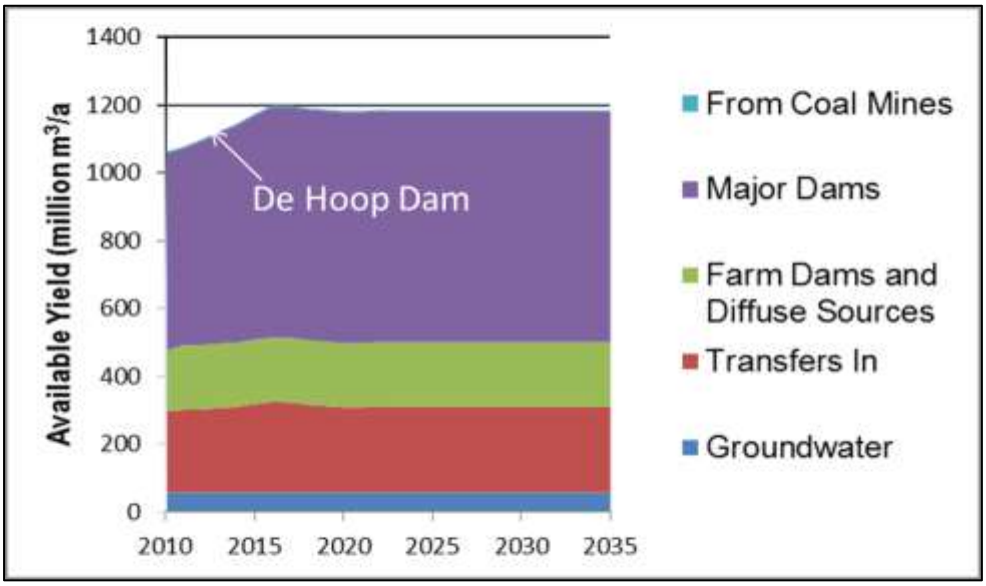


Figure 5.6: Growth in system yield

6. WATER QUALITY

6.1 BACKGROUND

The Olifants River has been described as one of the most polluted rivers in Southern Africa, with the Loskop Dam acting as a repository for pollutants from the upper catchment of the Olifants River system (Grobler et al., 1994). Numerous previous reports and current studies focus on the water quality problems in the Olifants River catchment. These studies include the study that was conducted by the CSIR into the deaths of large numbers of the Nile Crocodiles (*Crocodylus niloticus*) at several points along the Olifants River. Several studies were also conducted by the Department of Water Affairs (DWA) as part of the Water Resources Planning Systems Series and focused on the water quality status and trends in streams and rivers in all the Water Management Areas (WMAs), as well as specifically the Olifants WMA. A study on the trophic state of dams by the DWA (DWA, October 2006) identified the Bronkhorstspruit Dam as being hypertrophic.

Although the studies conducted have shown that the Olifants is indeed a polluted river, none of these studies have been used to look into the fitness for use of the surface water of the Olifants River System. Therefore the main objective of this study is to ascertain whether these water quality problems have any effect on the availability of acceptable quality of water for all users in the catchment, by making use of the water quality guidelines as developed by the DWA, South Africa (DWA, 1996) as the main set of criteria for the evaluation process. This means that, with the data available, the Olifants River was looked at with specific focus on the possible impact of water quality on the water availability. The questions that were addressed were whether additional water would be needed to dilute some sources to mitigate the water quality problems and if the water quality problems could render a portion of the water not fit for use.

A separate water quality management strategy is being envisaged to address the water quality management issues. It is recommended that this strategy commence as soon as possible.

The water quality in the study area does not affect the management or availability of the resource (i.e. dilution is not required as yet) although there are limited locations where the water quality is only tolerable and is unacceptable at two sampling points. At many stations however, there is an upward trend in pollution.

Localised water quality problems must be addressed by intensified compliance monitoring and enforcement and by reducing pollution at source.

Despite the fact that the water quality in the system will not influence the water availability (**Table 6.3**), immediate attention should be given to the upward trends shown in **Table 6.4** so that the sustainability of the resource is ensured.

An issue that will require specific attention is the increasing decant of acid mine drainage. On the one hand it represents a potential source of water if treated properly, while on the other hand it represents a threat to future water quality if uncontrolled decanting is allowed to occur.

6.2 SOURCES OF POLLUTION

Water quality is determined by the activities in the catchment, the land use, and the geology.

The Olifants River Catchment contains three basic rock types which are sedimentary, igneous and metamorphic. None of these rock types are associated with significant water quality impacts due to mineralisation of the groundwater, and the groundwater recharge to the surface water system is normally of a good quality.

There is a large amount of mining, predominantly for coal, and other industrial activities around the Wilge River, Bronkhorstspruit, Klein Olifants and Olifants Rivers, which are the main contributors to poor in-stream and riparian habitat conditions where acid leachate from mines is a primary contributor to poor water quality and instream conditions. At present these water quality effects are fairly limited in extent and confined to some specific streams.

Poorly treated domestic waste water is causing an increase in nutrients and thereby a change in the trophic state of the dams in the upper catchment. Irrigation return flows also cause a rise in salinity levels downstream of irrigated areas.

6.3 ACTUAL WATER QUALITY VERSUS WATER QUALITY OBJECTIVES

Water quality guidelines published by the Department were used to develop combined fitness for use categories. This was done by selecting the value for the most sensitive use, for each constituent to arrive at the management levels or combined fitness-for-use.

Industrial water use represents only a relatively small quantity of the total water use, and in general terms, if the water is fit for domestic purposes, it is fit for industrial purposes. A notable exception to this is the sulphate concentration which will affect the power generation industry before it becomes a problem for other user categories. This issue therefore has to be dealt with separately.

The future growth in demand is foreseen to be mainly an increase in existing use. The only new users that have been identified are the new mines that are developed. These do not require any special water quality conditions, and therefore future water quality objectives will not differ from the present.

6.3.1 Water Assessment Categories

The water assessment categories used are shown in **Table 6.1**.

Table 6.1: Water Quality Assessment Categories

Fitness for use range in which the variable falls			Water quality assessment category	Colour code
Median	75th percentile	95th percentile		
Ideal	Ideal	Ideal	Ideal	Blue
Ideal	Ideal	Acceptable	Acceptable	Green
Ideal	Acceptable	Acceptable		
Acceptable	Acceptable	Acceptable		
Ideal	Ideal	Tolerable		
Ideal	Acceptable	Tolerable	Tolerable	Yellow
Acceptable	Acceptable	Tolerable		
Acceptable	Tolerable	Tolerable		
Tolerable	Tolerable	Tolerable		
Any other combination			**Unacceptable**	**Red**

6.3.2 Sampling Sites Used

Only the DWA National Water Quality Monitoring stations in the Olifants WMA were used for the water quality assessment. Data was obtained from previous studies, and generally ranged from the early 1970s to October 2008. **Table 6.2** presents a list of the monitoring stations which were reviewed.

Table 6.2: List of DWA Water Quality Monitoring Stations

Area	Monitoring Station	Date of first Sample	Date of last Sample	No of Samples
Witbank Dam Catchment	B1R001Q01	1972/01/04	2005/05/27	808
	Rietspruit	1997/10/02	2005/05/27	461
	Rietspruit Dam	1998/07/27	2005/05/27	299
	Tweefontein	1997/10/02	2005/05/27	442
	Bethal Road Bridge	1997/10/02	2005/05/27	382
	B1H020	1990/05/01	2005/05/27	926
	B1H006	1982/10/13	2005/05/17	684
	B1H019	1990/05/09	2005/05/27	951
	B1H017	1990/01/02	2005/05/17	871
	B1H021	1990/07/02	2005/05/27	1 043
	B1H018	1991/05/27	2005/05/27	925
	B1H005	1979/11/20	2005/05/27	1 057
	Duvha Road Bridge	1997/10/02	2005/05/27	299
Wilge River and Loskop Dam Catchment	B2H003	1983/05/03	2005/05/18	507
	B2H004	1984/10/27	2005/05/18	786
	B2H007	1985/08/26	2005/05/18	787
	B2H010	1983/07/29	2005/05/17	241
	B2H014	1991/01/30	2005/05/17	490
	B2H015	1994/01/05	2005/05/04	425

Area	Monitoring Station	Date of first Sample	Date of last Sample	No of Samples
	B1H002	1979/05/05	2005/05/16	790
	B3R002	1972/08/31	2005/04/15	864
Middelburg Dam Catchment	B1H012	1993/11/16	2005/05/27	960
	B1H015	1983/02/01	2005/05/13	994
	B1H004	1966/04/18	2005/05/16	838
	B1R002Q01	2002/08/07	2003/08/27	48
Middle Olifants Catchment	B3R001Q01	1968/03/19	2007/02/13	211
	B3R005Q01	1983/04/05	2007/05/10	295
	B3H021	1994/01/06	2007/02/27	292
	B3H007	1992/08/19	2007/02/28	484
	B3H017	1993/09/01	2007/02/28	386
	B3H001	1976/10/12	2007/02/16	583
	B5R002	1998/07/01	2007/03/27	152
	B5H004	1993/09/01	2007/05/11	381
	B3H002	1998/12/15	2004/10/13	299

Figure 6.1 shows the location of the DWA water quality stations that were used for the analysis.

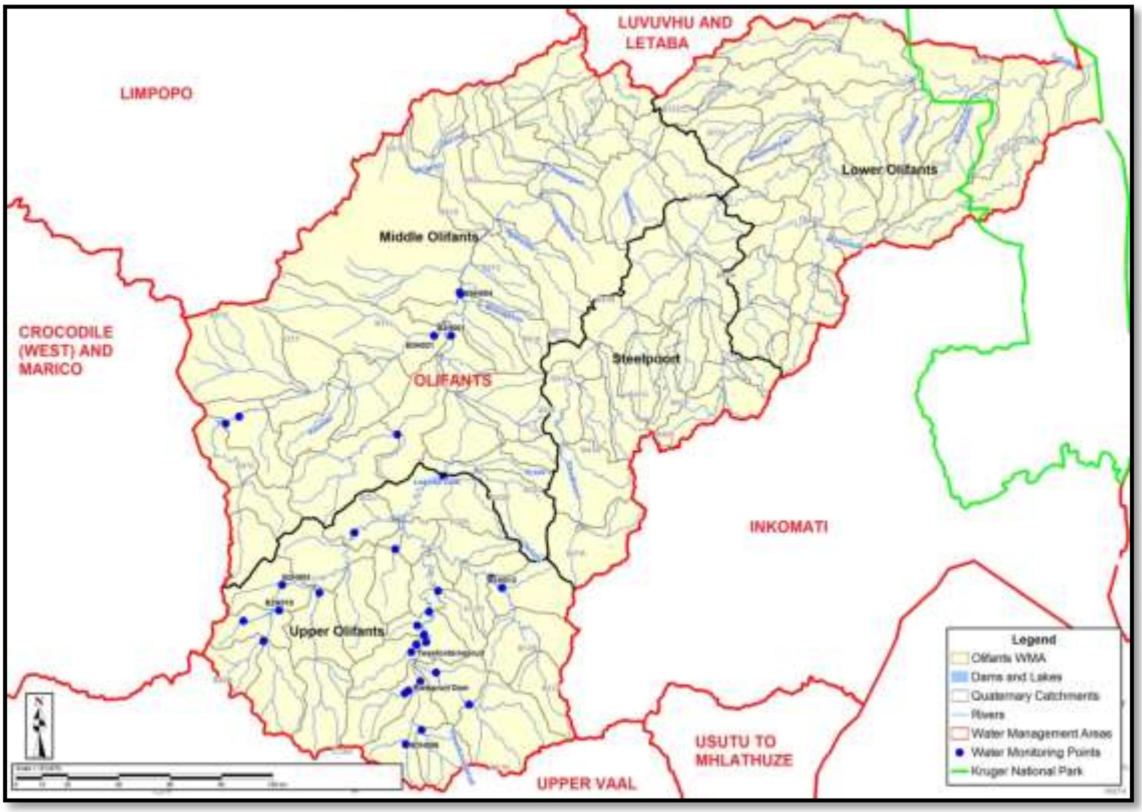


Figure 6.1: DWA Water Quality Monitoring Stations

6.3.3 Water Quality Situation in the Olifants River System

There are a number of water quality concerns in the catchment, primarily downstream and close to point sources of pollution. This is often due to lack of treatment or poor management of treatment works, so that the required effluent standards are not being met. However the quality of water in the catchment is generally suitable for most users, although there are some exceptions.

Table 6.3 shows the water quality assessment (using the colour codes described in **Table 6.1**) of the fitness-for-use of the water resources using the median values. The assessment indicates that most of the resources show a water quality that is "ideal" for use in the Olifants River System. The only immediate cause for concern is the pH values at station B1H004 in the Middelburg Dam catchment, which is in the unacceptable range.

The phosphates levels in the Olifants River System are within acceptable ranges.

The Middelburg Dam (station B1H004) is thus under pressure as reflected by the low pH, high levels of ammonia as well as nitrite/nitrate levels. The low pH levels are due to acid mine water as a result of mining activities in the study area.

The high levels of ammonia and nitrate/nitrite levels, especially in the Middelburg Dam catchment can be ascribed to the use of fertilisers and as a result of poor sewage treatment.

The phosphates are slightly high throughout the study area, but within the acceptable range. This is due to improper use of fertilisers, as well as discharge of untreated or partially treated sewage into water sources.

The Electrical Conductivity (E Cond.) values are also slightly high, but still within acceptable and tolerable ranges.

Most of the dams in the Olifants River System are oligotrophic, except for the Bronkhorstspruit Dam, which is in a hypertrophic state. However, nutrient levels have been steadily increasing over the last number of years. This is due to the substantial sewage treatment plant return flow volumes in the Klipspruit, Witbank and Middelburg Dams and Loskop Dam catchments. The return flows contribute to the base flow into Loskop Dam and have been cited as a cause of eutrophication in the upper reaches of the Loskop Dam and the Klein Olifants River (DWA, 2004).

Although the sulphate levels are generally within ideal and acceptable ranges, previous studies have shown that, if the situation with respect to acid mine drainage is not dealt with properly, the sulphate concentrations in the Loskop Dam will over time exceed the acceptable levels. The solution to this will be to treat the water by means of desalination. This will not only solve the water quality problem, but also make a source of water available for domestic and industrial use in the upper parts of the catchment.

Table 6.3: Water Quality Assessment: Median

Area	Monitoring Point	EC	NO_3/NO_2	PO_4	NH_3	pH	Cl	SO_4
Witbank Dam Catchment	B1R001Q01	48.65	0.14	0.01		7.80	16.30	143
	Rietspruit	48				7.91	44.00	53
	Rietspruit Dam	29.35				8.24	26.00	33.42
	Tweefontein	82.3				7.88	82.00	77
	Bethal Road Bridge	60.8				7.71	24.00	61.2
	B1H020	111.05	0.042	0.015	0.045	7.76	44.40	381.8
	B1H006	25.90	0.090	0.015	0.042	7.70	11.5	21.2
	B1H019	78.35	0.046	0.0120	0.04	7.640	20.693	237.68
	B1H017	58.95	0.01	0.019	0.01	8.33	24.75	47.10
	B1H021	45.25	0.28	0.09	0.041	8.23	22	67.8
	B1H018	33	0.01	0.022	0.01	8.11	19.10	31.4
	B1H005	63.25	0.158	0.014	0.04	7.97	20.10	179
	Duvha Road Bridge	52.55				8.07	22.00	50.8
Wilge River and Loskop Dam Catchment	B2H003		0.09	0.02	0.01	8.17	10.40	
	B2H004		0.12	0.01	0.05	8.19	6.50	
	B2H007		0.60	0.01	0.04	8.17	6.60	
	B2H010		0.01	0.02	0.05	8.23	12.22	
	B2H014		0.10	0.01	0.01	8.04	8.00	
	B2H015		0.07	0.01	0.01	7.83	8.00	
	B1H002	54.3	0.23	0.01	0.05	7.39	10.00	379.89
	B3R002	27.8	0.11	0.01	0.05	7.40	14.10	63
Middelburg Dam Catchment	B1H012	76.1	0.04	0.01	0.04	7.96	20.53	288.8
	B1H015	50.7	0.08	0.01	0.04	7.94	14.40	159.35
	B1H004		1.27	0.01	0.12	3.96	41.85	
	B1R002Q01	44						134
Middle Olifants Catchment	B3R001Q01		0.01	0.01	0.01	7.67	12.36	
	B3R005Q01		0.08	0.01	0.05	8.09	17.30	
	B3H021		0.18	0.03	0.01	8.31	179.25	
	B3H007		0.07	0.02	0.01	7.95	9.40	
	B3H017		0.15	0.01	0.04	7.87	13.14	
	B3H001		0.33	0.01	0.04	8.06	45.85	
	B5R002		0.08	0.02	0.02	8.11	37.22	
	B5H004		0.16	0.01	0.02	8.11	33.45	
	B3H002	131.85						431.64

6.3.4 Trend Analysis

A summary of the water quality trends over the length of the available record is presented in **Table 6.4**. An upward trend is depicted in red, a downward trend in blue while a static condition is shown in green. A blank cell denotes that there was no data to determine the trend.

Table 6.4: Summary of Trend Analysis

Area	Monitoring Point	EC	NO_3/NO_2	PO_4	NH_3	pH	Cl-	SO_4
Witbank Dam Catchment	B1R001Q01	R	B	R	B	G	R	R
	Rietspruit	B				G	B	R
	Rietspruit Dam	G				G	R	R
	Tweefontein	R				G	R	R
	Bethal Road Bridge	R				G	R	R
	B1H020	R	G	G	B	G	B	R
	B1H006	R	B	R	G	G	B	R
	B1H019	B	G	G	G	G	B	B
	B1H017	G	B	G	G	G	G	G
	B1H021		G	R	G	G	R	G
	B1H018	G	G	G	B	G	B	R
	B1H005	R	B	G	G	G	R	R
	Duvha Road Bridge	R				G	G	R
Wilge River and Loskop Dam Catchment	B2H003		R	G	G	G	R	
	B2H004		R	G	B	G	B	
	B2H007		B	G	B	G	B	
	B2H010		B	R	R	G	R	
	B2H014		R	R	G	G	R	
	B2H015		G	R	G	G	R	
	B1H002	B	B	G	G	G	R	G
	B3R002	R	B	G	B	G	R	R
Middelburg Dam Catchment	B1H012	B	G	G	G	G	R	B
	B1H015	R	B	R	G	G	R	R
	B1H004		G	R	B	R	B	
	B1R002Q01	R						R
Middle Olifants Catchment	B3R001Q01		B	G	R	G	R	
	B3R005Q01		B	G	G	G	R	
	B3H021		B	G		G	R	
	B3H007		B	G	G	G	R	
	B3H017		G	R	G	G	R	
	B3H001		R	G	G	G	G	
	B5R002		B	G	R	G	R	
	B5H004		B	G	G	G	G	
	B3H002Q01	R						R

Although the chlorides are generally within the “ideal” range, trend analysis shows that these are on an upward trend. This is probably due to an increased discharge of treated waste water.

The trend analysis also shows EC as being on an upward trend for most of the stations. This may be attributed to the various mining activities in the study area. During the late 1990s there was a sudden increase in the electrical conductivity of the water in the Loskop Dam. This was maintained until 2005/2006, after which there has been a gradual reduction in electrical conductivity. This can possibly be related to the neutralisation of acid mine drainage water in the catchment, which was discontinued around 2005 (**Figure 6.2**).

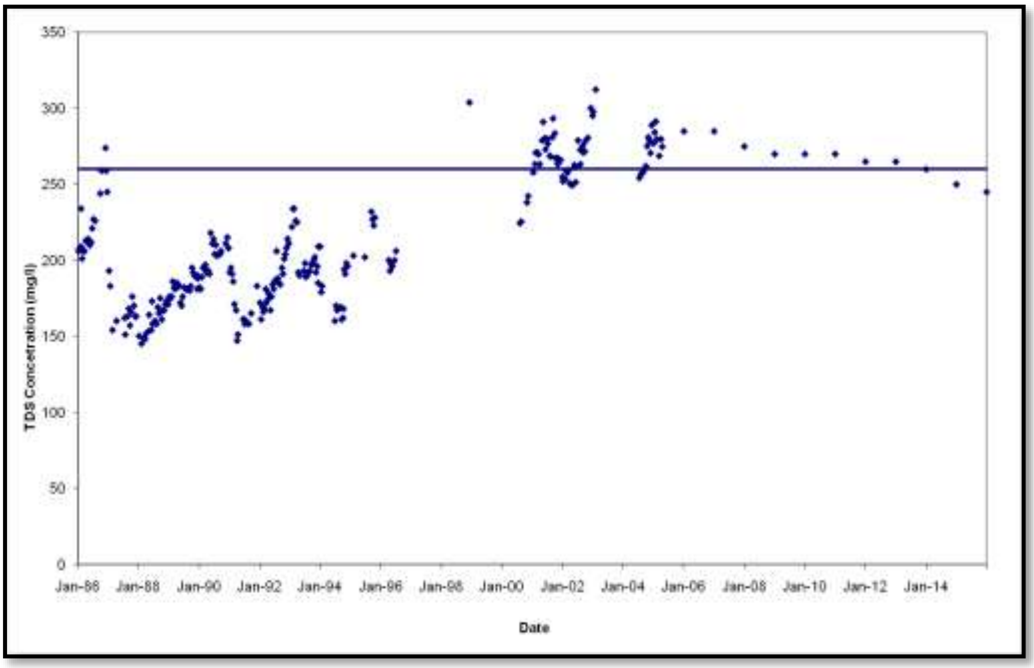


Figure 6.2: Electrical Conductivity Trend in the Loskop Dam – historic and predicted

The quality of the water is currently deteriorating and this trend will continue if appropriate management actions are not taken. It is necessary to substantially reduce or eliminate the discharge of poorly treated waste water from urban areas, and employ best practice in the agricultural sector. Less obvious but potentially serious problems associated with substances such as trace metals must be dealt with at source; these represent a pollution problem, and not a water resource management problem.

7. THE WATER BALANCE

7.1 CURRENT WATER BALANCE WITH NO INTERVENTIONS

The water balance, based on estimated 2010 water requirements, all at equivalent 1:50 year assurances of supply, is shown in **Table 7.1**. Water deficits are shown in brackets.

Table 7.1: 2010 Water Balance (Units: million m^3/a)

Management Zone	Water Requirement	Total Water Resource	Minimum Flow Rule	Losses	Water Balance
Upper Olifants	609	630	0	0	21
Middle Olifants	187	185	(19)	0	(21)
Lower Olifants	220	248	(19)	(5)	4
TOTAL	**1 016**	**1 063**	**(38)**	**(5)**	**4**

Note: *Excluding De Hoop Dam*

The current water balance does not take into account the additional yield that will soon become available from the De Hoop Dam or the impact of the recommended EWRs. The environmental release of 19 million m^3/a from Phalaborwa Barrage shown in **Table 7.1** is a current arrangement and will keep the Olifants River flowing through the Kruger National Park, down to the confluence with the Letaba River. **Table 7.2** therefore presents the water balance with the De Hoop Dam operational and the Ecological Reserve (ER) implemented. The ERs in this case have been based on the most likely EWR scenario in which the flood requirements have been removed.

Operationalising the Reserve and new operating rules can only be completed by about 2013/14. De Hoop Dam will then have been commissioned and the resulting water balance is shown in **Table 7.2.**

Table 7.2: Current Water Balance with De Hoop Dam and the Ecological Reserve (Units: million m^3/a)

Management Zone	Water Requirement	Water Resource	Losses	EWR	Water Balance
Upper	609	630	0	(40)	(19)
Middle**	187	284	0	(57)	40
Lower	220	248	(5)	(60)	(37)
TOTAL	**1016**	**1162**	**(5)**	**(157)**	**(16)**

Note: *Including De Hoop Dam*

The balance shown in **Table 7.1**, indicate a surplus in the Upper Olifants. However, there are areas within the Upper Olifants which are (or soon will be) experiencing water supply problems due to limited resources. These are the Western Highveld area (specifically those towns and villages supplied from the Mkhombo Dam) and EMalahleni (formerly Witbank) which is abstracting more from the Witbank Dam than is sustainable in the long-term. These problems can be solved by means of re-distributing the resources within the Upper Olifants and/or water conservation measures.

The Middle Olifants is currently in deficit but the construction of the De Hoop Dam will alleviate this deficit and make some additional water available for allocation.

The Lower Olifants is currently in deficit after operationalization of the ER, which indicates that without interventions the ER will not be met. The balance for the Lower Olifants also assumes that upstream users will fulfil their obligations towards meeting the Reserve. Should this not materialise, the deficits in the Lower Olifants will be much higher than indicated in **Table 7.2.**

It is important to note that the water shortages experienced by diffuse irrigators will not be addressed by this reconciliation strategy.

7.2 FUTURE WATER BALANCE WITH NO INTERVENTIONS

The future water balance was determined with the water requirement growth assumptions as described in Section 5.2.

Table 7.3 indicates the future water balances including the ER for 2035.

Table 7.3: Future (2035) Water Balance assuming high growth rates (Units: million m^3/a)

Management Zone	Water Requirement (high growth)	Water Resources	Losses	ER	Water Balance
Upper	631	641*	0	(40)	(30)
Middle	310	284	0	(57)	(83)
Lower	230	267	(5)	(60)	(28)
Total	**1171**	**1192**	**(5)**	**(165)**	**(149)**

* Increased transfers from Vaal System to ESKOM.

There will be significant shortfalls in all water management zones with a total shortfall of 159 million m^3/a. Interventions are necessary for the system to be in balance. Possible reconciliation options are described in Section 8.

The water balance is shown graphically in **Figure 7.1**. The increase in the water resource is due to the construction of the De Hoop Dam, phased in over 5 years to allow for filling.

The water requirements therefore exceed the availability and the catchment is, by definition, “stressed”.

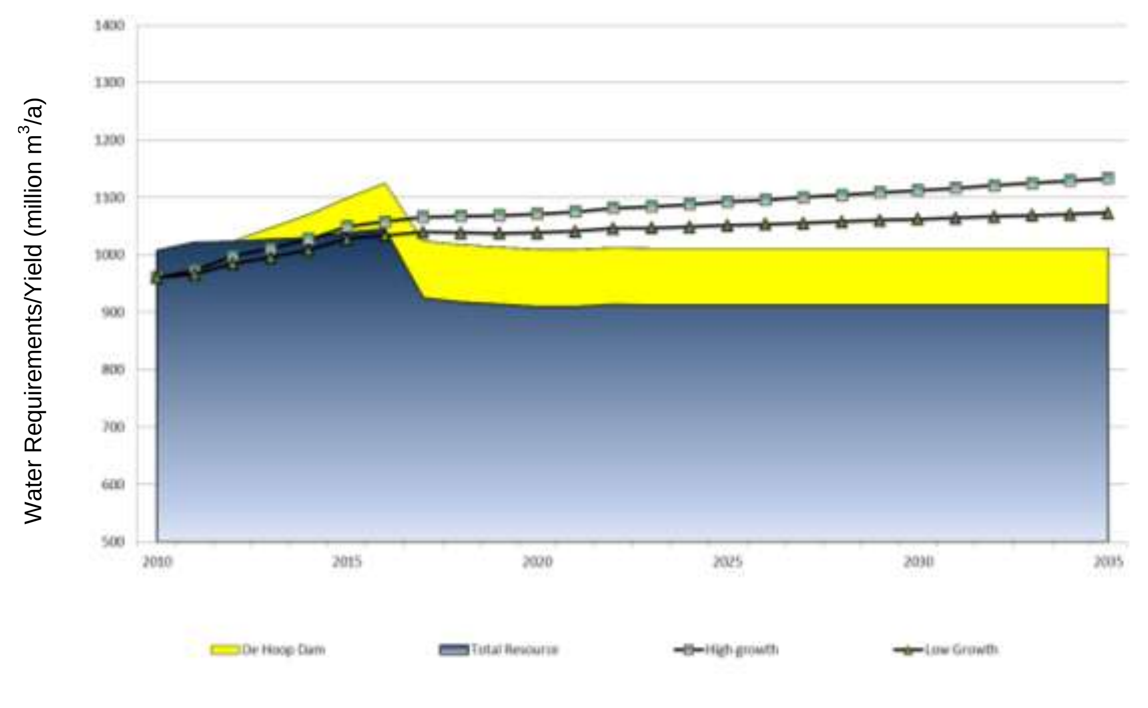


Figure 7.1: Water Balance of the Olifants River Basin

From the graph it is clear that a water deficit will be experienced early as from the year 2016 for the high and low water requirements scenarios if the ecological Reserve is operationalized from 2016 within one year.

8. POSSIBLE INTERVENTION SCENARIOS

8.1 INTRODUCTION

Intervention scenarios compromise combinations of reconciliation options, which can be divided into two main categories, i.e.

- Reconciliation Options that reduce the water requirements.
- Reconciliation Options that increase the water supply.

8.2 RECONCILIATION OPTIONS THAT WILL REDUCE WATER USE OR WATER REQUIREMENTS

8.2.1 Eliminating Unlawful Water Use

In Section 4.1, **Table 4.2**, it was illustrated that the irrigated area increase from 1998 to 2004 by 104.9 km^2 (or 10 490 ha) and that this reduces the system yield by 17.4 million m^3/a (**Table 4.3**). Not all of this 10 490 ha can be regarded as unlawful as some of this area could be existing lawful water use under Section 33 of the NWA. Note that the increased irrigated area within irrigation boards were assumed to be lawful if they fell within the scheduled irrigation area.

It is therefore uncertain which portion of the 10 490 hectares can be regarded as unlawful and this can only be confirmed through the validation and verification (V&V) process which is currently being conducted by the Mpumalanga Region of DWA.

For the purpose of this strategy it was assumed that at least half of the 10 490 ha is unlawful and that 8.5 million m^3/a can be gained in system yield if this unlawful water use is eliminated.

Eliminating unlawful use does not require the completion of the full validation and verification process. As soon as one unlawful user is detected then action can be taken. Indeed action should be taken in order to set an example, stop growth of the practice, and hopefully get some other unlawful users to voluntarily withdraw their use.

The full benefit of the action of eliminating unlawful water use can however only be achieved in approximately 2018 as can be seen from **Figure 8.1**.

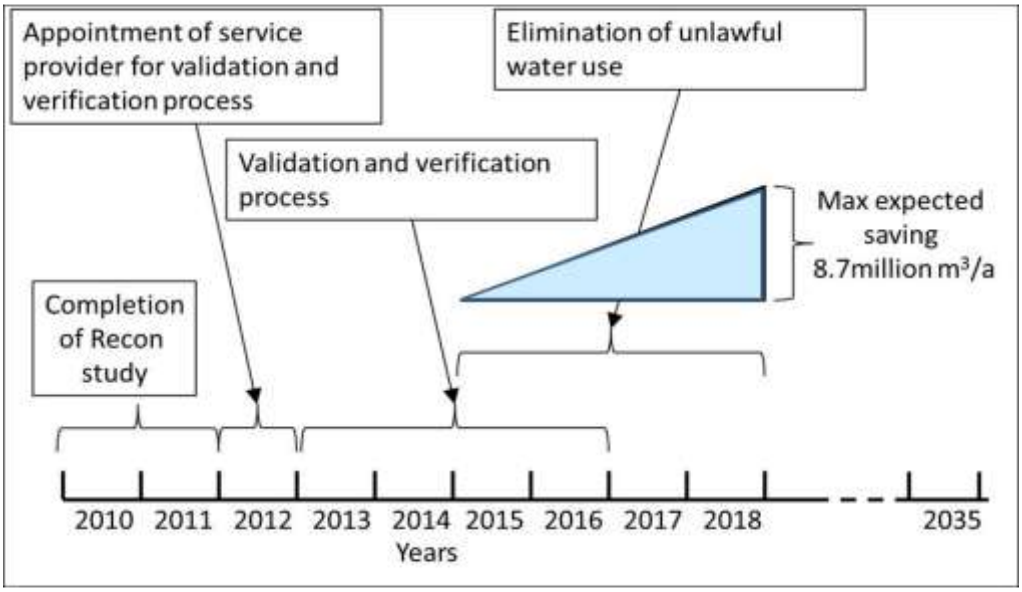


Figure 8.1: Timescale for eliminating unlawful water use

The department is legally bound, in terms of the National Water Act, to execute this option. This action should therefore no longer be postponed and the department should appoint the necessary service provider for resuming the validation and verification process (which has come to a halt) in 2012 or do the work in-house, starting in that same year.

The management activity for addressing unlawful water use is Compliance Monitoring and Enforcement (CME). The estimated quantity of water which can be freed up by implementing Compliance Monitoring and Enforcement (CME) is the management activity of is estimated at 8.5 million m^3/a with the assumption that 50% of the increased irrigation area is unlawful. The CME process could start immediately and run parallel to the validation and verification process. It is estimated that it will only be completed four years after the completion of the validation and verification process owing to possible protracted court cases.

By applying the Pareto principle (i.e. 80% effect with 20% of the effort) the biggest transgressors should be selected first so that the maximum savings in the shortest possible period can be achieved.

8.2.2 Water Conservation and Water Demand Management (WC/WDM)

WC/WDM is about the more efficient use of water. Implementation of WC/WDM has the potential to fairly quickly reduce water use significantly and alleviate some of the pressure on the available water resources.

WC/WDM can be applied in all water use sectors. In the study area the focus was put on three of the water use sectors, i.e.:

- Irrigation
- Urban / Domestic
- Mining

Each of these sectors and how they can reduce their water requirements are described below.

It was assumed that all three sectors can start applying WC/WDM measures immediately and that it will take approximately 5 years to phase in the full benefits of the water saving for the irrigation and domestic water use sectors and 10 years for the mining sector.

(a) Increased Efficiency of Water Use in the Irrigation Sector

This reconciliation option applies to all scheduled and unscheduled irrigation areas in the Olifants River catchment.

The irrigation sector is by far the largest water user in the Olifants River catchment, with an estimated requirement of 486 million m^3/a (adjusted to 98% assurance of supply), comprising 48% of the water requirements within the catchment. Any percentage reduction in water use in this sector will therefore have a significant effect on the total water requirements within the catchment.

Two main areas for improving efficiency of water use or water conservation and demand management can be considered:

- Reduce losses in the bulk supply canals and reticulation systems.
- More efficient on farm irrigation use thus reducing supply to the farm edge.

The reduction of losses in the bulk supply canals and reticulation systems can be achieved by a variety of actions and work has already been done on major maintenance and refurbishing of some schemes. The main problems identified are canal leaks. The earth canals can be replaced with concrete linings or pipelines as was done for the Blyde River Irrigation Board. Existing concrete canals that leak can be sealed by replacing worn panels or by applying sealants on the joints and other appropriate measures.

An action to identify sources of losses would be to install meters at all unmetered supply points and overflows to the river, and to replace/repair all faulty meters.

The merits of refurbishing/upgrading the bulk water supply canals should be carefully considered for each of the irrigation schemes. If they are to form part of the Reconciliation Strategy, there must be clarity that the water savings will benefit the Olifants system as a whole, i.e. the “lost” water is not currently appearing as return flows to be abstracted from the river downstream. It is also important that the water saved is made available to the system, thus reducing the deficit, and not taken up by users on these schemes.

More efficient irrigation after farm edge supply is the responsibility of each irrigation farmer. This can be done in various ways, e.g. upgrading of the irrigation system, better scheduling, switching over to crops which use less water, etc. Most of the irrigation farmers have already switched to one or another form of mechanised irrigation and are very conscious of water losses and the general observation was made that there is relatively little scope for huge water savings in field edge supply.

A practice which has been applied up to now is that, since allocations are by volume, and not by hectares of irrigation, any saving in water use can be to the benefit of the irrigation farmer. Farmers can thus expand the area of irrigation, should they succeed in using less water per hectare.

The WC/WDM beyond the field edge supply should therefore be linked to Compulsory Licensing (paragraph 8.2.4) or Water Trading by the state (paragraph 8.2.5). It is foreseen that 35 million m^3/a can be save through WC/WDM applied by each irrigator without any prejudice of that irrigator in terms of income loss. (From the report "Possible water conservation and Water Demand Management Measures", *Report No P WMA 04/B50/00/8310/5* of this study (hereafter WC/WDM report)). This potential saving has been split pro-rata to the irrigation areas for each of the three Management Zones.

(b) WC/WDM in the Urban / Domestic Water use Sector

In general, huge water losses occur in many of the South African towns and there is potential for water savings.

The most recent information on the potential for WC/WDM is contained in a study entitled "The Development of a Comprehensive Water Conservation and Water Demand Management Strategy and Business Plans: EMalahleni Municipality" undertaken for the Department of Water Affairs. The Strategy developed for EMalahleni Municipality focuses on Loss Management as well as more efficient water use. Examples of loss management and efficient water use initiatives are listed below.

- Loss management
    - Pressure management
    - Retrofitting and removal of wasteful devices
    - Improved management (sectorisation, metering, billing)
    - Mains replacement
    - Leak detection and repair

    This primarily applies to the water distribution system, but losses from the sewer system, overflows from manholes and pump stations, etc., can also lead to reduction in return flows and pollution of the resource.

- Improved efficiency
  - Public awareness
  - Efficient appliances: (washing machines, toilet cisterns etc.)
  - Low flow shower heads
  - Water efficient gardens
  - Tariffs, metering and payment collection

The WC/WDM report estimated that a total of 20 million m^3/a can be saved in the Urban water use sector. This saving has been split pro-rata to the urban water use in each of the three Management Zones.

Indicative cost of urban WC/WDM is set out in **Table 8.1** below.

Table 8.1: Indicative cost of urban WC/WDM in the Olifants catchment

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Estimated Cost (R million)	35	57	69	67	27	7	7	5	4	7

(c) WC/WDM in the Mining Sector

A small saving in water use can be expected from the mining sector. Different types of mines follow different processes and each process must be investigated to determine where water savings are possible. Where not practiced as yet, mines should also reuse its process water for the purpose of gardening, dust suppression, etc.. Discussions with representatives in the mining sector confirmed that an overall water saving of 5 – 10% is possible, (Bierman, 2012), but that the migration into a different process will be costly. The mines therefore need more time to plan and implement such measures.

It was agreed that 10 years is a reasonable time for the mines to transform their processes.

A quantity of 5 million m^3/a can eventually be saved by the mining sector.

(d) WC/WDM in the Energy Generating Sector

The energy generating sector should, like other water use sectors, participate in WC/WDM initiatives. However, all water used by ESKOM in the Olifants catchment is transferred from neighbouring catchments (Usuthu, Komati and Vaal Rivers) and any water savings from ESKOM's side will simply mean a reduction in the quantity of water transferred from the neighbouring catchments.

If considered that ESKOM consumes all the water without discharging any water into the Olifants system, the conclusion can be drawn that any savings from ESKOM's side will have no impact at all on the the water balance of the Olifants system.

The SC/WDM option for the energy generating sector was therefor not further considered for the purposes of this study.

8.2.3 Reducing Assurances of Supply

Further water allocations may be possible if existing water users agree to accept lower assurances of supply.

The generally accepted assurances of supply for the different sectors and used for modelling the water balances are as follows:

Power generation	-	99.5% (1 in 200 years risk of failure)
Domestic water use	-	98% (1 in 50 years risk of failure)
Industrial water use	-	98% (1 in 50 years risk of failure)
Mining water use	-	98% (1 in 50 years risk of failure)
Irrigation water use	-	80% (1 in 5 years risk of failure)

There might be irrigators who would find it quite acceptable to adopt lower assurances of supply than 80% subject to negotiated compensation. Possible incentives could be the lowering of water charges in times of water shortages or compensating for damages that result from water shortages. However it is not known whether the farming community will be amenable to accepting lower assurances of supply.

For the purpose of this Preliminary Reconciliation Strategy, it was assumed that the irrigators prefer the status quo and that no significant reduction in water requirement is possible.

It is however recommended that negotiations with the water user associations and irrigation board are continued to explore this option. It was however not possible to reach an agreement within the timespan of this study.

8.2.4 Compulsory Licensing

The NWA allows the Minister to require the licensing of all water use. The procedure means that nearly all existing users would have to apply for a licence. The Minister considers all the licence applications, taking cognisance of the water availability, and may licence or where required reduce the existing uses to ensure that International Obligations and the Reserve (BHN and EWR) are met within the water balance. The Minister may also reallocate the available water in fair and equitable manner.

The procedure for compulsory licensing is described in Sections 43 to 48 of the National Water Act (Act 36 of 1998). The process is started when the responsible authority (in this case the Minister in view of the fact that a CMA has not yet been established), issues a notice in the Government Gazette that water users must apply for licences within a certain period of time.

The procedure makes provision for the compilation of a proposed allocation schedule and any water user will have the opportunity to object to his/her new water allocation within 60 days after the proposed allocation schedule has been published in the Government Gazette. After considering all objections, the Preliminary Allocation Schedule must be published and after a prescribed appeal period the Preliminary Schedule becomes the Final Allocation Schedule.

Compulsory Licensing can possible be linked to a WC/WDM initiative. If curtailment of water entitlements is found to be the only way to achieve a water balance, the objective should be to minimise the economic impact on the water users and the consequent job losses. By applying WC/WDM together with compulsory licensing, the water users can reduce their water requirements while retaining their current levels of income. However water users must then be prevented from expanding their enterprise with the saved water. The saved water will then become available for reallocation when implementing compulsory licensing.

An issue linking Compulsory Licensing with WC/WDM is timing. If a WC/WDM initiative precedes a compulsory licensing process, the WC/WDM measures will be to the immediate advantage of the water user insofar that the water user may lawfully expand his/her enterprise with saved water and means that when compulsory licensing is implemented these now efficient users will not have WC/WDM as a way of making up for cuts in allocations assuming that these users will then be operating at maximum efficiency.

It is not good practice to postpone any WC/WDM initiative if Compulsory Licensing is not ready to be implemented at the same time, e.g. if the compulsory licensing process has to wait for the processes of validation and verification of water entitlements. If Compulsory Licensing cannot start immediately, the linking of this process with the WC/WDM should rather not be considered. The linking of WC/WDM with the Purchasing of Water Entitlements (see paragraph 8.2.5) could then instead be undertaken.

The timing of licensing followed by WC/WDM processes for the Olifants WMA is illustrated in **Figure 8.2**. It should be noted that the benefits of carrying out WC/WDM after compulsory licensing can only be reaped at a relatively late stage (2021). It is not recommended to postpone the launch of a major WC/WDM initiative for the irrigation sector so long. If WC/WDM is launched before compulsory licencing it is true that users who are already as efficient as possible and who are using their full entitlement when compulsory licencing is introduced will be economically prejudiced.

If WC/WDM is introduced after compulsory licencing, it may be easier because users will have a story incentive to be more efficient to compensate for the reduced allocation. However some users may already have improved efficiency because of increased water and electricity tariffs so the implications may be similar.

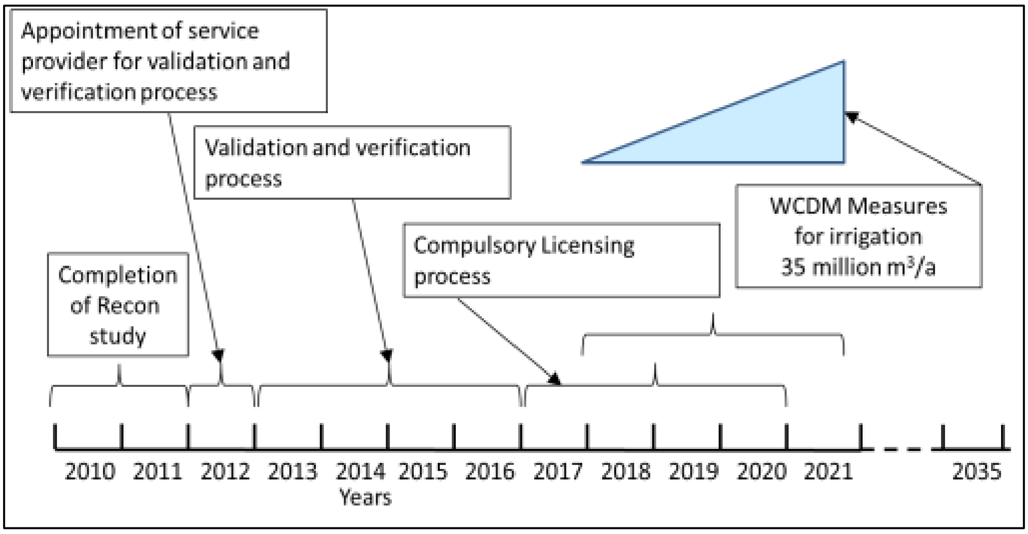


Figure 8.2: Timing of Compulsory Licensing Combined with WC/WDM

Compulsory Licensing as a standalone curtailment process can certainly reduce the water requirements on the system but should only be applied if this as one of the last resorts to achieve a water balance since it may have significant social consequences, e.g. economic prejudice of the water users, job losses, etc. However it is a relatively inexpensive, but very tedious process.

8.2.5 Water Trading

- **Purchasing water entitlements**

  Another approach to reduce water use would be for the Minister to levy an additional water use charge on all users of water originating in the Olifants River Catchment in terms of Section 57 of the NWA. This levy must be in accordance with the pricing strategy which provides for, inter alia, setting water use charges for achieving the equitable and efficient allocation of water (Section 56 (c) of the NWA). The financial contributions of all the water users would be ring-fenced and used to buy out water entitlements from those water users who are willing to sell, e.g. by tender process. This process can then be continued until the necessary water balance is achieved.

  Alternatively the purchase of water entitlements can be funded from the fiscus. Whichever financing strategy is followed, the purchase of water entitlements can lead to social consequences such as job losses of farm workers and must therefore be considered with great caution. Checks and balances need to be built into the process to mitigate the social consequences. For example, irrigation farmers could be allowed to sell off only a portion of their entitlements that will not cause significant economic prejudice.

The linking of WC/WDM savings to such a selling opportunity is a possible measure that will not necessarily cause economic prejudice and social hardships. It means that a water user, after applying WC/WDM can offer a portion of his/her entitlement representing the amount of water saved, to the water resource authority at an agreed price. This option is attractive in the sense that it can be implemented almost immediately and is not dependent on completion of the entire validation and verification processes. It is only those water users who offer a portion of their water use entitlements for sale whose entitlements must be validated and verified and this can be done on an ad hoc basis.

The process is relatively inexpensive, either funding mechanism can be used, and it is easy to implement. However an appropriate policy within the Department of Water Affairs needs to be developed and user guidelines need to be prepared.

The timing of the purchasing of water entitlements that are linked to WC/WDM savings is shown in **Figure 8.3**.

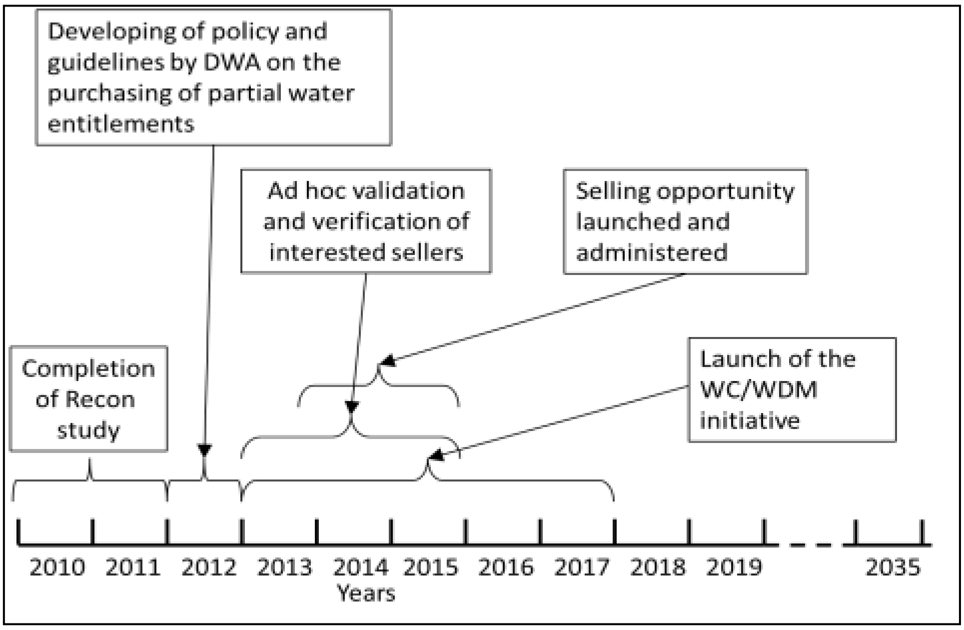


Figure 8.3: Timing of the purchase of WC/WDM savings

- **Transfer of water entitlements**

  Transfer of water entitlements is a mechanism where the water use entitlement of a water user or group of users can be acquired by a different water use sector. An example could be where a new mine needs water and the mine buys out all or part of the water entitlement of an irrigation farmer or group of farmers.

Transfer of water entitlements is based on the willing buyer/willing seller principle.

This option will reduce the total water requirements of the system insofar that the water requirements of the buyer (e.g. a mine) will have been accounted for in the planning and the seller's (e.g. irrigator) water requirement will also be included in the total water requirements. If however the buyer applies for a new water requirement which has not been planned for, then the water trading will merely allow movement of water entitlements among the water use sectors without any difference in the total water requirements on the system.

Water trading should be regulated as it could lead to severe social impacts and job losses if a commercial farming enterprise closes down. *Only if there is no other way out and water is urgently needed in the short term, should the transfer of complete water entitlements be considered.* The partial purchase of water entitlements is preferred.

The option to transfer water entitlements is dependent on the administrative processes in terms of Section 25 of the NWA and the compiling of the contract between the buyer and seller and the issuing of the new water use licence.

8.3 RECONCILIATION OPTIONS THAT WILL INCREASE WATER SUPPLY

8.3.1 Groundwater Development

Generally groundwater can only be used for domestic and stock watering and supply for small villages supplied by well fields. However the karst or dolomite aquifers of the Eastern Escarpment could be developed and scientifically selected boreholes should yield more than 5 ℓ/s each. These resources in the dolomite aquifer of the Escarpment could be used for future development as a regional groundwater resource. See groundwater availability map in **Figure 5.2**.

The effect of groundwater abstraction on the surface water flow is still uncertain. If, for example, water is abstracted from the Malmani Dolomite aquifer, and it reduces the low flow in the Olifants River somewhere lower downstream, it could have an impact on the ecological environment in that stretch of river. This aspect needs to be carefully investigated as well as the feasibility of constructing a weir in the Olifants River to retain groundwater for development.

For the purposes of this Final Reconciliation it is assumed that only 35 million m^3/a (50% of the reported available yield) can be exploited and that groundwater projects will progressively be developed over the entire planning period of this study.

A qualitative consideration of the water availability map (**Figure 5.2**) and the existing water stress areas (Section 5.1.2), led to the following breakdown of the 35 million m^3/a, assumed to become available from groundwater resources:

- Upper Olifants - 5 million m^3/a
- Middle Olifants - 15 million m^3/a
- Lower Olifants - 15 million m^3/a

8.3.2 Transferring Treated Effluent from the East Rand

It is possible to pump treated effluent from the Vaal System over the catchment divide into a tributary of the Upper Olifants River. For this assessment, the seven most suitable treatment works in the Vaal River Basin were selected. The concept of the project is shown on the map in **Figure 8.4** and the details are given in **Table 8.2.**

Figure 8.4: Waste Water Treatment Works in Ekurhuleni

While the water is assumed to comply with the "general standard", this is considered to be unacceptably high in nutrients for discharge into the Olifants System, so provision has been made for tertiary treatment (potentially reverse osmosis) of the effluent so as to have a maximum phosphate content of 0,1 mg/ℓ. The treated water could then be used to augment the supplies for power generation by ESKOM, thereby reducing demands on both the Olifants and Inkomati catchments.

The effluent will, as far as possible, be pumped from one Waste Water Treatment Works (WWTW) to another, with a central collection point at Daveyton. There the effluent will be treated before being pumped over the divide to the Olifants catchment to a point about 10 km north of Delmas. The discharge point has not yet been investigated in terms of the receiving stream's capacity, so it might be necessary to move this further downstream, or to undertake river protection measures.

Table 8.2: Details of Assumed Treated Effluent Scheme

WWTW	Location	Capacity (Mℓ/d)	Assumed Yield[1]		Pipeline							Pumps (kW)	Dam (Ml)	Cost (R Million)	URV (R/m³)
			(million m³/a)	(m³/s)	Destination	(m³/s)	Km	Start El	High pnt	End El	Diam				
Daveyton	Daveton	16	4.7	0.148	Discharge pt	1.213	21.6	1 590	1 633	1 536	900	650	17	301	0.81
JP Marais	Benoni	15	4.4	0.139	Daveyton	0.445	9	1 597	1 629	1 590	600	310	6	96	0.67
Rynefield	Benoni	13	3.8	0.120	JP Marais	0.120	3.9	1 605	1 608	1 597	300	62		35	1.05
Benoni	Benoni	10	2.9	0.093	JP Marais	0.093	9.7	1 653	1 657	1 597	300	27		65	2.32
Jan Smuts	Brakpan	10	2.9	0.093	JP Marais	0.093	7.2	1 602	1 605	1 597	400	48		42	1.25
Welbedacht	Springs	35	10.2	0.324	Daveyton	0.620	7	1 577	1 607	1 602	700	424	9	96	0.62
Ancor	Springs	32	9.3	0.296	Welbedacht	0.296	12.5	1 573	1 573	1 601	500	260		121	1.44
		131	38.3	1.213			70.9							466	3.83[2]
Tertiary Treatment Works at Daveyton WWTW: Capacity 136 Mℓ/day														657	3.48
													TOTAL (Excluding VAT)	**1 123**	**7.31**

1 Assumed equal to 80% of capacity

2 Weighted averages accumulated along the route

The effluent from these WWTWs currently flows into the Vaal River and has been taken into account in the calculation of the Vaal River System yield. Transferring this water to the Olifants will mean that the next Vaal River augmentation scheme after the Lesotho Highlands Water Project-Phase II (LHWP2), which has a URV of R6.14/m^3 will be required sooner than otherwise. LHWP2 will only be able to supply water by 2021 by when there will already be shortages on the Vaal.

Their actual current and likely future discharges have not been determined at this stage, and only their design capacities are known. Because of the seasonal peaks typical of effluent discharges, it has been assumed that 80% of the capacity will be available to transfer on a continuous basis. The combined yield of the selected works is then 38.3 million m^3/a.

Preliminary estimates of costs and Unit Reference Values (URVs) based on 2010 cost levels, for this option is also given in **Table 8.2.**

While this scheme obviously lends itself to being implemented in phases, it has been assumed at this stage that the entire scheme will be implemented at once.

8.3.3 Transferring More Water from Vaal Dam

DWA has recently commissioned a scheme (the Vaal River Eastern Sub-System Augmentation Project (VRESAP) scheme) which pumps 160 million m^3/a of raw water from the Vaal Dam to the Vaal-Olifants watershed. This water is fully committed to Sasol at Secunda in the Vaal catchment and ESKOM in the Upper Olifants catchment. This scheme comprises a 1900 mm diameter pipe over 110 km, to Knoppiesfontein on the Watershed, from where it gravitates down a 20 km long pipe to discharge into the Trichardtspruit, a tributary of the Olifants River.

This scheme could be duplicated to transfer another 160 million m^3/a, into the upper Olifants River. The costs of the VRESAP scheme, escalated to 2010, amounts to about R3 500 million. The Nett Present Value (NPV) of operational and maintenance costs amounts to R4 923 million which gives a URV of R3.60/m^3. It should, however, be noted that the Vaal River raw water tariff must be paid for all water supplied from that area. Considering that the water will only be available after the construction of LHWP2, this tariff will be significant. While the tariff is not yet known, the URV of the LHWP2 is R6.14/m^3. Augmentation of the Vaal after LHWP2 will also have to be brought forward.

8.3.4 Dam construction to increase yield through storage

- **Introduction:**

  The existing ratio of storage to MAR indicates that yield can be increased through storage.

  A number of options have been investigated but it is probable that only one will be sufficient to meet future requirements.

The economics of dam construction for agriculture is generally unfavourable. Upstream dams will significantly reduce the yield of any downstream dams.

- **Raising of Blyderivierspoort Dam**

  The existing Blyderivierspoort Dam at the location shown on **Figure 8.5** is a gravity arch structure in a particularly narrow section of the Blyde River canyon.

  The existing storage capacity is 54,6 million m^3/a, which is only 20% of the present day MAR. This means that there is plenty of scope for raising. However, a site visit showed that the site is ideal for the height of the existing dam and raising the dam will pose some challenges.

  Topographically, an extension of the left flank will need to run at an upstream angle along the highest route up a flat ridge, and there is no left flank to take the thrust from a gravity arch any higher than the current level.

  The most recent dam safety evaluation reported that the original geotechnical investigation had concluded that the site was unsuitable for an arch dam due to the weak rock, particularly at the higher levels of the existing structure. Of particular concern was the presence of a narrow band of shale near the top of the existing structure, and the dam safety evaluation expressed concern that two blocks on the left flank were at risk of failure if the shale had weathered as a result of saturation by the water in the dam. Converting the existing structure to a gravity dam will reduce the resulted stresses in the foundation and would ameliorate this problem.

  It is therefore proposed that the dam can be raised by flattening the downstream slope and designing the existing structure as a gravity dam which, in plan, follows the existing structure. This will allow the alignment to kink at the flanks of the existing structure. While it has been assumed for the costing undertaken for this study, that the raised flanks will also be gravity structures, it is much more likely that the raised left flank will be in the form of an embankment.

  The stability of the ridge on the left bank must also be investigated as part of any future studies. Raising the dam by 35 m and 55 m has been considered.

  The 55 m raising will increase the yield of the dam by 110 million m^3. The estimated cost of such a project will be R2.98 billion with a URV of R2.99/m^3.

- **New Dam Downstream Of The Original Rooipoort Site**

  In 1993 and again in 2001, DWA undertook feasibility studies for a possible dam on the Olifants River at Rooipoort, see **Figure 8.5**, but found that the dam was not very favourable for a number of reasons:

  - The yield was relatively small because of the many upstream dams;
  - Geotechnical investigations established that the dam had particularly unfavourable foundations;
  - The dam would have flooded two provincial roads which would cost as much to relocate as the cost of the dam wall; and
  - The dam would flood all or part of some 12 villages, requiring relocation of more than 300 households.

  In 2007, DWA undertook a study to compare the Rooipoort Dam with the proposed De Hoop dam on the Steelpoort River. It was found that for the same construction cost, the De Hoop Dam yield was twice as much as the Rooipoort Dam, and did not have the serious social impacts as the Rooipoort Dam. The De Hoop site was therefore selected, and the dam is currently under construction.

  A dam at a site identified some 20 km, show in **Figure 8.5**, downstream of Rooipoort might be more favourable, with a slightly higher yield, being downstream of the Mohlapitse tributary, and with fewer social impacts, but this has not been studied at this time.

  As part of this study, yields have been recalculated for the Rooipoort dam using the same assumptions regarding upstream catchment conditions as for the other dams described below. Costs have been escalated to 2010 levels from previous 2007 estimates.

  The yield is estimated at 59 million m³/a and the cost will be in the order of R1140 million with a URV of R2,14/m³.

  Any dam on the Middle Olifants River similar to the Rooipoort site is likely to require the relocation of households together with schools, businesses, etc. and could also inundate significant areas of irreplaceable agricultural land. The impact is provisionally assessed as high.

- **New Dams in the Olifants River Gorge**

  The Olifants River Gorge stretches for 152 km from the Steelpoort River confluence to the Strydom tunnel. Within this reach, the only access to the river is at the Ga-Madin village at 145 km.

Two potential dam sites have been identified on this reach, as indicated on **Figure 8.5**, namely:

i) Godwinton, at km 12; and
ii) Chedle, at km 140.

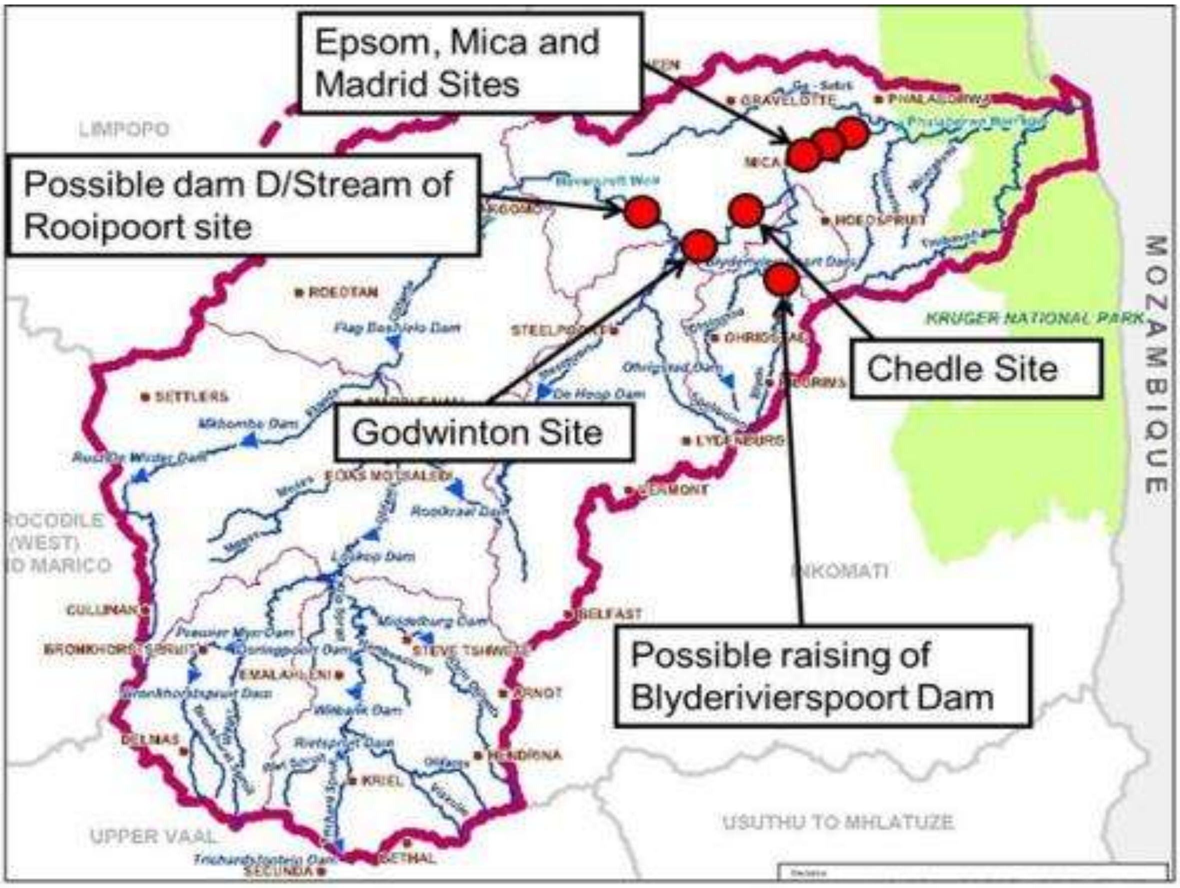


Figure 8.5: Possible Dam Sites

The Godwinton site is underlain by dolomite with chert beds. The Chedle site is underlain by micaceous graphitic shale inter-layered with sandy shale, but pushes the water back into the dolomite area which extends upstream to well beyond the maximum dam water levels.

The typical cavernous nature of dolomites means that the foundations of the Godwinton site must be proven by detailed geotechnical investigations. More important is the possibility of both dams draining into the dolomites, either putting water into an enormous and inaccessible sink, or perhaps providing additional storage. Detailed investigations will be required of water table levels around the dam basin. It will be required to determine whether water will drain into or out of the dams, and to what extent.

Another opportunity, as yet quite unexplored, is that the dolomitic geology in the vicinity of the Godwinton and Chedle sites could allow for the underground storage of Olifants River water by directing this into dolomitic caverns as artificial recharge. If this water could be stored in, and recovered from, these dolomitic aquifers it could reduce or even eliminate the need for a storage structure. Whilst this opportunity is at this stage uncertain, more certainty would be an outcome of the geological studies required by a feasibility study into the construction of Godwinton or Chedle, and may warrant investigation in its own right.

Both sites are topographically suitable for very high dams, but the maximum height is limited by the resultant flooding of a number of villages on the banks of the Steelpoort River. For the purpose of this report, it has been assumed that the full supply level (FSL) should be limited to 610 masl (MFL 620 masl) making the Godwinton Dam 60 m high and the Chedle Dam 70 m. This would require the relocation of some 30 households and a school. Raising the FSL by 20 m would flood an additional 65 households.

The Godwinton site is particularly well located to supply water to the major pump station currently being planned at Steelpoort as part of the ORWRDP-2, should it be necessary to supplement supplies from De Hoop Dam.

The environmental impact of both the Godwinton and Chedle Dams on the pristine river gorge is expected to be high.

Either of these dams would yield in the order of 100 million m³/a. The cost estimates for both of these dams, i.e. R52 million for Godwinton and R111 million for Chedle could be gravely underestimated because of the difficulties of access to the sites. The URVs of the two dam sites of R0,23 /m³ and R0,29/m³ respectively could also be much higher because of inaccessibility for construction equipment, but will still be the lowest URVs of all the development options.

- **New Dams in the Lower Olifants River**

  To maximise the yield from the Olifants River, it is necessary to capture the flow from all the major tributaries. The reach immediately downstream of the Blyde River confluence has therefore been examined and three possible dam sites, shown in **Figure 8.5**, have been identified, namely:

  i) Epsom
  ii) Mica
  iii) Madrid

  The Epsom site is located immediately downstream of the Blyde/Olifants confluence, which makes it favourable in that water will be stored in both river valleys. The valley is relatively flat and a 50 m high dam (FSL 430 masl) would require a 1,7 km long dam wall, plus a 150 m long saddle dam. A 60 m high dam would require a 3 km long wall. The 50 m high dam will flood relatively small areas of irrigated land on both the Olifants and Blyde Rivers, but the areas have not been estimated as this would be very dependent on tail water effects.

The Mica site is located 8 km downstream of the Blyde River confluence, and the Madrid site is some 20 km further downstream. Neither site is topographically very suitable, being in a flat valley, and both sites will require long dam structures. Both sites are limited to a dam wall height of approximately 60m and even at this level will require significant saddle dams to close low spots between surrounding hills.

The main difference between the two sites is the infrastructure, which would be inundated and which would need to be relocated. The R40 provincial road and a railway line cross the Olifants River at Mica, and R530 crosses the Makhutswi tributary near its confluence with the Olifants.

A dam at the Madrid site **(Figure 8.5**) would inundate all three bridges (R40, R530 and rail), which would need to be replaced at a much higher level with high approach fills, and the roads and railway line would have to be relocated over a significant distance. Some 3,5 km of the R530 would be inundated.

The Mica Dam site is located downstream of only the R530 road bridge. Although a portion of the railway line will need to be relocated, its bridge need not be affected. However, restriction on the dam wall height limits the storage capacity of the Mica site to only 514 million m^3, which is equivalent to 0,5 Mean Annual Runoff (MAR), while at the same site the Madrid site can store 1 700 million m^3 or 1,5 MAR.

All three options will inundate significant areas of relatively pristine riverine vegetation, but this is considered to be a relatively low impact. The main biophysical impact will be on the downstream river ecology, especially through Kruger National Park, and depending on the extent to which EWRs are met, the impact could be anywhere between positive to severely negative.

Only the Madrid and Epsom dams have been costed, and for the more favourable Epsom dam, the cost was estimated at R4 820 million, which is very high. Either dam would however yield approximately 286 million m^3/a provided there are no new upstream dams which results in a relatively favourable URV of R1,58/m^3. The Madrid dam could yield more, but at a higher URV.

8.3.5 Utilising the Acid Mine Drainage in the Upper Olifants

Acid mine drainage (AMD) is associated with mining activities where the mines dewater their works in order to be able to extract coal. This is associated with both underground and open cast mining.

The relatively high permeability of rehabilitated open cast mines and utilisation of the underground storage in the decommissioned mine workings can increase the system yield. Similarly, the shafts and galleries of decommissioned underground mines can be used as storing capacity for underground water, which will also increase the system yield. The contaminated nature of the water makes treatment or dilution of this underground water from decommissioned mines essential.

It is important to note that much of this water, from dewatering of presently operating mines and decant from decommissioned mines, would have returned to the river as base flow even without any mining. The increase in reliable yield has been quantified in a detailed study, (Golder, 2011) and is relatively small at present, but will reach a peak in approximately 5 years (2015) for the Witbank Dam Catchment and in approximately 2030 for the Middelburg Dam catchment.

Modelling by Golder Associates has shown that an additional future yield of 22 million m^3/a can be expected (See Section 5.2.4).

The treatment and re-use of acid mine drainage water has already been implemented with a reverse osmosis plant with a capacity of 9 million m^3/a. (25 Ml/d). To provide additional capacity to meet the additional yield of 22 million m^3/a, is expected to cost approximately R75 million with a URV of R6.31 /m^3.

It should be noted that the mine owners are legally obliged to treat the AMD that drain from their mines before returning it to the river. This water, if treated to potable standards, can be used to supply domestic users, but the capital cost will be substantially more than that quoted above.

It is expected that the AMD occurrence in the Middle and Lower Olifants Management Zones will be much less than in the Upper Olifants Management Zone. Information on AMD quantities were only available for the Upper zone, therefore it was assumed that AMD contributions to the yield of the system in the Middle and Lower zones can be is regarded as insignificant for the purpose of this study.

8.3.6 Re-using Sewage Effluent Polokwane and Mogalakwena

The return flow from municipal sewage works within the Olifants catchment remains in the system and is being reused indirectly by water users (mainly irrigators) further downstream.

The return flows from Polokwane and Mogalakwena, however, will be lost to the Olifants System if not being re-used. This continuous outflow of sewage water could be a further source of water. One of the mines in Mogalakwena has already entered into a contract with Polokwane Municipality in which the mine will purchase 8 million m^3/a treated sewage water from Polokwane. This quantity of water is shown as a “transfer-in” for the Middle Olifants Management Zone in **Table 5.7** of this report.

The future expected return flows for Polokwane (excluding the 8 million m^3/a referred to above), and Mogalakwena are shown in **Figure 8.6**.

The curves in **Figure 8.6** must, however, be used with caution. If WC/WDM initiatives were to be launched in Polokwane and Mogalakwena, the return flows will be affected. An amount of losses can also be expected in the treatment process. It is therefore recommended that the curves in **Figure 8.6** are reduced by 20% to make provision for these uncertainties.

For the purpose of the strategy it was assumed that an additional 4 million m^3/a (above the 8 million m^3/a currently being sold by Polokwane) can be immediately made available and that this quantity can grow to approximately 10.7 million m^3/a by the year 2035. This sewage water needs to be treated to a standard which will be acceptable for the purpose of the water use.

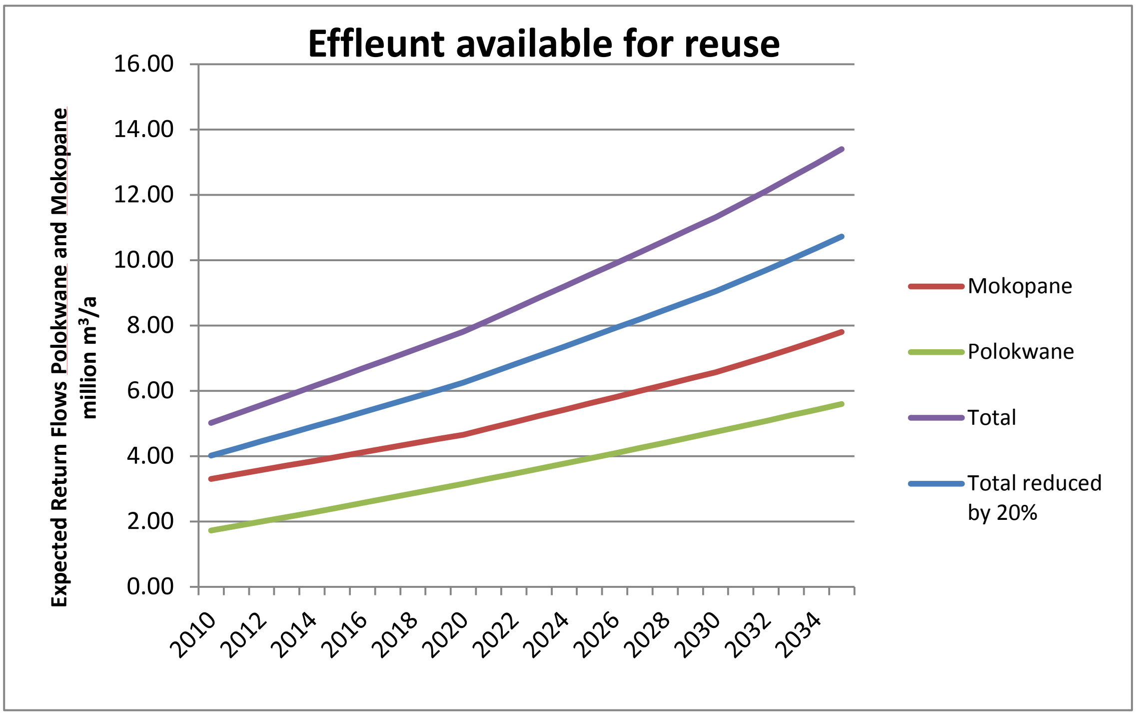


Figure 8.6: Expected Available Return Flows in Polokwane and Mogalakwena. The Total Reduced By 20% curve was used for this Final Strategy

8.3.7 System Operating Rules

The dams within the Olifants River are currently mostly operated independently, with little or no consideration of the state of storage of other dams or the system as an integrated system. The exception is the water supply to Phalaborwa that can be supplied from the Phalaborwa Barrage and/or from the Blyderivierspoort Dam. A recently completed report on the operating rules of the Blyderivierspoort Dam indicates that a significant yield of 40 million m^3/a can be obtained from the Phalaborwa Barrage if supported by occasional releases from Blyderivierspoort Dam. The additional yield of

40 million m^3/a was already accounted for when determining the system yield since the operating rule is already being applied and the additional yield could therefore not be added again.

It is probable that further yield can be gained if other dams (e.g. Loskop Dam and Flag Boshielo Dam) are operated as a system but this would require a separate study. No reliable information on the expected additional yield was available, but this should be studied as soon as possible. The further study will be a recommendation of this strategy.

This measure is fairly simple to implement and the cost will be relatively low. It can also show quick results.

The lead time for implementing System Operating Rules would be approximately 2 years.

8.3.8 Rainfall Enhancement

Cloud seeding was found to benefit the yield of farm dams but not the runoff to the Vaal catchment, when practiced in the Bethlehem area of the southern Free State. The programme has since been moved to the escarpment areas of the Eastern Cape, where some measure of success was experienced in increasing the rainfall over commercial tree plantations. [Eales, et. Al, 1996]

Such a programme could possibly be replicated for the Olifants catchment. The possible benefits and costs would need to be properly investigated. This would require a pilot project to assess the benefits and costs.

For the purpose of this strategy this option was not further explored or considered as a result of the possible negative social and environmental impacts that were pointed out.

8.3.9 Removal of Invasive Alien Plants

The impact of IAPs has already been described in Section 4.1.6 of this report where it was shown that 21 million m^3/a yield is taken up by these plants. The complete removal of IAPs will increase the yield by this volume. DWA Working for Water Teams are already working at 6 different sites within the WMA. In view of the fact that there is a continuous growth of IAPs and regrowth on cleared areas, which will need follow-up treatment, it will be difficult and costly to eradicate all IAP in a short time span. It was therefore assumed that at least 50% of the 21 million m^3/a will be gained over the planning period of the strategy.

8.3.10 Water Transfer from the Crocodile (West) River System

Flows in the Crocodile (West) river are continuously increasing as a result of increasing discharges from numerous waste water treatment works (WWTW) which discharge into various tributaries of the main stem river. These works collect effluent from the whole of the City of Tshwane and the northern half of

Johannesburg, totalling a considerable volume. However, much of this water enters the Crocodile (West) River relatively far downstream on the westward flowing river, and the cost of pumping the furthest water to the Olifants River would be exorbitant.

There are also water requirements in other areas which may be supplied from the Crocodile (West) System and these include the supplies to Tshwane and Johannesburg Metros and augmenting the Mokolo System.

In other studies for DWA, the increase in the yield of existing dams, as a result of the increasing inflows on the Crocodile (West) and its tributaries have been calculated. This study focused on the available increasing yield of the closest dams, as listed in **Table 8.3.**

Table 8.3: Water Available from Selected Crocodile (West) River Dams (million m^3)

Dam	2015	2020	2030
Hartebeespoort dam	24.0	29.0	58.5
Klipvoor Dam	0	4.7	17.0
Roodeplaat dam	26.5	36.0	33.0

Source: BKS, Support to the Mokolo-Crocodile WAP Team (Draft)

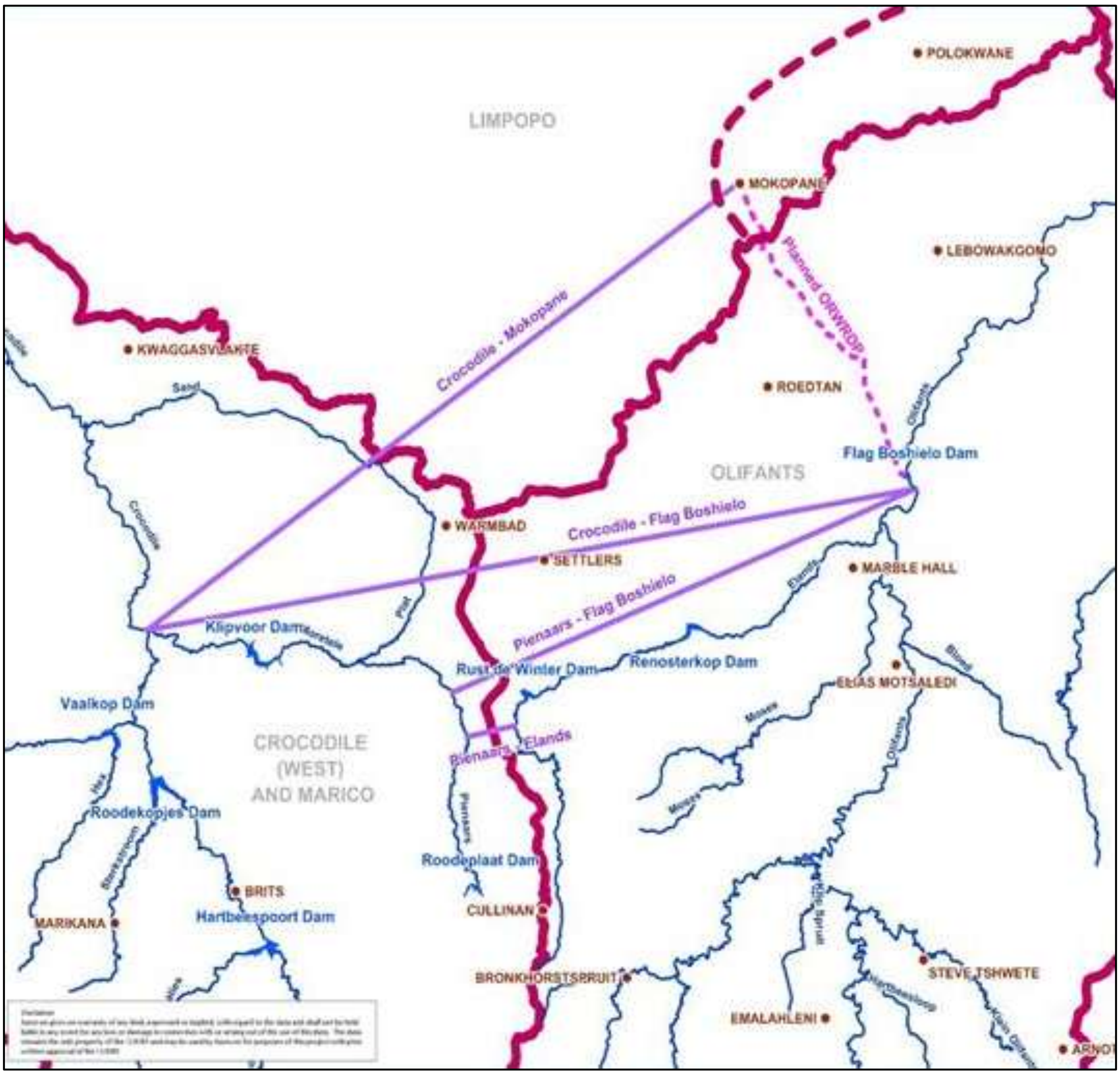


Figure 8.7: Crocodile (West) - Olifants Transfer Options

As shown on **Figure 8.7** and in **Table 8.4** four options have been considered, namely:

i) To abstract water from a weir on the Pienaars river some 40 km downstream of Roodeplaat Dam and pump it in a 12 km long pipeline to discharge it into a tributary of the Elands river. The water would then flow down the river for 10 km, through the Rust De Winter Dam, another 45 km down the river, through the Mkhombo Dam and another 70 km down the river to the Flag Boshielo dam. The rivers are known to suffer from high losses and to calculate the URV it has been assumed that only 50% of the water pumped will reach Flag Boshielo Dam. Despite the apparently relatively low costs, uncertainty about the extent of the losses which occur, and the possibility that very little water might reach the Flag Boshielo Dam, result in this option being considered a high risk and it is not favoured.

ii) To abstract water from a weir on the Pienaars river some 55 km downstream of Roodeplaat Dam and pump it through a 115 km long pipeline, to discharge into the Elands river just upstream of the Flag Boshielo Dam.

iii) To abstract water from the Crocodile river just downstream of the confluence of the Moretele river confluence and pump it through a 180 km long pipeline, to discharge it just upstream of the Flag Boshielo Dam.

iv) To abstract water from the Crocodile river just downstream of the confluence of the Moretele river confluence and pump it through a 180 km long pipeline, to discharge it at Pruissen outside Mogalakwena. This alternative would replace a scheme planned by DWA (ORWRDP-2B) to transfer water from Flag Boshielo to the same point, making that volume of water available for other users in the Olifants region. The cost of that scheme must be compared with the cost of first transferring the water from the Crocodile to Flag Boshielo Dam and the transferring it to Mogalakwena.

The estimated cost of each of the four options is set out in **Table 8.4,** as well as the URVs. The Pienaars-Elands option is by far the cheapest, but the transmission losses along the Elands River are a point of great uncertainty.

Table 8.4: Details of Crocodile (West) Transfer Options

Transfer Option	Pipe Length (km)	Supply (million m^3/a)	Cost (R x 10^3)	URV (R/m^3)
i) Pienaars - Elands	12	30/15	213	1.57
ii) Pienaars – Flag Boshielo Dam	115	30	1 268	3.82
iii) Crocodile – Flag Boshielo	180	60	3 926	6.43
iv) Crocodile - Mogalakwena	180	25	3 728	14.51
ORWRDP-2B: Flag Boshielo - Mogalakwena	**72**	**25**	**1 034**	**5.37**

An important observation is that the Pienaars-Flag Boshielo Dam (Option ii) added to the planned ORWRDP-2B pipeline from Flag Boshielo Dam to Mogalakwena, is actually cheaper (has a lower URV) than option (iv), the pipeline from the Crocodile (West) River directly to Mogalakwena. Was this not the case, the ORWRDP-2B pipeline would have to be reconsidered. The reason for the high URV is the high pumping cost to lift the water over the Crocodile-Mogalakwena watershed.

8.3.11 Desalination of Sea Water

With South Africa bordered by ocean to the east, south and west, it cannot be said that the country will ever be short of water per se. Rather, the problem is the quality of that water and the location relative to the majority of users in the central highveld of the country.

The option of desalination of sea water and pumping it to the Olifants river basin has not been considered independently in this study and the following information is quoted from a study on the DWA by BKS, "Assessment of the Ultimate Potential and Future Marginal Cost of Water Resources in South Africa". (DWA, 2010)

Table 8.5: Details of Desalination Options

Capacity (million m^3/a)	Pipeline		Power Required Desalination + Pumps (MW)	Cost (R Million)	URV (R/m^3)
	Length (km)	Diameter (mm)			
100	490	1 700	90 + 80	12 970	44.45
200	490	2 250	179 +159	19 400	59.84

The water was assumed to be abstracted and desalinated near Lake Sibaya on the KZN coast. The alternative of abstracting water in Mozambique would result in a shorter pipeline and would also need to be investigated, but any optimisation study must also consider other South African users, and the details in the table must be considered as the guiding URVs.

8.4 CONSIDERATIONS FOR SELECTING THE MOST APPROPRIATE RECONCILIATION OPTIONS

8.4.1 Basis for water reconciliation

Reflecting on the status of the water resources of the basin, described above, it is necessary to agree on specific principal management objectives for the future use of the resource. These objectives are associated with a number of assumptions that had to be made for the catchment.

The principal water reconciliation objectives are to:

- Recognise South Africa's International Obligations in terms of the Southern African Development Community (SADC) Revised Protocol on Shared Water Courses in terms of which there should be fair and equitable sharing of the water resource between South Africa and Mozambique.
- Balance the social and economic water requirements and the protection of the environment to achieve sustainable development.
- Ensure that water is used efficiently
- Eliminate all unlawful water use

The initial assumptions on future water use are:

Assumption 1: Water for basic human needs in the study area will be made available. Together with this, appropriate sanitation must be provided.

Assumption 2: The Environmental Water Requirements (EWR) will be met as soon as practicable. The water required to maintain, and where agreed, improve the environmental status of the Olifants Catchment, should be supplied.

Assumption 3: Water for strategic use for the benefit of the country (e.g. water supply to power stations) will receive priority above any other economic development.

Assumption 4: Water for Economic growth in the study area, within the policy parameters of the government, will be provided.

Assumption 5: There will no further expansion in total irrigation and total forestry.

8.4.2 International obligations

In this catchment the only country affected is Moçambique.

- In 1971 Portugal and South Africa agreed to raise Massingir Dam with no compensation payable to South Africa. Portugal accepted that water in the Olifants River will decrease. South Africa may not use Massingir water except for domestic and stock drinking purposes.

- Previous agreements between South Africa and Portugal still remain and in terms of these agreements, there are no limitations to further developments in the catchment by South Africa. The Government of South Africa is also a signatory to the Revised Protocol on Shared Watercourse Systems in the Southern African Development Community (SADC) Region. The character of this protocol promotes inter alia the sustainable, equitable and reasonable utilisation of shared watercourse systems and avoiding causing any negative impact to the neighbouring state. There are specific provisions in terms of which State Parties shall exchange information and consult each other and, if necessary, negotiate the possible effects of planned measures on the condition of a shared watercourse.

8.4.3 Summary of the Yield and Cost Information of the Reconciliation Options

Table 8.6 and **Table 8.7** summarises the yield, cost and URV information of various reconciliation options. The desalination and importation of seawater has also been included in the table so that this can serve as an indicative value with which the others can be compared.

Table 8.6: Options for reducing water requirements

Option	Yield/Water Saving (million $m^{3/}a$)	Cost as NPV (R million)	URV (R/m^3)
Eliminating Unlawful Irrigation use	8.7	12	0.12
Removal of Alien Invasive Plants	15	120	0.76

Option	Yield/Water Saving (million m^3/a)	Cost as NPV (R million)	URV (R/m^3)
WC/WDM: Urban	20	285	1.48
Compulsory Licensing	35	32	0.07
Water Trading	35	175	0.35

Table 8.7: Options for increasing water supply

Option	Yield (million m^3/a)	Capital Cost (R million)	URV (R/m^3)
Removal of Alien Invasive Plants	15	120	0.76
Rooipoort Dam	59	1 140	2.14
Dam in Olifants Gorge:			
Godwinton	100	132	0.14
Chedle	100	200	0.20
Dam in Lower Olifants:			
Epsom	286	4 820	1.58
Madrid	440	8 800	1.71
Raising of Blyderivierspoort Dam	110	2 977	2.99
Transfer from ERWAT ∗	38.3	1 123	7.31
Transfer from Vaal Dam ∗	160	3 500	3.60
Transfer from Crocodile (West):			
Pienaars – Flag Boshielo Dam	30	1 268	3.82
Crocodile – Flag Boshielo Dam	60	3 926	6.43
Crocodile – Mogalakwena **	25	3 728	14.51
Transfer from Massingir Dam	50	2 000	4.85
Desalination of Sea Water	100	12 970	44.45

∗ *Excludes cost of early augmentation of the Vaal System. (LHFP2 (URV R6.14/m^3))*

∗∗ *This option could replace the currently planned ORWRDP-Phase 2B*

All cost estimates based on 2010 prices.

In selecting which, if any of these options must be considered further, it is important to note the location of the demands in relation to where these options have been assumed to deliver water. The following important factors are also highlighted:

i) The site just downstream of the Rooipoort Dam has high social costs and is located on a stretch of river whose flow is already much reduced. Much of its yield would therefore be allocated to meeting the EWR.

ii) The uncertainty regarding the suitability of the dolomitic foundations and basin make the technical feasibility of a dam in the Olifants Gorge questionable. A detailed geo-hydrological study would be required before any of these dams could be considered further.

iii) Dams in the lower Olifants river, as well as the Blyderivierspoort, are poorly located in relation to the demands and the cost of pumping this water to the users would be exorbitant.

iv) Transferring treated effluent from the ERWAT WWTW or raw water from Vaal Dam would both exacerbate water shortages in the Vaal river basin, for which LHWP2 is currently being planned and can be considered as transferring LHWP2 water. The URV of that scheme is currently estimated at R6.14/m^3, which must be added to the cost of transferring the water to the Olifants river.

v) Transferring water from the Crocodile (West) river to the Olifants river seemed favourable at a certain stage of the study. The water in the Crocodile (West) River was allocated to ESKOM's proposed coal burning power stations at Lepalale. At some stage during the course of this study, a portion of the water could become available as ESKOM no longer envisaged all its power stations any more in that area. This situation however changes continuously and no final decision on ESKOM's power stations has been taken. In the meantime the Tshwane City Council has also shown an interest to reuse the return flow in the Pienaars River where the water could be abstracted for the transfer to the Olifants catchment. This was therefore a promising intervention option, but in the light of the dynamics, it seems that the water will eventually not be available for the Olifants and the option is therefore no longer considered.

vi) Desalination of sea water and pumping it from the coast is not considered to be viable in the short to medium term, and the costs are presented only to give an indication of what might eventually be necessary should water demands continue to grow beyond the planning horizon of this study.

8.4.4 Environmental Screening of Options

The environmental screening focused on the possible schemes considered in the strategy and aims to:

- summarise any key environmental or social issues that should be taken in account when considering and comparing options;
- identify any environmental or social "fatal flaws" or "red flags" associated with any of the projects; and
- identify environmental authorisations that will be required for any of the projects.

The assessment is based on available documented information, and no site visits, field work or additional data collection were undertaken to verify or update the available information. Implementation of the Reserve (surface water, groundwater and water quality aspects) during construction and operational phases is assumed to be a condition of any proposed scheme. It is assumed that this will ensure that the aquatic ecology and requirements for basic human needs are adequately provided for and protected.

The most well-known conservation area is the Kruger National Park (KNP) located in the Lower Olifants sub-area of the Olifants WMA. There are two centres of endemism within the Olifants WMA: namely the Sekhukhuneland, and Wolkberg Centres of Endemism. These areas contain high levels of diversity with many species restricted entirely to these areas. As such they are of high priority in terms of conservation. The high biodiversity and the many unique plant species restricted to these areas means that they are particularly vulnerable.

The construction of bulk water supply infrastructure such as dams and pipelines require the environmental authorisation impact assessment process that includes a public participation process.

Potential impacts on adjacent groundwater using landowners, surface flow and riverine ecology and groundwater dependent ecosystems could potentially be affected by groundwater development if it is not implemented sustainably.

Any water transfers into the catchment will impact on the receiving streams due to an increase in their flow and loss of natural variability with consequent ecological affects. Organisms from the donor catchment will inevitably be transferred with the water.

The use of treated acid mine drainage can increase the system yield and improve the water quality. No significant impacts are expected and there will be benefits in improved water quality.

Transferring treated effluent from the East Rand will require right of access and aqueduct servitudes and may result in water quality problems.

Transferring additional water from the Vaal Dam will also require servitudes for a pipeline and application of the Vaal River tariff will result in a high water price.

The raising of the Blyderivierspoort Dam or construction of any of the possible five new large dams identified will have potentially significant social and ecological impacts which will require a full environmental and social impact assessment and to which the hierarchy of mitigation measures (enhance, avoid, reduce, restore, compensate, offset) will have to be applied.
The increase on utilisable yield from removal of the invasive alien vegetation is expected to be negligible, but this option will have a positive impact on biodiversity.

No fatal flaws have been identified for any of the options considered. The construction of large dams is expected to have the greatest ecological and social impacts.

8.4.5 Selection of reconciliation scenarios

A reconciliation scenario comprises a combination of reconciliation options which will render a resultant water balance. The list of possible reconciliation options were first screened at the screening meeting held in the Kruger National Park on 7 July 2010. At that meeting an agreement was reached on which options warranted further investigation. Thereafter a further process of screening followed over time through discussions at the Study Management and Study Steering Committees. A host of criteria were used to decide on the list of reconciliation options (which constitutes the reconciliation scenario) for each management zone. The criteria were:

- Fatal flaw
- Political acceptability
- Yield contribution / water requirement reduction
- Capital cost of option
- Operational cost of option
- URV
- Biophysical impacts
- Social impacts
- Ease of implementation
- Capacity of implementing institution
- Time required to implement
- Certainty that it will work
- Eventual happiness among water user sectors
- Impact on neighbouring country (Mozambique)

The overarching criterion was the requirement to achieve a water balance in each management zone and the entire catchment.

9. RECONCILING THE WATER REQUIREMENTS WITH THE WATER RESOURCE (SCENARIOS)

9.1 INTRODUCTION

In Section 8, the various reconciliation options are described. These can be divided into reconciliation options, for reducing the water requirement and reconciliation options for increasing the water supply.

The additional yield of the De Hoop Dam is superimposed on the system yield as if De Hoop Dam were to be one of the reconciliation options. This was done so that the effect of the De Hoop Dam yield on the total system yield could be easily observed. It must however be understood that the construction of De Hoop Dam is well underway and that De Hoop Dam is no longer an option to be decided upon. This intervention must therefore be regarded as a certain increase in the water supply.

The total water balance of the whole catchment and the water balances of each of the three Management Zones are shown and discussed in the following sections.

9.2 WHOLE CATCHMENT

9.2.1 The selected Reconciliation Options: Whole Catchment

Table 9.1 shows the reconciliation options for reducing water requirements that are recommended for implementation for the entire Olifants WMA.

Table 9.1: Reconciliation Options that will reduce water requirements

Option	Starting Year	Duration (Years)	% Saving	Estimated Saving (million m^3/a)	Comments
WC/WDM Irrigation	2013	5	3.3%	17	Two focus areas: • Improved Irrigation Systems is 19 million m^3/a • Improved conveyances (reducing canal/pipe leaks) is 16 million m^3/a Need to be linked to water trading in order to get the savings back into the system instead of horizontal expansion by the irrigation farmers. Expected savings is 35 million m^3/a, but it is assumed that only 50% of the irrigation farmers will put their savings on offer for purchase.

Option	Starting Year	Duration (Years)	% Saving	Estimated Saving (million m^3/a)	Comments
WC/WDM Urban	2013	5	18.8%	19.8	This saving is regarded as achievable.
WC/WDM Mining	2015	10	6.8%	5	This saving will necessitate transformation from existing processes to alternative processes which will be costly and more time was consequently allowed. Regarded as achievable by the mining industry.
Unlawful Water Use	2012	4	2.1%	8.5	The yield impact as a result of the increased irrigation is 17.4 million m^3/a. This irrigation expansion is not all unlawful as part of it could have expanded through water savings. It was assumed that 50% of this is unlawful. This assumption can only be verified after the completion of the validation and verification processes, but is regarded as a fairly conservative assumption.
TOTAL SAVING / YIELD				**50.3**	

The reconciliation options described in Section 8.2, which have not been included in the water requirement scenarios, are the following:

- Reducing assurances of supply (paragraph 8.2.3), and
- Compulsory licensing (paragraph 8.2.4)

Both these options will result in a reduction in water requirements, but it is likely that these options will have negative social implications. They both entail water curtailments which will be unpopular and which need to be negotiated with the water management institutions. Another disadvantage of compulsory licensing is that it has a very long lead time as shown in **Figure 8.2.** These options can be included as contingency options, should any one of the chosen options not materialise or be less effective than anticipated.

Water trading of full irrigation entitlements remains a possibility but is impossible to quantify without knowing the willing buyers and willing sellers. This full entitlement water trading can also lead to severe social consequences.

The included reconciliation options that will increase the system yield are listed in **Table 9.2**.

Table 9.2: The most promising and selected reconciliation options that will increase the system yield

Option	Starting year	Duration (years) to full yield	Estimated Yield (million m^3/a)	Comments
Removal of IAPs	2012	23	10.5	Half of the estimated water use by IAPs, i.e. 0.5 x 21 million m^3/a.
Development of Groundwater Schemes	2012	23	35	Half of availability as modelled by AGES. Not all areas are accessible and half of the availability is regarded as exploitable.
Treatment of decanting water from the coal mines in the Witbank Dam Catchment	2015	1	12	Graph in **Figure 5.4** shows the results of a model estimating the future decant from mines in the Witbank Dam Catchment. The additional decant from 2011 – 2015 is 12 million m^3/a.
Treatment of decanting water from the coal mines in the Middelburg Dam Catchment	2030	1	10	Graph in **Figure** 5.5 shows the result of a model estimating the future decants from mines in the Middelburg Dam Catchment. The additional decant from approximately 2020 – 2030 is 10 million m^3/a.
Sewage water reuse – Polokwane and Mogalakwena	2012	23	11	Treatment will be necessary. Water can be reused by the mines.
		TOTAL YIELD	**78.5**	

There were a number of other reconciliation options to increase supply with relative low URVs, but it seemed that these options (mostly additional infrastructure e.g. dams) will not be necessary for achieving the required water balance. Despite the low URVs, it will be very difficult to get them accepted by all from an environmental point of view, e.g. the dams in the Olifants River Gorge.

9.2.2 Water Demand / Water Supply Graphs: Whole catchment

The high and low scenario water requirements over the 25 year planning period as well as the system yield over the same period as shown in **Figure 9.1**.

It was assumed that the ecological Reserve will only be operationalized after the De Hoop Dam has filled in 2016 and that the planning for this operationalization and the setting up of operating rules and a monitoring network must be done before that. It was further assumed that the operationalization of the Reserve must be done in the shortest possible time and 1 year was allowed for this. **Figure 9.1** clearly shows the sudden drop in yield as a result of the ecological Reserve.

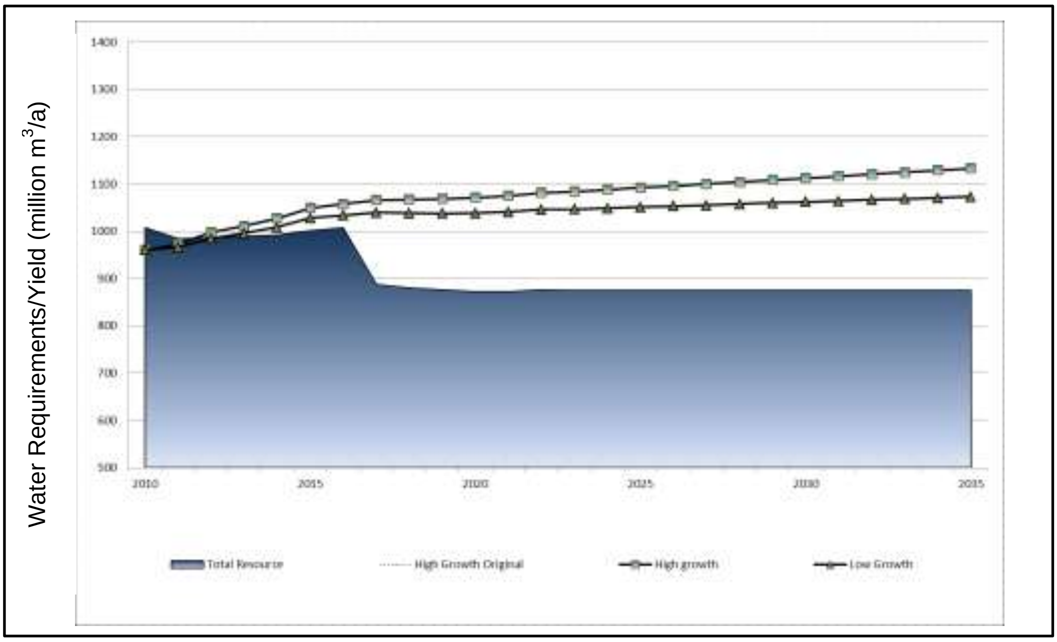


Figure 9.1: System yield of the entire catchment with the ecological Reserve component and the low and high water requirements curves

The current compensation releases from Flag Boshielo Dam and the Phalaborwa Barrage, both 19 million m^3/a will stop when the full ecological Reserve releases are allowed for.

Figure 9.2 shows the effect of applying the selected reconciliation interventions that will reduce the water requirements as listed in **Table 9.1**. The original curve for the high water requirement is shown as a dotted line so that the effect of the interventions is clearly visible.

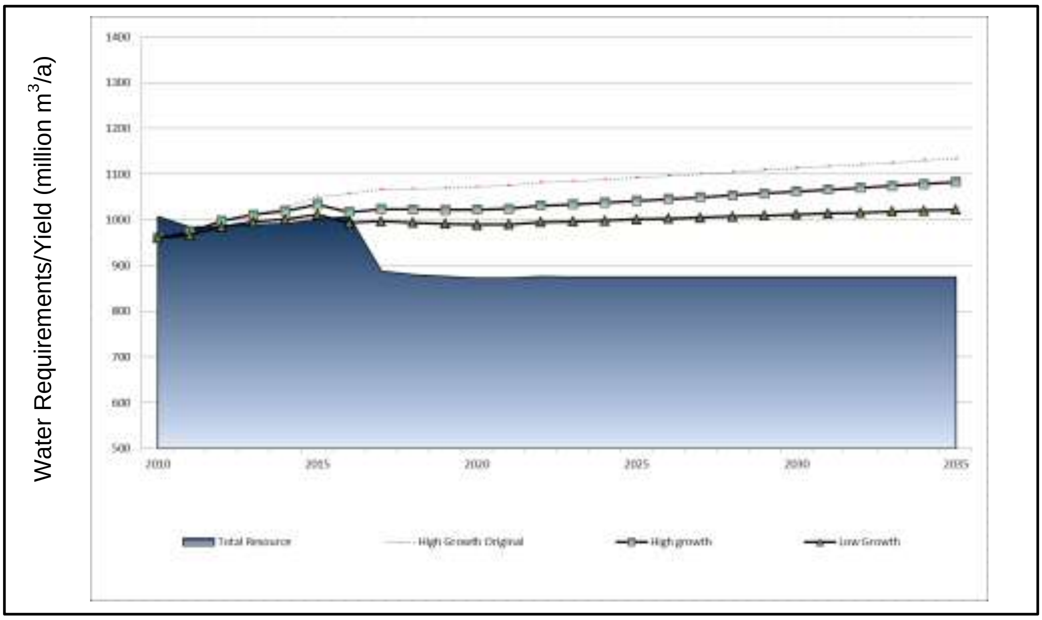


Figure 9.2: Entire catchment: Reconciliation interventions applied that will reduce the water requirements

In **Figure 9.3** the De Hoop Dam has been added. There however is still a water deficit for the high water demand scenario which needs to be resolved with further measures.

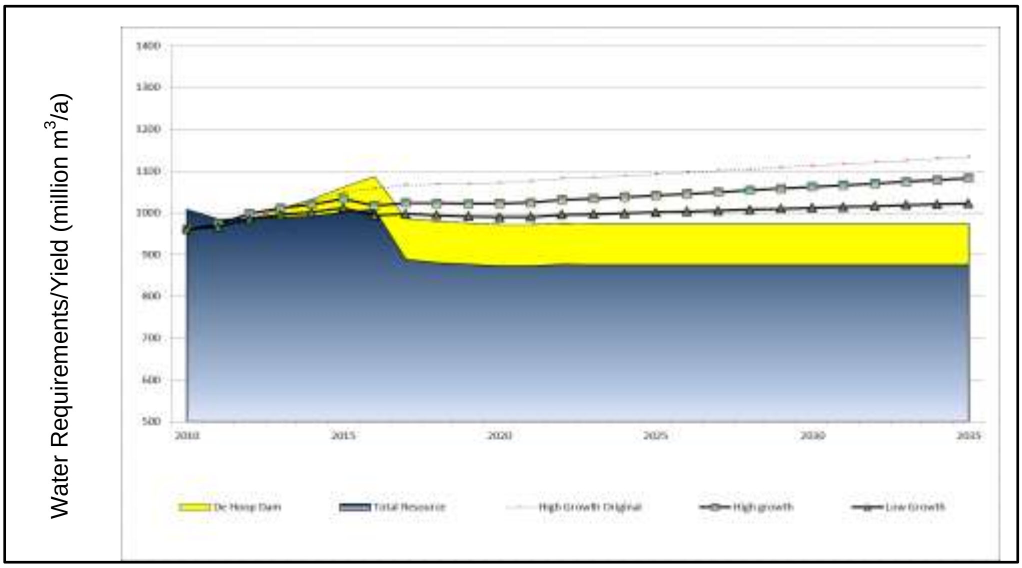


Figure 9.3: Effect of De Hoop Dam on entire catchment – Water Requirement Reduction activities applied

Figure 9.4 finally shows the effect of applying all recommended reconciliation interventions, i.e. those that will reduce water requirements as well as those that will increase the system yield (the latter listed in **Table 9.2**).

A water balance is achieved with the selected reconciliation options applied.

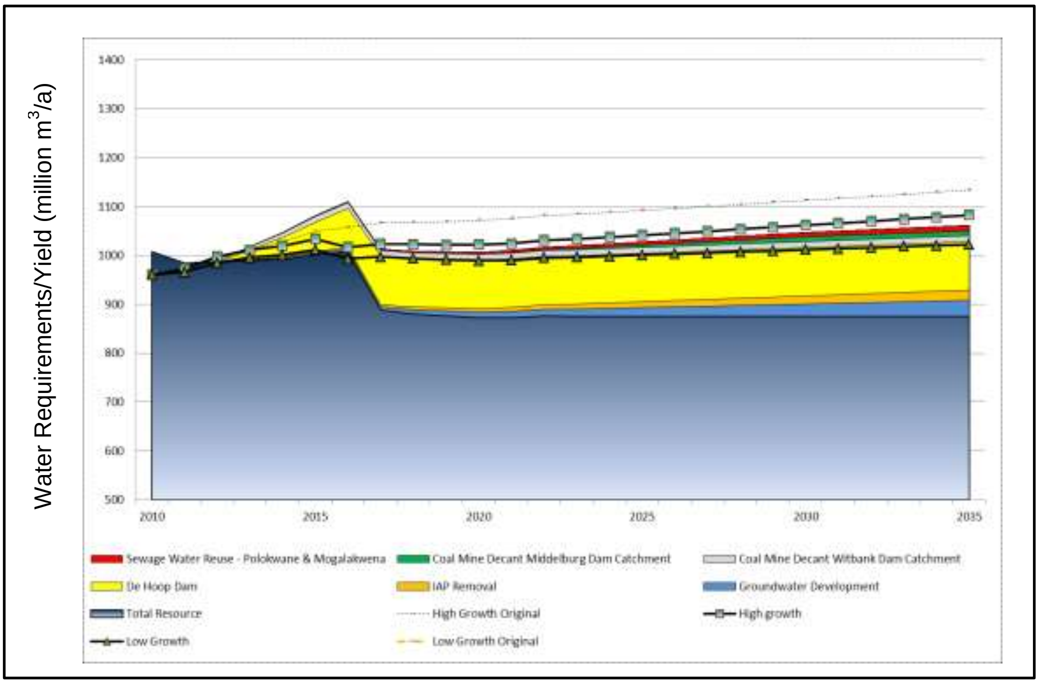


Figure 9.4: Entire catchment with all interventions applied

The system is almost in balance with a small deficit below the high water requirement curve as from 2017.

9.3 UPPER OLIFANTS MANAGEMENT ZONE

9.3.1 The Selected Reconciliation Options: Upper Olifants

The selected reconciliation options that will reduce the water requirements are listed in **Table 9.3**.

Table 9.3: Reconciliation options that will reduce the water demand for Upper Olifants

Envisaged Intervention	Expected incremental saving million m^3/a	Expected date to be operational	Time to reach full saving (Y)
WC/WDM for irrigation and savings offered to purchase	8.8	2013	5
WC/WDM Urban	10.5	2013	5
WC/WDM Mining	1.5	2013	10
Eliminating unlawful water use	6.4	2015	5

The expected WC/WDM savings for irrigation as set out in **Table 9.1** has been split for the three management zones pro rata to the irrigation water use in each of the three areas. In order to limit horizontal expansion of irrigation land with the saved water, it is recommended that WC/WDM for irrigation is combined with water trading (see paragraph 8.2.5). It is unknown how many irrigators will put their WC/WDM water savings on offer for sale and only half of the expected WC/WDM savings for irrigation was taken into account in the water balance.

For the Upper Olifants management zone, this saving was 8.8 million m^3/a. The WC/WDM savings for the urban and mining sectors were similarly sub-divided. Most of the unlawful water use is in the Upper and Middle Olifants management zone and the value in **Table 9.1** was split in these two zones pro-rata to the increased irrigation areas in these zones.

The selected reconciliation options that will increase the water supply are listed in **Table 9.4**.

Table 9.4: Selected Reconciliation options that will increase the water supply for Upper Olifants

Envisaged Intervention	Expected incremental yield (million m^3/a)	Expected date to be operational	Time to reach full yield (Y)
Groundwater development	5	2012	23
Water reuse – from coal mines in Witbank Dam Catchment	12	2011	5
Water reuse – from coal mines in Middelburg Dam Catchment	10	2020	10
IAP removals	5.9	2012	23

Envisaged Intervention	Expected incremental yield (million m^3/a)	Expected date to be operational	Time to reach full yield (Y)
Transfer water from Vaal Dam	30	2026	1

By looking at the Groundwater Availability Map in **Figure 5.2** and the considerations described in Section 5.1 it was decided to only count half of the additional available groundwater (i.e. ½ of 70 million m^3/a for the whole catchment) because of possible inaccuracies with the modelling and because many areas in the catchment are inaccessible for a borehole drill. It was also assumed that the available exploitable groundwater in the Upper Olifants will be 5 million m^3/a, i.e. 14.3% of the available groundwater in the catchment.

It was assumed that only 50% of the loss of yield owing to IAPs 11.8 million m^3/a, would be regained since the working for water programme is a continuous programme which will not be completed within the planning horizon of the study. There will be a continuous growth of IAPs as well as regrowth where the Working for Water team needs to follow up their operations. It will therefore be difficult and costly to catch up and overtake the growth rate of the IAPs and to eradicate all plants over the planning period of the strategy. If the teams can achieve 50% eradication, it means that they will indeed be overtaking the growth rate of the IAPs.

9.3.2 Water Demand / Water Supply graphs: Upper Olifants

Without the Reserve, this Management Zone would have had a surplus, i.e. the system yield would have exceeded the high water requirement scenario for the whole planning period**.** However the surplus turns into a small water deficit just after 2022. The ecological Reserve was assumed to be operationalized in 2016. The basic human needs (BHN) component of the Reserve has already been accounted for in the domestic water requirements of the Management Zone. The effect of the ecological component of the Reserve which reduces the system yield by 40 million m^3/a, can be observed in **Figure 9.5**.

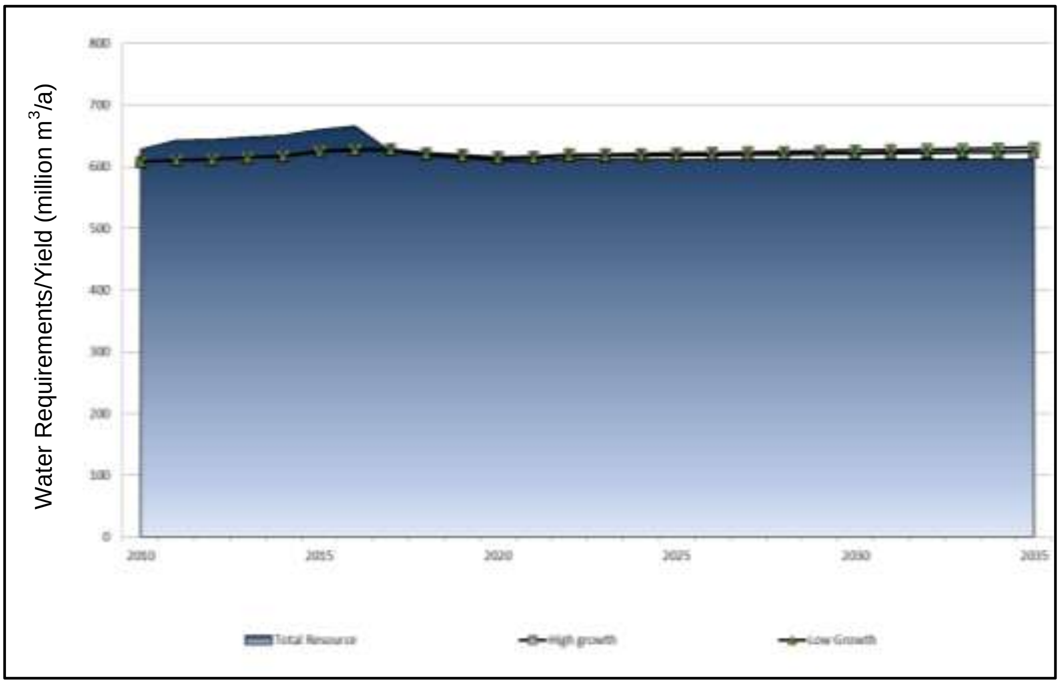


Figure 9.5: Upper Olifants Management Zone: No interventions and ecological Reserve operational from 2016

In **Figure 9.6** the reconciliation options that will reduce the water requirements have been applied and the graph shows that only these reconciliation options on their own already turns the water deficits in the Upper Olifants management zone into a surplus.

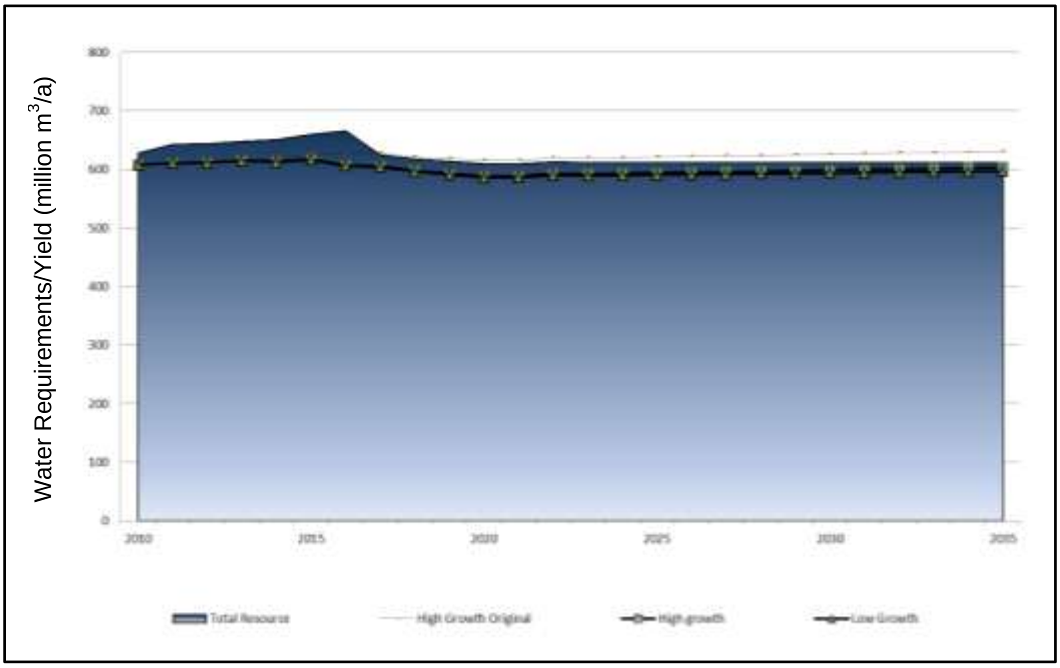


Figure 9.6: Surplus in the Upper Olifants as a result of water requirement reduction activities

Figure 9.7 illustrates what the effect will be of the reconciliation options that will increase the water supply. This will increase the surplus for the Upper Olifants water management zone, but this water will be needed for the Middle and Lower Olifants management zones.

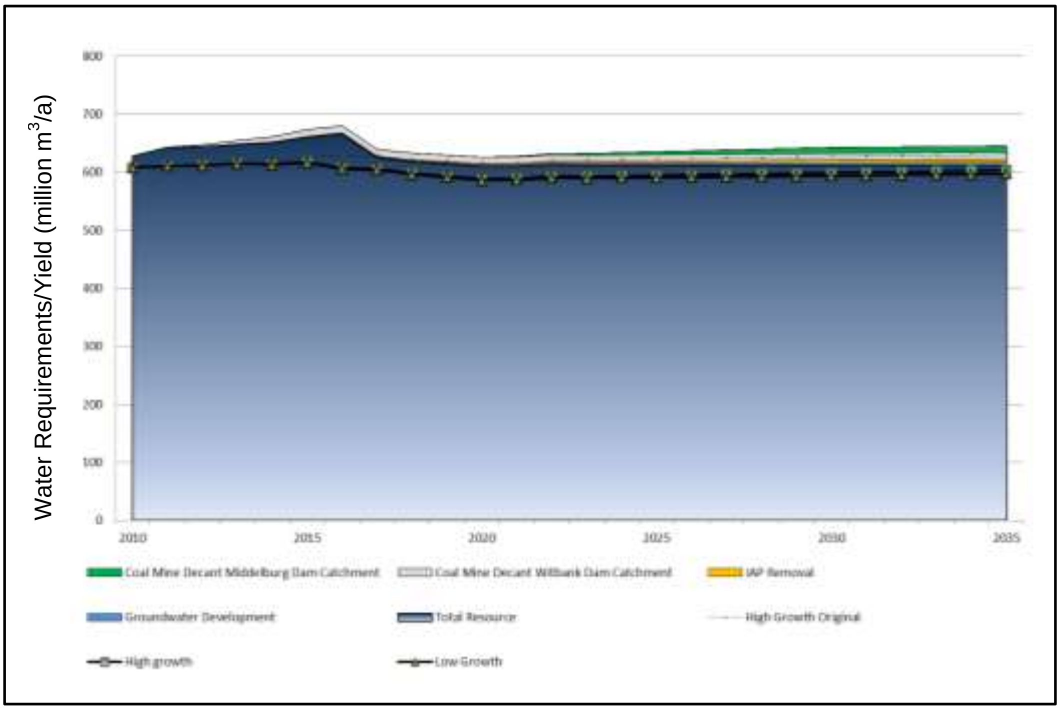


Figure 9.7: Upper Olifants Management Zone: All reconciliation options implemented

9.3.3 Actions that need to be started as a matter of urgency

The implementation of WC/WDM in irrigation relies on the co-operation of the water users and their willingness and ability to bring about a real reduction in water use. For the agricultural sector more efficient water use has in the past resulted in horizontal expansion (i.e. where a larger area is irrigated with the same quantity of water), and therefore no reduction in water use. The only way to increase the available resource from the reduced water demand is to make it attractive for irrigators so that they put their water savings on sales offer instead of expanding horizontally. The policy and guideline document for the purchase of partial water entitlements must be completed within the first implementation year i.e. 2012 and the planning of the WC/WDM measures completed in the same year so that they can be implemented as from 2013.

For the other users WC/WDM is a once-off saving on current water use only, as future demands have been calculated without allowing for more than acceptable losses. However, if WC/WDM is not enforced, the future demands will be even higher than calculated. For this reason it is absolutely essential that the WC/WDM targets for the urban and mining sectors are achieved.

Combatting unlawful water use is dependent on the Validation and Verification (V&V) processes but it is not necessary that the V&V processes are complete before the prosecutions can start. The V&V and prosecution processes can run almost in parallel and as V&V for an area gets completed the prosecutions can immediately proceed. It is however important that the V&V process which has been suspended, is resumed as early as possible in the first implementation year, i.e. 2012.

The treatment and re-use of acid mine drainage (AMD) water is also an option that can be implemented as and when the decanting mine water becomes available (**Figure 5.4** and **Figure 5.5**) and has already been implemented on a small scale. The potential is however relatively small at present but will reach a peak in approximately 4 years (2015) for the Witbank Dam Catchment and in approximately 2030 for the Middelburg Dam catchment. The treatment plants and mine linkages must be ready in these respective years.

9.4 MIDDLE OLIFANTS MANAGEMENT ZONE

9.4.1 Distributing De Hoop Dam Water

The Middle Olifants Management zone includes the Steelpoort Tributary where the De Hoop Dam is currently being constructed. The De Hoop Dam will eventually also supply water to rural areas and mines which are currently being supplied out of Flag Boshielo Dam. When the water balance of the Middle Olifants Management Zone is therefore considered, it must be kept in mind that some of the water shortages at Flag Boshielo Dam will be augmented from De Hoop Dam and that the timing of the ORWRDP phases of this water transfer becomes important.

The Middle Olifants Management Zone is firstly considered as a whole. In order to determine if any short term water shortages will occur during the construction of the ORWRDP, the water demand and availability were split for the Steelpoort Sub-catchment and the remaining Middle Olifants River main stem, including Flag Boshielo Dam. The reconciliation graphs for the two separate portions of the Middle Olifants Management Zone are dealt with in Paragraph 9.4.4.

9.4.2 The Selected Reconciliation Options: Middle Olifants

The selected reconciliation options that will reduce the water requirements are listed in **Table 9.5**.

Table 9.5: Reconciliation options that will reduce the water demand for Middle Olifants

Envisaged Intervention	Expected incremental saving (million m^3/a)	Expected date to be operational	Time to reach full saving (Y)
WC/WDM for irrigation and savings offered for purchase	2.8	2013	5
WC/WDM Urban	6.4	2013	5
WC/WDM Mining	1.6	2013	10
Eliminating unlawful water use	2.1	2015	5

Similar to the Upper Olifants Management Zone, the WC/WDM savings in the irrigation sector must be limited to water trading in order to avoid horizontal expansion of irrigation and to ensure that these savings become available for reallocation.

Although no new licences have been issued, the expansion in irrigation over the last number of years has reduced the system yield by an estimated 4.2 million m^3/a in the Middle Olifants Management Zone. The expansion cannot all be regarded as illegal and it was assumed that half of the 4.2 million m^3/a can be taken from the water requirements if all the unlawful water use gets eliminated.

The selected reconciliation options that will increase the water supply are listed in **Table 9.6**.

Table 9.6: Reconciliation options that will increase the water supply for Middle Olifants

Envisaged Intervention	Expected incremental yield/saving (million m^3/a)	Expected date to be operational	Time to reach full saving (Y)
De Hoop Dam	99**	2012	5
Groundwater development	15	2012	23
IAP removals	1.6	2012	23
Excess flow from Upper Olifants Management Zone	Varies*	From 2015	20
Reuse sewage water in Polokwane and Mogalakwena	12 (Starting at 4.5)	From 2012	23

* Not linear. Excess from Upper Olifants plotted on graph of Middle Olifants
** Net yield gain is 66 million m^3/a. Since the 33 million m^3/s EWR is shown separately on the graph, the total yield without its reduction for EWR is tabled here.

As described under 9.2.1, it was assumed that only half of the modelled volume is regarded as available exploitable groundwater. With the dolomite corridor running almost along the border of the Middle and Lower Olifants Management Zones, it was assumed that 15 million m^3/a (42.9% of 35 million m^3/a) will be exploitable in the Middle Olifants Management Zone.

It can be expected that a significant volume of excess water will flow from the Upper Olifants to the Middle Olifants Management. The excess flow has been added as additional yield for the Middle Olifants Management Zone.

It was again assumed that only 50% of the yield loss owing to IAPs (11.8 million m^3/a) would be regained for the same reason as mentioned under Paragraph 9.3.1.

Return flows as described in Paragraph 8.3.6 and shown in **Figure 8.6** can be reused. The sewage water need to be treated and can then be supplied to the mines in Mogalakwena. A quantity of 8 million m^3/a, is already supplied from Polokwane in this manner.

The ecological Reserve in the Middle Olifants Management Zone is 57 million m^3/a, i.e. 33 million m^3/a on the Steelpoort River which was linked to De Hoop Dam and 24 million m^3/a on the main stem. Currently 19 million m^3/a, should already be released out of Flag Boshielo Dam for ecological purposes. The Reserve will therefore increase the release from Flag Boshielo Dam by 5 million m^3/a.

9.4.3 Water Demand / Water Supply Graphs – Middle Olifants

This Management Zone will already have a deficit, i.e. high and low water requirement scenarios will exceed the system yield as shown on **Figure 9.8.** The predicted surplus from the Upper Olifants without reconciliation options does not improve the situation much. The deficit increases even further when the Reserve is operationalised. This was assumed to happen in 2016 when De Hoop Dam had a chance to fill and some of the water demand, currently under Flag Boshielo Dam, can be transferred to De Hoop Dam.

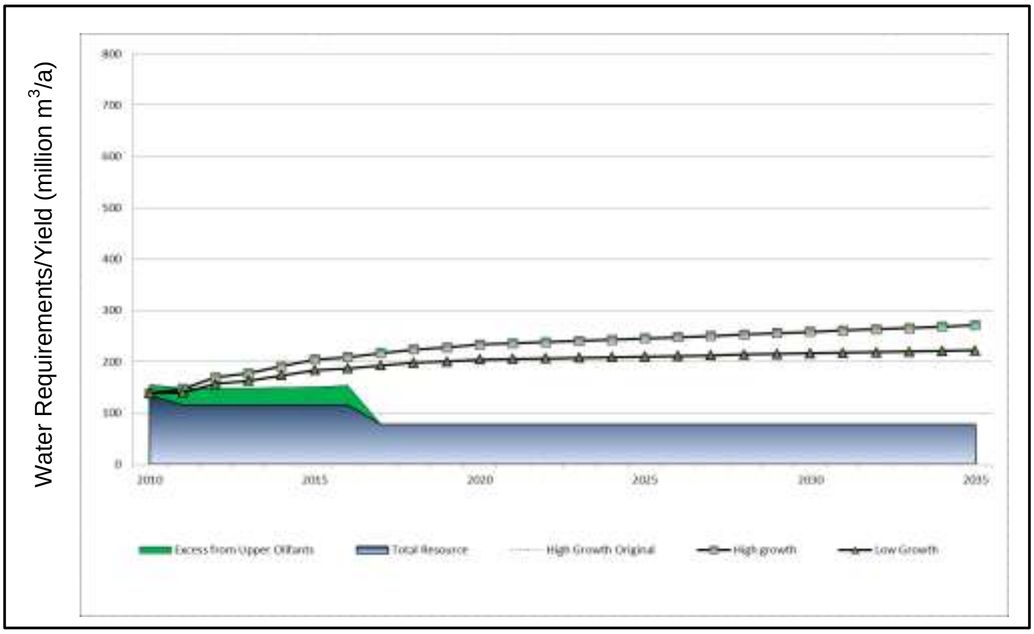


Figure 9.8: Water demand versus water supply: Middle Olifants

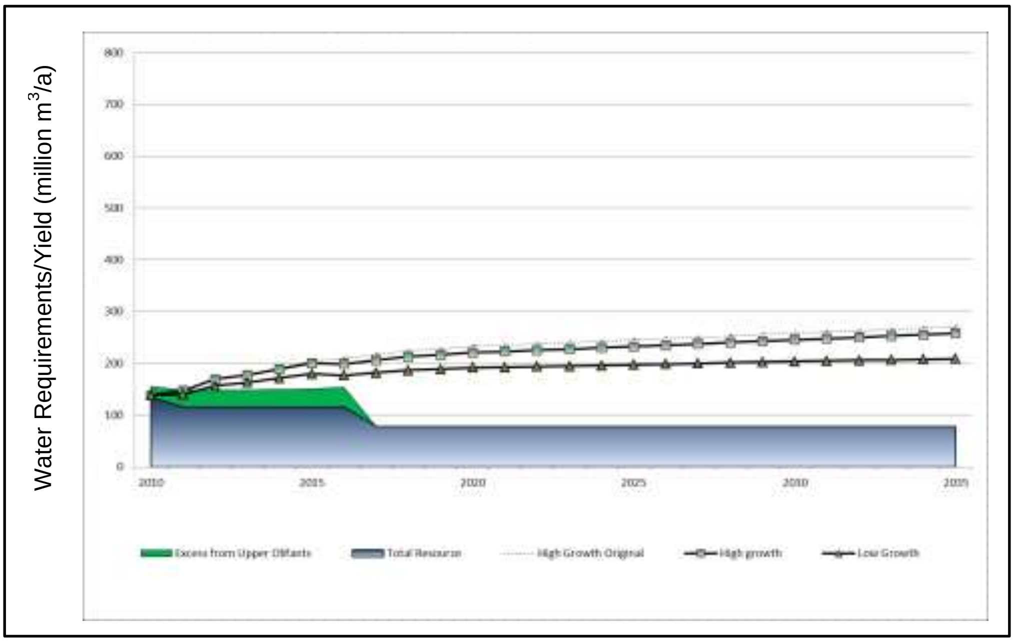


Figure 9.9: Middle Olifants Management Zone: Reconciliation options applied that will reduce the water requirements

By applying the water reconciliation options that will reduce the water demand, i.e. WC/WDM and eradication of unlawful water use, the high and low water demand scenario curves can be drawn down somewhat (**Figure 9.9)** but the water deficit situation remains, even after De Hoop Dam is added to the yield. This is shown in **Figure 9.10**.

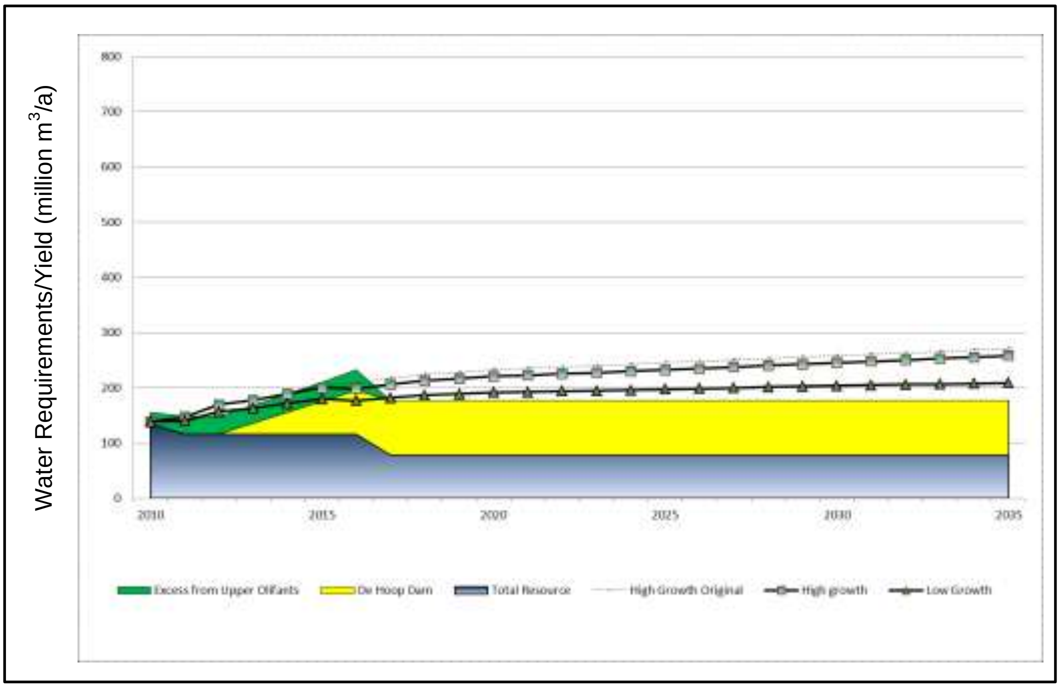


Figure 9.10: Middle Olifants with De Hoop Dam added and the reducing water requirement options applied

The water deficit situation can only be brought into balance with the reconciliation options that will increase water supply as per **Table 9.6** together with the excess water from the Upper Olifants Management Zone. Only a small deficit on the high growth curve occurs in the last three years. This is illustrated in **Figure 9.11.**

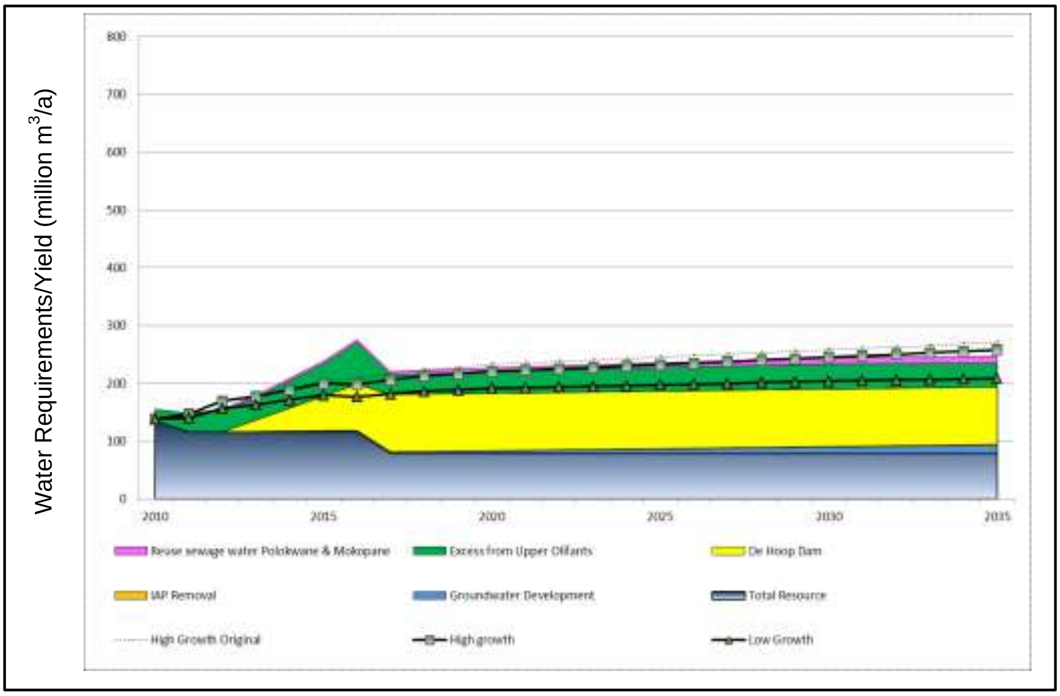


Figure 9.11: Water balance possibility for the Middle Olifants Management Zone with all interventions applied

9.4.4 Split between Steelpoort River and the Olifants River Main Stem

Supply areas that are currently being supplied from Flag Boshielo Dam will be transferred to the supply of De Hoop Dam as and when the pipeline infrastructure phases of the Olifants River Water Resources Development Project (ORWRDP) are being commissioned. A scenario where the full water supply areas, which are earmarked for the ORWRDP pipeline phases, can be supplied from De Hoop Dam was therefore tested for a water balance. It was therefore assumed that the full water demand for mining in the Middle Olifants and for the rural villages that are dependent on surface water will be supplied from the De Hoop Dam. This included the water transfer to Polokwane. A small quantity of water of 4 million m^3/a would still be needed out of Flag Boshielo Dam to make provision for the rural villages near the Olifants main stem which cannot be reached from the ORWRDP pipelines.

The high and low scenario water demand curves for this scenario are shown in **Figure 9.12**.

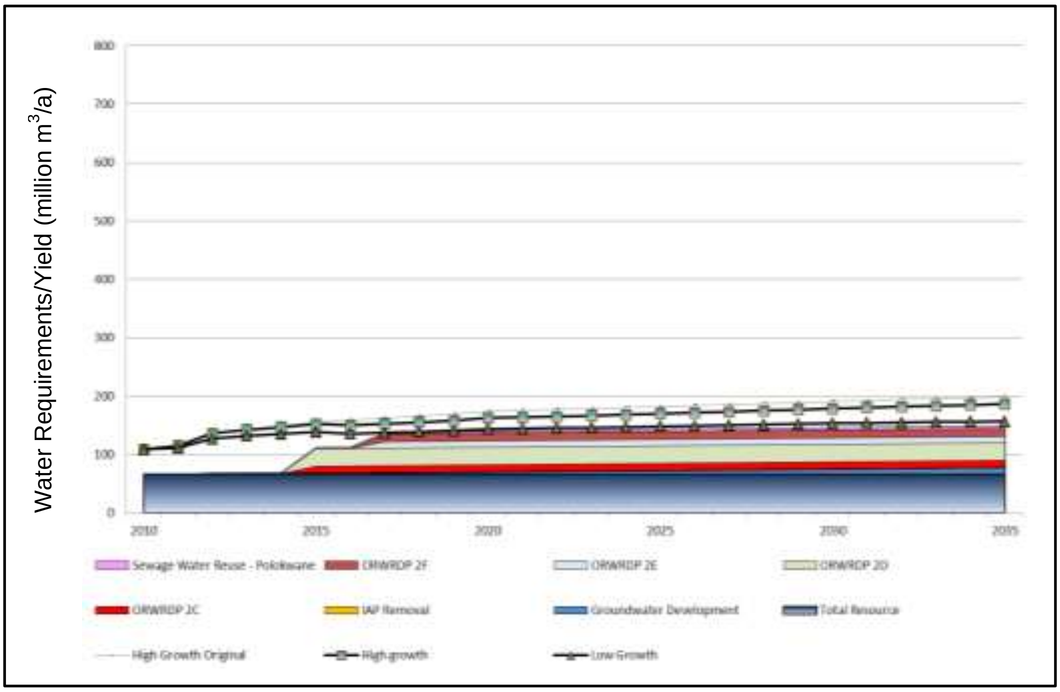


Figure 9.12: Steelpoort River – No water balance after all interventions and Phases 2C- 2F of ORWRDP commissioned

The available yield of De Hoop Dam (i.e. 99 million m^3/a minus the Reserve for the Steelpoort River) was then subdivided between Phases 2C – 2F of the ORWRDP in accordance to the total water demand in those supply areas. The different phases, their assumed supply quantities and the expected commissioning dates are provided in **Table 9.7**.

Table 9.7: Assumed water supply by the different ORWRDP phases and their expected commissioning dates

ORWRDP Phase	Assumed Supply Quantity (million m^3/a)	Expected Commissioning date
2C	12	2014
2D	30	2014
2E	11	2016
2F	13	2016
2C – 2F TOTAL	**66**	**2016**

Other interventions that increase water supply, namely groundwater development, IAP removal and sewage water reuse in Polokwane as listed in **Table 9.7** were also added to the water resource.

In **Figure 9.12** increase in water supply as a result of the different phases of the ORWRDP is shown as each phase is commissioned. This graph however shows that the De Hoop Dam cannot supply in the total need for which the ORWRDP was planned and that the deficit must be augmented from another source.

Table 9.8: Interventions for Steelpoort River that will increase the water supply

Envisaged Intervention	Expected incremental saving (million m^3/a)	Expected date to be operational	Time to reach full saving (Y)
Groundwater Development	7.5	2012	23
IAP Removal	1.6	2012	23
Sewage water reuse Polokwane	4.5 (Starting at 1.6)	2012	23

Subsequently the remaining high and low scenario water demands of the Middle Olifants Management Zone, including the water transfer to Mogalakwena were plotted on the graph in **Figure 9.13** and compared with the water availability from Flag Boshielo Dam. The yield of Flag Boshielo Dam will be increased through the excess water flow which is expected from the Upper Olifants Management Zone and through other interventions that will increase the water supply as shown in

Figure 9.13: Flag Boshielo Dam and Olifants River Main Stem: Surplus conditions, mainly as a result of excess flow from the Upper Olifants Management Zone

Table 9.9. From **Figure 9.13** it is clear that there will be a water surplus all the time for the scenario where the Mogalakwena area, existing irrigation and the villages between Flag Boshielo Dam and Olifantspoort Weir are supplied. It was then concluded that Flag Boshielo will still have to continue supplying areas and mines which were earmarked for the ORWRDP and augment the water supply from the Steelpoort River.

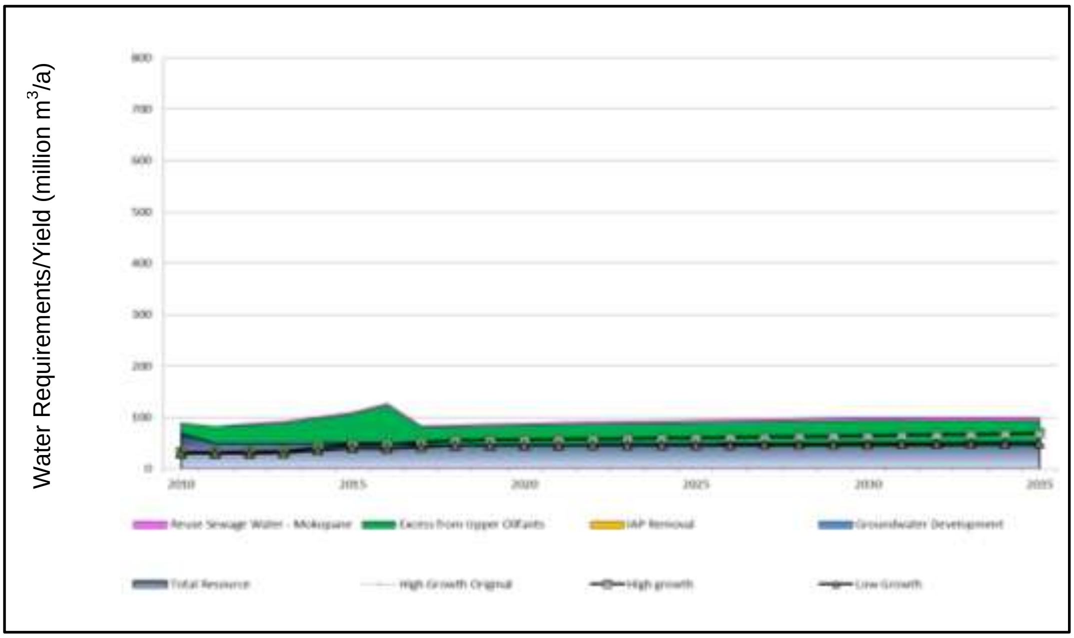


Figure 9.13: Flag Boshielo Dam and Olifants River Main Stem: Surplus conditions, mainly as a result of excess flow from the Upper Olifants Management Zone

Table 9.9: Interventions on Flag Boshielo Dam and Olifants Main Stem that will increase water supply

Envisaged Intervention	Expected incremental saving (million m^3/a)	Expected date to be operational	Time to reach full saving (Y)
Groundwater Development	7.5	2012	23
Excess from Upper Olifants	Varies 20 – 40	2011	24
Reuse of sewage water from Mogalakwena	6.2 (Starting at 2.9)	2012	23

In order to determine these demands, the differences (deficits) between the high and low scenario water demand curves and the water supply in **Figure 9.12** were then added to the high and low water demands of **Figure 9.13.** The new water demand curve after the addition is shown on **Figure 9.14**.

The result can be seen on the graph and a small water deficit can be expected from 2012 to 2014 only on the high growth water demand curve. The reason for this small deficit is the difference in the commissioning dates of the ORWRDP pipeline phases and the assumed linear progressing in 5 years to full yield of De Hoop Dam.

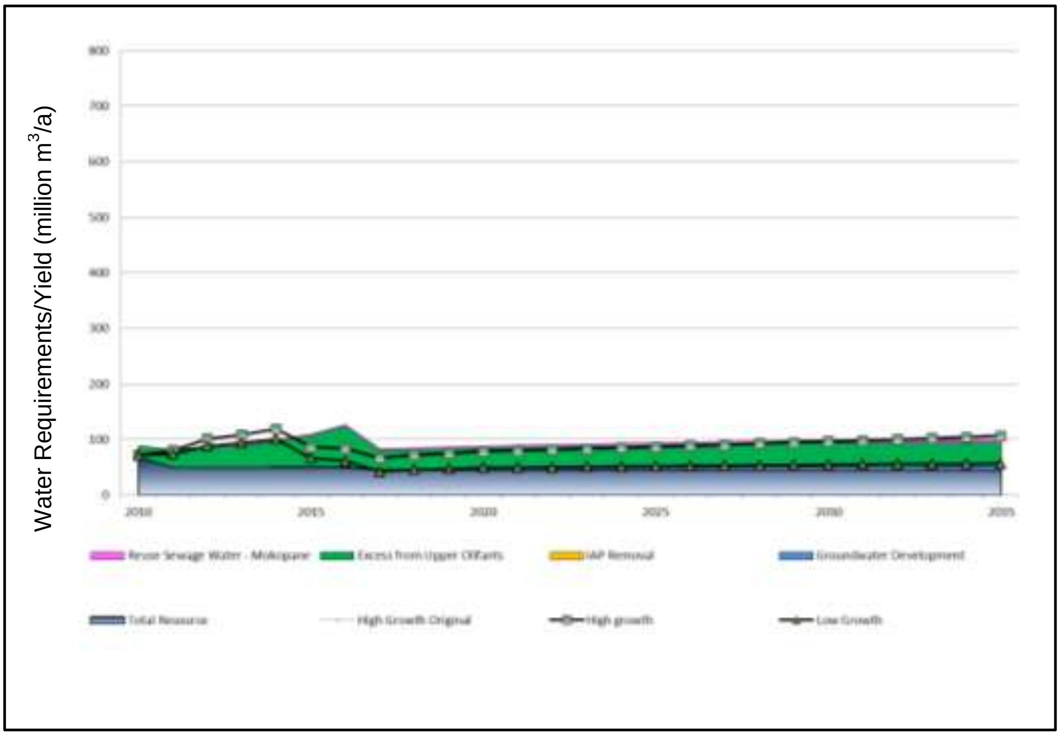


Figure 9.14: Flag Boshielo Dam and Olifants River main stem – Water deficit of ORWRDP added as demand

9.4.5 Actions that need to be started as a matter of urgency

The current situation cannot be allowed to continue. While it will take time for De Hoop Dam to fill and yield its full potential, the growth in the water demand must be slowed down as a matter of urgency. The reconciliation options to reduce the water requirement must be implemented without further delay.

The excess flow from the Upper Olifants Management Zone should be monitored carefully. It is important that the predicted water decant from the coal mines be confirmed. If this flow is not realised, consideration must be given to the trading of water entitlements from the irrigation sector to the mining. There is however no reason why the predicted excess flows from the Upper Olifants should not be trusted as the investigation by Golder Associates report very favourably about the mine decants and the additional yield created by the rehabilitated and decommissioned mines.

As explained under 9.2.3, it is important that WC/WDM and the purchase of partial water entitlements be linked and that the policy and guideline document for the purchase of partial water entitlements is completed within the first implementation year, i.e. 2012 and that WC/WDM is also planned in 2012 and started in 2013.

As explained under 9.2.3 the V&V and prosecution processes can run almost in parallel. As V&V for an area gets completed the prosecutions can immediately proceed. It is however important that the currently suspended V&V process is resumed as early as possible in the first implementation year, i.e. 2012.

The immediate water deficits on the Flag Boshielo Dam and Olifants main stem in the Middle Olifants Management Zone may need some attention. The deficits will be relatively small and it is suggested that it is made up by temporary water restrictions where only the low scenario water requirements are supplied over the period of 3 years (i.e. 2012 – 2014). Alternatively irrigation water can be purchased or leased on a temporary basis.

9.5 LOWER OLIFANTS MANAGEMENT ZONE

9.5.1 Present situation

The Lower Olifants is currently in surplus since the ecological Reserve has not as yet been operationalized. There is an arrangement whereby at least 0.5 m^3/s is released out of the Phalaborwa Barrage for 10 months of the year and 1 m^3/s for two months of the year. The purpose of this release is to ensure that there is always water in the Lower Olifants River as it flows through the Kruger National Park down to its confluence with the Letaba River. The total volume of this release is 18.5 million m^3/a. The operationalization of the Reserve will have the implication that it will reduce the system yield by a further 41 million m^3/a. This will turn the Lower Olifants Management Zone into a deficit as can be seen in **Figure 9.15.** The basic human needs (BHN) component of the Reserve has already been accounted for in the domestic water requirements of the management zone.

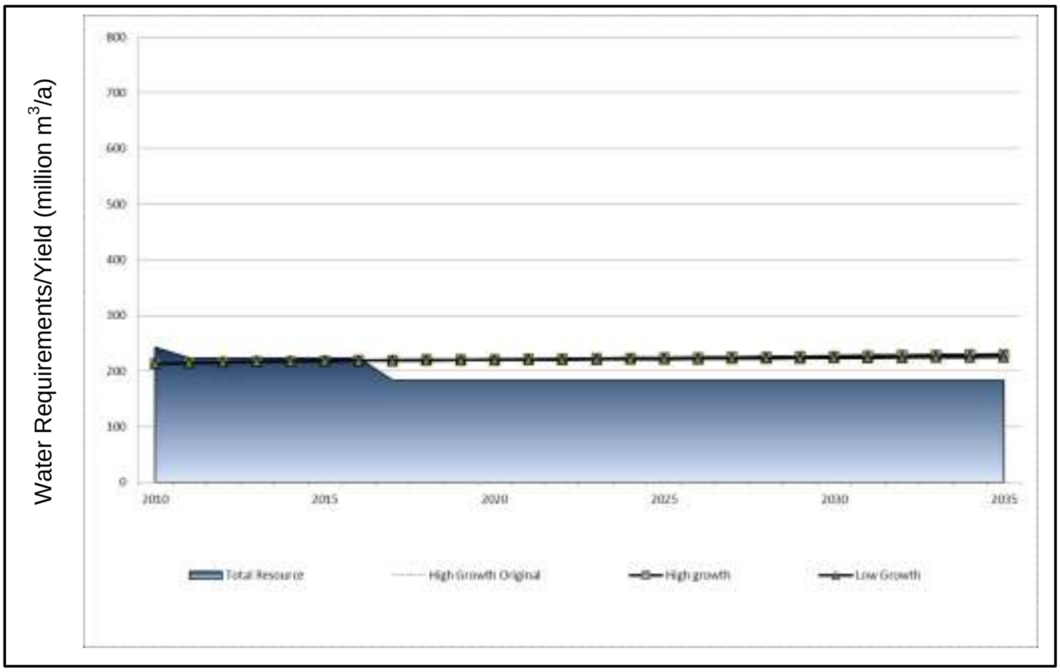


Figure 9.15: Lower Olifants in deficit as from 2016 after operationalization of the ecological Reserve

9.5.2 The Selected Reconciliation Options: Lower Olifants

The selected reconciliation options that will reduce the water requirements are listed in **Table 9.10**.

Table 9.10: Reconciliation options that will reduce the water demand for Lower Olifants

Envisaged Intervention	Expected incremental saving (million m^3/a)	Expected date to be operational	Time to reach full saving (Y)
WC/WDM for irrigation and savings offered to purchase	5.4	2013	5
WC/WDM Urban	3.1	2013	5
WC/WDM Mining	1.8	2013	10

Similar to the Upper and Middle Olifants Management zone, the WC/WDM savings in the irrigation sector must be linked to water trading in order to avoid horizontal expansion of irrigation and to ensure that these savings become available for re-allocation.

The growth in irrigation water use that impact on the system yield is concentrated in the Upper and Middle Olifants Management Zones and almost no growth was observed in the Lower Olifants Management Zone. The eradication of unlawful irrigation water use is therefore negligible and is ignored as a management option in this Management Zone.

The selected reconciliation options that will increase the water supply are listed in **Table 9.11.**

Table 9.11: Reconciliation options that will increase the water supply for Lower Olifants

Envisaged Intervention	Expected Incremental yield (million m^3/a)	Expected date to be operational	Time to reach full yield (Y)
Groundwater development	15	2012	23
IAP removals	3	2012	23

Groundwater development has again been factored in for this Management Zone and 15 million m^3/a have been added to the system yield. It was assumed that this development will progressively happen over the full planning horizon of the study.

It was again assumed that only 50% of the yield loss owing to IAPs (6 million m^3/a), would be regained since the working for water programme is a continuous programme which will not be completed within the planning horizon of the study.

9.5.3 Water Demand / Water Supply Graphs: Lower Olifants

The deficit after operationalising the Reserve in 2016 is alleviated after implementing the reconciliation options that will reduce the water requirements (**Table 9.10**) but the system will still remain in deficit as shown in **Figure 9.16**.

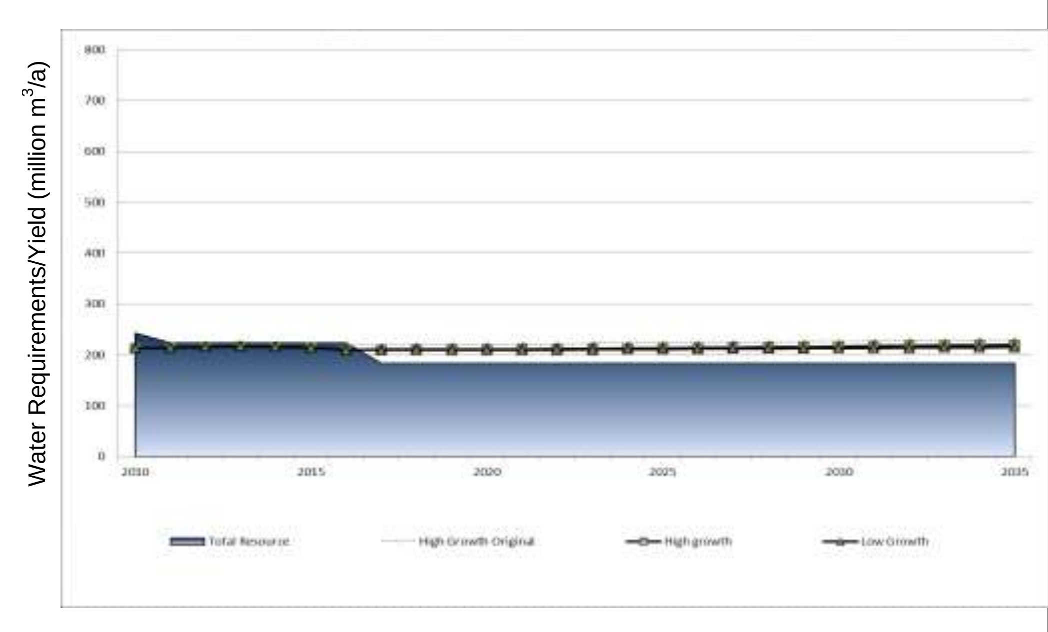


Figure 9.16: Lower Olifants system yield and reduced high and low water requirement

When the reconciliation options, that will increase the system yield, are implemented, a slight improvement is achieved but the system will remain with a deficit. This is shown in **Figure 9.17**.

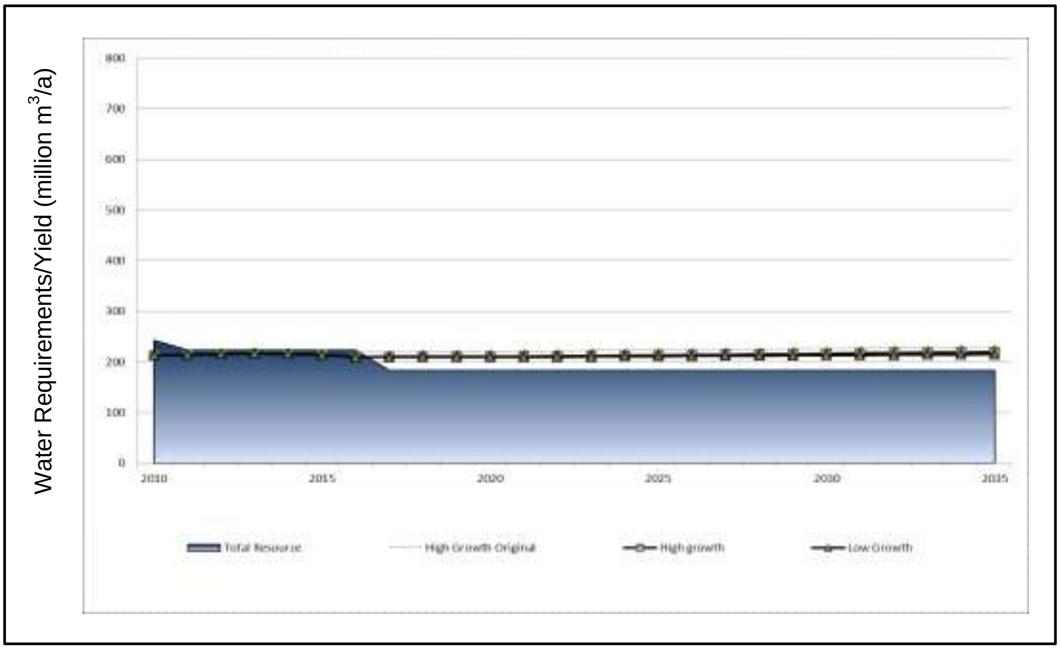


Figure 9.17: All measures on Lower Olifants: Water deficit still remains after operationalising of the Reserve

9.5.4 Actions that need to be started as a matter of urgency

Although this Management Zone is currently experiencing a water surplus, this surplus is required for the Reserve. The reconciliation options as in **Table 9.10** and **Table 9.11** must therefore be implemented as scheduled.

Groundwater needs to be developed over the full planning period of 25 years.

As with the other two Management Zones, it is important that WC/WDM and the purchase of partial water entitlements are linked and that the policy and guideline document for the purchase of partial water entitlements is completed within the first implementation year, i.e. 2012 and that WC/WDM is also planned in 2012 and started in 2013.

As for the other two Management Zones, it is again absolutely essential that the WC/WDM targets for the urban and mining sectors are achieved as future water demands have been calculated without allowing for more than acceptable losses.

The measures listed in **Table 9.10 and Table 9.11** are however not adequate and further measures are necessary to bring the system into balance

A number of dam development options have been investigated as described in *Report No. P WMA 04/B50/00/8310/14*, "Management and Development Options and Cost Estimates Report". The dams in the lower Olifants, i.e. Epsom, Mica and Madrid sites will have significant social impacts and have relative high URVs. The raising of the Blyderivierspoort Dam will have less social and environmental impacts but the foundation conditions on the left flank of the dam are a risk. The two dams in the Olifants River Gorge have low URVs but lots of resistance is expected from an environmental point of view.

The deficit is however so small (in the order of 20 million m^3/a) that a dam cannot be justified. It is recommended that the real situation is monitored and if necessary, irrigation water can be purchased. The irrigation boards should identify those farmers who are currently not utilizing their first water entitlements and the farmers can then be approached first.

10. THE OLIFANTS RECONCILIATION STRATEGY IN A NUTSHELL

The following is envisaged for the Olifants catchment for the next 25 years:

i. The Reserve needs to be operationalized as soon as practical. It is expected that this will be achieved in 2016 as De Hoop Dam reaches its full yield potential.

ii. Water required to supply the current and future social and economic activities in the Olifants catchment will have to come from the catchment's local resources, except for the power stations within the catchment.

iii. Water to power stations will continue to be supplied from the Usuthu, Komati and Vaal systems.

iv. Water required by the Polokwane and Mokopane supply areas will be augmented from the Olifants catchment.

v. Water requirements can be balanced by availability through the implementation of the following measures:
   - Eliminating unlawful water use. The target date for the majority of transgressions to be addressed is 2018, after which compliance monitoring and enforcement will remain an on-going activity.
   - Introducing water conservation and water demand management (WC/WDM) in all sectors. Full water savings need to be achieved within five years in the irrigation and urban water use sectors, and within 10 years in the mining sector.
   - The introduction of a mechanism whereby water saved through water use efficiency (WUE) measures, especially in agriculture, can be traded back into the market. This means that water users will be in a position to sell their water savings, and not necessarily use this water to expand horizontally.
   - The treatment of acid mine drainage water to an acceptable standard, either for immediate direct use or before it is allowed to decant into the river system.
   - Invasive alien plants must be removed. Working for Water programmes must be accelerated to ensure that at least 50% of infested areas, plus all new growth, is eradicated by 2035.
   - Groundwater resources must be developed as a priority. The Malmani dolomites must be investigated as a possible resource for a regional water supply scheme.
   - Return flows from Polokwane and Mokopane should be reused by the urban or mining sector.

vi. All above measures lean more towards management interventions rather than development interventions. An orchestrated effort is necessary to ensure that objectives are achieved. If these implementation measures are not as successful as assumed, in spite of the fact that the assumed measures are conservative, the water will have to be reallocated to other use by means of compulsory licensing or by buying out water entitlements in respect of value irrigation.

11. RISKS AND UNCERTAINTIES

The following risks and uncertainties have been identified:

- The extent of unlawful water use is unknown. Until the V&V processes are complete, the water reconciliation strategy will have to rely on the best estimates.

- The possible additional yield which could become available as a result of additional infiltration into existing and decommissioned coal mines is based on the best information available. A study is currently being conducted to improve the confidence in this information but the results of this study were not ready for the purpose of this strategy.

- The results of the Agricultural Research Council (ARC) survey on Invasive Alien Plants (IAPs) need to be verified. It appears as if there could be an over-estimation of IAPs in the Upper Olifants Management Zone, but if correct, it will affect the current water balance negatively in this zone.

- The success of the purchasing of water entitlements (WC/WDM savings) as an option is difficult to predict. It is not clear how many water users would, in the longer term, offer water entitlements or parts thereof for sale and how much water will eventually be freed up. Care must be taken that irrigation farmers don’t cause social upheaval by selling their water entitlements. There must therefore be a well-structured policy in place that will prevent interested sellers from going overboard.

- The cooperation of District and Local Municipalities is of utmost importance for achieving the WC/WDM targets in the urban water use sector.

- The postponement of the establishment of the Olifants Catchment Management Agency is seen as a core fundamental stumbling block in implementing the strategy successfully. If the establishment of the CMA is delayed furhter, the successful implementation of this strategy holds a significant risk.

- Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc. This may not necessarily materialise to the extent, or within the time frames that has been assumed in this study.

- The outcome of the Resource Classification process that has now started as a separate study can have a significant impact on the setting of the resource quality objectives and therefore the EWRs. This in turn may have an impact on the assured yield of the system.

- Tshwane Metro provided new water requirements for Bronkhorstspruit Town and Thembisile right at the end of the study of approximately 73 million m^3/a, which is significantly higher than documented in this study. It is however suspected that Tshwane is referring to the water treated at Bronkhorstspruit Town and that their figure represents peak water demands and not yearly average water demands. These uncertainties could not be resolved as part of this study as the inputs were only provided at the close of the study, but it should be taken further in the envisaged Maintenance Study. Detail of the Tshwane inputs are documented in Appendix B of this report.

- The Olifants River Joint Water Forum and Anglo American Platinum commented that they are concerned about relying too much on the water management interventions (e.g. WC/WDM, eradication of unlawful water use end removal of alien invasive plants) and that development options such as the transfer of treated sewage water from Ekurhuleni should have been allocated a higher priority. The water management options require huge amounts of energy from various role players and failure in coordinating these activities effectively holds a risk of not achieving the future water balance.

12. IMPLEMENTATION ARRANGEMENTS

It must be realised from the outset that DWA, as trustee of the country's water resources, is only facilitating the process of water reconciliation planning and that implementation is the responsibility of many more institutions.

12.1 INSTITUTIONAL RESPONSIBILITIES

The following entities will play a crucial role in all aspects of implementation of the strategy:

- DWA Regional Office;
- CMA;
- ESKOM;
- Mines;
- Industries
- Municipalities;
- Water Boards;
- Irrigation Boards and Water User Associations;
- Organised Agriculture; and
- Nature Conservation Institutions (e.g. South African National Parks (SANP))

As far as the water supply to towns is concerned, the municipalities have a crucial role to play. The actual planning work for water supply to municipalities is covered in the All Towns Study which was done by DWA, parallel to this study (DWA, 2010). Municipalities however need to take responsibility not exceeding the water demand by launching initiatives on both the water requirement side for meeting the legitimate demands of users by managing the water supply side. WC/WDM is very important and municipalities must ensure that everything possible is done to ensure that water is used efficiently. Municipalities are dependent on the cooperation of each of their citizens and therefore initiatives such as public awareness campaigns and encouragement campaigns for e.g. retrofitting water saving devices must run parallel with WC/WDM actions that have to be performed by the municipality staff such as leakage detection on pipelines, improved metering, etc.

On the supply side, municipalities must realise that groundwater, which is often overlooked, can also offer reconciliation solutions. Groundwater is highly suited for small town domestic supply and in this basin should always be one of the first options to be considered before turning to a surface water option.

The Local Municipalities of eMalahleni and Steve Tshwete need to consider further use of decanted mine water from the coal mine fields which can be reclaimed to drinking water standards.

The fact that a CMA hasn't been established as yet for a complex and water stressed catchment such as the Olifants catchment is a disadvantage. A CMA needs to be established as a matter of urgency since the Olifants catchment contains all the elements that are normally considered important for determining the priority for CMA establishment, e.g.:

- International river;
- Water transfers in and out of the catchment;
- Strategic water users, e.g. power stations;
- Huge irrigation demand;
- Water quality problems – catchment earmarked as a pilot catchment for the Waste Discharge Charge System;
- Significant economic development (e.g. mines);
- Need for nature conservation (e.g. KNP and other nature reserves)

A CMA is indispensable when reconciliation options such as compulsory licensing purchase of water entitlements and operation rules are considered.

It is recommended that the Department takes a relook at the priority of this catchment in terms of CMA establishment and put all measures in place to accelerate the process for its establishment.

Table 12.1 outlines the different interventions that have been considered for achieving a water balance, the required actions and the institutional responsibilities. It should be noted that the responsibility allocations and target dates are indicative. A detailed action plan needs to be compiled in which the actions will have to be broken down further with specific responsibilities and time lines. This will however form part of the implementation process.

Table 12.1: Institutional Responsibilities

Intervention	Brief Description of Actions	Primary Responsibility	Comments	Target Date
Addressing the unlawful irrigation use (Compliance monitoring and Enforcement)	• Validation and verification	DWA Regional Offices	CMAs will take over this responsibility once established	End 2016
	• Directives to unlawful water users	DWA Regional Offices	CMAs will take over this responsibility once established	End 2018
	• Legal action where needed	DWA Legal Services	CMAs will take over this responsibility once established, but assisted by DWA Legal Services	End 2018
	• Maintenance of lawful water use in controlled areas	IBs / WUAs	Supervised by Regional Office and, once established, the CMA	On-going

Intervention	Brief Description of Actions	Primary Responsibility	Comments	Target Date
WC/WDM Urban	• Pressure management; mains replacement; Leak detection and repair	Water Services providers (District Municipalities, Local Municipalities, Water Boards, WUAs), Industries	Each water services provider must develop their own plan	End of 2016 for WSPs with plans
	• Public awareness on efficient appliances, water efficient gardening, retrofitting, friendly and informative billing, etc.	Water Services providers and the broad public	Awareness launches to be arranged by water services providers. Could be assisted by DWA Water Use Efficiency.	End 2017 for those that still need to do planning
	• Water pricing	DWA Head Office	In line with Water Pricing Strategy	
WC/WDM Mining	• Process adaptations for enabling water recycling and water reuse	Mine owners and Operators, Industries		End 2021
	• Retrofitting water saving devices	Mine owners and Operators, Industries		End 2016
WC/WDM in the irrigation sector (in-field measures)	• Improved systems	Irrigators		End 2016
	• Repair leakages	Irrigators		End 2016
	• Improved scheduling	Irrigators		End 2016
	• Seal lei dams	Irrigators or IBs on behalf of Irrigators		End 2016
WC/WDM in the irrigation sector (addressing canal/pipe leaks)	• Accelerated programmes for refurbishing and replacing worn-out conveyance systems	IBs and WUAs		End 2016

Intervention	Brief Description of Actions	Primary Responsibility	Comments	Target Date
Water Trading (Purchase of water entitlements)	• Develop policy and guidelines	DWA HO	Necessary to build in check and balances	End 2012
	• Launch of WC/WDM initiative and water trading process	DWA HO DWA Regions Later CMA	Need to be linked to WC/WDM. CMA becomes involved once established	End 2015
	• Validation and verification	DWA Regions	CMA will take over. V&V done ad hoc for entitlements of willing sellers	End 2015
Removal of IAPs	• Removal of plants	Working for Water Teams	CMAs, IBs, WUAs, Forestry Companies, Local Municipalities can all perform this function and should collaborate with the DWA Working for Water Teams	On-going. Removal must be faster than the growth of IAPs. Reduce IAPs by at least 50% over 23 years.
	• Rehabilitate land and re-establish indigenous vegetation	WfW Teams		
	• Follow up and maintenance	WfW Teams		
Groundwater Development	• Borehole siting • Drilling • Infrastructure development	DMs, LMs, Water Boards, Mine Companies, Industries, Private individuals	Licenses (if applicable) to be issued by DWA Regional Offices or later CMA	On-going from 2012
Operationalization of the Reserve	• Complete Water Resource Classification	DWA HO		End 2012
	• Establish flow monitoring network	DWA Regions, IBs, WUAs, WBs		End 2015
	• Establish operating rules	DWA Regions, IBs, WUAs, WBs		End 2015
	• Monitor and adjust	DWA Regions, IBs, WUAs, WBs		Beginning of 2016

Intervention	Brief Description of Actions	Primary Responsibility	Comments	Target Date
Treating AMD	• Feasibility Study	Mine Companies and DWA	Remaining Mine companies must treat their own AMD and DWA will take responsibility of decommissioned mines with no owners or where owners cannot be traced.	2015 for AMD in Witbank Dam Catchment
	• Design			
	• Tenders			2020 for AMD in Middelburg Dam Catchment
	• Construction			

12.2 FUNDING

Capital will be required for recycling/treating AMD and to refurbish water supply infrastructure as part of WC/WDM. No other capital expenditure is required to implement the proposed short-term actions, Operational funding from the DWA will be required for some of the other actions.

Capital investment will be required if any one of the structural development options is pursued. A capital project such as the construction of a dam can be funded from either the fiscus or it can be undertaken by an institution such as the TCTA which also can obtain funds from international financial markets or funding agencies, e.g. The World Bank. Normally the purpose of the project will determine whether the project should be DWA funded or funded from elsewhere. Should the project for example be needed for the water supply to resource poor communities, funding out of the fiscus could be considered by Parliament. Water supply to enterprises that can redeem the capital expenditure themselves, is then normally funded off-budget outside DWA.

At present the treatment of AMD is undertaken as a privately funded project by the mines. The water is sold at below the treatment cost to the municipality, and the balance is absorbed by the mines. This model may not be sustainable in the long run as the quantity of water to be treated increases and the number of mines declines. At the same time the quantity of AMD water may eventually exceed the requirements of the municipalities. Under these circumstances a different funding model may have to be considered. Treatment of AMD from decommissioned mines where the owners can no longer be traced will be the responsibility of the State.

A possible solution would be to make the water available to ESKOM for power generation, which would then free up part of the water that is currently transferred from the Vaal River to the Olifants River. Under the principle that “the polluter pays” the cost of treating the AMD can then be passed on to the consumer in the form of an increase in the electricity tariff. In this way it would be possible to recover the full cost and thereby ensure the sustainability of the project.

13. RECOMMENDATIONS FOR FURTHER WORK (This Strategy)

RECOMMENDATIONS TOWARDS IMPLEMENTATION

- The ecological categories and Reserve quantum adopted in this final reconciliation strategy must be compared with the results of the current Departmental Water Resource Classification study, once the study is complete.
- All management options (except compulsory licensing) to reduce the water requirements must be implemented as soon as possible.
- The WC/WDM in the irrigation sector should be linked to water trading.
- A policy and guideline document on the purchase of partial water entitlements (save water through WC/WDM measures) are urgently required and should be produced by DWA during the first year of implementation 2012.
- The validation and verification process must be resumed and accelerated. Various interventions are dependent on this process, e.g. purchase of water entitlements, water trading, compulsory licensing and eliminating unlawful water use.
- The establishment of a catchment management agency for the Olifants River should be accelerated.
- Groundwater development in unstressed aquifers must be encouraged. Groundwater in stressed aquifers must be managed and regulated better.
- The impacts of all interventions must be continuously monitored. Given the many uncertainties it is essential to stay ahead, respond rapidly, and to manage the system as indicated by successes or failures in measures applied.
- The intended Water Quality Management strategy must commence and be completed and water pollution must be addressed at source.

RECOMMENDATIONS FOR FURTHER WORK

The following further work is recommended:

- A possible regional water scheme with the Malmani dolomites as resource should be investigated. The impact of groundwater abstraction from the Malmani dolomites must be explored further in order to establish whether there is any impact on the surface water base flow in the Olifants River. The possibility of artificial recharge of the Malmani dolomites with surface water should also be investigated.
- Operating rules for possibly operating Middelburg Dam, Witbank Dam, Loskop Dam, De Hoop Dam and Flag Boshielo Dam as a system must be developed and implemented, including the management of river losses.
- The accuracy of the Agricultural Research Council Study on the Invasive Alien Plants infestation should be determined.

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Appendix A

Tables A-1 to A-11

1999 results of Eco-Classification in terms of the PES and the Recommended Ecological Category (REC) and the 2010 results per reach of the Olifants River

EWR 1: OLIFANTS RIVER LODGE

Table A- 1: Overall 1999 Result, PES and 2010 Result for EWR 1: Olifants River Lodge Reach

Driver Components	1999 PEC	1999 REC	2010 PES & REC	Change
HYDROLOGY	D			-
NUTRIENTS	C	C	C/D	-
TDS	D	C	C	=
WATER QUALITY	D	C	C	-
GEOMORPHOLOGY	C	C		
Response Components	**PES**	**1999 REC**	**2010 PES**	**Change**
FISH	E	C	D/E	-
MACRO INVERTEBRATES	C	C	D	-
INSTREAM			D	-
RIPARIAN VEGETATION	C	C	C	=
ECOSTATUS	D	C	D	-
INSTREAM IHI	D	C	C/D	-
RIPARIAN IHI	C	C	D	=
EIS	High		Moderate	

Key
- \- Negative Change
- \+ Positive Change
- = No Change

The 1999 EWRs were set for a C and a D ecological classification. The C EWR was for the REC based on the HIGH EIS. As the EIS is now MODERATE, and the REC) a D, it is recommended that the D EC EWR (1999) should be used for yield modelling purposes and planning.

EWR 3: KLEIN OLIFANTS RIVER LODGE

Table A- 2: Overall 1999 Result, PES and 2010 Result for EWR 3: Klein Olifants River Lodge Reach

Driver Components	1999 PEC	1999 REC	2010 PES	2010 REC	Change
HYDROLOGY	D				
NUTRIENTS	D		C/D		
TDS	C	C	C	C	
WATER QUALITY	C	C	C	C	=
GEOMORPHOLOGY	C	C			
Response Components	**1999 PES**	**1999 REC**	**2010 PES**	**2010 REC**	**Change**
FISH	D	C	D	D	-
MACRO INVERTEBRATES	C	C	D/E	D	-
INSTREAM			D/E	D	-
RIPARIAN VEGETATION	C	C	C/D	C/D	-
ECOSTATUS	D	C	D	D	-
INSTREAM IHI	D	C	C/D		
RIPARIAN IHI	D	C	D		
EIS	Moderate		Moderate		

Key
- Negative Change
+ Positive Change
= No Change

The 1999 EWRs were set for a C and a D ecological classification. The C EWR was for the REC. As the EIS is MODERATE, and the REC a D, it is recommended that the D EC EWR (1999) is used for yield modelling purposes and planning.

EWR 4: WILGE RIVER

Table A- 3: Overall 1999 Result, PES and 2010 Result for EWR 4: Wilge River Reach

Driver Components	1999 PEC	1999 REC	2010 PES	2010 REC	Change
HYDROLOGY					
NUTRIENTS	C	B	C		-
TDS	A	A	B		=
WATER QUALITY	B	B	B/C	B	-
GEOMORPHOLOGY	B	B			
Response Components	**1999 PES**	**1999 REC**	**2010 PES**	**2010 REC**	**Change**
FISH	B	B	C	B	-
MACRO INVERTEBRATES	B	B	C/D	B/C	-
INSTREAM			C	B	-
RIPARIAN VEGETATION	B	B	A/B	A/B	=
ECOSTATUS	B	B	C	B	
INSTREAM IHI	B	B	C		
RIPARIAN IHI	B	B	A/B		
EIS	High		High		

Key
- Negative Change
+ Positive Change
= No Change

The 1999 EWRs were set for a B and a C ecological classification. The B EWR was for the REC. As the EIS is HIGH, and the REC a B, it is recommended that the B EC EWR (1999) should be used for yield modelling purposes and planning. It must be noted, however, that without addressing the water quality problems, these flows will not achieve the REC.

EWR 5: OLIFANTS RIVER (THE MANSION)

Table A- 4: Overall 1999 Result, PES and 2010 Result for EWR 5: Olifants River (The Mansion) Reach

Driver Components	1999 PEC	1999 REC	2010 PES & REC	Change
HYDROLOGY	E/F			
NUTRIENTS	B	C	C	-
TDS	C	C	B	+
WATER QUALITY	C	C	B/C	+
GEOMORPHOLOGY	C	C		
Response Components	**1999 PES**	**1999 REC**	**2010 PES & REC**	**Change**
FISH	C	C	C/D	=
MACRO INVERTEBRATES	B	C	C/D	-
INSTREAM			C/D	-
RIPARIAN VEGETATION	C	C	B/C	=
ECOSTATUS	C	C	C	=
INSTREAM IHI	D	C	C/D	
RIPARIAN IHI	C	C	C	
EIS	High		Moderate	

Key
- Negative Change
\+ Positive Change
= No Change

The 1999 EWRs were set for a B* and a C ecological classification. The B EWR was for the REC. As the EIS is now MODERATE, it is recommended that the C EC EWR (1999) be used for yield modelling purposes and planning

EWR 6: ELANDS RIVER

Table A- 5: Overall 1999 Result, PES and 2010 Result for EWR 6: Elands River Reach

Key
- Negative Change
+ Positive Change
= No Change

Driver Components	1999 PEC	1999 REC	2010 PES	2010 REC	Change
HYDROLOGY	E/F				
NUTRIENTS	B	B	C	C	-
TDS	D	D	D	D	=
WATER QUALITY	D	D	C	C	-
GEOMORPHOLOGY	D	D			
Response Components	**1999 PES**	**1999 REC**	**2010 PES**	**2010 REC**	**Change**
FISH	E	D	D/E	B	+
MACRO INVERTEBRATES	D	D	C	B/C	+
INSTREAM			D	B	
RIPARIAN VEGETATION	D	D	C/D	A/B	-
ECOSTATUS	E	D	C/D	B	+
INSTREAM IHI	E	D	D/E		
RIPARIAN IHI	D	D	D		
EIS	Moderate		Moderate		

The 1999 EWRs were set for a D and a C ecological classification. In this situation, it is, however, more logical to, with whatever volumes are being released, design more ecologically-friendly operating rules. This would be more relevant than a EWR.

EWR 8: OLIFANTS RIVER (STELLENBOSCH)

Table A- 6: 1999 Result, PES and 2010 Result for EWR 8: Olifants River (Stellenbosch) Reach

Driver Components	1999 PEC	1999 REC	2010 PES & REC	Change
HYDROLOGY	E/F			
NUTRIENTS	B	B	B	?
TDS	E	D	C	?
WATER QUALITY	D	D	C	?
GEOMORPHOLOGY	E	?	E	=
Response Components	**1999 PES**	**1999 REC**	**2010 PES & REC**	**Change**
FISH	D	D	D	=
MACRO INVERTEBRATES	D	D	C/D	=
INSTREAM			C/D	
RIPARIAN VEGETATION	D	D	C	=
ECOSTATUS	E	D	C/D	=
INSTREAM IHI	E	D	C/D	
RIPARIAN IHI	E	D	C/D	
EIS	Moderate		Moderate	

Key
- Negative Change
+ Positive Change
= No Change

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

EWR 9: STEELPOORT RIVER

Table A- 7: Overall 1999 Result, PES and 2010 Result for EWR 9: Steelpoort River Reach

Key
- Negative Change
+ Positive Change
= No Change

Driver Components	1999 PEC	1999 REC	2010 PES & REC	Change
HYDROLOGY	B/C			
NUTRIENTS	B	B	B	=
TDS	C	C	B/C	=
WATER QUALITY	C	C	B	=
GEOMORPHOLOGY	D	?		
Response Components	**1999 PES**	**1999 REC**	**2010 PES & REC**	**Change**
FISH	D	D	C	=
MACRO INVERTEBRATES	D	D	C/D	=
INSTREAM			C/D	
RIPARIAN VEGETATION	D	D	D	=
ECOSTATUS	D	D	C/D	=
INSTREAM IHI	D	D	C	
RIPARIAN IHI	E	D	C/D	
EIS	High		Moderate	

During 1999, the EIS was HIGH, but the REC was set for a D EC. As the D EC equates to the C/D (2010) EC, the D EWR can be used for yield modelling.

EWR 12: BLYDE RIVER

Table A- 8: Overall 1999 Result, PES and 2010 Result for EWR 12" Blyde River Reach

Driver Components	1999 PEC	1999 REC		2010 PES	2010 REC	Change
HYDROLOGY	B					
NUTRIENTS	B	B		B	B	=
TDS	B	B		B	B	=
WATER QUALITY	B	B		B	B	=
GEOMORPHOLOGY	B	B			B	=
Response Components	**1999 PES**	**1999 REC**		**2010 PES**	**2010 REC**	**Change**
FISH	B	B		C	B	=
MACRO INVERTEBRATES	B	B		B	B	=
INSTREAM				B/C	B	
RIPARIAN VEGETATION	B	B		B	B	-
ECOSTATUS	B	B		B/C	B	=
INSTREAM IHI	B	B		C		
RIPARIAN IHI	B	B		B/C		
EIS	High			High		

Key
- Negative Change
+ Positive Change
= No Change

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

EWR 13: OLIFANTS RIVER (GRIETJIE)

Table A- 9: Overall 1999 Result, PES and 2010 Result for EWR 13: Olifants River (Grietjie) Reach

Key
- Negative Change
+ Positive Change
= No Change

Driver Components	1999 PEC	1999 REC	2010 PES & REC	Change
HYDROLOGY	C/D			
NUTRIENTS	C	B	B	=
TDS	C	C	C	=
WATER QUALITY	C	B/C	B/C	=
GEOMORPHOLOGY	D	D		
Response Components	**1999 PES**	**1999 REC**	**2010 PES & REC**	**Change**
FISH	C	C	D	=
MACRO INVERTEBRATES	C	C	C	=
INSTREAM			D	
RIPARIAN VEGETATION	C	C	B/C	=
ECOSTATUS	C	C	C	
INSTREAM IHI	D	C	C	
RIPARIAN IHI	C	C	B/C	
EIS	High		Moderate	

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

EWR 15: OLIFANTS RIVER (MAMBA)

Table A- 10: Overall 1999 Result, PES and 2010 Result for EWR 15: Olifants River (Mamba) Reach

Key
- Negative Change
+ Positive Change
= No Change

Driver Components	1999 PEC	1999 REC	2010 PES	2010 REC	Change
HYDROLOGY	D				
NUTRIENTS	C	B	D	C	=
TDS	D	C	D	C	=
WATER QUALITY	D	C	C	C	=
GEOMORPHOLOGY	D	C			
Response Components	**1999 PES**	**1999 REC**	**2010 PES**	**2010 REC**	**Change**
FISH	C	C	D	C	=
MACRO INVERTEBRATES	C	C	C	B	=
INSTREAM			C/D	B/C	
RIPARIAN VEGETATION	C	C	B/C	B	=
ECOSTATUS	C	B	C	B	=
INSTREAM IHI	C	C	D		
RIPARIAN IHI	C	C	B		
EIS	Very High		High		

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

EWR 16 & 17: OLIFANTS RIVER (BALULE)

Table A- 11: Overall 1999 Result, PES and 2010 Result for EWRs 16 & 17: Olifants River (Balule) Reach

Key
- Negative Change
+ Positive Change
= No Change

Driver Components	1999 PEC	1999 REC	2010 PES	2010 REC	Change
HYDROLOGY	D				
NUTRIENTS	C	B	D	C	=
TDS	D	C	D	C	=
WATER QUALITY	D	C	C	C	=
GEOMORPHOLOGY	C	C			
Response Components	**1999 PES**	**1999 REC**	**2010 PES**	**2010 REC**	**Change**
FISH	C	C	D	B	=
MACRO INVERTEBRATES	C	C	C	B	=
INSTREAM			C	B	
RIPARIAN VEGETATION	C	C	B/C	B	=
ECOSTATUS	C	C	C	B	=
INSTREAM IHI	C	C	C/D		
RIPARIAN IHI	C	C	B/C		
EIS	Very High		High		

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

Appendix B
Late Water Requirements Inputs for Further Study

B1. Introduction

Very late water requirements inputs have been received as comments from Tshwane Metro and the Industrial Development Corporation. Inclusion of these inputs would mean the redoing of all the water requirement projections and the water balance modelling. Since the study report was already finalised, such additional work was not possible before the expiry date of the study programme and within the budget of the study. The comments are however documented in this Appendix B and must be taken into account during the contemplated follow-up Maintenance Study.

B2. Comments from Tshwane Metro

The following comments were received in an e-mail from Tshwane Metro:

"We must mention that City Of Tshwane came on board late as a results some of our comments now, may have already been discussed during the study. However, herewith below, comments from City of Tshwane on the Olifants Reconciliation Strategy Study: Draft Final Strategy Report;

- Bronkhorstbaai & surrounding areas: The current DWA allocation from the Bronkhorstspruit Dam for the Bronkhorstbaai, Summerplace & other users around the Bronkhorstspruit Dam is in total 1042 kl/d. According to the latest masterplan, the existing water treatment plant at Bronkhorstbaai must be extended to a capacity of 9000kl/d to accommodate future developments around the dam. Therefore the DWA allocation must be increased to 9000 kl/d for the City of Tshwane to accommodate any future developments around the Bronkhorstspruit Dam area.

- Bronkhorstspruit Town: The current DWA allocation from the Bronkhorstspruit Dam for Bronkhorstspruit Town is 11 Ml/d, and the Thembisile allocation is 11.8 Ml/d giving a total of 22.8 Ml/d. The current water demand for Bronkhorstspruit Town and Thembisile has already reached the maximum capacity of the Bronkhorstspruit Water Treatment Plant of 54 Ml/d. According to the latest masterplan, the existing water treatment plant at Bronkhorstspruit must be extended to a capacity of 200 Ml/d to accommodate future developments in the Bronkhorstspruit & surrounding areas, and therefore the DWA allocation must be increased to 200 Ml/d for the City of Tshwane to accommodate any future developments.

- If the water allocation from the Bronkhorstspruit Dam cannot be increased, additional measures to augment the water supply to the Bronkhorstspruit & surrounding areas must be investigated to facilitate future developments as follows;
    - Possibility of constructing a new dam, where the three rivers i.e. Wilge River, Bronkhorstspruit River, and Hondespruit River joins, approximately 8 to 10 km east of Bronkhorstspruit, which can assist with the water shortage and limited water supply in Bronkhorstspruit, Ekangala and Thembisile areas. The new dam can also supply water to Cullinan and Refilwe.

- Rand Water taking over supply to Thembisile from City of Tshwane so that the Thembisile water allocation can be reserved for Bronkhorstspruit and the surrounding areas.
- DWA looks into augmenting the transfer scheme into the upper Olifant Catchment."

B3. Qualitative Response from the PSP

The stated water requirements for Bronkhorstspruit Town and Thembisile are significantly higher than the water requirements documented in the study reports. However it is not certain whether Tshwane is using the same naming convention as in the study reports. When Tshwane Metro refers to Bronkhorstspruit, they could be referring to the water treated there and supplied from the Bronkhorstspruit Water Treatment Works, which includes the Western Highveld in the Olifants Reconciliation Study report. An effort was made to get hold of Tshwane's latest Masterplan without success to date. It is further suspected that Tshwane is referring to the peak water requirements and not the yearly average requirements.

The water requirements as stated by Tshwane need to be taken further in the contemplated Maintenance Study for the Olifants Catchment. The following must be ascertained.

- Naming convention must be consistent for comparison purposes.
- Water requirements should be yearly average.

If the water demand was indeed under-estimated in the Olifants Reconciliation Strategy Study, augmentation options must be investigated. The first one suggested by Tshwane Metro (dam at confluence of Wilge River, Bronkhorstspruit and Hondespruit Rivers) will not significantly increase the yield of the Olifants system and will reduce the yield for the water users downstream of that point. The Rand Water option or the transfer of treated sewage water from Ekurhuleni could be options that can be considered.

B4. Comments from IDC

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14 December 2011

Ms. Jolinda Folscher
Aurecon Centre
Lynwood Bridge Office Park
4 Daventry Street
Lynwood Manor
0081

Dear Ms. Folscher

Water Requirements for Industrial Plants in Middelburg and Phalaborwa

The Industrial Development Corporation (IDC) has appointed Hatch and K2S to undertake feasibility studies for an industrial project with plants located in Phalaborwa and Middelburg areas.

Through interaction with the Department of Water Affairs office in Bronkhorspruit, the project team has been notified by the Department of Water Affairs of the current Olifants River System Reconciliation Study by Aurecon and requested to submit the project water requirements to you.

Water demand to the two project sites is summarized in the table below.

Site	Purpose	Potential Source	Demand (Ml/day)	Demand (Mm³/a)	By When
Middelburg	Construction	TBA	3	1	2013-2016
Phalaborwa	Construction	Lepelle Northern Water	0.01	0.004	2014-2016
Middelburg	Operations	Coal Mines Decant (Middelburg & eMalahleni)	40	15	2016
Phalaborwa	Operations	Lepelle Northern Water and Ba-Phalaborwa Local Municipality	1.7	1	2016

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Ms. Jolinda Folscher
Aurecon Centre
14 December 2011
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You are kindly requested to incorporate the above water requirements into the reconciliation study.

Please feel free to contact the undersigned should you require any further information.

Yours faithfully

Tielman de Villiers
Project Manager

Hangwani Makwarela pp
Lead: Water & Waste Management

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B5. Response from PSP

It is only the coal mine at Middelburg that require a significant volume of water per year (15 million m^3/a). The rest are very small water demands that can be easily accommodated. The new coal mine at Middelburg could reduce the water decant from existing coal mines on which the Middle Olifants will be dependent. This aspect needs to be studied.