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

WP10197

Preliminary Reconciliation Strategy Report

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Preliminary Reconciliation Strategy

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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.

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 Natural 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.

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.

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

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 to 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
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
MAR	Mean Annual Runoff
NPV	Nett Present Value
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
SADC	Southern African Development Community
UN	United Nations
URV	Unit Reference Value
VRESAP	Vaal River Eastern Sub-system Augmentation Project
WCDM	Water Conservation Demand Management
WC	Water Conservation
WDM	Water Demand Management
WMA	Water Management Area
WRC	Water Research Commission
WUA	Water User Association
WWTW	Waste Water Treatment Works

EXECUTIVE SUMMARY

Introduction

The water requirements in the Olifants Water Management Area (WMA) and adjacent supply areas of Polokwane and Mokopane, have increased substantially over the last number of years due to increases in a range of activities including power generation, mining, the steel industry, urban development and agriculture. The mining industry in particular has grown significantly.

Figure E1 *shows the Study Area. The Olifants Catchment has been divided into three management zones, namely the Upper, Middle and Lower Olifants Management zones which are also shown on the map.*

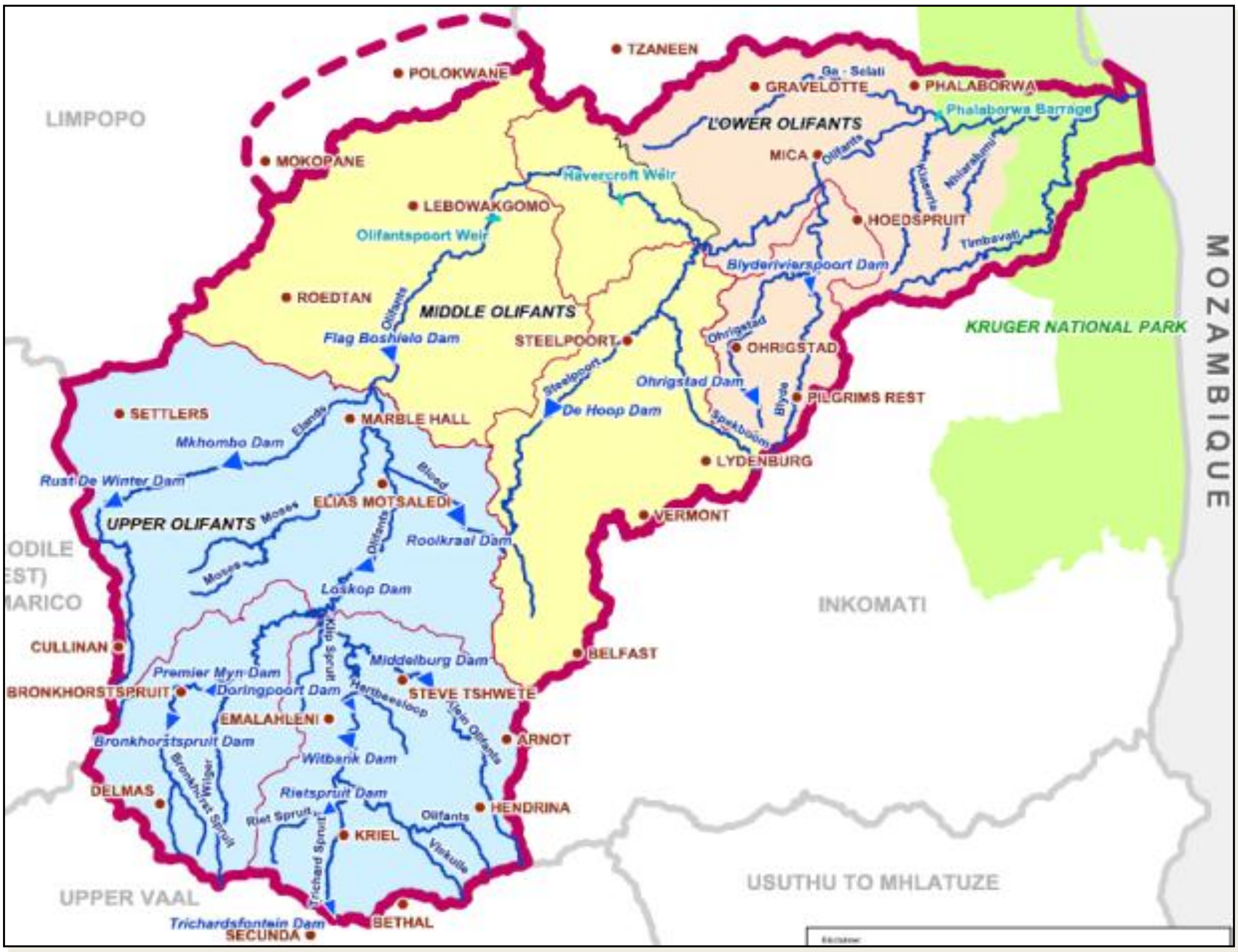

Figure E1: The Study Area

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

The study area requires a reconciliation strategy aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future.

The main output of this study will be a Final Reconciliation Strategy for achieving a balance between the requirements for water to support livelihoods and economic development, the available resource, and the conservation of the environment to sustain its functions for future generations. The use of the *water resource should be founded on the three principles of equity, sustainability and economic efficiency.*

As a result of the highly stressed condition of the study area and the fact that it will take a substantial period of time to develop the final reconciliation strategy, a first order or preliminary reconciliation strategy was required.

The following are regarded as objectives for the preliminary reconciliation strategy:

- *To provide an understanding of the surface and groundwater situation in the area of the Olifants River Supply System, in terms of water quantity and water quality.*
- *To describe the possible interventions that can address the current and projected future water resource deficiencies and water quality problems.*
- *To sequence these interventions and indicate which of these interventions will yield early benefits.*
- *To pave the way for the Final Reconciliation Strategy.*

This report represents the Preliminary Reconciliation Strategy.

The Reserve

The Reserve is that portion of the natural run-off that must be available in the river in order to sustain the aquatic ecology, and also to provide water for basic human needs (BHN). This is required by sections 16, 17 and 18 of the National Water Act (Act 36 of 1998) (NWA). The Reserve is not a steady flow, but a variable flow that mimics natural variation in flows in the river. The quantity that is required takes into account 'normal' conditions, as well as drought conditions.

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

The Olifants River Comprehensive Reserve Study was undertaken during 1999 and was only the second Comprehensive Reserve Study undertaken in South Africa.

Present Ecological State (PES 2010) and the Ecological Categories (ECs) were determined and compared with the 1999 EcoStatus and ECs. The Recommended Ecological Category (REC) at each site was then reviewed.

There were not many changes in the PES or REC from the 1999 study to 2010. In the upper part of the catchment, the REC has reduced from a C to a D, while in the lower part of the catchment, it has increased from a C to a B. This study did not recalculate the Ecological Water Requirements (EWRs) themselves, and only reconfirmed the ecological status of the catchment. The associated flows and rule tables are therefore the same as those developed in 1999.

A change from Category C to Category B in the lower part of the river may have a significant impact on the EWRs for that part of the river. However, since the EWR for the site just upstream of the Kruger National Park (KNP) was previously assessed as a Category B, and has remained so, the overall effect on the availability of water for beneficial use will probably be small. This will be confirmed later on in the study.

Water Resource Availability

- ***Groundwater***

  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 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 and 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 yields in the order of 0,5 ℓ/s.

  The Groundwater Yield Model indicated that there is a surplus of groundwater available in the order of at least 70 million m^3/annum, which can be developed for community water supply (SATAC Joint Venture, 2008).

  Groundwater is currently being over-utilised in certain areas of the Olifants Catchment, e.g. in the Delmas / Bapsfontein area where too much water is abstracted from the dolomitic aquifer. This has resulted in an increase in the number of sinkholes in that area over the last decade.

  There are therefore some areas of good yield and some really problematic over-abstractions that MUST be addressed.

- ***Surface Water***
  - Yield of Large Dams

    *The surface water resources of the Olifants River are already well developed, especially the upper reaches, with several large dams constructed to supply water to large irrigation schemes as well as to domestic and industrial water users. The significant dams with their historical firm yields and 1:50 year yields are listed in **Table E1**.*

Table E1: Large Dams in the Olifants River Catchment

Dam	Location		Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
	Management Zone	Quaternary Catchment			
Bronkhorstspruit	Upper	B20C	58.9	16.9	23.5
Middelburg	Upper	B12C	48.4	12.6	14.0
Witbank	Upper	B11G	104.0	29.5	33.0
Loskop	Upper	B32A	374.3	161	168
Rust de Winter	Upper	B31C	27.3	9.8	11.7
Mkombo with Weltevreden weir	Upper	B31F	205.8	11.7	11.7
Flag Boshielo	Middle	B51B	178.8	53.0	56.0
De Hoop (under construction)	Middle	B41H	347.4	98.0	99.0
Ohrigstad	Lower	B60E	13.2	18.9	19.8
Blyderivierpoort	Lower	B60D	54.6	110	130

Note: *Yields are before any allowances are made for the environmental water requirements*

- Diffuse Water Resources
  *In addition to the yield of the major dams listed in **Table E1**, 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, with these run-of-river sources also forming part of the water resource. 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 supplied from farm dams and run-of-river through the use of a water resources model and to equate the resource to the modelled supply. The diffuse water use is therefore in balance with the diffuse water resources.*

- 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 water transfers approximate 228 million m^3/annum. The transfers are fully utilised in meeting the requirements of the power stations so the effect on the water balance in the catchment is zero. There are also three small transfers into the Middle and Lower Olifants from the Letaba / Levhuvhu WMA.

  *The total surface water resource of the Olifants River catchment is summarised in **Table E2**.*

Table E 2: Summary of Total Current (2010) 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*	*Total*
Upper Olifants	*262*	*128*	*228*	***618***
Middle Olifants	*56*	*71*	*1*	***128***
Lower Olifants	*150*	*49*	*3*	***202***
Total	***468***	***248***	***232***	***948***

Note: *De Hoop Dam is excluded*

Current and Projected Water Requirements

- ***Current***
  The water user sectors in the study area are Domestic/Industrial, Mining, Agriculture, Irrigation, Power Generation and Forestry. The water requirements of these sectors are summarised in

Table E3.

Table E3: Current Water Requirements (2010) (All units in million m^3/a)

Management Zone	Domestic/ Industrial	Mining	Irrigation[1] (Adjusted to 98% assurance of supply)	Power Generation	Total
Upper Olifants	*109*	*21*	*254*	*228*	***612***
Middle Olifants	*39*	*24*	*93*	*-*	***156***
Lower Olifants	*21*	*36*	*161*	*-*	***218***
Total	***169***	***81***	***508***	***228***	***986***

Notes: 1 – The volume of water allocated for irrigation has been assumed to be at an assurance of supply of 80%.

Streamflow reduction due to afforestation is estimated at 31 million m^3/annum. This was taken into account when determining the available yield from dams and was not included as a water requirement in

Table E3.

- ***Future***

  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.

  There has been rapid growth in water use in the domestic/industrial sector especially in the metropolitan area of Emalahleni (formerly Witbank) and Middelburg, while the growth in water use in rural areas has been limited by the lack of water supply infrastructure.

  The mining sector grew very rapidly in the Middle Olifants due to the surge in the platinum price and this prompted the construction of the De Hoop Dam. However, the economic downturn in 2008 has put many new planned mining developments on hold. The rate of development and extent of future water requirements of the mining sector, are now uncertain. The most likely growth remains in the Middle Olifants, with very limited expansion of mining water demands in the remainder of the catchment.

  Although one or more additional power stations are planned for the catchment, the water transfers from the Upper Komati and Vaal Systems will be increased to meet the demands of these new power stations and the water balance of the Olifants River system itself will not be affected by these developments.

  Streamflow reduction due to afforestation will not increase as new licences for forestry will not be issued in the Olifants River catchment. The on-going removal of Invasive Alien Plants (IAPs) in the catchment should result in an increase in streamflow.

Water Quality

Water quality is determined by the activities in the catchment, the land use and the geology. Water quality guidelines published by the Department were used to develop a combined guideline for the study area based on Domestic, Agriculture and Aquatic Ecosystem water guidelines.

There are a number of water quality concerns in the catchment, for the most part immediately downstream of 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.

The Middelburg Dam (station B1H004) is under pressure as reflected by the pH, levels of ammonia as well as nitrite/nitrate levels. The low pH levels can be ascribed to acid mine water as a result of mining activities in the study area. The high levels of ammonia and nitrate/nitrite are primarily a consequence of the use of fertilisers, and a result of poor sewage treatment. The phosphates are slightly high throughout the study area, but still within the acceptable range. This is probably due to improper use of fertilisers, as well as discharge of untreated or partially treated sewage into water sources. Although the chlorides are generally within the ideal range, trend analysis shows that they are on an upward trend. This is probably due to an increased discharge of treated waste water.

The Electrical Conductivity (E.Cond) values are also slightly high, but still within acceptable and tolerable ranges. The trend analysis also shows E.Cond as being in an upward trend for most of the stations. This can be attributed to the various mining activities in the study area.

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, especially phosphorus, show an upward *trend. This can be ascribed to the substantial sewage treatment plant return flow volumes in the Klipspruit, Witbank and Middelburg Dams to 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).*

The quality of the water is currently deteriorating and this trend will continue if appropriate management actions are not taken. It is necessary, for example, to substantially reduce or eliminate the discharge of poorly treated waste water from urban areas, and employ best practice in the agricultural sector. Less visible problems associated with substances such as trace metals must be dealt with at source and represent a pollution problem, and not a water resource management problem.The exeption to this is the recovery and treatment of acid mine drainage in the upper part of the catchment. The water in the mined areas represent a source of water, while on the other hand, if the decanting water is not treated (desalinated), the water in the Loskop Dam will be compromised in terms of the sulphate concentrations. This will mostly affect the fitness for use for power generation.

The Water Balance

*The current (2010) water balance prior to the commissioning of De Hoop Dam is presented in **Table E4.** It is assumed here that the minimum low flows agreed to enter the Kruger National Park are the only assured flows released for the environment.*

Table E4: Water Balance with minimum Ecological flows into the KNP (Units: million m3/a)

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	612		6
Middle Olifants	128	156		(28)
Lower Olifants	202	218	18	(34)
Total	**948**	**986**	**18**	**(56)**

Note: Excludes De Hoop Dam

***Table E5** indicates the future water balances for 2030, including the full Ecological Reserve water requirements (EWR).*

The EWRs have been based on the 1999 Ecological Reserve study, completed in 2002 [DWAF, 2002].

Table E5: Future (2030) Water Balance (Units: million m^3/a) based on a High Growth Scenario

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	648	80	(110)
Middle Olifants	227	214	51	(38)
Lower Olifants	202	230	69	(97)
Total	**1047**	**1092**	**200**	**(245)**

Note: Includes De Hoop Dam

Both the current and future water balances show deficits for the system as a whole. The Middle Olifants will have a slight surplus once the commissioning of the De Hoop Dam is complete (prior to the phasing in of the Reserve), but by 2030 all Management Zones will have a water deficit if the EWR is supplied throughout the catchment.

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

Towards Achieving a Water Balance

- ***International Conventions and Requirements***
  After the Reserve, comprising Basic Human Needs and the environmental requirements, international obligations are afforded the second highest priority in the National Water Act (NWA). The international agreement between South Africa and Mozambique for Massinger Dam does not specify a minimum flow quantity or quality, but South Africa is party to international policies and protocol and the flow across the border must be reasonable (both in terms of quantity and quality).

- ***Water Quantity***
  The water requirements within the study area already exceed the available resource. This situation must be resolved through a combination of reducing the water requirements and increasing the available resource.

- ***Objectives and Assumptions for Water Reconciliation in the Catchment***
  Reflecting on the status of the water resources of the basin, described above, it is necessary to agree to objectives for the management assumptions on the future use of the resource.

  The water reconciliation objectives are to:
  - *Recognise South Africa's International Obligations in terms of sharing 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*
  - *To 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.*

    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 as far as possible be provided.*

    Assumption 5: *There will be no further expansion in the total irrigation area.*

Possible Intervention Options

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

A list of all identified reconciliation options was compiled and screened at a Preliminary Screening Workshop held on 7 July 2010. The following reconciliation options were retained after the screening and are currently being investigated.

- ***Options that will Reduce Water Requirements***
  - ***Eliminating Unlawful Water Use:*** *Eliminating unlawful use is a reconciliation option, that must be tackled by the Department as a matter of urgency. The volume of water that can be freed up can only be ascertained once the validation and verification studies have been completed by the DWA. For the purpose of this preliminary reconciliation strategy, it was assumed that at least 5% of the current irrigation water use can be recovered.*

  - ***Water Conservation and Demand Management:*** *Implementation of Water Conservation and Demand Management (WCDM) can rapidly and significantly reduce water use and alleviate some of the pressure on the available supply.*

  - ***Reducing Assurances of Supply:*** *Further water allocations may be possible if existing water users agree to accept lower assurances of supply. Possible incentives could be lowering water charges in times of water shortages, or compensating for losses as a result of increased water shortages.*

  - ***Compulsory Licensing:*** *The NWA allows the Minister to require all water use to be licensed. The procedure requires nearly all existing users to apply for a licence. The Minister considers all the licence applications taking cognisance of the water availability and may license or where required reduce the existing uses to ensure that the Reserve (EWR plus BHN) is met and there is a water balance. The Minister may also reallocate the available water in fair and equitable manner.*

  - ***Compulsory Levy and Purchasing Water Entitlements:*** *The full Compulsory Licensing process could be long and tedious. An alternative 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 would have to 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. This process can then be continued until the necessary water balance is achieved.*

- ***Options that will Increase Water Supply***
  - ***Groundwater Management and Development:*** *It is estimated that 25% of the aquifers in the Olifants River Catchment are over-utilised. It is also estimated that up to 70 million $m^{3/}$annum of additional groundwater resource could be the developed in the quaternary catchments that are not stressed. This is especially true for the dolomite aquifers in the northern escarpment areas where there is potential for the future development of regional groundwater resources. However, this will require very careful investigation and management.*

  - ***Utilising the Acid Mine Drainage in the Upper Olifants :*** *The possibility for reclaiming acid mine drainage water from coal mines and using underground water stored in the mine shafts exists in the upper part of the catchment. This water must be treated - with desalination using reverse osmosis a major part of the process.*

- ***System Operating Rules:*** *The dams within the Olifants River are currently all operated independently, without due consideration of the state of storage of other dams, or of the system as an integrated system. It is probable that operating rules which consider the conjunctive use of all resources within a systems context, and detailed information on the timing and location of water requirements (similar to the systems used in the Orange, Komati and Crocodile (East)) River basins, would improve the efficiency of use of the available resource.*

- ***Rainwater Harvesting:*** *Rainwater harvesting provides immediate access to water by homesteads and small community facilities such as schools or clinics for domestic purposes and for subsistence vegetable growing. It is particularly useful for those not located near to reticulation networks.*

- ***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.

- ***Importing Treated Effluent from the East Rand:*** *It is possible to pump treated effluent from the Vaal River System, over the catchment divide, into a tributary of the upper Olifants River. For this assessment the seven most suitable works were selected. 38 Million m^3 per year can be added via this configuration.*

- ***Importing of Water from Vaal Dam:*** *DWA recently commissioned the VRESAP scheme to pump 160 million m^3/annum of raw water from the Vaal Dam into 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 1 900 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/annum into the Upper Olifants River. The cost and availability of Vaal River water are major considerations.

- ***Water Transfer from the Crocodile (West) System:*** *A possible water transfer from the Crocodile (West) & Marico System, which has only recently become an option as a result of the lower water demand from the Crocodile than originally estimated, has not been investigated, but it will be considered in the run-up for the final Reconciliation Strategy.*

- ***Raising of Blyderivierspoort Dam:*** *The existing storage capacity is 55 million m^3/annum, which is only 20% of current day MAR. Whilst there is enough water, a site visit showed that the height of the existing dam is ideal for its situation, and that raising of the dam will pose significant challenges and be relatively expensive.*

- ***New Dam at Rooipoort:*** *In 1993 and again in 2001, DWA undertook feasibility studies for a possible dam on the Olifants River at Rooipoort, 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 that of the Rooipoort Dam, and did not have the serious social impacts identified for the Rooipoort Dam. The De Hoop site was therefore selected, and the dam is currently under construction.

It has recently been suggested that a dam at a site approximately 20 km downstream of Rooipoort might be more favourable, with a slightly higher yield, being downstream of the Mohlapitse tributary, and with less social impacts than the Rooipoort site, but this has not been studied at this time.

- ***New Dams in the Olifants River Gorge:*** *Two potential dam sites have been identified downstream of the Steelpoort tributary, namely:*
  i) Godwinton; and
  ii) Chedle.

  Both sites are located on dolomite. The typical cavernous nature of dolomites means that the foundations for both dam sites must be proven by more detailed geotechnical investigations than usual. Equally important is the possibility of both dams draining out and into the dolomites through the dam basins. Detailed investigations will be required of water table levels around the dam basin to determine whether water will drain out of the dams, to what extent, and whether this would be recoverable.

  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. Such option has not as yet been investigated and could be considered when investigating the two dam sites in greater detail.

- ***New Dams in the Lower Olifants River:*** *To maximise the yield from the Olifants River, it would be 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 have been identified, namely:*
  i) Epsom;
  ii) Mica; and
  iii) Madrid.

  A dam at any of these sites will be very expensive compared with dams in the Gorge and are too low down in the catchment to supply users other than the Kruger National Park.

- ***Removal of Invasive Alien Plants:*** *The current infestation of 1 917 km^2 is estimated to use 31 million m³/annum more water than the indigenous vegetation which these invasives have replaced. It is estimated that, with an intensive clearing programme, 15 million m^3/annum could be added back into the system over the next 8 years, with more to follow. Actual impacts on yield require additional assessment.*

Balancing the Water Requirements with the Water Resource

The management reconciliation options can generally be implemented sooner than the development reconciliation options and require less capital.

Table E6 *shows the management options that can make a significant difference in the water requirements or water availability along with the estimated savings/supply increases.*

Table E6: Management Options

Option	Starting Year	Duration (Years)	% Saving Supply increase	Estimated Saving / Yield million m^3/a	Comments
WCDM Irrigation	2011	5	10%	28	Includes both leakage controls through refurbishment of canals and beyond field edge water savings. Only scheduled irrigation was considered. Should be linked to compulsory licensing.
WCDM Urban	2011	5	15%	25	15% saving is attainable. Emalahleni has already developed a WCDM, strategy and the other towns should follow. Could start immediately.
WCDM Mining	2011	5	10%	8	Includes possibilities of water reuse and recycling. Should be linked to compulsory licensing.
Compulsory Licensing Irrigation	2015	4	See WCDM (10%)	See WCDM (28)	Dependent on validation and verification process (± 4 years) which must first be completed. Linked to WCDM.
Operating Rules	2011	2	5%	47	Requires minimum capital cost inputs.
Unlawful Water Use	2015	4	5%	25	Dependent on validation and verification process (± 4 years) which must first be completed.
Removal of IAPs	2011	8		15	Half of the estimated water use of 31 million m³/a.
			Total saving / yield	**133**	

Three possible reconciliation scenarios have been analysed, i.e.:

- ***Scenario 1:*** *Comprising the implementation of:*
  - *The management options as per* ***Table E6****, plus*
  - *The full Reserve (that will reduce the available water by 200 million m³/a at 98% of assurance), phased in over 8 years, plus*
  - *The groundwater development options phased in over 16 years, plus*
  - *De Hoop Dam commissioning in 2012; and*
  - *Godwinton Dam commissioning 2022.*

- ***Scenario 2:*** *Same as Scenario 1, but instead of the Godwinton Dam in 2022, the Vaal Transfer Scheme is also introduced in 2022.*

- ***Scenario 3:*** *Comprising the implementation of:*
  - *The management options as per Table E6 plus*
  - *Half the effect of the implementation of the Reserve (this will reduce the available water by 100 million m³/annum at 98% of assurance), phased in over 8 years, plus*
  - *The groundwater development options phased in over 16 years; and*
  - *No further dam or transfer option after De Hoop Dam.*

The results were as follows:

- *Water balances could be achieved for all three scenarios up to 2035.*
- *There is little difference between Scenario 1 and Scenario 2. The size of the Vaal Transfer Scheme can be halved to 80 million m³/annum.*
- *The Reserve plays a major role as can be seen with Scenario 3. For half the Reserve requirement, a water balance can be achieved. This is illustrated in* ***Figure E2****.*

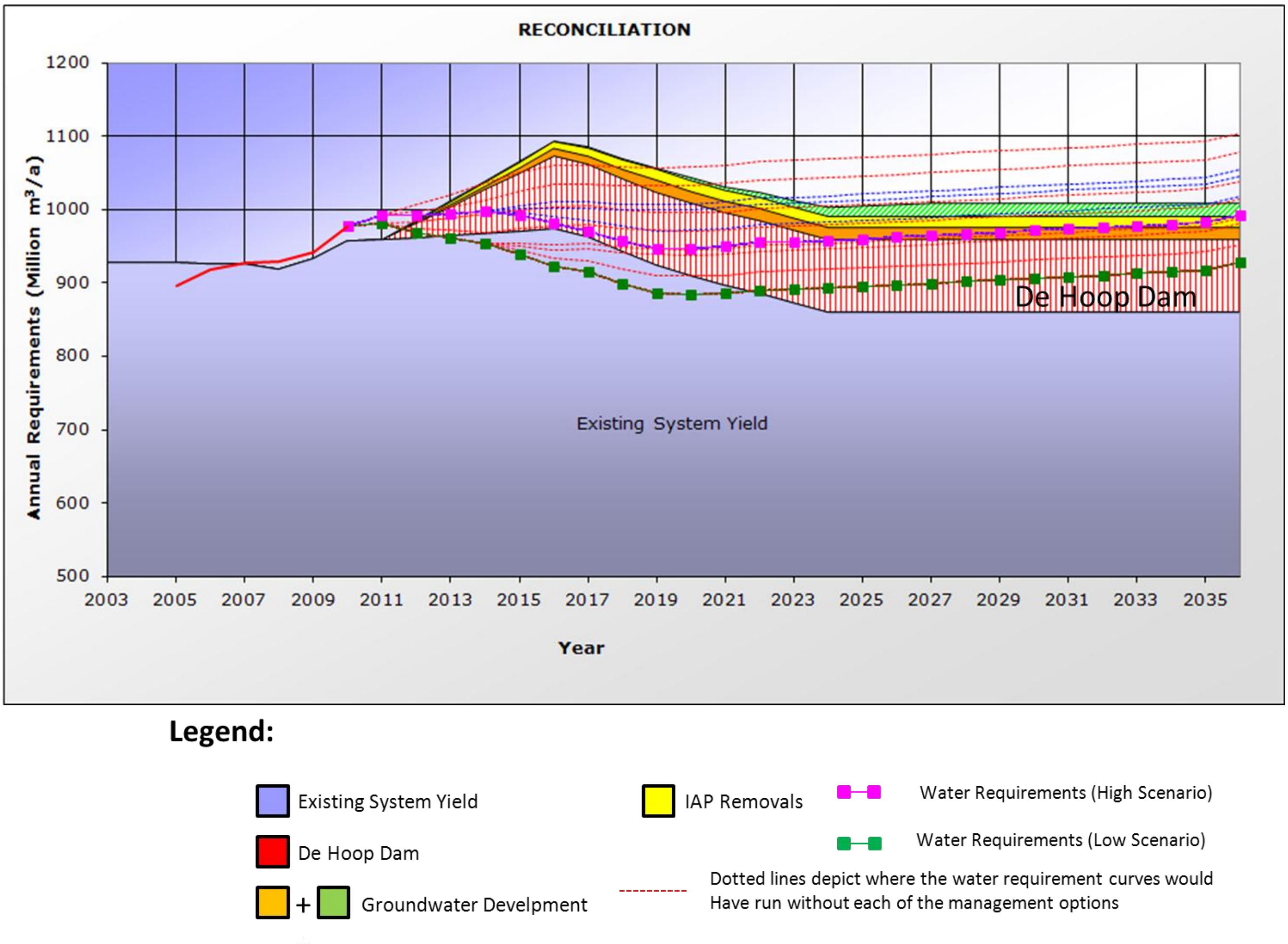

Figure E2: Water Balance – Scenario 3

Risk and Uncertainties

The following risks and uncertainties have been identified.

- *The requirements of the environmental Reserve are a major demand on the system, but whether the signed off requirements have been set too conservatively is still a question. A very small deviation here involves huge volumes of water. It is critically important that the needs of the Reserve should be re-assessed and correctly and accurately estimated.*
- *The extent of unlawful water use is a big unknown. Until the validation and verification processes are complete, the strategy will have to rely on the best estimates.*
- *The estimates for water savings on irrigation water could be inaccurate and attention is needed to improve the estimates. Since the irrigation sector represents such a large portion of the total water use, further work on this aspect is justified.*
- *The additional yield which becomes available as a result of additional infiltration on the surfaces of existing and decommissioned coal mines, as well as the storage volume created by the mine shafts and galleries is unknown. This aspect needs more attention.*
- *The Agricultural Research Council (ARC) survey on Invasive Alien Plants (IAPs) needs to be verified. The survey looks as if it could be an over-estimation of IAPs, but if correct, it will affect the water balance negatively. There are various methodologies for determining the streamflow reduction as a result of IAPs. Consensus needs to be reached within DWA on the methodology to be used in future. This study's methodology may differ from the one that will be adopted by DWA.*
- *The assumption that the water supply from farm dams and run-of-river uses is equal to the available water for these uses could have some inaccuracies. Neither an accurate usage per unit area nor the assurance of supply to these irrigators can be determined.*
- *The success of the compulsory levy and the purchasing of water entitlements as an option is difficult to predict. It is not clear how many water users would, in the longer term, offer water entitlements for sale and how much water will eventually be freed up. As a result of this uncertainty, the compulsory licensing alternative was chosen for the analyses.*
- *It is not known whether farmers will consider accepting lower assurances of supply. If so, this could be a valuable option to be assessed further.*
- *Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc.*
- *The outcome of the 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.*
- *If any one of the investigated dam options needs to be factored in, the dolomite dam basins and foundation of the Godwinton and Chedle sites need to be investigated further.*

Recommendations

The following is recommended:

- *The uncertainties listed above need to be investigated further in order to base the Final Strategy on improved information.*
- *A thorough investigation into the Reserve is recommended, as a lesser effect of the implementation of the Reserve could render a further large augmentation option after De Hoop Dam unnecessary (See Scenario 3).*
- *All the possible management options to reduce water requirements should be implemented as soon as possible.*
- *The WCDM for irrigation and mining should be linked to compulsory licensing or the compulsory levy for purchasing water entitlements. In the case of compulsory licensing, the validation and verification process needs to be complete.*
- *The option of implementing a compulsory levy to fund the purchase of water from willing sellers could also be explored. Compulsory licensing must, however be initiated. Should a compulsory levy be accepted and implemented, this would reduce the impact of compulsory licensing.*

- *The validation and verification process should be accelerated. Both the compulsory licensing and the completion of eliminating of unlawful water use are dependent on this task.*
- *The establishment of a catchment management agency for the Olifants River has to be accelerated.*
- *Groundwater development in unstressed sub-catchments must be encouraged. 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.*
- *Bulk water abstraction from the Malmani aquifer where it crossed the Olifants River must be investigated together with the possibility of artificial recharge with surface water.*
- *An indicative conclusion at this point in time is that either the Godwinton or Chedle dam sites would provide the most economical development option; these are well located in relation to the mining developments in the Middle Olifants River. Further investigations into these dam sites are recommended.*
- *The two water transfer options also seem too costly despite the advantage of bringing water to the headwaters of the catchment. A possible water transfer from the Crocodile system, which has only recently become an option as a result of lower water demand from the Crocodile than originally estimated, has not yet been investigated. It is recommended that its investigation is included in the final reconciliation strategy.*
- *Water trading should be encouraged, with the State providing the market and buying out water to meet the needs of the Reserve. This would provide water at a far lower cost than the construction of an additional dam, or the importation of Vaal River water.*
- *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.*

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1. INTRODUCTION

1.1 PURPOSE OF THIS STUDY

The water requirements in the Olifants Water Management Area (WMA) and adjacent supply areas Polokwane and Mokopane have increased substantially over the last number of years due to diverse activities, e.g. power generation, mining, the steel industry, urban development, eco-tourism and agriculture. The mining industry in particular has grown fast.

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

The study area requires a reconciliation strategy needed aimed at alleviating the current water deficits and at ensuring a sustainable water supply for the foreseeable future.

Figure 1.1 shows the Study Area.

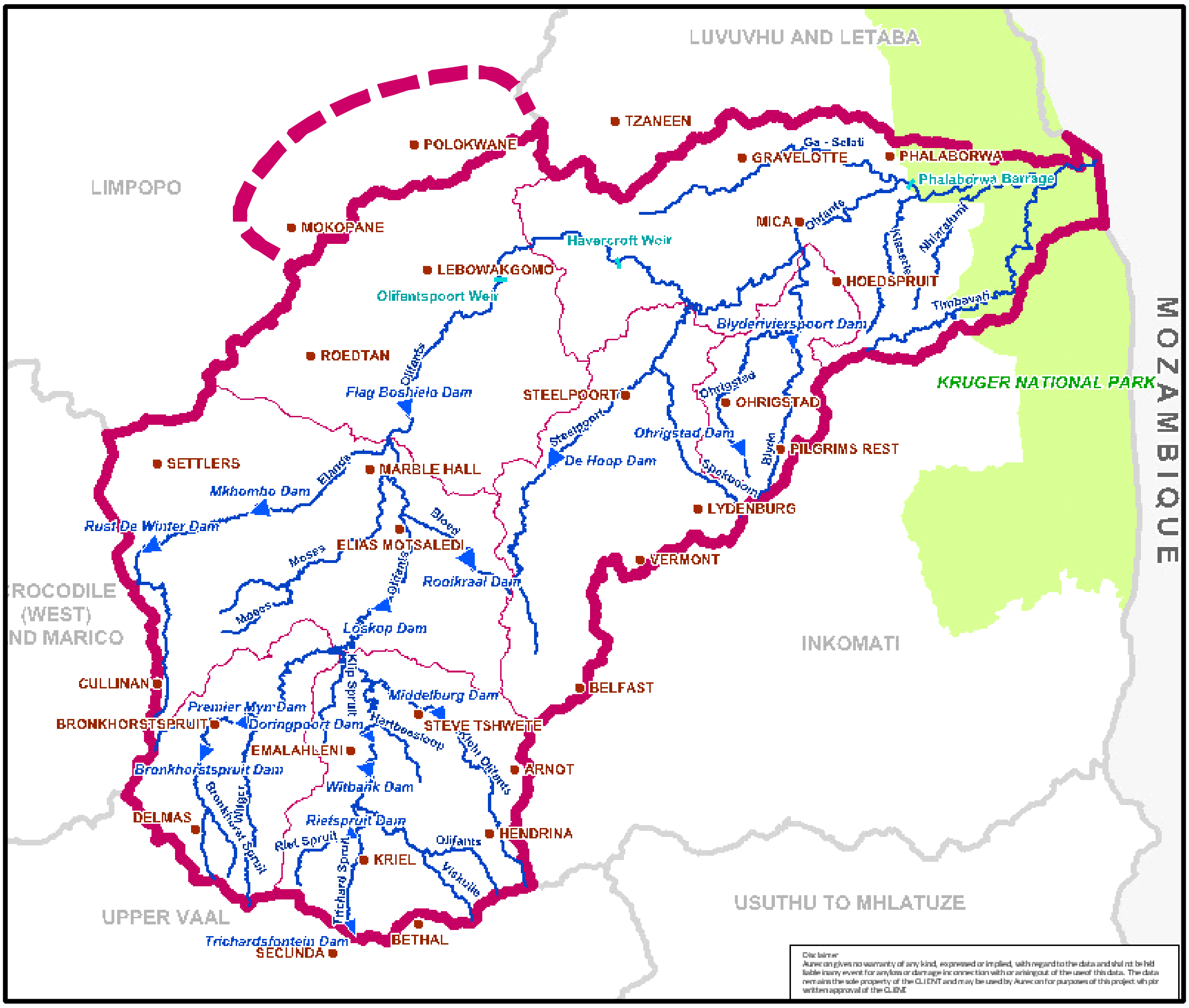


Figure 1.1: Study Area

1.2 PURPOSE OF THIS REPORT

The main output of this study is a Final Reconciliation Strategy for achieving a balance between the requirements for water to support livelihoods and economic development, the available resource and the conservation of the environment to sustain its functions for future generations. The use of the water resource will be founded on the three principles of equity, sustainability and economic efficiency.

As a result of the highly stressed condition of the study area and the fact that it would take a substantial period of time to develop the Final Reconciliation Strategy, interim first order or preliminary reconciliation strategy was required.

The following are regarded as objectives for the preliminary reconciliation strategy:

- To provide an understanding of the water situation in the Olifants Study Area in terms of water quantity and water quality.
- To describe the possible interventions that can address the current and projected future water resource deficiencies and water quality problems.
- To sequence these interventions and indicate which of these will yield immediate benefits.
- To pave the way for the Final Reconciliation Strategy.

This report represents the Preliminary Reconciliation Strategy.

1.3 REPORT STRUCTURE

This report basically describes three main aspects, namely:

- The status quo of the water resources in the Olifants River catchment;
- A reflection on the status quo, in other words the meaning of the water situation, water deficits/surpluses and where they occur and water quality problems; and
- Interventions that could be implemented in order to reconcile water requirements with water availability in terms of both water quality and quantity.

Sections 1-7 cover the study area overview in which current and future water requirements and availability in terms of water quality and quantity are described.

Section 8 describes the reflection on the water resource situation and the Integrated Water Resources Management (IWRM) opportunities and objectives for the catchment based on this reflection.

Sections 9-15 deal with the possible intervention options, the implementation arrangements and the required public engagement to implement these options.

2. OVERVIEW OF THE STUDY AREA AND STUDY PROCEDURE

2.1 SYSTEM DESCRIPTION

The study area consists of the Olifants River Catchment and its immediate supply zones, i.e. the urban areas of Polokwane and Mokopane. 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 additional dams were constructed to meet growing domestic, industrial and mining water requirements. The dams are all operated independently of each other with the possible exception of water court orders that require releases from the Witbank and Loskop Dams to compensate downstream users. However, these water court orders do not seem to have been upheld in recent times.

While the majority of water users obtain their water from the major dams referred to above, there are also a large number of irrigators 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 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 envisaged flow of the processes.

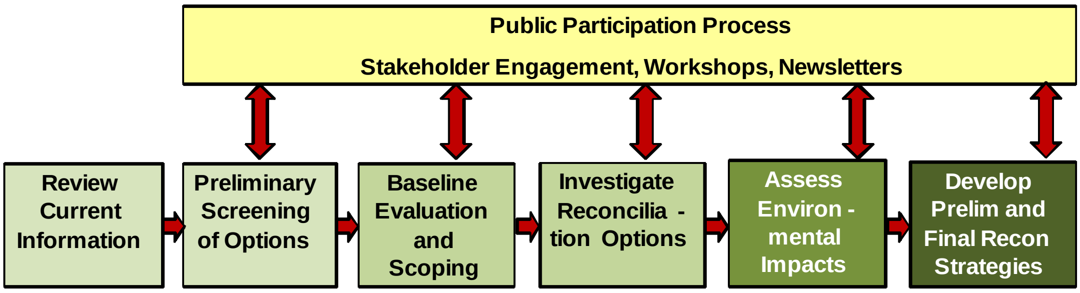


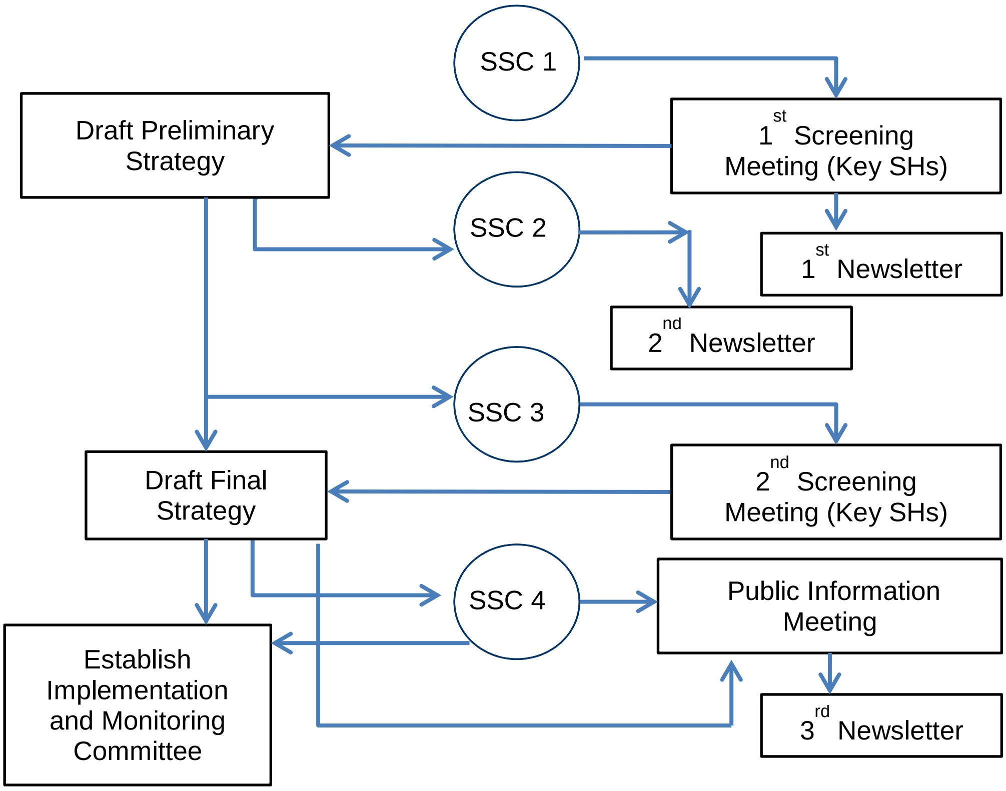
Figure 2.1: Technical and Public Participation Process

The technical process has already started with a review and consolidation of the available information from previous and current reports on the Olifants Catchment.

The review was performed through a preliminary screening workshop 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.

Further steps of the technical process, i.e. baseline evaluation and scoping, investigation of reconciliation options and assessment of environmental impacts all lead to the development of the strategies. A preliminary strategy will first be developed halfway in the study to obtain an understanding of the reconciliation possibilities and to address the immediate needs and the final strategy will be developed once more information has been obtained on the selected reconciliation alternatives.

To achieve the objectives of this study, all possible stakeholders are consulted through workshops and information sessions. The diagram in **Figure 2.2** depicts the processes to be followed in the engagements.



Note: SSC = Study Steering Committee

Figure 2.2: Process for Stakeholder Engagement

3. THE RESERVE

3.1 PREVIOUS ECOLOGICAL WATER REQUIREMENTS (EWRS) STUDY DONE FOR THE SYSTEM

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 to 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 BHN component of the Reserve has been catered for in the total water requirements for domestic water use (See paragraph 5.2.2) and the focus of the description below is entirely on the ecological component of 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**.

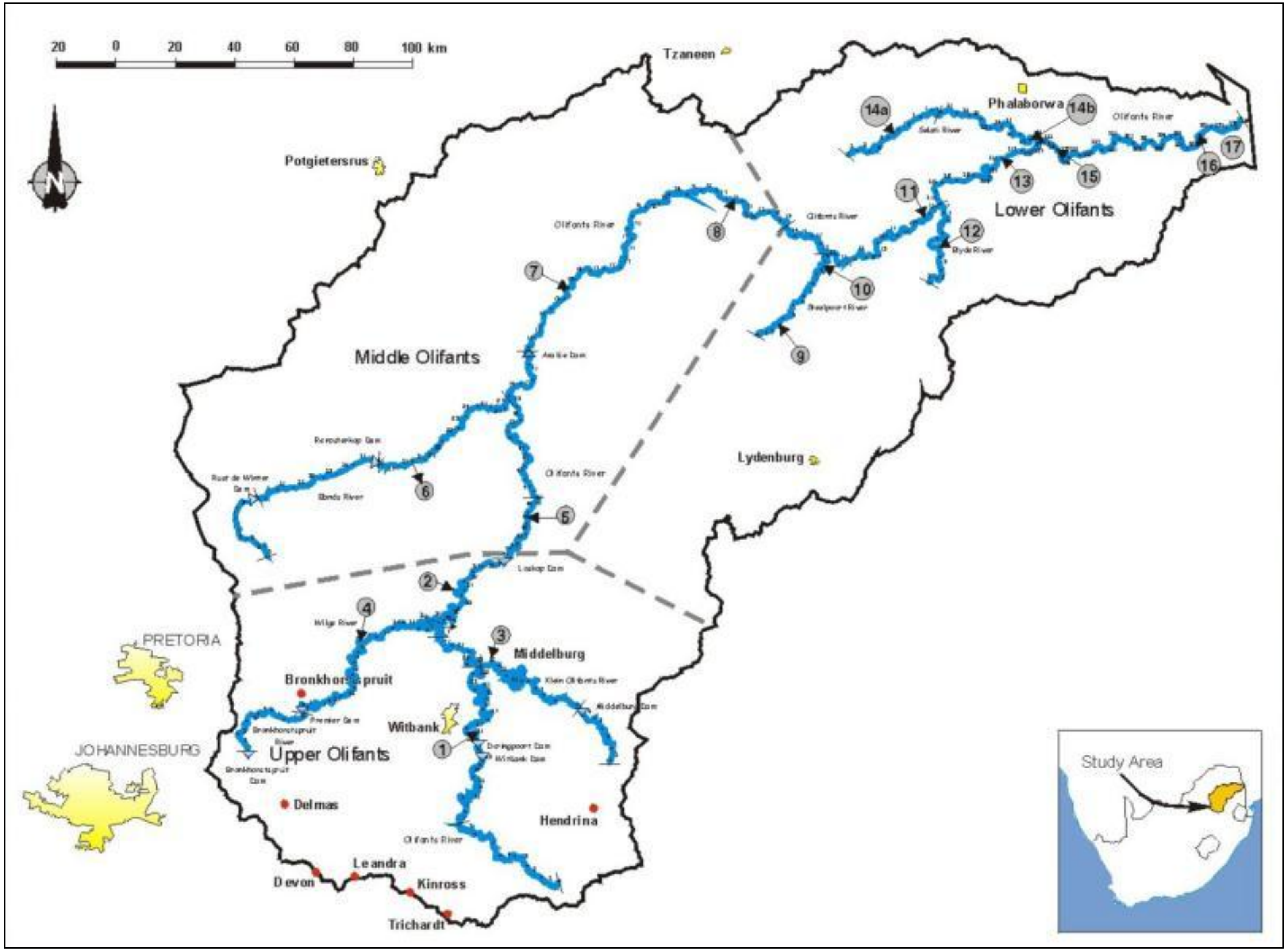


Figure 3.1: Olifants IFR Sites from the Ecological Reserve Report [by BKS, dated July 2001]

3.2 ECOLOGICAL CHANGES SINCE PREVIOUS EWR DETERMINATIONS

As part of the current study, the Eco-Classification (i.e. the process to determine PES, EIS and 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 were affected. 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 Recommended Ecological Category (REC) and the 2010 results per reach of the Olifants River.

Table 3.1 below summarises the information in **Tables A-1 to A-11** of **Appendix A** and illustrates how the ECs have changed for the whole Olifants River Catchment from 1999 to 2010. A "=" symbol indicates no change in recommended EC, whereas a "+" and "-" symbol respectively indicates an higher and a lower recommended EC.

Table 3.1: Overall 1999 Result

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

3.3 IMPLICATIONS

There were not many changes in the PES or REC from the 1999 study to 2010. In the upper part of the catchment, the REC has changed from a C to a D, while in the lower part of the catchment (Sites 16 and 17); it has changed from a C to a B. It should be noted that this study did not recalculate the EWRs themselves, and only reconfirmed the ecological status of the catchment. The associated flows and rule tables are therefore the same as what was developed in 1999.

A change from Category C to Category B in the lower part of the river will have a significant impact on the EWRs for that part of the river. However, since the EWR for Site 15, which is just upstream of the KNP, was a Category B in the past and has remained so, the overall effect on the availability of water for beneficial use will probably be small. This will be confirmed later on in the study.

4. WATER RESOURCE AVAILABILITY

4.1 GROUNDWATER

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 also available in the fractured karst (dolomite) aquifer 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 and 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 yields in the order of 0,5 ℓ/s. **Table 4.1** provides a summary of the typical hydrogeological characteristics.

The Groundwater Yield Model indicated that there is a surplus of groundwater available in the order of at least 70 million m³/a, which can be developed for community water supply (SATAC Joint Venture, 2008), as illustrated in **Table 4.2**.

Groundwater is currently being over-utilised in certain parts of the Olifants catchment, e.g. in the Delmas / Bapsfontein area where too much water is abstracted from the dolomitic aquifer for irrigation. This has resulted in an increase in the number of sinkholes in that area over the last decade.

There are therefore some areas of good yield and some really problematic over-abstractions that must be addressed.

Table 4.1: Summary of Typical Hydrogeological Characteristics (Source: Olifants River Internal Strategic Perspective (ISP))

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	Intergranular 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	Intergranular 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	Intergranular 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	Intergranular and fractured	1 NO_3 problem in Springbok Flats
Clarens SST	2 830	1-2	10-20	30-70	Intergranular and fractured	0
Mudstone and shale (Irrigation) Sandstone (Ecca)		> 0.5	10-20	802-120	Intergranular and fractured	2 or 3
Norite and gabbro	5 800	0.5 – 2 Occasionally > 5	10-20	30-80	Intergranular 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
Dolomite	1 615	< 1 - > 5 Potentially > 20	0 - >50	30-250	Fractured and karst	0 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 (Lowveld)	9 200	0.5 – 2 Occasionally > 5	5-15	30-80	Intergranular and fractured	1 Isolated NO_3 in settlements

Table 4.2: Olifants Catchment: Groundwater Balance

Item	ANNUAL VOLUME IN MILLION M^3
Estimated recharge	+ 860
Estimated evaporation losses	- 500
Community Water Supply	- 93
Irrigation	- 72
Estimated EWR requirement	- 125
POTENTIALLY AVAILABLE	70

Figure 4.1 shows the Malmani Dolomite outcrops to the east of the Pretoria Formations covering a wide area. The dolomites form extensive areas with rugged topography and are mostly undeveloped. North of Lebowakgomo, the dolomite outcrop extends west and forms a small outcrop in catchment B5IE, (Middle Olifants Management Zone). In this area, groundwater is abstracted from the dolomite for the Zebediela estate farms. (SATAC Joint Venture, 2008).

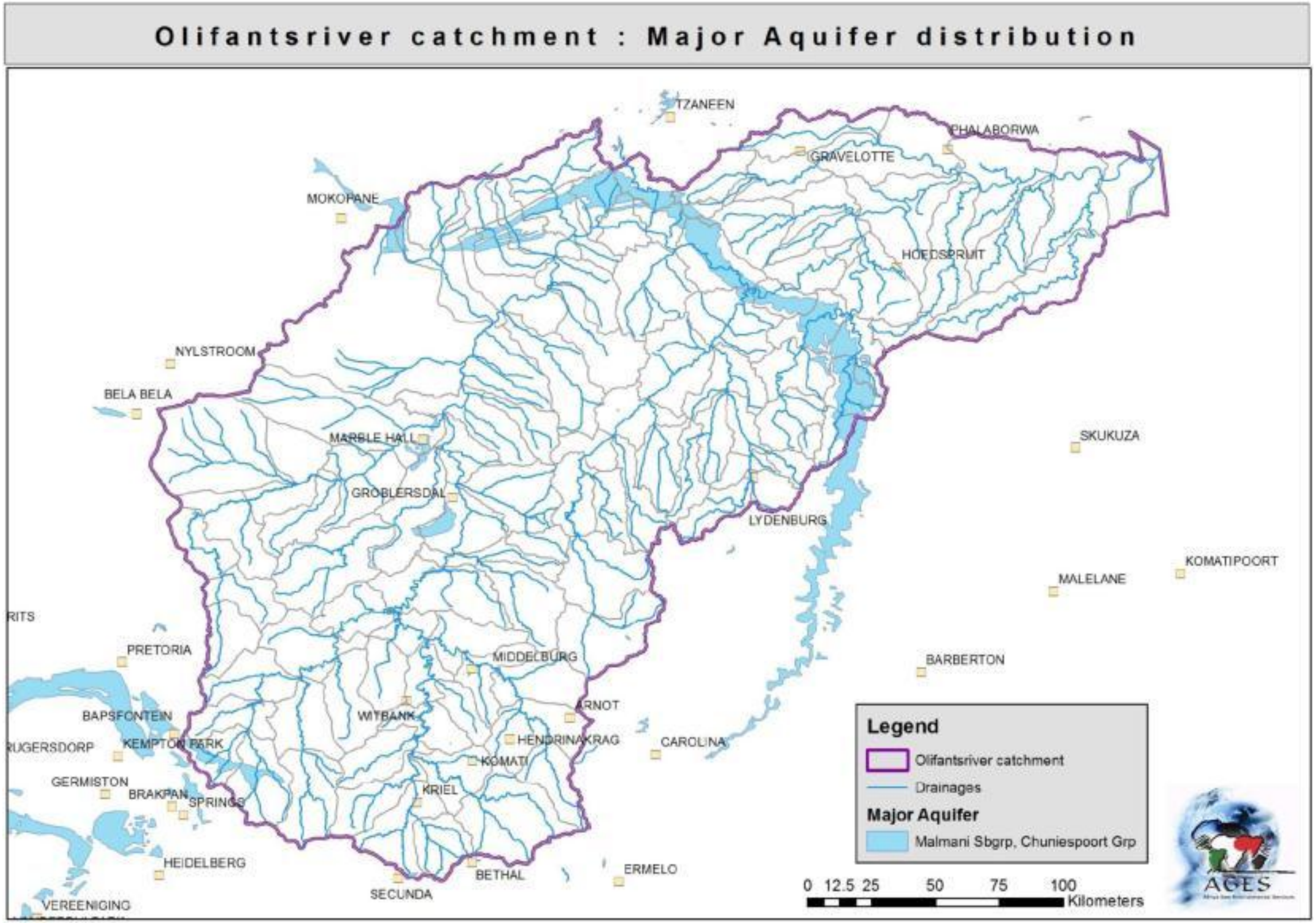


Figure 4.1: The Malmani Dolomite outcrops to the east of the Pretoria Formations

Figure 4.2 reflects the groundwater problem areas within the Olifants catchment (SATAC Joint Venture, 2008). The following areas need attention:

- Delmas / Bapsfontein: Over abstraction from the dolomite aquifer
- Emalahleni / Middelburg area: Acidic water from coal mining operations
- Springbok Flats Area: Over-abstraction and pollution problems – mainly nitrates and fluorides
- Zebediela: Over-abstraction from the dolomite aquifer.
- Eastern Bushveld Platinum Mines: Over-abstraction and water quality problems due to mining activities.
- Steelpoort / Burgersfort area: Over-abstraction and water quality problems due to mining activities.
- Dullstroom / Lydenburg area: Water quality problems due to sanitation – mainly nitrates.
- Kruger National Park: Water quality problems as a result of upstream surface water pollution.

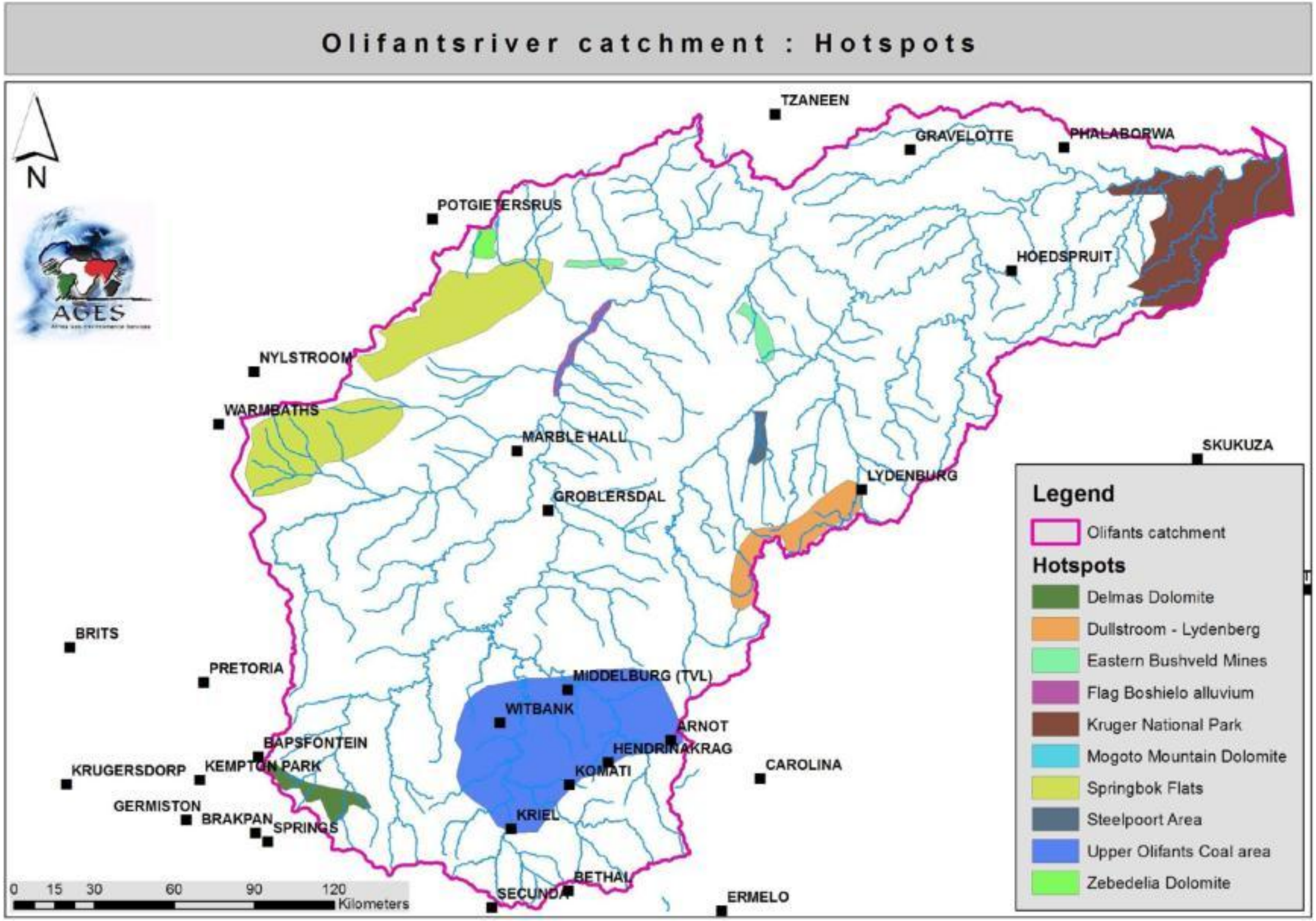


Figure 4.2: Groundwater problem areas within the Olifants catchment

Groundwater management strategies will have to be put in place to address the above problems and can be included in the Catchment Management Strategy which has to be developed by a future Catchment Management Agency.

The over abstraction from the dolomite aquifer in the Delmas / Bapsfontein area has led to a significant increase in sinkholes. (Jasper Muller Ass, 2005). This is illustrated in **Figure 4.3** which makes a comparison between the number of sinkholes in 1998 and 2004.

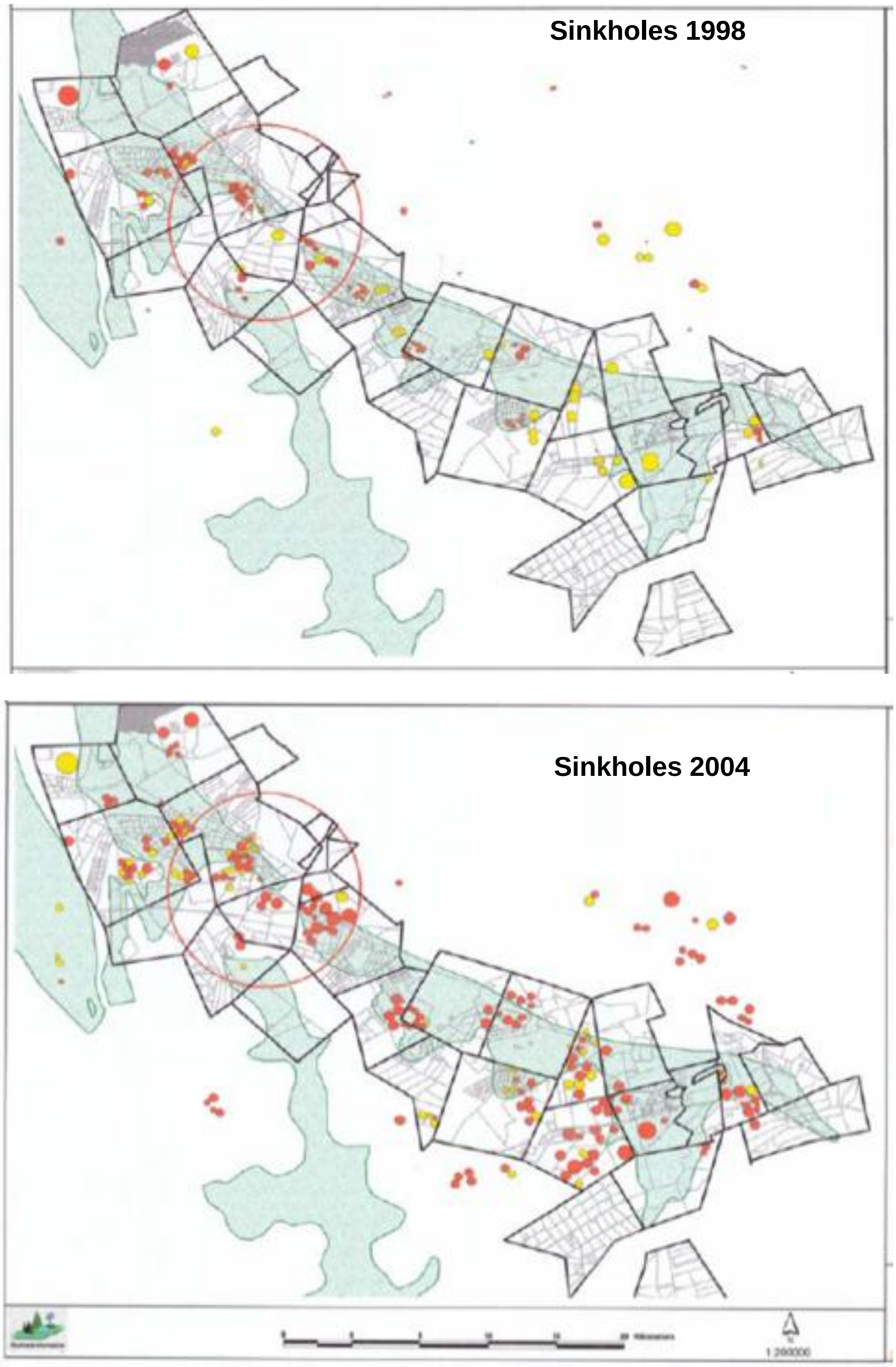


Figure 4.3: Sinkholes in 1998 and 2004

4.2 SURFACE WATER

For the purpose of the analysis for the surface water availability and requirements, the Olifants Catchment has been divided into three management zones as illustrated in **Figure 4.4**.

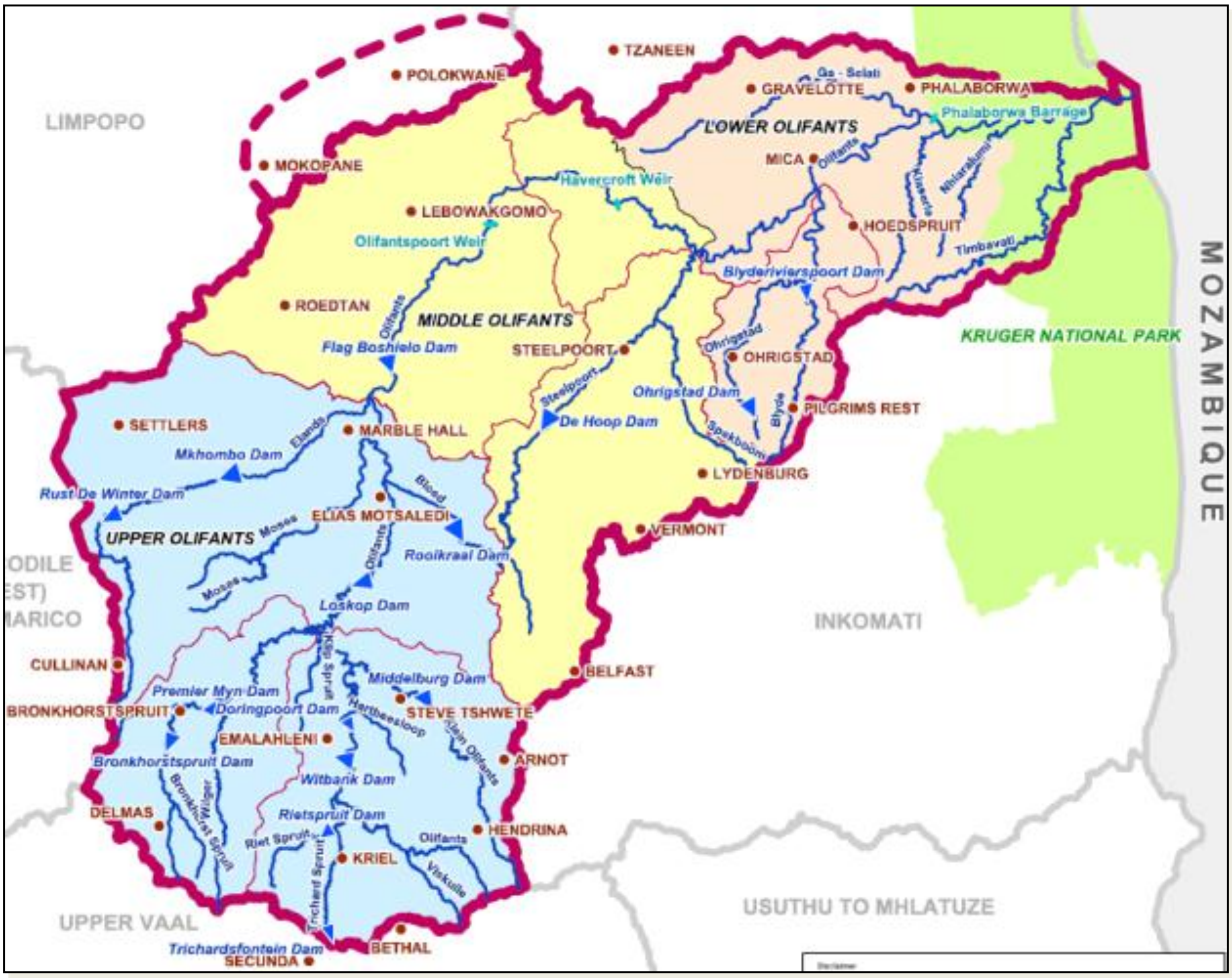


Figure 4.4: Management Zones of the Olifants Catchment

4.2.1 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 4.3**.

Table 4.3: Large Dams in the Olifants River Catchment

Dam	Location		Full Supply Capacity (million m^3)	Historic Firm Yield (million m^3/a)	1:50 Year Yield (million m^3/a)
	Management Zone	Quaternary Catchment			
Bronkhorstspruit	Upper	B20C	58,9	16,9	23,5
Middelburg	Upper	B12C	48,4	12,6	14,0
Witbank	Upper	B11G	104,0	29,5	33,0
Loskop	Upper	B32A	374,3	161	168
Rust de Winter	Upper	B31C	27,3	9,8	11,7
Mkombo with Weltevreden weir	Upper	B31F	205,8	11,7	11,7
Flag Boshielo	Middle	B51B	1788	53,0	56,0
De Hoop (under construction)	Middle	B41H	347,4	98,0	99,0
Ohrigstad	Lower	B60E	13,2	18,9	19,8
Blyderivierspoort	Lower	B60D	54,6	110	130

Note: *Yields are before meeting the EWR water requirements*

The historic firm and the 1:50 yields of all the dams in **Table 4.3** is lower than the storage capacity of the dams except for the Ohrigstad and Blyderivierspoort Dams, which is an indication that the Blyde River tributary is currently not utilised to its full potential.

4.2.2 Diffuse Water Resources

In addition to the yield of the major dams listed in **Table 4.4**, there are a large number of farm dams in the Olifants River catchment that contribute to the yield of the system. Also, there are many water users, mostly irrigators, that abstract water directly from the river and this run-of-river uses 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 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 4.4** summarises the diffuse water resources of the study area.

Table 4.4: 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**

4.2.3 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, so the effect on the water balance in the catchment is zero. There are also three small transfers into the Middle and Lower Olifants from the Letaba/Levhuvhu WMA. 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.

The total surface water resource of the Olifants River catchment is summarised in **Table 4.5**.

Table 4.5: Summary of 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	Total
Upper Olifants	262	128	228	**618**
Middle Olifants	56	71	1	**128**
Lower Olifants	150	49	3	**202**
Total	**468**	**248**	**232**	**948**

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

5. CURRENT WATER USE AND PROJECTED WATER REQUIREMENTS

5.1 CURRENT WATER USE

5.1.1 Irrigation Sector

Irrigation is the largest water user in the Olifants River catchment, with two large concentrations of irrigation downstream of the Loskop and Blyderivierspoort Dams. The total estimated irrigation requirement (as estimated with the use of irrigation models) is 708 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 508 million m^3/a on average, with assurances varying from as little as 10% to 100%, depending on the location in the catchment.

Details of the scheduled areas and application rates within irrigation boards is attached as **Appendix B**. However, it must be borne in mind that the majority of the irrigated area lies outside of irrigation boards.

Table 5.1 lists the estimated water demands and supply to the irrigators in the Olifants River Catchment.

Table 5.1: 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	168	146	171	108	254
Middle Olifants	24	21	105	72	93
Lower Olifants	120	113	120	48	161
Total	**312**	**280**	**396**	**228**	**508**

5.1.2 Domestic and Industrial Sector

Domestic and industrial water use within the Olifants River catchment is summarised in **Table 5.2.** Since industrial users are supplied by municipalities in most cases, it is difficult to distinguish between urban and industrial use. The only well documented industrial water use is that of Highveld Steel which obtains approximately 8 million m^3/annum from the Witbank Dam via the Emalahleni Municipality.

With the exception of the Western Highveld area, which is supplied from the Mkombo and Bronkhorstspruit Dams and (more recently) transfers from the Vaal System, domestic and industrial users receive their water at a high level of assurance. The reason for the low level of assurance in the Western Highveld is due to the water demand exceeding the available resource by a considerable margin.

5.1.3 Mining Sector

The water requirements of the mining sector are also summarised in **Table 5.2**. Many of the mines, and especially the coal mines located in the Upper Olifants, make use of groundwater obtained through their mine dewatering activities. This water use does not impact on the water quantity of the system and was therefore not taken into account in the water balance. However, the water quality from the mines is of concern.

Table 5.2: Domestic and Mining Requirements (million m^3/a)

Management Zone	Domestic and Industrial Requirements (million m^3/a)	Mining Requirements (million m^3/a)	Total (million m^3/a)
Upper Olifants	109	21	**130**
Middle Olifants	39	24	**63**
Lower Olifants	21	36	**57**
Total	**169**	**81**	**250**

5.1.4 Power Generation

There are several large power stations located in the Upper Olifants which have large water requirements related to their wet cooling process. All of these power stations are supplied from either the upper Komati or the Vaal Systems. The estimated supply to these power stations in 2010 is 228 million m^3/a. See **Table 5.3.**

The Kendal power station utilises a dry cooling process which uses 15 times less water than the wet cooled process for the same amount of power generated. A new power station, referred to as the Kusile Power Station, near Emalahleni, is under construction but this power station is also based on a dry-cooling process with limited water requirements.

Table 5.3: Power Stations in the Olifants River Catchment

Power Station	Cooling Process
Arnot	Wet
Duvha	Wet
Hendrina	Wet
Kriel	Wet
Matla	Wet
Kendal	Dry
Kusile (under construction	Dry

5.1.5 Other

There is limited afforestation 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 5.4,** has already been factored in when calculating the yields of major dams and the diffuse water resources.

Table 5.4: Streamflow Reduction due to Afforestation

Management Zone	Streamflow Reduction (million m^3/a)
Upper Olifants	5,6
Middle Olifants	4,8
Lower Olifants	20,6
Total	**31,0**

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 Study (OWAAS) are summarised in **Table 5.5**. More recently, the Agricultural Research Council [ARC, 2010] carried out an intensive study to update estimates of Invasive Alien Plants (IAPs) in the catchment. This study indicates areas of IAPs that are significantly greater than those estimates used in previous studies. These areas are also provided in **Table 5.5**.

Table 5.5: Summary of Areas of IAPs (Units: Km^2)

Management Zone	OWAAS (2010)	ARC (2010)
Upper Olifants	459	1540
Middle Olifants	929	651
Lower Olifants	529	485
Total	**1 917**	**2 676**

The streamflow reduction due to IAPs is given in **Table 5.6**. This was calculated using duration curves based on the known impacts of commercial afforestation in South Africa [Gush, *et al*, 2002].

Table 5.6: 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	Not stated	**81,8**

The estimated available surface water resource (**Table 4.5**) took account of Invasive Alien Plants to the extent estimated and used in the OWAAS. The ARC study suggests significantly greater areas of IAPs and hence a greater streamflow reduction meaning that there could be less water available in the 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 accuracy of the ARC study however, needs to be verified. A meeting was held with key role players in the IAP field at which it was decided that a workshop needs to be held to debate these issues and agree on a way forward.

The cost associated with removing these IAPs was obtained from the ARC report [ARC, 2009

Table 5.7: Impact of IAPs on the Yield of Dams

Sub-catchment	Yield million m³/a			Cost (R million)	Unit cost (R/m³)
	Without IAPs	With IAPs	Impact		
Bronkhorstspruit	23,3	22,5	0,8	15,5	19,4
Middelburg	24,5	24,2	0,3	13,2	44,0
Witbank	57,5	55,4	2,1	75,4	35,9
Loskop	158,7	151,9	6,8	199,7	29,4
Rust de Winter	14,5	13,8	0,7	20,3	29,0
Mkombo	14,6	13,5	1,1	23,4	21,2
Flag Boshielo	67,1	63,9	3,2	165,6	51,8
De Hoop	109,2	98,8	10,4	99,8	9,6
Blyde River	178,5	172,5	6	56,0	9,3
		TOTAL	**31,4**	**668,9**	**21,3**

Table 5.8 provides a summary of all the water use requirements in the Olifants Catchment.

Table 5.8: Summary of Water Requirements (Units: million m3/a)

Management Zone	Irrigation	Domestic, Industrial	Mining	Power Generation	Total
Upper Olifants	254	109	21	228	**612**
Middle Olifants	93	39	24	0	**156**
Lower Olifants	161	21	36	0	**218**
Total	**508**	**169**	**81**	**228**	**986**

5.2 PROJECTED FUTURE WATER REQUIREMENTS

The estimated high growth scenario within the Olifants River Basin is shown graphically in **Figure 5.1** and is discussed in detail in the following sections.

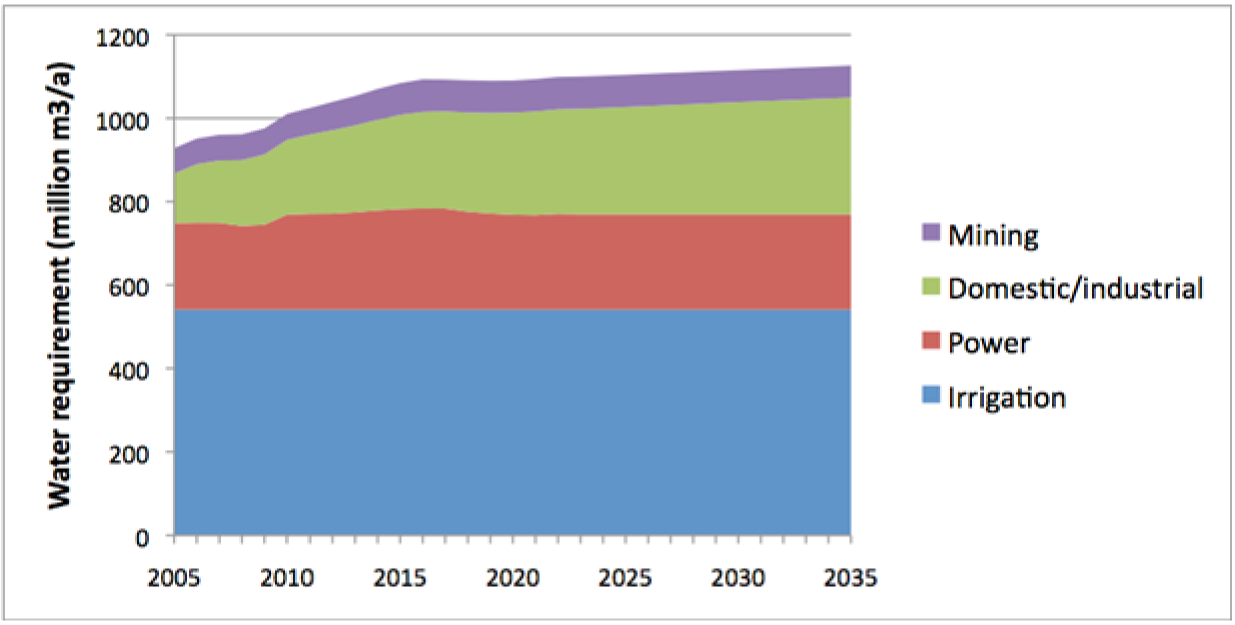


Figure 5.1: High Growth Scenario

5.2.1 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.

5.2.2 Domestic and Industrial Sector

There has been rapid growth in the domestic 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 2030 is shown in **Table 5.9.** This is based on the IWRMP report on the Upper and Middle Olifants (DWAF, 2008) with similar growth factors applied in the Lower Olifants.

Table 5.9: Growth in Requirements – Domestic, Industrial and Power Generation (Units: million m^3/a)

Management Zone	2010 Requirements (million m^3/a)	2030 Requirements (million m^3/a)
Upper Olifants	361	396
Middle Olifants	63	143
Lower Olifants	57	69
Total	**481**	**608**

5.2.3 Mining Sector

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 construction of the De Hoop Dam. However, the economic downturn in 2008 put many new planned mining developments on hold and the future requirements of the mining sector are now uncertain. The most likely growth remains in the Middle Olifants, however, with limited expansion of mining water demands in the remainder of the catchment.

5.2.4 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 externally. A new plant, the Kusile Power Station, is being constructed near Emalahleni and falls within the Olifants River catchment, but will obtain its water from Vaal System. Also, since this new power station will utilise a dry-cooling process, the additional water requirements due to this plant are limited. The Komati Power Station is also being re-commissioned and its water has 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 and the water balance of the Olifants River catchment will not be affected by this growth.

5.2.5 Other

Streamflow reduction due to afforestation will not increase as new licences for forestry will not be issued in the Olifants River catchment. The on-going removal of IAPs in the catchment should result in an increase in flow although actual areas and water resource impacts must still be confirmed. Scenarios will be modelled to indicate the gain in yield with the reduction in IAPs.

5.3 CONFIDENCE ENVELOPES

The growth in water demands indicated in Section 5.2 is a conservative (i.e. relatively generous) high growth scenario assuming that the profitability and subsequent growth in the mining industry will recover to 2008 levels. The growth in urban water supply is assumed to continue to grow as rapidly as in the past few years.

The low growth scenario assumes a more pessimistic view in terms of growth in the mining industry and urban population, while the irrigation and forestry requirements remain constant for both scenarios.

6. WATER QUALITY

6.1 BACKGROUND

Various previous reports and current studies focus on the water quality problems in the Olifants River catchment. In this study the Olifants River was looked at in its entirety with specific focus on the possible impact of water quality on the water availability. The question that needed to be addressed was therefore whether additional water would be needed to address the water quality problems that are experienced in certain areas.

6.2 SOURCES OF POLLUTION

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, 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.

Irrigation return flows is also causing a rise in salinity levels downstream of irrigatied areas.

6.3 ACTUAL WATER QUALITY VS. WATER QUALITY OBJECTIVES

Water quality is determined by the activities in the catchment, the land use, and the geology. Water quality guidelines published by the Department were used to develop combined

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 is therefore 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 the water quality objectives will not differ from what they are at 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.

6.3.3 Water Quality Situation in the Olifants River System

There are a number of water quality concerns in the catchment, primarily close downstream of 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.

The Middelburg Dam (station B1H004) is 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 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 Dam, Witbank and Middelburg Dams to 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)

Table 6.2 is the water quality assessment 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 phosphates levels in the Olifants River System are within acceptable ranges. The only cause for concern is the pH values at station B1H004 in the Middelburg Dam catchment, which is in the unacceptable range.

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 6.2: Water Quality Assessment: Median

Area	Monitoring Point	EC	NO_3/ NO_2	PO_4	NH_3	pH	Cl
Witbank Dam Catchment	B1R001Q01		0,14	0,01		7,80	16,30
	Rietspruit					7,91	44,00
	Rietspruit Dam					8,24	26,00
	Tweefontein					7,88	82,00
	Bethal Road Bridge					7,71	24,00
	B1H020	111,05	0,042	0,015	0,045	7,76	44,40
	B1H006	25,90	0,090	0,015	0,042	7,70	11,5
	B1H019	78,35	0,046	0,0120	0,04	7,640	20,693
	B1H017	58,95	0,01	0,019	0,01	8,33	24,75
	B1H021	45,25	0,28	0,09	0,041	8,23	22
	B1H018	33	0,01	0,022	0,01	8,11	19,10
	B1H005	63,25	0,158	0,014	0,04	7,97	20,10
	Duvha Road Bridge					8,07	22,00
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
	B3R002	27,8	0,11	0,01	0,05	7,40	14,10
Middelburg Dam Catchment	B1H012		0,04	0,01	0,04	7,96	20,53
	B1H015		0,08	0,01	0,04	7,94	14,40
	B1H004		1,27	0,01	0,12	3,96	41,85
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

6.3.4 Trend Analysis

A summary of the water quality trends is presented in **Table 6.3**. 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 6.3: Summary of Trend Analysis

Area	Monitoring Point	EC	NO_3/NO_2	Po4	NH3	pH	Cl
Witbank Dam Catchment	B1R001Q01		B	R	B	G	R
	Rietspruit	B				G	B
	Rietspruit Dam	G				G	R
	Tweefontein	R				G	R
	Bethal Road Bridge	R				G	R
	B1H020	R	G	G	B	G	B
	B1H006	R	B	R	G	G	B
	B1H019	B	G	G	G	G	B
	B1H017	G	B	G	G	G	G
	B1H021		G	R	G	G	R
	B1H018	G	G	G	B	G	B
	B1H005		B	G	G	G	R
	Duvha Road Bridge	R				G	G
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
	B3R002	R	B	G	B	G	R
Middelburg Dam Catchment	B1H012		G	G	G	G	R
	B1H015			R	G	G	R
	B1H004		G	R	B	R	B
Middle Olifants Catchment	B3R001Q01		B	G	R	G	R
	B3R005Q01		B	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

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 also be attributed to the various mining activities in the study area.

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.

6.3.5 Summary of Findings

The water quality in the study aea is generally suitable for use, although there are exceptions.

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

The current water quality in the system will not influence the water availability as described in section 7. But immediate attention should be given to the upward trends shown in **Table 6.3**.

An issue that will require specific attention is the 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 decanting is allowed to occur uncontrolled.

7. THE WATER BALANCE

7.1 CURRENT WATER BALANCE WITH NO INTERVENTIONS

The water balance, based on estimated 2010 water requirements, is shown in **Table 7.1**. Water deficits are shown in brackets.

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

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	612		6
Middle Olifants	128	156		(28)
Lower Olifants	202	218	18	(34)
Total	**948**	**986**	**18**	**(56)**

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 EWRs. **Table 7.2** therefore presents the water balance with the De Hoop Dam operational and the Ecological Reserve (ER) implemented. The EWRs have been based on the 1999 ER study completed in 2002 [DWAF, 2002], but will need to be updated and taken through the full classification process before full implementation will be possible.

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

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	612	80	(74)
Middle Olifants	227	156	51	20
Lower Olifants	202	218	69	(85)
Total	**1 047**	**986**	**200**	**(139)**

Note: *Including De Hoop Dam*

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 ecological Reserve for 2030.

Table 7.3: Future (2030) Water Balance (Units: million m^3/a)

Management Zone	Total Water Resource	Water Requirement	EWR	Water Balance
Upper Olifants	618	648	80	(110)
Middle Olifants	227	214	51	(38)
Lower Olifants	202	230	69	(97)
Total	**1 047**	**1 092**	**200**	**(245)**

Note: *Including De Hoop Dam*

Both the current and future water balances show deficits for the system as a whole. The Middle Olifants will have a slight surplus once the commissioning of the De Hoop Dam is complete (prior to the phasing in of the Reserve), but in 2030 all Management Zones will have a water deficit if the EWR is supplied throughout the catchment.

The above 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 Reserve was assumed to be phased in over a period of 8 years from 2016.

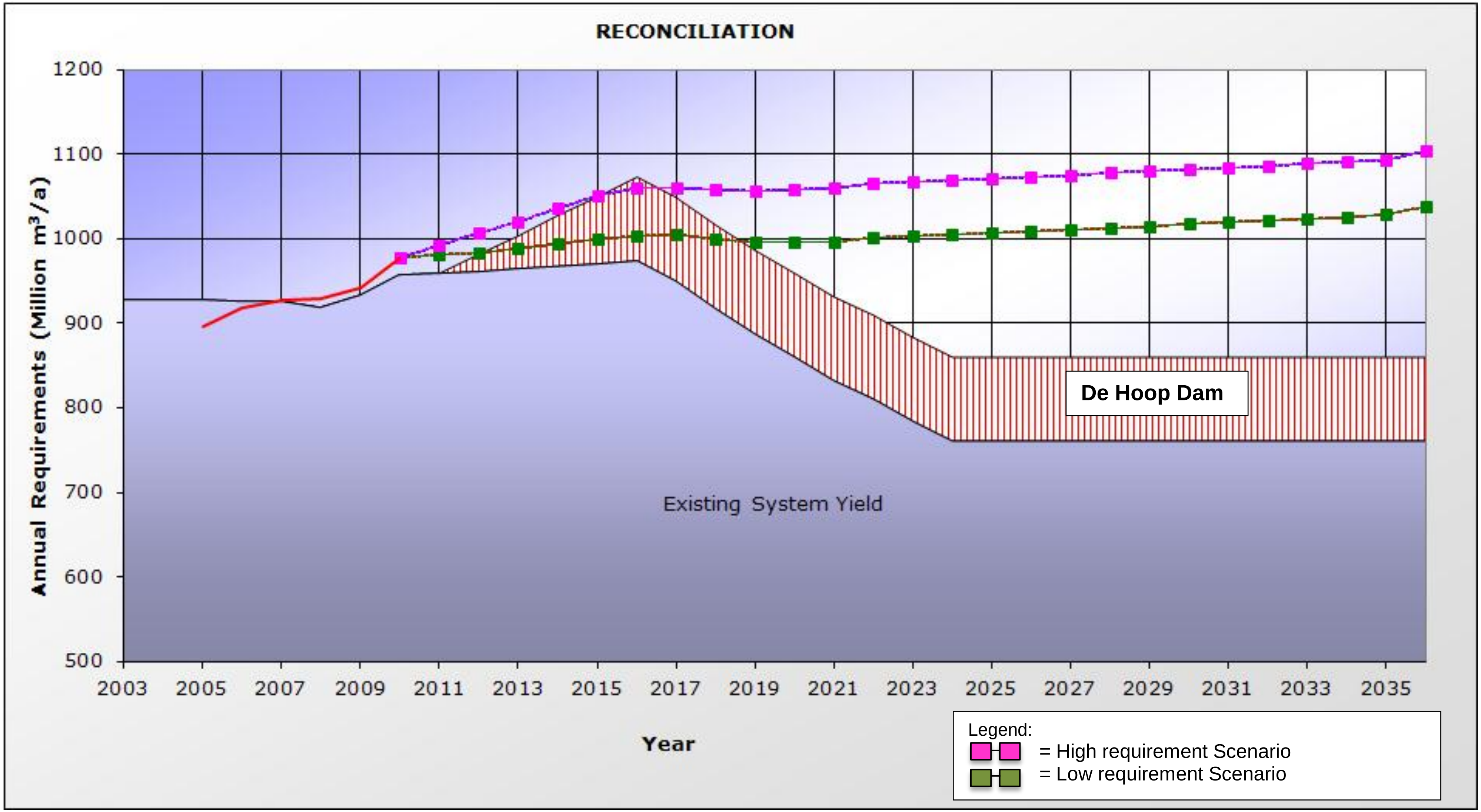


Figure 7.1: Water Balance of the Olifants River Basin

From the graph it is clear that a water deficit will be experienced from the year 2017 for the high water requirements scenario and two years later for the low water requirements scenario, as a result of the impact of implementation of the Reserve.

7.3 SURPLUSES / SHORTFALLS

The balances 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 Mkombo 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 slight deficit (without the ER), but including the Reserve results in large deficits, 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.

For the future the situation is much worse and, as can be seen in **Table 7.3** and **Figure 7.1**, all Three Management Zones will have water deficits in 2030 and the total water deficit for the whole catchment will have grown to 245 million m^3/a.

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

8. TOWARDS ACHIEVING A WATER BALANCE

8.1 INTERNATIONAL CONVENTIONS AND REQUIREMENTS

After the Reserve, comprising Basic Human Needs (BHN) and the environmental requirements, international agreements are afforded the second highest priority in the National Water Act (NWA). The International agreement between South Africa and Mozambique for Massinger Dam does not specify a minimum flow quantity or quality, but South Africa is party to international policies and protocol and the flow across the border must be reasonable (both in terms of quantity and quality).

8.2 WATER QUANTITY

The water requirements within the study area already exceed the available resource. This situation must be resolved, and logic suggests a combination of reducing the water use and increasing the available resource.

8.3 OBJECTIVES AND ASSUMPTIONS FOR WATER RECONCILIATION IN THE CATCHMENT

Reflecting on the status of the water resources of the basin, described above, it is necessary to agree on objectives for the management assumptions on the future use of the resource.

The 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.

9. POSSIBLE INTERVENTION OPTIONS

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

A list of all identified reconciliation options was compiled and screened at a Preliminary Screening Workshop held on 7 July 2010. The following reconciliation options were identified after the screening and are currently being investigated.

9.1. OPTIONS THAT WILL REDUCE WATER REQUIREMENTS

9.1.1. Eliminating Unlawful Water Use

Eliminating unlawful use is a reconciliation option, that must be tackled by the Department as a matter of urgency. The volume of water that can be freed up can only be ascertained once the validation and verification studies have been completed by the DWA.

Unlawful Water Use is expected to be found on a large scale amongst the irrigation users. **Table 9.1** provides an indication of the extent to which irrigation use has expanded from 1996 to 2004. It shows that the total irrigation has increased from 838 km² to 1 139 km², i.e. by 38% in 8 years' time or nearly 5% per year. This irrigation expansion is not necessarily all unlawful. Expansion in area could have taken place by using the allocated quantities of water more efficiently. However, the suspicion exists that a portion of the irrigation expansion was affected through unlawful water use.

Table 9.1: Growth in Irrigation Use (units km²)

Catchment	Irrigation Area	
	1996	2004
Upstream of Loskop dam	121	234
B30 (Elands, Moses, Olifants)	440	519
B40 (Steelpoort)	41	76
B50 (Olifants)	67	84
B60 (Blyde)	92	129
B70 (Olifants, Selati)	67	97
TOTAL	**828**	**1139**

Currently the precise extent of unlawful use will remain a huge uncertainty until the validation and verification process which is currently being done by the DWA Regional Office in Mpumalanga, is complete.

For the purposes of this preliminary reconciliation strategy it is assumed that at least 5% of the 38% irrigation expansion is unlawful and could be curtailed through appropriate compliance and enforcement (CME) measures.

The assumption of 5% may be conservative and will be adjusted in the Final Reconciliation Strategy, if necessary. It was estimated conservative, also because of the possibility that legal prosecutions may not necessarily in all cases be successful.
In the interim, the study team will focus on this aspect in order to get better information.

Eliminating unlawful use does not require the completion of the full validation and verification process. As soon as any 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 quantity of water which can be freed up by implementing Compliance Monitoring and Enforcement (CME) is estimated at 25 million m^3/a. 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.

9.1.2. Water Conservation and Water Demand Management (WCDM)

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

WCDM 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 WCDM measures immediately and that it will take approximately 5 years to phase in the full benefits of the water saving.

(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 508 million m^3/annum (adjusted to 98% assurance of supply), comprising 67% 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 through 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 for 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 appearing as return flows to be abstracted downstream in the river. 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.

This will be one of the structural options that can be considered and needs more investigation. This structural option will be weighed up against the other structural options when drawing up the Final Reconciliation Strategy.

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 after 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 WCDM beyond field edge supply should therefore be linked to Compulsory Licensing where the water allocation of each irrigator can be trimmed. It is foreseen that 10% water savings can be achieved with WCDM applied by each irrigator without any prejudice of that irrigator in terms of income loss. This saving will be shown under compulsory licensing.

(b) WCDM 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 WCDM 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, legislation)
  - Mains replacement
  - Leak detection and repair

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

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

It is very difficult to determine what the total water saving potential is in all the urban areas in the Olifants River system. As detailed information exists for the Emalahleni Area, this information has been used as the basis for the calculations and it is assumed that a similar type and magnitude of water saving would also exist in all the other urban areas.

The estimated possible saving for Emalahleni is 43 million m^3/a, which represents approximately 27% of the current water requirements. Of this 22% can be achieved through water loss management and 9% through increased water use efficiency.

It is uncertain whether the other Olifants Catchment towns will show the same potential as Emalahleni. It is therefore recommended to set an achievable target of 15% overall savings for all the towns in the catchment.

(c) WCDM in Mining

Mines are spread over significant sections of the study area but primarily in the Upper and Middle Olifants.

The perception exists that mines already use their water efficiently and that there is little scope of improvement. However through changing the mining processes and reusing and recycling the water used for mining, further savings are possible.

A 10% saving was assumed for water requirements for mines.

9.1.3. Reducing Assurances of Supply

Further water allocations may be possible if existing water users agree to accept lower assurances of supply. Possible incentives could be the lowering of water charges in times of water shortages or compensating for damages that result from water shortages.

The generally accepted assurances of supply for the different sectors and also used for modelling the available water 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)
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 incentives (e.g. paying out compensation for consequent losses).

It is not known whether the farming community will be amenable to accepting lower assurances of supply.

As part of this study, the farmer associations will be consulted in this regard and in the Final Reconciliation Strategy it will be confirmed whether reducing of assurances of supply should still be one of the options.

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.

9.1.4. Compulsory Licensing

The NWA allows the Minister to require the licensing of all water use. The procedure means 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 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 be linked to a WCDM 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 WCDM together with compulsory licensing, the water users can reduce their water requirements while retaining their current levels of income. Water users however won't be able to expand their enterprise with the saved water. The saved water will therefore become available for reallocation when implementing compulsory licensing.

The disadvantage of linking the compulsory licensing process to a WCDM initiative is that the implementation of WCDM would have to be delayed, given that the compulsory licensing process is dependent on the completion of the validation and verification task which could take as long as four years. If WCDM is implemented with immediate effect, the saved water may lawfully be utilised for horizontal expansion of the enterprise without the water authority being able to prevent this. Later implementation of compulsory licensing with consequent water curtailments will then inevitably lead to economic prejudice as further WCDM possibilities will by then be limited or completely exhausted.

The target WCDM water savings as described in Section 9.2, i.e. 10%, 15% and 10% for the irrigation, domestic/industrial and mining sectors respectively are assumed to become available for reallocation if compulsory licensing is linked to the WCDM initiative.

At issue in the implementation of WCDM is that saved water may **lawfully** be taken up for use in horizontal expansion. This may be to the immediate advantage of the user but means that when compulsory licensing is implemented these now efficient users will not have WCDM as a way of making up for cuts in allocations (of course this applies to users who are already operating at maximum efficiency). WCDM will only alleviate the stress on the water balance, and reduce the need for compulsory reallocations, if water saved is returned to the system - and an innovative approach is necessary in addressing this conundrum. The introduction of a compulsory levy, which provides the funds to buy up water saved (through a form of water trade) rather than to see it used in horizontal expansion, would be one approach, and this is discussed in Section 9.1.5 below. There must be other ways of users pre-empting the impacts of compulsory licensing, but these would require carefully structured cooperation and agreement between users and water management authorities to ensure that those who do implement WCDM and who voluntarily reduce or trade their saved allocations, are not prejudiced by this when Compulsory Licensing is finally implemented.

9.1.5. Compulsory Levy and Purchasing Water Entitlements

The full Compulsory Licensing process can be long and tedious. An alternative approach to reduce water use would be where the Minister levies 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.

For the purpose of this strategy it was assumed that the WCDM/Compulsory Licensing approach would rather be used as the compulsory licensing process is enforceable through the NWA while it is uncertain now many water entitlements or portions thereof will be offered to the water authority for purchasing.

9.1.6. Water Trading

Water trading 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 the water entitlement of an irrigation farmer or group of farmers.

Water trading is based on the willing buyer/willing seller principle.

This option will not necessarily reduce the total water requirements of the system but will allow movement of water entitlements among the water use sectors. It can therefore reduce the water requirement within one water use sector but will at the same time increase the water supply in another.

9.2. OPTIONS THAT WILL INCREASE WATER SUPPLY

The following reconciliation options to increase the water supply of the system were retained after the preliminary screening process and are currently being investigated:

9.2.1 Groundwater Development

It is calculated [SATAC Joint Venture of SSI and Africon in Association with Knight Piesold Consulting, Sigodi Marah martin and Ages, 2008] that 25% for the aquifers in the Olifants River Catchment are over-utilised. It is estimated that up to 70 million m³/a of additional groundwater resource could be the developed in the quaternary catchments that are not stressed. This is especially true for the dolomite aquifers in the northern escarpment areas where the resources could be used for future development as regional groundwater resources.

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.

For the purposes of the Preliminary Reconciliation it is assumed that only 35 million m³/a (50% of the reported available yield) can be exploited and that groundwater projects will progressively be developed over the next 16 years.

9.2.2 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 were selected. The concept of the project is shown on the map in **Figure 9.1.**

Figure 9.1: 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.

Details of the envisaged scheme are shown in **Table 9.2,** from which it can be deduced that 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 9.2: 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)
			($x10^6$ m^3/a)	(m^3/s)	Destination	(m^3/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 Daveton WWTW: Capacity 136 Ml/day														657	3,48
													TOTAL (Excl 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 will be required sooner than otherwise. That cost must still be assessed, and like the Vaal Dam option, will be payable in the form of the Vaal River raw water tariff.

For the purpose of this report, the additional Vaal River tariff was estimated at R4.50/m^3.

The seven treatment works have been selected based on their capacities and their location relative to the Olifants catchment. They are listed in **Table 9.2**. 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 9.2.**

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.

9.2.3 Transferring More Water from Vaal Dam

DWA has recently commissioned a scheme (the Vaal River Eastern Sub-System Augmentation Project (VRESAP) scheme) to pump 160 million m³/a of raw water from the Vaal Dam into 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 m³/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/m³. 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 the next phase of the Lesotho Highlands Water Project (LHWP), this tariff will be significant. While the tariff after construction of the LHWP is not yet known, it is assumed for the purposes of this report that it will be in the order of R4,50/m³.

9.2.4 Raising of Blyderivierspoort Dam

The existing Blyderivierspoort Dam 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, suggesting 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 m³. The estimated cost of such a project will be R2,98 million with a URV of R2,99/m³. From an economic point of view, this option is therefore less attractive than the two dam options in the Olifants River Gorge, described in Paragraph 9.2.6.

9.2.5 New Dam at Rooipoort

In 1993 and again in 2001, DWA undertook feasibility studies for a possible dam on the Olifants River at Rooipoort, 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 be flooded 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 downstream of Rooipoort might be more favourable, with a slightly higher yield, being downstream of the Mohlapitse tributary, and with relatively few 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.

9.2.6 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 km 145.

Two potential dam sites have been identified on this reach, as indicated on Figure 9.2, namely:

i) Godwinton, at km 12; and
ii) Chedle, at km 145.

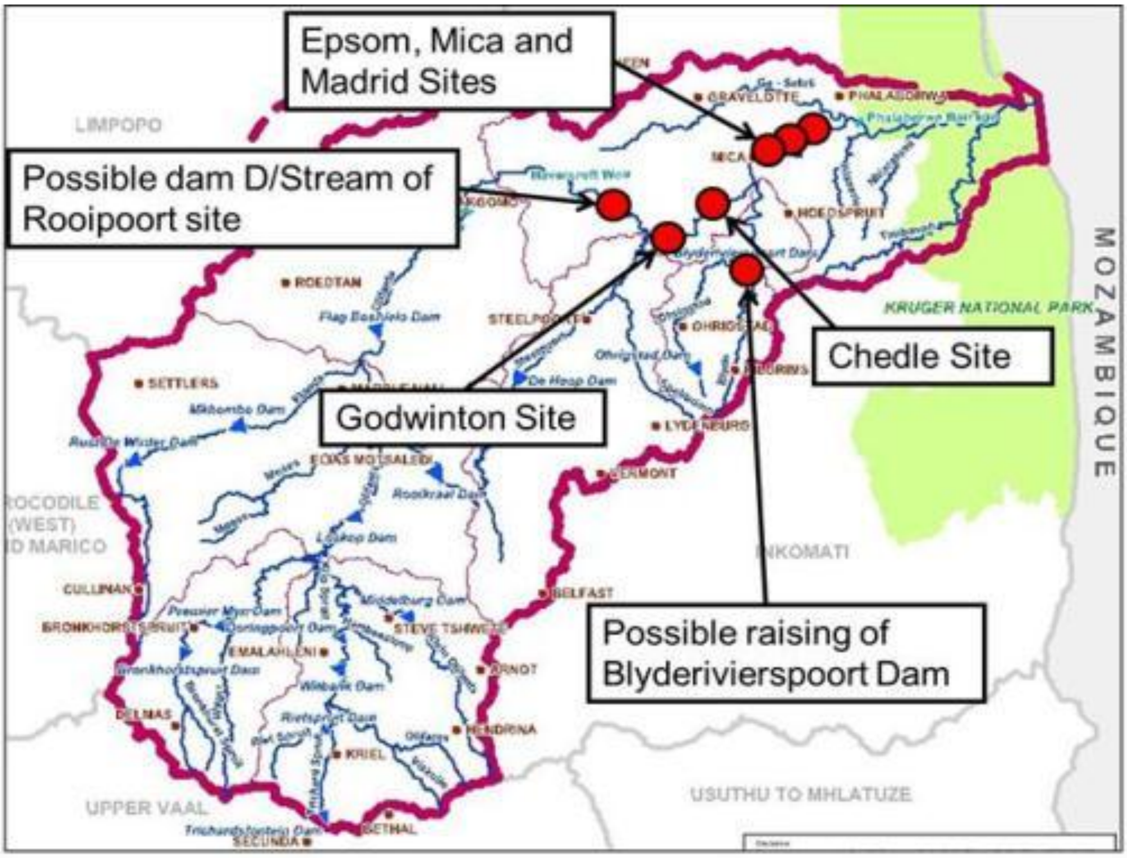


Figure 9.2: Possible Dam Sites

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.

Each of these dams would yield in the order of 100 million m^3/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 / m^3 and R0,29 / m^3 respectively could also be much higher because of inaccessibility for construction equipment, but will still be the lowest URVs of all the development options.

9.2.7 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 have been identified, namely:

i) Epsom
ii) Mica
iii) Madrid

The three sites are also shown on **Table 9.3**.

The Epsom site is located immediately downstream of the Blyde/Olifants confluence, which makes it favourable in that water will be stored up in both rivers. 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, nor will both sites get away with short 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 **(Table 9.3)** 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 dam has been costed and the cost was estimated at R4 504 million, which is very high. The dam would however yield approximately 286 million m^3/a which results in a relatively favourable URV of R1,71 / m^3.

9.2.8 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, can the shafts and gallaries of decommissioned underground mines 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.

The additional yield which the higher infiltration and the water storage in the mines will provide has not as yet been determined. More attention will be given to this aspect for the Final Reconciliation Strategy.

9.2.9 System Operating Rules

The dams within the Olifants River are currently all operated independently, with little or no consideration of the state of storage of other dams or the system as an integrated system. It is probable that operating rules, which consider the conjunctive use of all resources within a systems context, and detailed information on the timing and location of water requirements (similar to the systems used in the Orange, Komati and Crocodile (East)) basins, could improve the efficiency of use of the available resource.

The volume of additional water per year that will become available by applying system operating rules is still uncertain and more attention needs to be given to this aspect when preparing the Final Reconciliation Strategy. Provisionally it is estimated at 5% of the total water supplied by the current infrastructure.

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

It was assumed that the lead time for implementing System Operating Rules would be 2 years.

9.2.10 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.

9.2.11 Removal of Invasive Alien Plants

As described earlier in this report, the best estimate of water use of the current infestation of 1 917km^2 of IAPs, over and above the water use of the replaced indigenous vegetation, is 31 million m^3/a.

The Working for Water teams are already busy with a programme of removing invasive alien plants. If all IAPs are removed then the annual flows should increase by 31 million m^3, although this does not translate directly into utilisable yield.

It is assumed that the current programme will be continued and will even be intensified so that the current infestation will be halved in 8 years' time, putting 15 million m^3 of water back into the system.

9.2.12 Water Transfer from the Crocodile (West) River System

A possible water transfer from the Crocodile (West) & Marico System, which has only recently become an option as a result of the lower water demand from the Crocodile than originally estimated, has not been investigated, but it will be considered in the run-up for the final Reconciliation Strategy.

9.3. SUMMARY OF THE YIELD AND COST INFORMATION OF THE WATER TRANSFER AND WATER STORAGE OPTIONS

Table 9.3 summarises the yield, cost, unit cost and URV information of the dam and water transfer 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 9.3: Comparison of Options

	Yield ($x10^6$ m^3/a)	Cost (R x 10^6)	Unit Cost (R/m^3)	URV (R/m^3)	Comments
Ekurhuleni Effluent	38,3	1,123		7,31	Excludes cost of LHWP (URV: R6,14/m^3)
Import from Vaal Dam	160	3,500		3,60	
Rooipoort Dam	59	1,140	19,32	2,14	
Raising Blyderivierspoort Dam	110	2,977	27,06	2,99	Excludes cost of land
Godwinton Dam	100	52	0,52	0,23	
Chedle Dam	100	111	1,11	0,29	
Madrid Dam	286	4,504	15,75	1,71	
Desalination of Seawater	100	13,000		45,00	

From **Table 9.3** it can be concluded that one of the Godwinton and Chedle dams will be the most economical dam option. The transfer options, i.e. Ekurhuleni Effluent and the Importation of Raw Water from Vaal Dam are more expensive and yield higher URV values than any of the dam options. It is important that the URV cost of R6,14/m^3 is added to the URVs of both these options. Vaal Catchment water has been assumed to be available for this exercise but this must be confirmed should any of the transfer options be considered. The only advantage of the transfer options is that water will be made available high up in the Olifants catchment which makes the water more accessible. This must be regarded as provisional as the transfer of water from the Crocodile (West) River System has not as yet been investigated.

10. BALANCING THE WATER REQUIREMENTS WITH THE WATER RESOURCE (SCENARIOS)

In Section 9, the various reconciliation options are described. These can be divided into management and development options, both for the water requirement and water supply groups.

The management reconciliation options can generally be implemented sooner than the development reconciliation options and require less capital. **Table 10.1** shows the management options that will make a significant difference in either the water requirements or water availability.

Table 10.1: Management Options

Option	Starting Year	Duration (Years)	% Saving Supply increase	Estimated Saving / Yield million m^3/a	Comments
WCDM Irrigation	2011	5	10%	28	Includes both leakage controls through refurbishment of canals and beyond field edge water savings. Only scheduled irrigation was considered. Should be linked to compulsory licensing.
WCDM Urban	2011	5	15%	25	Could start immediately.
WCDM Mining	2015	5	10%	8	Should be linked to compulsory licensing.
Compulsory Licensing Irrigation	2015	4	See WCDM (10%)	See WCDM (28)	Dependent on validation and verification process (± 4 years) which must first be completed. Linked to WCDM.
Operating Rules	2011	2	5%	47	Relatively cheap to implement. Could render quick wins.
Unlawful Water Use	2012	4	5%	25	The completion of eliminating unlawful water use is dependent on validation and verification process (± 4 years) which must first be completed.
Removal of IAPs	2011	8		15	Half of the estimated water use of 31 million m^3/a.
			Total saving / yield	**133**	

The management reconciliation options were all favourably reviewed at the Preliminary Screening Meeting and could be all pursued. However the compulsory licensing option and the alternative of levying a charge to purchase water entitlements were regarded as mutually exclusive. For the analysis it was decided to choose the compulsory licensing alternative as in Section 543-48 of the NWA.

10.1. SELECTING THE MOST FAVOURABLE OPTION COMBINATION

Three possible reconciliation scenarios have been analysed, i.e.:

Scenario 1:

i) The high and low water requirements projection.
ii) The management options implemented as in **Table 10.1**.
iii) The full Reserve (i.e. 200 million m^3 at an equivalent of 98% assurance of supply) phased in from 2016 over a period of 8 years, starting with the agreed low flow of 18,4 million m^3/a, which is the current provision made for the Kruger National Park.
iv) Groundwater development options phased in over the next 16 years.
v) De Hoop Dam commissioned in 2012.
vi) Godwinton Dam commissioned in 2020 (yield 100 million m^3).

Table 10.2 provides the set-up information for Scenario 1.

Table 10.2: Set-up Information – Scenario 1

Intervention	Year of First Water or Saving Million m^3/a	Yield Million m^3/a
WCDM Urban	2012	25
WCDM Mining	2015	8
WCDM Irrigation	2015	28
De Hoop Dam	2012	99
System Operating Rules	2012	25
Eliminating Unlawful Use	2012	25
Compulsory licencing	2015	Linked to WCDM
Godwinton Dam	2022	100
Groundwater Options	2011	35
IAP Removals	2011	15
TOTAL		**360**

Scenario 2:

i) Same as Scenario 1 except the water transfer from Vaal Dam instead of the Godwinton Dam.

Table *10.3* provides the set-up information for Scenario 2.

Table 10.3: Set-up information for Scenario 2

Intervention	Year of First Water or Saving Million m^3/a	Yield Million m^3/a
WCDM Urban	2012	25
WCDM Mining	2015	8
WCDM Irrigation	2015	28
De Hoop Dam	2012	99
System Operating Rules	2012	25
Eliminating Unlawful Use	2012	25
Compulsory licencing	2015	Linked to WCDM
Vaal Transfer	2022	160
Groundwater Options	2011	35
IAP Removals	2011	15
TOTAL		**420**

Scenario 3:

i) The high water requirements projection.

ii) Half the effect of the implementation of the Reserve (this will reduce the available water by 100 million m³/annum at 98% of assurance), phased in over 8 years, starting with the agreed 18,4 million m³/a, which is the current provision made for the Kruger National Park.

iii) The management options implemented as in **Table 10.1**.

iv) Groundwater development options phased in over the next 16 years.

v) No dam or transfer option.

Table 10.4 provides the set-up information for Scenario 3.

Table 10.4: Set-up information for Scenario 3

Intervention	Year of First Water or Saving Million m^3/a	Yield Million m^3/a
WCDM Urban	2012	25
WCDM Mining	2015	8
WCDM Irrigation	2015	28
De Hoop Dam	2012	99
System Operating Rules	2012	25
Eliminating Unlawful Use	2012	25
Compulsory licencing	2015	Linked to WCDM
Groundwater Options	2011	35
IAP Removals	2011	15
TOTAL		**260**

10.2. WATER DEMAND / WATER SUPPLY GRAPHS

The results of Scenario 1 are reflected in **Figure 10.1**.

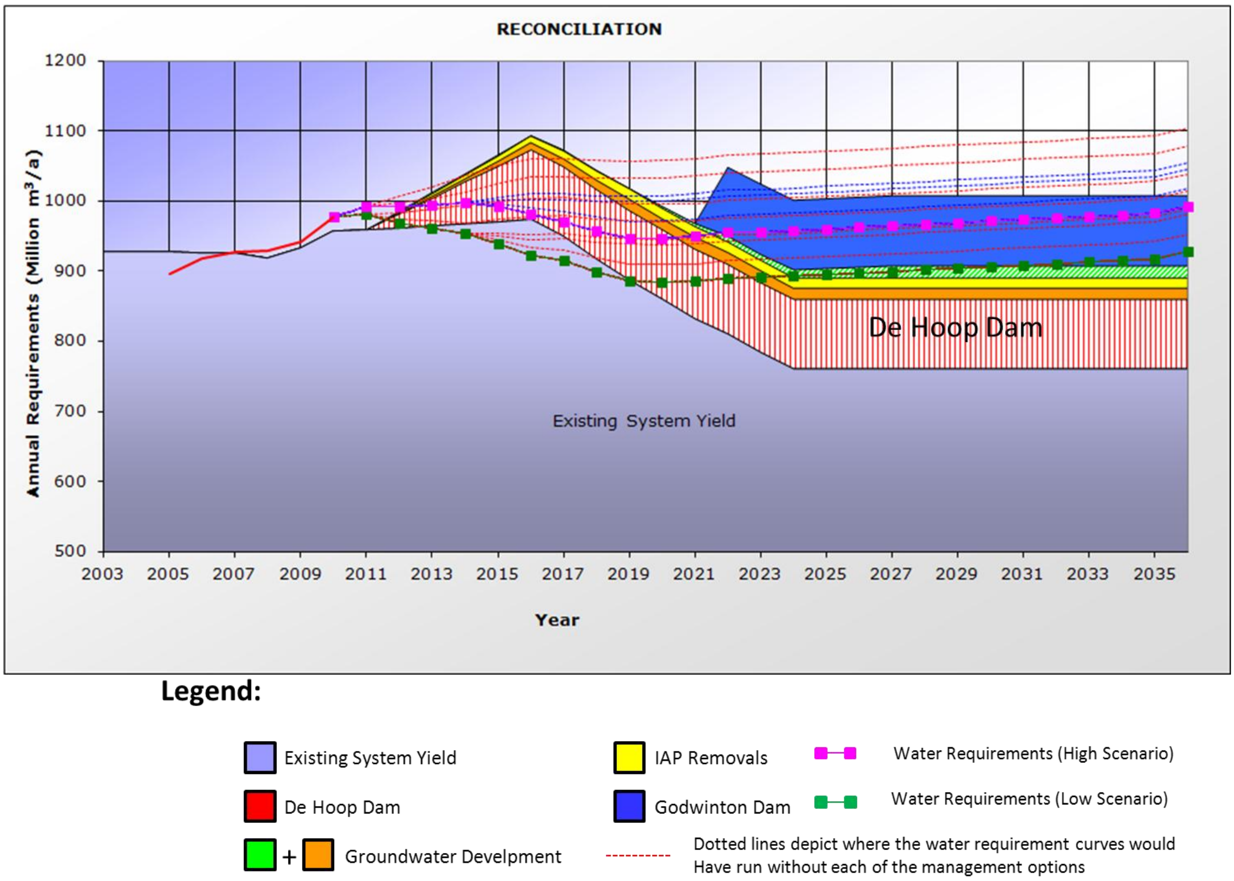


Figure 10.1: Water Balance – Scenario 1

The following can be concluded from the water balance graph of **Figure 10.1**:

- The current water requirements exceed the current water supply slightly but the growth in water requirements is counteracted by the implementation of the management measures.
- The commissioning of the De Hoop Dam and the smaller supply options such as groundwater development and IAP brings further relief and ensures that the supply exceeds the water requirement until 2021.
- The phasing in of the Reserve from 2016 will require the development and commissioning of the Godwinton Dam from 2021 (high demand curve).
- The low water requirement scenario will enable the postponement of the next water supply option until 2032.

The results of Scenario 2 are reflected in **Figure 10.2.**

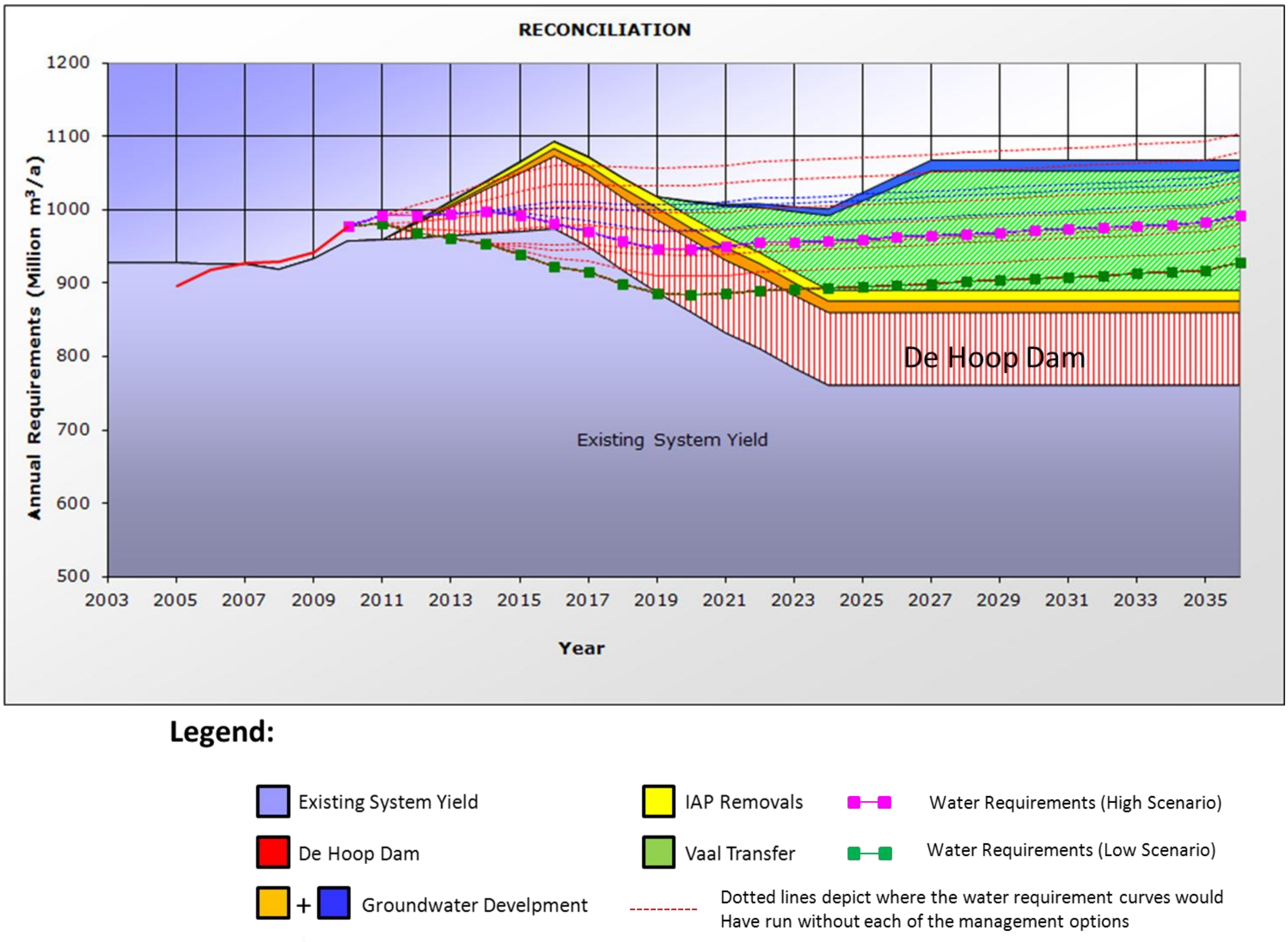


Figure 10.2: Water Balance – Scenario 2

The following can be concluded from the water balance graph of **Figure 10.2**:

- The 160 million m³/a additional supply (duplication of current VRESAP scheme) is unnecessary high and an augmentation scheme of half the size (80 million m³/a) will satisfy the growing high water requirement curve.
- The commissioning of the transfer scheme can be postponed until 2032 for the low water requirement scenario.

The results of Scenario 3 are reflected in **Figure 10.3**.

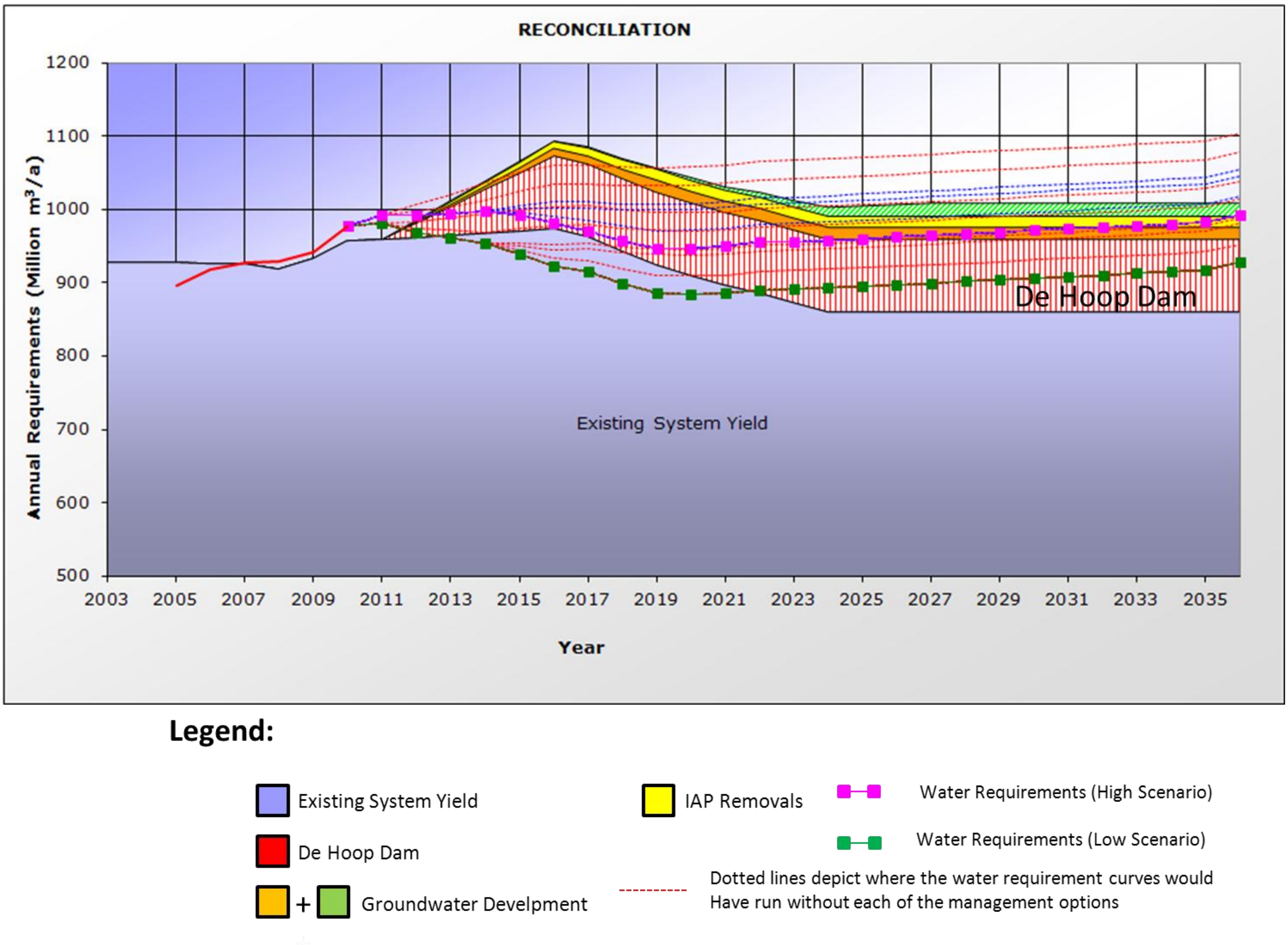


Figure 10.3: Water Balance – Scenario 3

The following can be concluded from the Water Balance graph of **Figure 10.3**.

- The signed off Reserve of 1999 has a huge impact on the water balance of the system.
- A less conservative Reserve will bring the system into balance for both the high and low water requirement scenarios.
- It is worth spending more time and funding on the verification of the Reserve. It must be confirmed whether the high flows (freshets) releases are really necessary and whether the current natural high flows won't satisfy the EWRs.

11. SHORT-TERM OPTIONS THAT WILL GIVE RELIEF FROM CURRENT WATER DEFICIT AND WATER QUALITY PROBLEMS

The water balance has shown that there is currently a shortage of 150 million m^3/a, and that this will increase to 245 million m^3/a by 2030.

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. Most of the management options to reduce the water requirement have a lead time of 4 – 5 years. However the two management options that can be implemented almost immediately and which will show early benefits are:

- Integrated System Operating Rules (will increase water supply over the short term).
- WCDM for the Domestic / Industrial sector.
- Eliminating Unlawful Water use for individual water users whose water use validation and verification is dealt with.
- Groundwater development
- Rainwater harvesting
- Water Trading
- Removing alien invasive plants

Smaller Groundwater development options can also bring relief for certain local water users.

Rainwater harvesting is an on-going proposition for each household and any household can immediately reap the benefits from such an option.

12. RISKS AND UNCERTAINTIES

The following risks and uncertainties have been identified.

- The requirements of the environmental Reserve are a major demand on the system, but whether the signed off requirements have been set too conservatively is still a question. A very small deviation here involves huge volumes of water. It is critically important that the needs of the Reserve should be re-assessed and correctly and accurately estimated.
- The extent of unlawful water use is a big unknown. Until the validation and verification processes are complete, the strategy will have to rely on the best estimates.
- The estimates for water savings on irrigation water could be inaccurate and attention is needed to improve the estimates. Since the irrigation sector represents such a large portion of the total water use, further work on this aspect is justified.
- The additional yield which becomes available as a result of additional infiltration on the surfaces of existing and decommissioned coal mines, as well as the storage volume created by the mine shafts and galleries is unknown. This aspect needs more attention.
- The Agricultural Research Council (ARC) survey on Invasive Alien Plants (IAPs) needs to be verified. The survey looks as if it could be an over-estimation of IAPs, but if correct, it will affect the water balance negatively.
- The assumption that the water supply from farm dams and run-of-river uses is equal to the available water for these uses could have some inaccuracies. Neither an accurate usage per unit area nor the assurance of supply to these irrigators can be determined.
- The success of the compulsory levy and the purchasing of water entitlements as an option is difficult to predict. It is not clear how many water users would, in the longer term, offer water entitlements for sale and how much water will eventually be freed up. As a result of this uncertainty, the compulsory licensing alternative was chosen for the analyses.
- It is not known whether farmers will consider accepting lower assurances of supply. If so, this could be a valuable option to be assessed further.
- Implementation of many of the management options is dependent on the cooperation of institutions such as local authorities, mining companies, etc.
- The outcome of the 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.
- If any one of the investigated dam options needs to be factored in, the dolomite dam basins and foundation of the Godwinton and Chedle sites need to be investigated further.

13. 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.

13.1. 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. Parks Board)

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 is done by DWA, parallel to this study. Municipalities however need to take responsibility for meeting the water demand by launching initiatives on both the water requirement side and the water supply side. WCDM 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 WCDM 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 should always be one of the first options to be considered before turning to a surface water option.

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 Charging System;
- Significant economic development (e.g. mines);

- Need for nature conservation (e.g. KNP and other nature reserves)

A CMA is indispensible when reconciliation options such as compulsory licensing 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 it establishment.

Table 13.1 outlines the different interventions that have been considered for Scenarios 1-3 in Section 10, the required actions and the institutional responsibilities.

Table 13.1: Institutional Responsibilities

Intervention	Brief Description of Actions	Primary Responsibility	Comments
Addressing the unlawful irrigation use	• Validation and verification	DWA Regional Offices	CMAs will take over this responsibility once established
	• Directives to unlawful water users	DWA Regional Offices	CMAs will take over this responsibility once established
	• Legal action where needed	DWA Legal Services	CMAs will take over this responsibility once established, but assisted by DWA Legal Services
	• Maintenance of lawful water use in controlled areas	IBs / WUAs	Supervised by Regional Office and, once established, the CMA
WCDM 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 plan
	• 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.
	• Water pricing	DWA Water Services	In line with Water Pricing Strategy
WCDM Mining	• Retrofitting water saving devices	Mine owners and Operators, Industries	
	• Process adaptations for enabling water recycling and water reuse	Mine owners and Operators, Industries	
WCDM Irrigation	• Sealing of Canals and bulk water supply infrastructure	IBs and WUAs	Assisted by the DWA Regional Office for State owned infrastructure
	• More efficient on-farm irrigation use	Irrigators	Advised and assisted by IBs, WUAs, Extension officers of Provincial Department of Agriculture

Intervention	Brief Description of Actions	Primary Responsibility	Comments
Compulsory Licensing Irrigation	• Validation and verification	DWA Regional Office	CMAs will take over this responsibility, once established
	• All actions as described in Sections 43 to 48 of NWA	DWA Regional Office assisted by DWA Head Office (Directorate Water Abstraction and Instream Use)	CMAs will take over this responsibility, once established Note: Compulsory Licensing need to be linked to WCDM
System Operating Rules	• Development of Rules	DWA (Water Resource Planning Systems)	
	• Implementation of Rules	DWA Regional Office, IBs and WUAs	CMAs will take over DWA Regional Office responsibility, once established DWA Regional Office will then adopt an oversight role
Removal of IAPs	• Removal of IAPs • Follow ups and maintenance	DWA (Working for Water Team)	CMAs, IBs, WUAs, Forestry Companies, Local Municpalities can all perform this function and should collaborate with the DWA Working for Water Teams
Groundwater Development	• Borehole siting • Drilling • Infrastructure development	DMs, LMs, Water Boards, Mine Companies, Industries, Private individuals	Licences (if applicable) to be issued by DWA Regional Offices or later CMA
Implementation of the Reserve	• River flow monitoring	DWA Regional Offices, IBs, WUAs, Water Boards	CMAs will take over responsibility from DWA Regional Office, once established
	• Required releases from dams	DWA Regional Offices, IBs, WUAs, Water Boards	
	• Abstraction control	IBs, WUAs	
Construction of new dams / transfer schemes	• Prefeasibility Study • Feasibility Study • Design • Tenders • Construction	DWA (Various directorates) / Implementing Agent (e.g. TCTA)	Can be done with departmental budget or off-budget funding

13.2. FUNDING

Apart from capital that may be required to refurbish water supply infrastructure as part of WCDM, no other capital expenditure is required to implement the proposed short-term actions, but 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, 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.

The water deficit described earlier in Section 5 can mainly be ascribed to the implementation of the Reserve. Therefore, should a dam project be considered for phasing in the Reserve, it is likely that fiscus funding will have to be considered.

14. RECOMMENDATIONS

The following is recommended:

- The uncertainties listed in section 12 need to be investigated further in order to base the Final Strategy on improved information.
- A thorough investigation into the Reserve is recommended, as a lesser effect of the implementation of the Reserve could render a further large augmentation option after De Hoop Dam unnecessary (See Scenario 3).
- All the possible management options to reduce water requirements should be implemented as soon as practical.
- The WCDM for irrigation and mining should be linked to compulsory licensing or the compulsory levy for purchasing water entitlements. In the case of compulsory licensing, the validation and verification process needs to be complete.
- The option of implementing a compulsory levy to fund the purchase of water from willing sellers could also be explored. Compulsory licensing must, however be initiated. Should a compulsory levy be accepted and implemented, this would reduce the impact of compulsory licensing.
- The validation and verification process should be accelerated. Both the compulsory licensing and the completion of eliminating of unlawful water use are dependent on this task.
- The establishment of a catchment management agency for the Olifants River has to be accelerated.
- Groundwater development in unstressed sub-catchments must be encouraged. 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.
- Bulk water abstraction from the Malmani aquifer where it crossed the Olifants River must be investigated together with the possibility of artificial recharge with surface water.
- An indicative conclusion at this point in time is that either the Godwinton or Chedle dam sites would provide the most economical development option; these are well located in relation to the mining developments in the Middle Olifants River. Further investigations into these dam sites are recommended.
- Raising of the Blyderivierspoort Dam and new dams at Rooipoort and Madrid (representing the three sites in the lower Olifants) are all very costly, and other than Rooipoort, are not suitably located to serve any user except the KNP.
- The two water transfer options also seem too costly despite the advantage of bringing water to the headwaters of the catchment. A possible water transfer from the Crocodile system, which has only recently become an option as a result of lower water demand from the Crocodile than originally estimated, has not yet been investigated. It is recommended that its investigation is included in the final reconciliation strategy.
- Water trading should be encouraged, with the State providing the market and buying out water to meet the needs of the Reserve. This would provide water at a far lower cost than the construction of an additional dam, or the importation of Vaal River water.
- 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.

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APPENDIX A

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

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		

Key
- Negative Change
+ Positive Change
= No Change

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

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	

Key
- Negative Change
+ Positive Change
= No Change

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

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	

Key
- Negative Change
+ Positive Change
= No Change

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

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		

Key
- Negative Change
+ Positive Change
= No Change

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

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		

Key
- Negative Change
+ Positive Change
= No Change

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:
Schedule Irrigation with Irrigation Boards

Irrigation Board	Scheduled Area (ha)	Actual Area (ha) (if different from scheduled)	Application rate (m^3/ha/annum)	Allocated volume (million m^3/a)
BLOEMPOORT (Moos River, Loskopdam)	684		6 200	4.2
BLYDE RIVER (Blyde dam, Driehoek/Moriah/ Jongmanspruit & river abstr.	8 978		9 900	85.2
GOUSBERG (Wilge River)	1 325		7 700	10.2
GROOT DWARSRIVER (Der Brochen Dam)	1 202	41	6 700	5.1
HEREFORD (Olifants River, Loskopdam)	4 466		6 200	27.7
KASPERNEK-VYEHOEK	514		9 200	4.7
KLASERIE RIVER	786		9900	7.8
LAER SPEKBOOM RIVER (Steelpoort River)	1 037	750	5 000	13.2
LOSKOP	16 117		7 700	161.3
METZIRR SCHEME (Moetladimo Dam)	82		7 700	0.6
OLIFANTS RIVER (Loskopdam)	1 732		7 600	13.2
SELONS RIVER (Selons Dam)	777		6 200	4.8
CENTRAL STEELPOORT RIVER	549	350	7 700	4.2
TRANS ELANDS (Elands River)	716		7 700	5.5
UPPER SELATI RIVER	722		9 900	7.1
WATERVALS RIVER (Buffelskloof Dam)	2 436		7 000	17.1
CENTRAL OLIFANTS (LEBOWA)	2 338		7 700	18.0
ORIGHSTAD RIVIER	1 857		7 000	13.0
CATCHMENT TOTAL	**46 318**			**403.1**