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

WP10197

Management and Development Alternatives and Cost Estimates Report

Original

FINAL REPORT
December 2011

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Report no.: P WMA 04/B50/00/8310/9

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LIST OF REPORTS

Title	Report Number
Inception Report	P WMA 04/B50/00/8310/1
Summary Report	P WMA 04/B50/00/8310/2
Extent of Invasive Alien Plants and Removal Options	P WMA 04/B50/00/8310/3
Future Water Reuse and other Marginal Water Use Possibilities	P WMA 04/B50/00/8310/4
Possible Water Conservation and Demand Management Measures	P WMA 04/B50/00/8310/5
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Glossary of Terms

Allocatable Water
Water available to allocate for consumptive use.

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

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

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

Existing Lawful Use Unlawful Water Use
A water use which is not authorised in terms of the National Water Act (Act 36 of 1988)

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.

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

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

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

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

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

Reserve
The Reserve is that portion of the natural flow that has to be available in a river or stream in order to sustain the aquatic ecology, and also to provide for basic human needs, in order to

comply 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.

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

AMD	Acid Mine Drainage
BHN	Basic Human Needs
CMA	Catchment Management Agency
CME	Compliance Monitoring and Enforcement
DWA	Department of Water Affairs
EWR	Ecological Water Requirements (Ecological Component of the Reserve)
IB	Irrigation Board
IAP	Invasive Alien Plants (vegetation)
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resources Management
KNP	Kruger National Park
LHWP2	Lesotho Highlands Water Project – Phase 2
MAR	Mean Annual Runoff
NGDB	National Groundwater Data Base
NPV	Nett Present Value
NWA	National Water Act (Act 36 of 1998)
OWAAS	Olifants Water Assessment and Availability Study
SSC	Study Steering Committee
URV	Unit Reference Value
V & V	Validation and Verification
VRESAP	Vaal River Eastern Sub-system Augmentation Project
WC/WDM	Water Conservation / Water Demand Management
WfW	Working for Water
WMA	Water Management Area

EXECUTIVE SUMMARY

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.

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. A number of reconciliation options have been considered to achieve this and to form part of such a reconciliation strategy. Reconciliation options include both management and development options.

This report presents an assessment of the alternative management and development (structural measures) reconciliation possibilities that have been considered to address the water resource challenges.

The results of this assessment are summarised below.

Table E1: *Management Options*

Option	Yield/Water Saving (million m^3/a)	Cost as NPV (R million)	URV (R/m^3)
Eliminating Unlawful Irrigation use	8.7	12	0.12
Removal of Alien Invasive Plants	15	120	0.76
WC/WDM: Urban	20	285	1.48
Compulsory Licensing	35	32	0.07
Purchasing Water Entitlements	35	175	0.35

Table E2: *Development Options*

Option	Yield (million m^3/a)	Capital Cost (R million)	URV (R/m^3)
Rooipoort Dam	59	1 140	2.14
Dam in Olifants Gorge:			
Godwinton	100	132	0.14
Chedle	100	200	0.20
Dam in Lower Olifants:			
Epsom	286	4 820	1.58
Madrid	440	8 800	1.71
Raising of Blyderivierspoort Dam	110	2 977	2.77
Transfer from ERWAT *	38.3	1 123	7.31
Transfer from Vaal Dam *	160	3 500	3.60

Option	Yield (million m^3/a)	Capital Cost (R million)	URV (R/m^3)
Transfer from Crocodile (West):			
Pienaars – Flag Boshielo Dam	*30*	*1 268*	*3.82*
Crocodile – Flag Boshielo Dam	*60*	*3 926*	*6.43*
Crocodile – Mokopane	*25*	*3 728*	*14.51*
Transfer from Massingir Dam	*50*	*2 000*	*4.85*
Groundwater Development	*35*	*48*	*0.13*
Utilising Acid Mine Drainage	*22*	*75*	*6.31*
Desalination of Sea Water	*100*	*12 970*	*44.45*

* *Excludes cost of LHFP (URV R6.14/m^3)*

A preliminary environmental screening exercise was undertaken and no fatal flaws have been identified for any of the options considered. The construction of large dams is expected to have the greatest ecological and social impacts.

The selection of options is considered further in the Final Reconciliation Strategy Report.

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1. INTRODUCTION

1.1 BACKGROUND

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.

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. A number of reconciliation options have been considered to achieve this and to form part of such a reconciliation strategy. Reconciliation options include both management and development options.

Reconciliation options can address both water quality and water quantity problems. However, as described in Report PWMA 04/B50/00/8310/7 of this study, the water quality problems in the catchment have to do with contamination from point sources that need to be addressed at these point sources and the water quality problems therefore won't affect the availability of the water for the purpose of this reconciliation study. Apart from the treatment of AMD in the Upper Olifants Catchment, the focus of this report therefore falls mainly on reconciliation options that will address water quantity shortfalls.

1.2 OBJECTIVES OF THIS REPORT

The Preliminary Reconciliation Strategy (Report PWMA 04/850/00/8310/13 of this study) described the status quo in the Olifants catchment, provided a first order water balance and described the possible reconciliation options that were considered to address the water shortages. This report presents an assessment of the alternative management and development (structural measures) reconciliation possibilities that can be considered to address the water resource challenges.

This report:

- Describes the identified and screened management and development options.
- Compares the estimated cost and Unit Reference Values (URVs) of the options with each other in order to select the most preferable ones for inclusion into the Final Reconciliation Strategy.

1.3 STRUCTURE OF THE REPORT

This report provides a brief overview of the existing development of the water resources in the study area as well as the water requirements, the water balance and water shortages.

Management reconciliation options can either reduce the current water requirements or increase the water supply. Both these types of management options are described in this report.

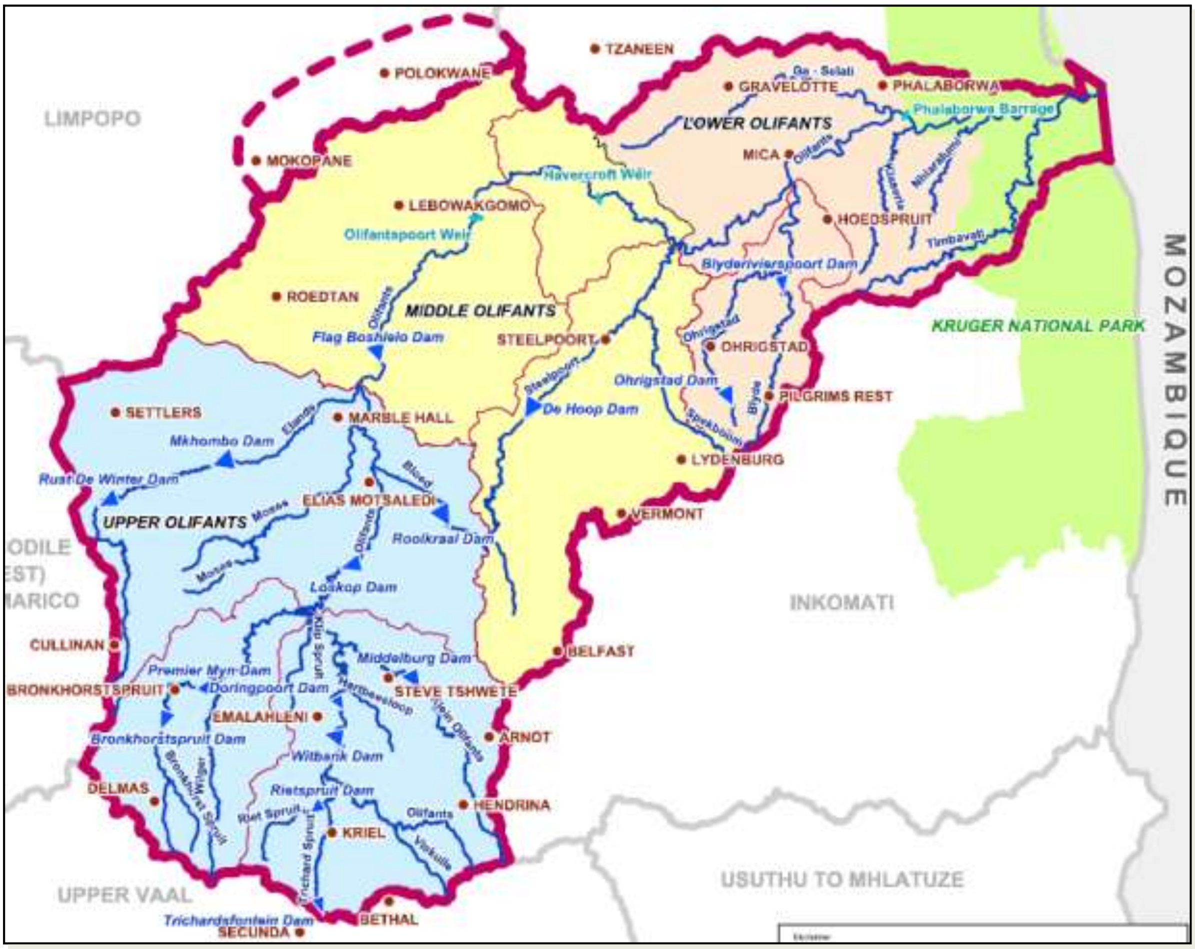
This report also includes a preliminary identification of possible dam sites and interbasin transfers. This is followed by indicative cost estimates and URV determinations of the reconciliation options which will enable the decision makers to select the better options from an economic point of view.

2. OVERVIEW OF THE WATER SITUATION IN THE STUDY AREA

2.1 WATER AVAILABILITY

The availability of surface water is described in detail in the Water Requirements and Water Resources report (Report PWMA 04/B50/00/8310/6) of this study and a brief summary of the contents is provided below:

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 on Error! Reference source not found.

Figure 2.1: Management Zones of the Olifants Catchment

There are several large dams as well as smaller farm dams that provide water to users. In addition, ground water as well as water transfers from other catchments for the power stations in the catchment contribute to the yield of the Olifants River system.

The available yield of the entire Olifants system is shown in **Figure 2.2.**

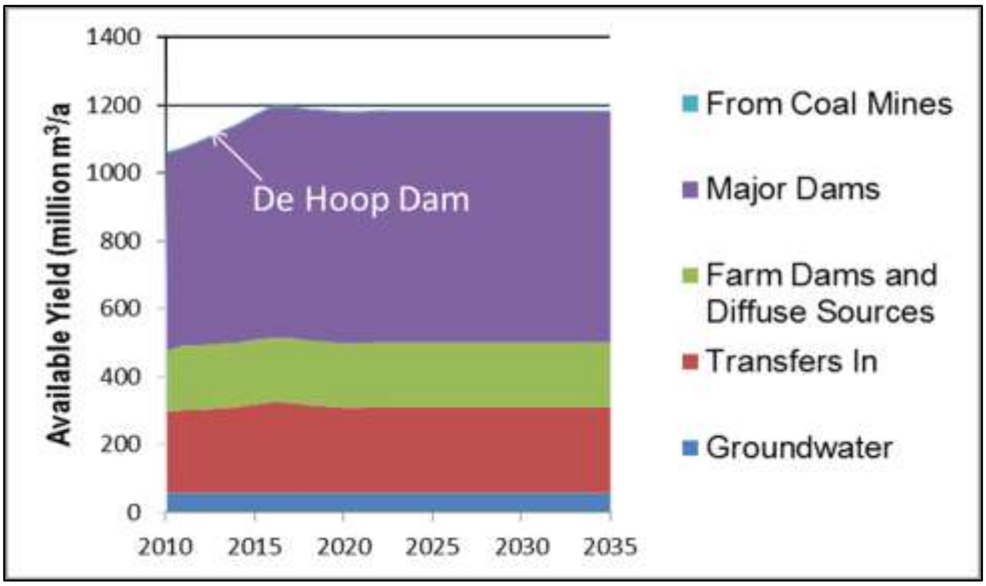


Figure 2.2: Available yield of the Olifants River System

The available groundwater is spread over the entire Olifants River catchment but higher yielding aquifers are found in the dolomite sub-structures in the Upper Olifants and along the escarpment which traverses the Middle Olifants Sub-catchment from North-west to South-East. The map in **Figure 2.3** provides an indication of the yields that can be expected over the Olifants River water management area. The net potential groundwater available is estimated at 70 million m^3/a.

The Reserve has not yet been implemented in the Olifants River catchment but it is estimated that it would reduce the available yield by 221 million m^3/a. The Reserve contains a high flow component and the release of such high flows through the outlet structures of the dams would not be possible since the outlet capacities of the existing dams are too small. Provision can therefore only be made for that portion of the Reserve that is practically implementable and this will reduce the available yield of the system by 157 million m^3/a. It is expected that the high flow component of the Reserve will be satisfied from the many tributaries downstream of the dams.

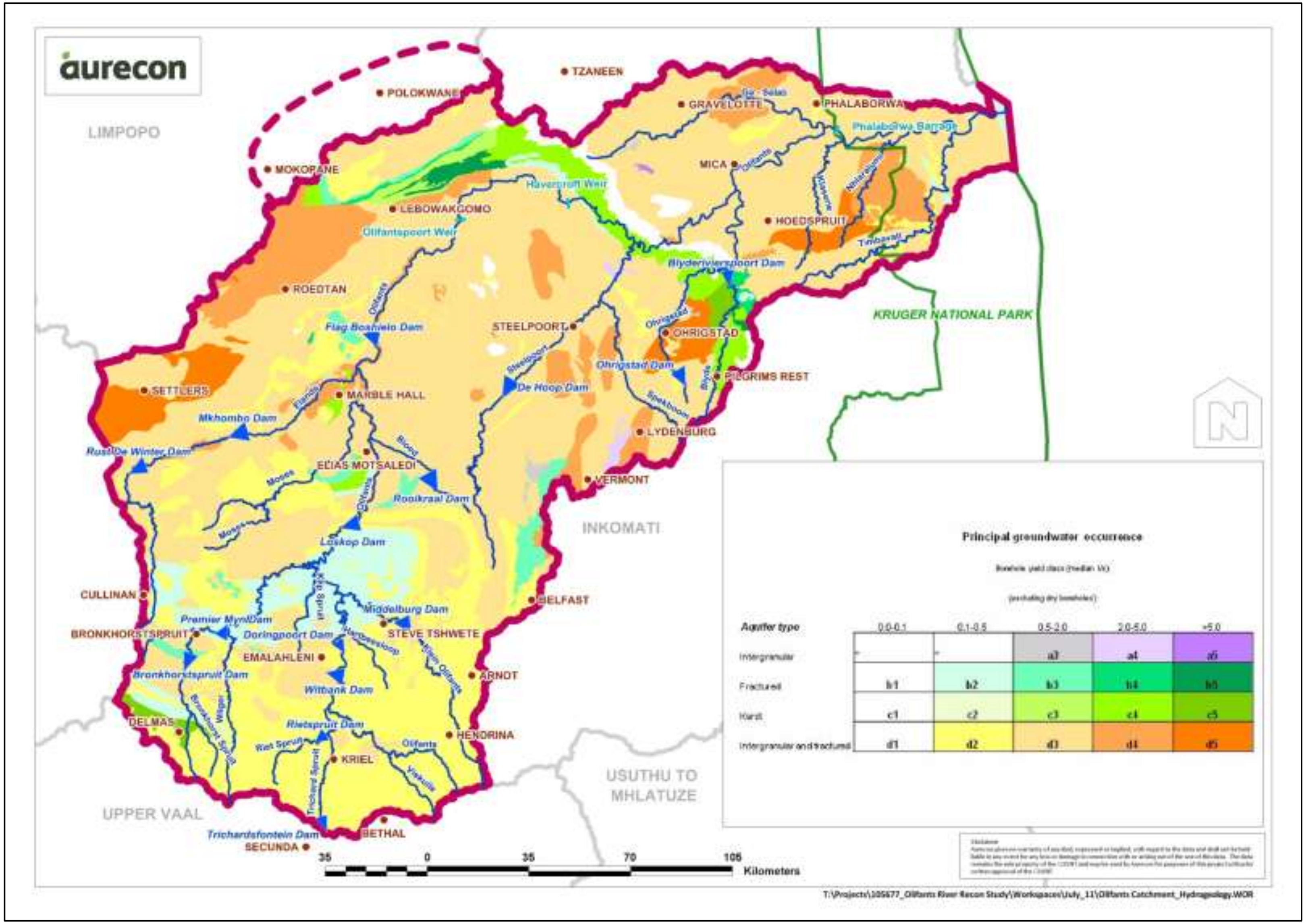


Figure 2.3: Groundwater availability in the Olifants River Catchment

2.2 WATER USE AND FUTURE WATER REQUIREMENTS

The increase in water demands are mainly driven by domestic use and the mining industry. The current water use from the system for the different economic activities is illustrated in **Figure 2.4.**

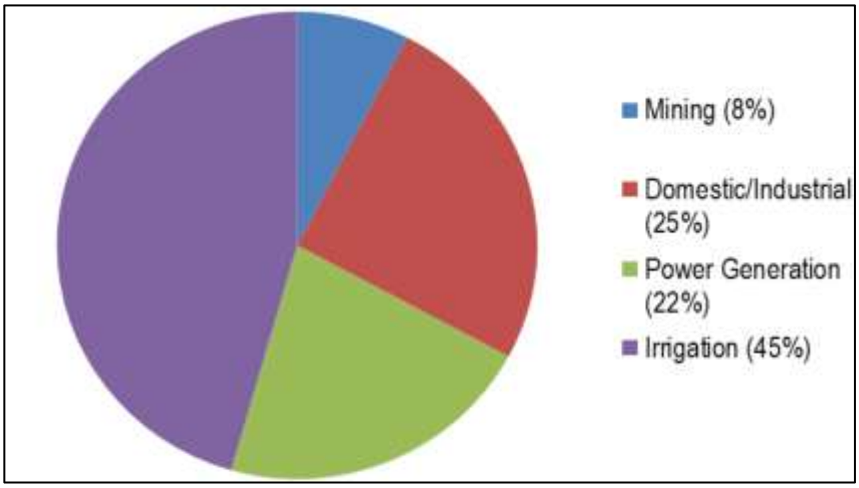


Figure 2.4: Current Water Use for economic activities (%)

The expected high growth water requirements for the next 25 years are shown in **Figure 2.5.**

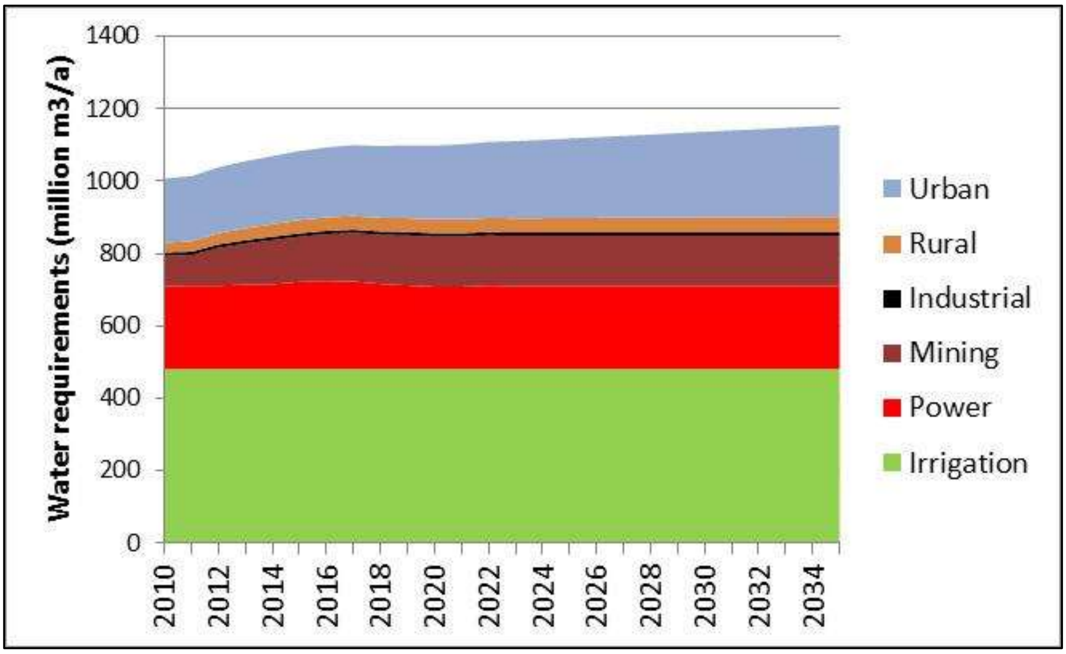


Figure 2.5: Water Requirements

2.3 WATER BALANCE

The water balance of the Olifants River System was calculated with the water requirements and water availability and is reflected in **Figure 2.6**. The future water balance shows the Reserve operationalised in 2016 in and as can be seen there is a water deficit of approximately 149 million m^3/a expected in the year 2035.

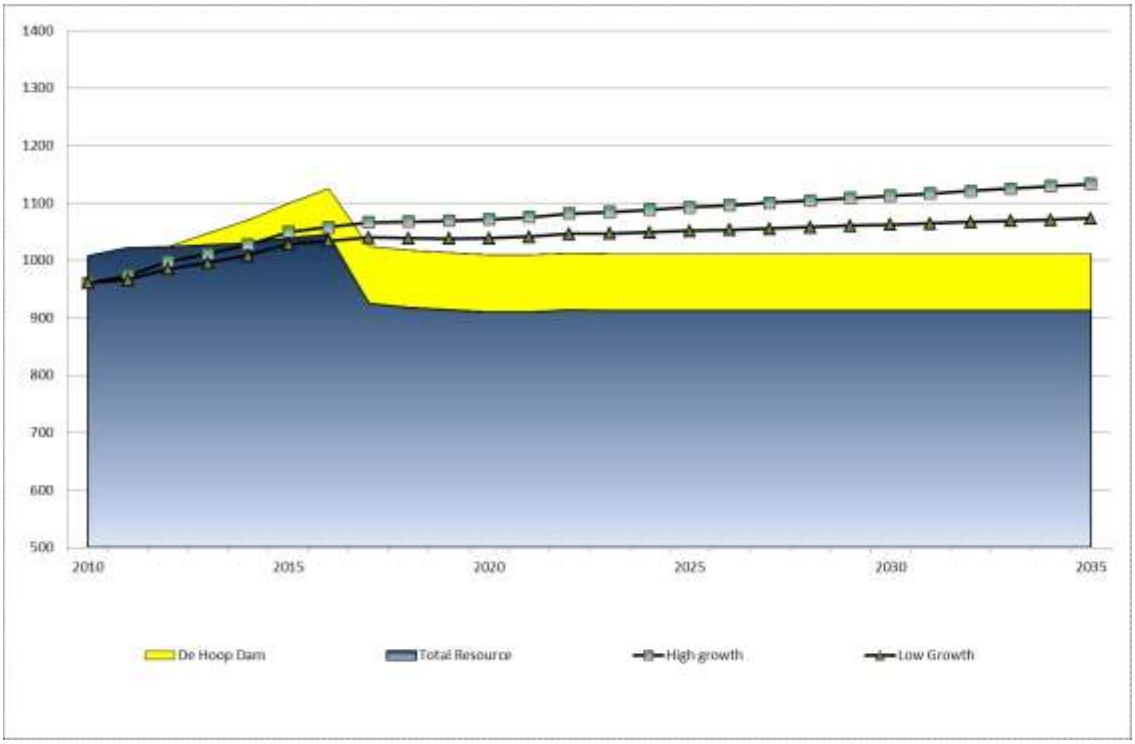


Figure 2.6: Water balance

3. POSSIBLE INTERVENTION OPTIONS

3.1 PRELIMINARY SCREENING WORKSHOP

A gross list of possible reconciliation options was compiled and was discussed at a preliminary screening workshop held on 7 July 2010. These options were screened by using the following criteria:

(a) A possible fatal flaw which will immediately exclude the option for any further consideration.
(b) The additional yield/water saving that can be achieved by the option.
(c) The capital cost required to implement the option.
(d) The operational cost of implementing the option.
(e) The Unit Reference Value.
(f) The social impacts
(g) Biophysical impacts
(h) The management intensity of the option, and
(i) The time required for implementation.

The screening process and outcome of the workshop is fully described in the Preliminary Screening and Schemes to be Investigated report (Report PWMA 04/850/00/8310/8).

This report will only address criteria (b) to (e) which deals with the yield, the cost of the interventions and the unit reference values.

3.2 CATEGORISATION OF POSSIBLE INTERVENTION OPTIONS

Intervention options or reconciliation options can be divided into two main categories, i.e.:

- Management Options
- Development Options

Water Management measures are practical steps that can be taken to improve the water use efficiency. Such measures can either reduce the water requirements or can increase the water supply.

3.3 COST AND UNIT REFERENCE VALUES OF MANAGEMENT OPTIONS

The following management options were identified and passed the screening process of the preliminary screening meeting:

3.3.1 Eliminating Unlawful Water Use

- **Yield/Water Savings**

  Eliminating unlawful use is a reconciliation option, which 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.

The reason is that despite the fact that no new water licences have been issued to the irrigation sector for many years, the irrigated area has increased substantially as can be seen in **Table 3.1**.

Table 3.1: Growth in irrigation use according to a recent OWAAS Study

Catchment	Irrigation Area (km^2)	
	1998	**2004**
Bronkhorstspruit	42.6	75.5
Middelburg	34.1	45.7
Witbank	41.7	55.6
Loskop	1.6	3.0
Flag Boshielo	177.7	192.2
De Hoop	13.7	22.8
B41 & B42 (Remainder)	52.1	53.4
Blyderivier	74.3	75.1
Phalaborwa Barrage (B50 & B70)	50.6	70.0
TOTAL	**488.4**	**593.3**

The irrigation expansion is not necessarily all unlawful. Expansion in area could have taken place by using the allocated quantities of water more efficiently.

A yield analysis was carried out to determine the increase in yield, should the increased irrigation be eliminated. The result of this analysis is shown in **Table 3.2.** From this table it is clear that 17.4 million m^3/a will become available for the hypothetical situation of removing all the expansion in irrigation.

Table 3.2: Increase in yield if growth in irrigation is removed

Dam	Yield (million m^3/a)		
	Yield	Yield as result of reduced irrigation	Increase in yield
Bronkhorstspruit	11.0	18.3	7.3
Middelburg	5.8	7.9	2.1
Witbank	23.0	24.0	1.0
Loskop	110	113	3.0
Rust de Winter	9.8	9.8	0.0
Mkombo	3.2	3.2	0.0
Flag Boshielo	27.8	27.8	0.0
De Hoop	65	69	4.0
Belfast	5.7	5.7	0.0
Der Bruchen	8.3	8.3	0.0
Buffelskloof	14.7	14.7	0.0
Lydenburg	2.5	2.5	0.0
Blyderivier	60.0	60.0	0.0
Origstad	18.9	18.9	0.0
Phalaborwa Barrage	34.7	34.7	0.0
TOTAL	**400.4**	**417.8**	**17.4**

The exact expansion in irrigation due to unlawful water use can only be confirmed after the validation and verification process which will be done by the Regions of DWA. This process is expected to take at least four years. If it is assumed that 50% of the irrigation expansion is as a result of water saving and the other 50% as a result of unlawful water use, it means that 8.7 million m^3/a water can become available if unlawful water use is eliminated.

- **Cost**

  Addressing illegal water use must be preceded by the validation and verification process. Validation is a process where the information in the departmental database – the Water Authorisation and Regulation Management System (WARMS), is checked against the development on the ground. Verification is a process where the lawfulness of the existing water use is checked. The validation and verification processes have already started and are approximately 20% complete. It is anticipated that it will take another three years to complete the work.

  DWA can do the validation and verification work in-house, but with the current capacity problems within the Department, consideration could be given to outsource the work. It is estimated that R4 million per year will be needed for three years.

It is not necessary to wait with legal action until all the validation and verification work is complete. The actions can be started progressively as certain areas are completed in terms of validation and verification. It was assumed that the legal action will be done in-house by the DWA Regions in cooperation with the Legal Services Directorate and that this work can be executed by existing staff under existing budgets.

- **Unit Reference Value**

  Assuming the cost of R4 million per year over three years and the linear growth of water savings over a similar period but with water savings lagged by one year, gives a URV of R 0.12/m^3.

3.3.2 Removal of Invasive Alien Plants

- **Yield/Water Savings**

  As described in the report on the “Extent of Invasive Alien Plants and Removal Options” (PWMA 04/B50/00/83/0/3), 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.

- **Cost**

  The Working for Water projects in the Olifants Catchment which are currently being run by DWA are shown in **Table 3.3.**

Table 3.3: Working for Water Projects in 2011

Project	Area to be cleared (Ha)	Budget for 2011/12 (R million)
Middelburg	5 740	2.5
Witbank	3 400	3.9
Lydenburg	3 533*	4.4*
Lower Steelpoort	1 614	1.9
Lebowakgomo	919	1.4
Lower Olifants	4 571	2.5
TOTAL	**19 777**	**16.6**

* The Lydenburg project covers 3 quaternary catchments of which only two are in the Olifants catchment and one in the Crocodile catchment (Inkomati WMA).

Each of the above projects is planned to be completed in approximately 5 years' time but the Working for Water staff indicated that the budget is insufficient and it will probably take longer to clear these areas.

With the assumption that ⅓ of the Lydenburg project will be spent in the Inkomati WMA, the total budget for 2011/12 is R15.1 million. It is assumed that this amount will stay constant in real terms for the following five years. Thereafter it is assumed that maintenance costs will amount to 0.5 % of the cumulative total (R0.6 million) per annum.

- **Unit Reference Value**

  This gives a URV of R 0.76/m^3.

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

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

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

- Irrigation
- Urban / Rural
- Mining

A comprehensive description of how each of these sectors can reduce their water requirements as well as the expected quantities of water that can be saved can be found in Report P WMA 04/B50/00/8310/5, "Possible Conservation and Water Demand Management Measures" of this study.

The results of this report are summarised in **Table 3.4** below.

Table 3.4: Summary of possible water savings

Sector	Current water requirement (million m^3/a)	Estimated saving (million m^3/a)	Comment
Urban	105.4	19.8	Achievable
Rural	40.3	8.3	Problematic
Irrigation • Improved irrigation systems • Improved conveyances	508	 19 16	Requires willing buyer/willing seller Very costly
Power generation	228	27.3	Very costly
Mining	73.5	5	
Industrial	8.4	~0	
TOTAL	**963.6**	**95.3**	

It was assumed that the Urban, Irrigation and Mining sectors can start applying WC/WDM measures immediately and that it will take approximately 5 years to phase in the full benefits of the water saving in the irrigation and urban water use sectors. The mining industry will require more time as current processes need to be changed which will have significant cost implications for the mining water users. A phasing period of 10 years was assumed for this sector.

The above quoted report also showed that significant water savings (27.3 m^3/a) can be achieved by adapting the current power stations. This, however, will be very costly and the cost detail of this intervention has not been obtained from Eskom.

The following savings from **Table 3.4** have been viewed as achievable and have been incorporated in the final strategy:

Urban	20 million m^3/a,
Irrigation	35 million m^3/a,
Mining	5 million m^3/a.

- **Cost**

  The cost of applying WC/WDM measures is significant. Cost estimates for WC/WDM measures in the urban sector have been obtained from the report "Development of a Comprehensive Water Conservation and Demand Management Strategy for the Emalahleni Local Municipality" (DWA 2008).

  These estimated costs have been extrapolated to all the other towns in the catchment. The cost estimates given in **Table 3.5** below are therefore only indicative of what urban WC/WDM can cost.

Table 3.5: Indicative cost of Urban WC/WDM in the Olifants Catchment

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

  The cost of achieving WC/WDM in the irrigation sector is difficult to estimate and has not been possible within the scope of this study. In a meeting with the Loskop Irrigation Board, the following was established:

  - The scheme is well managed and operational losses by spillage from the end of distribution canals is minimal, with little scope for improvement
  - The condition of the canals is poor and deteriorating, resulting in significant leakage, but maintenance is on-going. However, significant work can only be done when the canals are empty, which typically occurs only for three periods of about two weeks each per year. Achieving significant reduction of leaks will therefore require a different approach. This might involve pumping water around a

length of canal taken out of service, and/or compensating farmers for loss of production while taking sections of canal out of service.

- Significant savings are possible by lining the receiving lei dams, on the individual farms with plastic lining. Currently about 40% of the lei dams have been sealed and 60% are still unlined on the Loskop Irrigation Scheme. It is uncertain how much water can be saved by sealing the dams. A subsidy could possibly be considered to encourage individual farm owners to seal the dams over a shorter period.

- **Unit Reference Value**

  For Urban WC/WDM saving 20 million m^3/a, and costs as in **Table 3.5** above, the URV is R 1.48/m^3. No estimate has been possible for WC/WDM in the irrigation sector.

3.3.4 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).

During the Study Steering Committee meeting held on 27 May 2011, the opinion was expressed that the typical farmer in the Olifants catchment can easily adapt to an assurance of supply of 70%. This opinion might not so easily be accepted by the farming community if lowering of the assurance of supply is enforced without compensation.

This option has not been considered further as part of this study as it will require serious negotiations and agreements with the irrigation boards, WUAs and Farmer Associations. These further negotiations are, however, included as a recommendation for this study and if successful, this option will free up some additional water.

3.3.5 Compulsory licensing

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

The procedure for compulsory licensing is described in Sections 43 to 48 of the National Water Act (Act 36 of 1998). The process is started when the responsible authority (in this case the Minister in view of the fact that 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 WC/WDM initiative. If curtailment of water entitlements is found to be the only way to achieve a water balance, the objective should be to minimise the economic impact on the water users and the consequent job losses. By applying WC/WDM together with compulsory licensing, the water users can reduce their water requirements while retaining their current levels of income. 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 target WC/WDM water savings are described in Section 3.3.3, i.e. 20 million m^3/a for urban, 35 million m^3 for irrigation and 5 million m^3 for mining. If compulsory licensing is linked to WC/WDM, it can be assumed that these target savings will become available in the pool for re-allocation.

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

It is not good practice to postpone any WC/WDM initiative if Compulsory Licensing is not ready to be implemented at the same time, e.g. if the compulsory licensing process has to wait for the processes of validation and verification of water entitlements. If Compulsory Licensing cannot start immediately, the linking of this process with the WC/WDM should rather not be considered.

The timing of a possible compulsory licensing process for the Olifants WMA is illustrated in **Figure 3.1.** Cognisance should be taken that the benefits of a possible linking of compulsory licensing with WC/WDM can only be reaped at a relatively late stage (2021) and in this instance it is not recommended to postpone the launch of a major WC/WDM initiative for the irrigation sector so long. By that time some users might have taken the initiative to apply WC/WDM themselves, expanded horizontally and will be economically prejudiced if compulsory licensing is imposed on them while they have reached optimum efficiency in their irrigation practices.

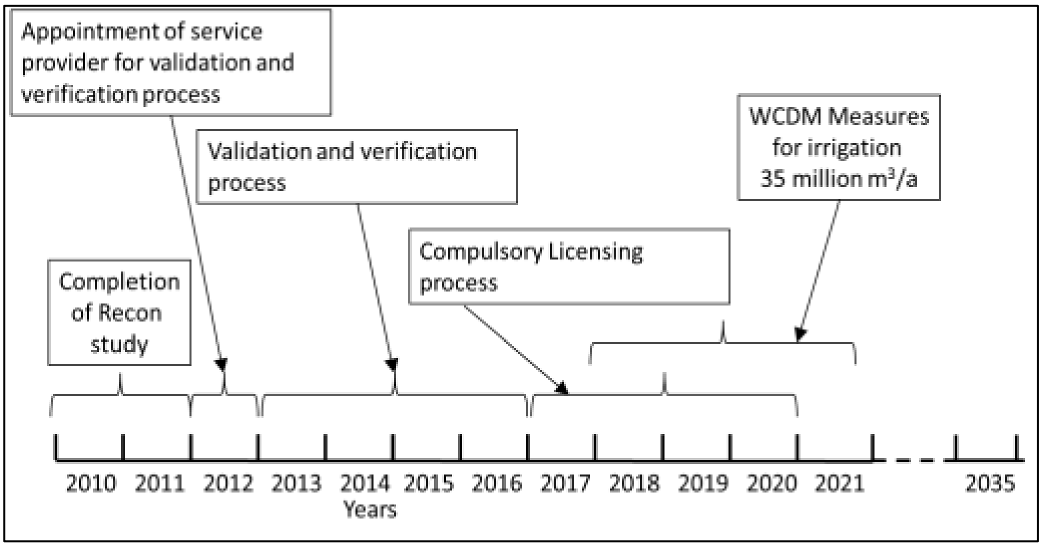


Figure 3.1: Timing of Compulsory Licensing Combined with WC/WDM

Compulsory Licensing as a standalone curtailment process can certainly reduce the water requirements on the system but should only be applied if this is one of the last resorts to achieve a water balance since it may have significant social consequences, e.g. economic prejudice of the water users, job losses, etc. It is however a relatively inexpensive, but very tedious process. Compulsory Licensing is not a mechanism to make water available for economic development. Its main purpose is to correct previous imbalances and inequities in water use.

- **Cost**

  The cost for compulsory licensing is estimated at R32 million, spread over 8 years. This cost includes the estimated cost of R12 million for validation and verification over the first 4 years.

- **Unit Reference Value**

  These costs yielding a saving of 35 million/m^3 result in a URV of R0.07/m^3.

3.3.6 Water trading

- **Purchasing WC/WDM Savings**

  Another 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 partial water entitlements from those water users who saved this water through WC/WDM and who are willing to sell, e.g. by tender process. This process can then be continued until the necessary water balance is achieved.

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

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

  The process is relatively inexpensive and easy to implement. An appropriate policy within the Department of Water Affairs however needs to be developed and user guidelines need to be prepared.

- **Cost**

  The administrative cost to purchase portions of the water entitlements is estimated at R1 million/a. In addition, the cost of the validation and verification process which is estimated at R3 million/a, must also be added.

  Water can be purchased at say R5/m^3 as a once off payment. For the 35 million m^3/a savings through WC/WDM, the cost for purchasing the saved water can run up to R175 million.

- **Unit Reference Value**

  This approach would result in a URV of R0.35.

- **Change of Hands – Full Entitlements**

  Water trading can also be 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.

  This type of 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.

  If however the water requirements of the buyer are already included in the planned water requirement scenario, then such a water trading transaction will indeed reduce the water requirements.

  Water trading should be regulated as it could lead to severe social impacts and job losses. Only if there is no other way out and water is urgently needed in the short term, should the water trading option be considered. The partial purchase of water entitlements is preferred. The cost of the full entitlement water trading has not been estimated as it will depend on the quantity of water offered. Such cost would not be a cost to any authority and can therefore not be used for the calculation of the URV.

3.3.7 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.

Two systems have been identified where system operating rules can achieve an increase in the calculated yield of dams:

i) The Blyderivierspoort dam and the Phalaborwa Barrage have already been modelled as a system, with the Blyderivierspoort dam only releasing water for Phalaborwa when there is insufficient water in the barrage. This has already been taken into account in the quoted yields for these dams and no further benefit is possible.

ii) The Flag Boshielo dam and the De Hoop dam have been modelled separately, but once the full ORWRDP-2 project has been implemented; there will be considerable flexibility in supplying demands from either dam. If one of the two dams is under pressure during a drought, then demands can be shifted to the other dam. If this operating rule is built into the yield model, then the calculated yield of both dams is expected to be higher

iii) The above combination of Flag Boshielo Dam and De Hoop Dam can be taken a step further by operating these two dams conjunctively with Loskop Dam, Middelburg Dam and Witbank Dam.

If the cost of the ORWRDP is ignored, having already been committed, then the only cost would be for the additional yield analysis which was not included in the scope for this study. The cost would therefore be small, and the URV would be negligible, but cannot be estimated until the yield study has been undertaken.

3.4 WATER RESOURCE DEVELOPMENT OPTIONS

The following development options were identified and passed the screening process of the preliminary screening meeting.

3.4.1 Possible new dams

A number of sites have been identified for the possible construction of dams. These are shown on **Figure 3.2** and are described separately in the following sections. It should be noted that all the costs and URVs quoted in this section are for raw water supplied at the dam wall, and do not include the cost of supplying this water to the demand centre.

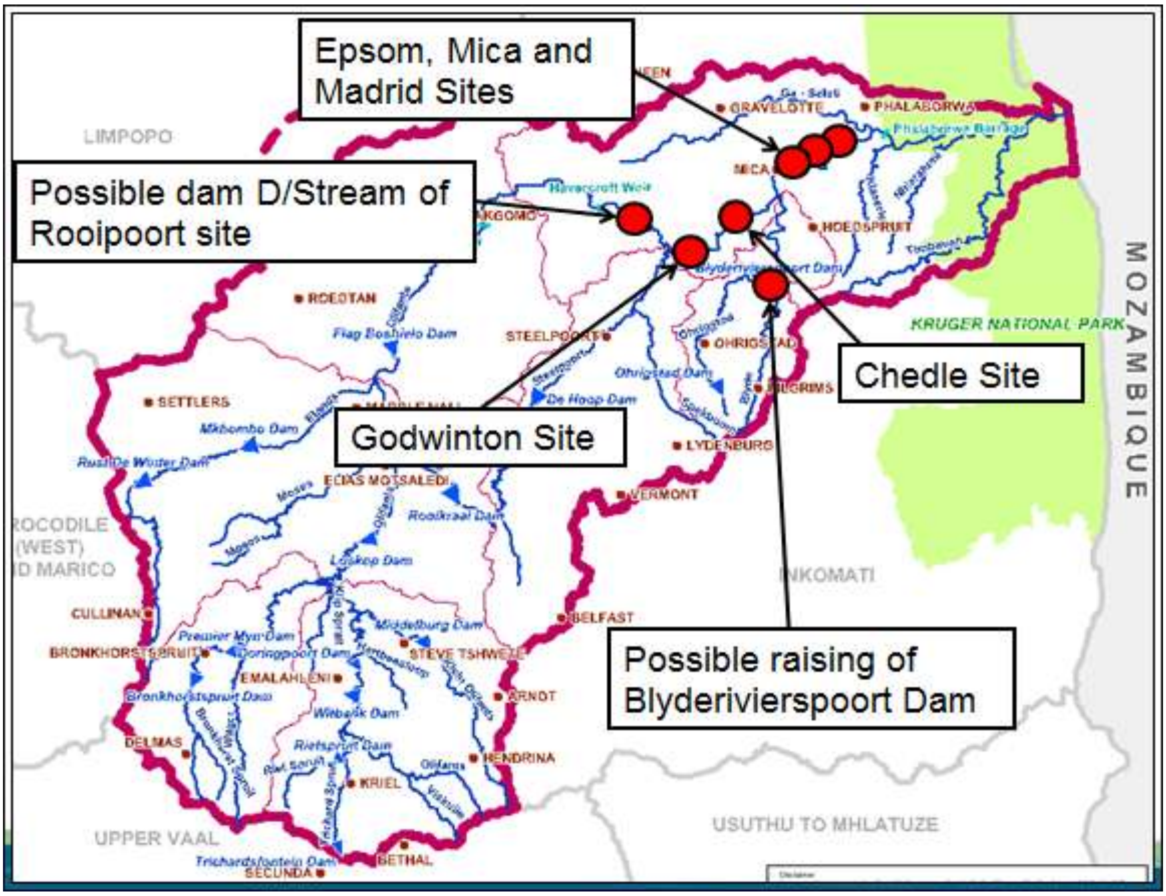


Figure 3.2: Locality of Possible Dam Sites

3.4.1.1. Rooipoort Dam

- **Site Description**

  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 flooded two provincial roads which would cost as much to relocate as the cost of the dam wall.
  - The dam 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.

It has recently been suggested that a dam at a site some 10 to 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 from previous 2007 estimates.

- **Yield and cost**

  The yield of the dam depends on its size. The graph in **Figure 3.3** shows cost versus yield where the yield can vary from 30 to 60 million m^3/a. The cost of a 60 million m^3/a dam will be close to R1.2 billion.

- **Unit Reference Value**

  The unit reference value of the 60 million m^3/a dam is R2.14/m^3

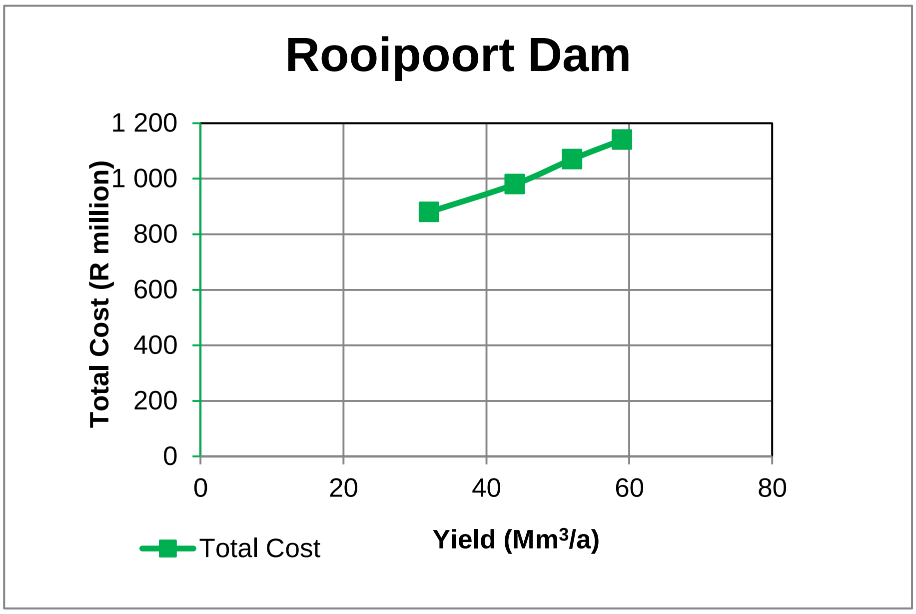


Figure 3.3: Rooipoort Dam Costs

3.4.1.2. New Dams in the Olifants River Gorge

- **Site Description**

  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 in **Figure 3.2**, namely:

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

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. Detailed investigations of water table levels around the dam basin will be required to determine whether water will drain into or out of the dams, and to what extent.

Both sites are topographically suitable for very high dams, but the maximum height is limited by the resulting 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. From a 2005 Google Earth image, it is estimated that 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.

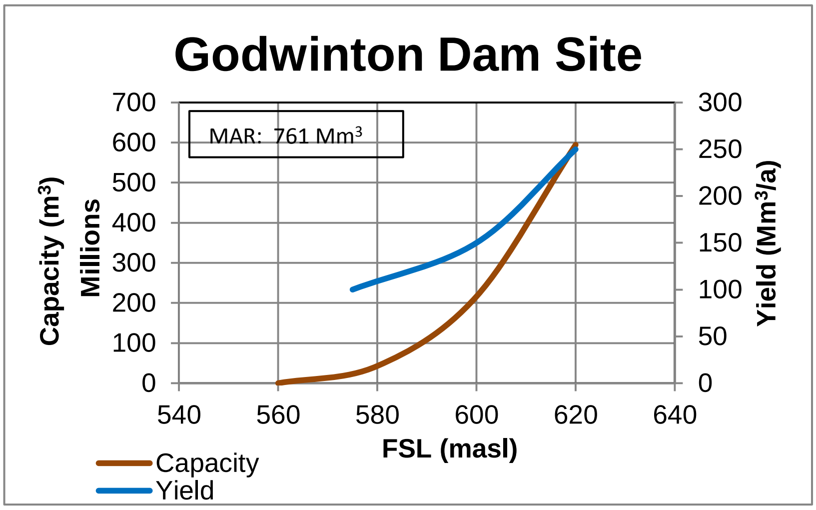


Figure 3.4: Godwinton Dam Site

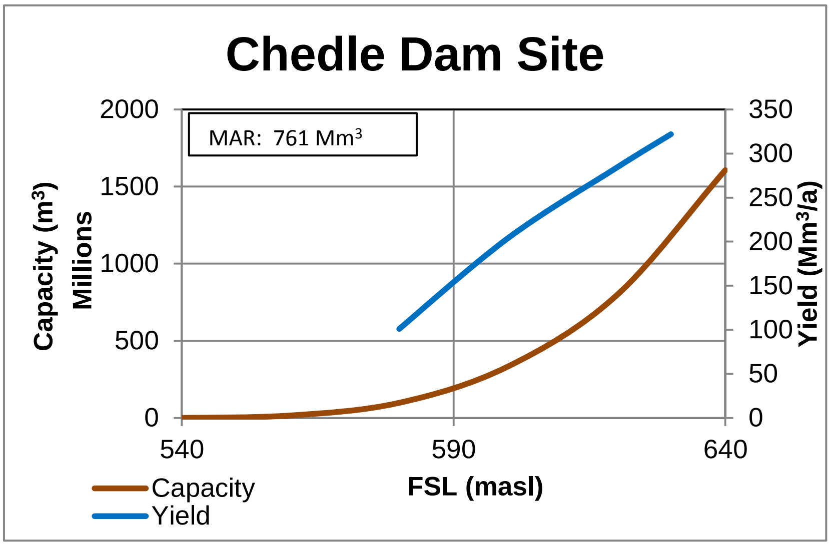


Figure 3.5: Chedle Dam Site

- **Yield and Cost**

  The graphs in **Figure 3.4** and **Figure 3.6** shows that the cost of Godwinton Dam will be just under R100 million for a dam with a yield of 100 million m^3/a (± 50m high), and will be in the order of R700 million for a dam with a yield of 250 million m^3 (70 m high).

  Figure 3.5 and **Figure 3.7** are similar graphs for the Chedle Dam Site. A dam with a yield of 100 million m^3/a will also cost approximately R100 million while a dam with a yield of 250 million m^3/a will cost in the order of R550 million.

  Note that the cost estimates for dams have been based on the all-in prices from De Hoop Dam, escalated to 2010.

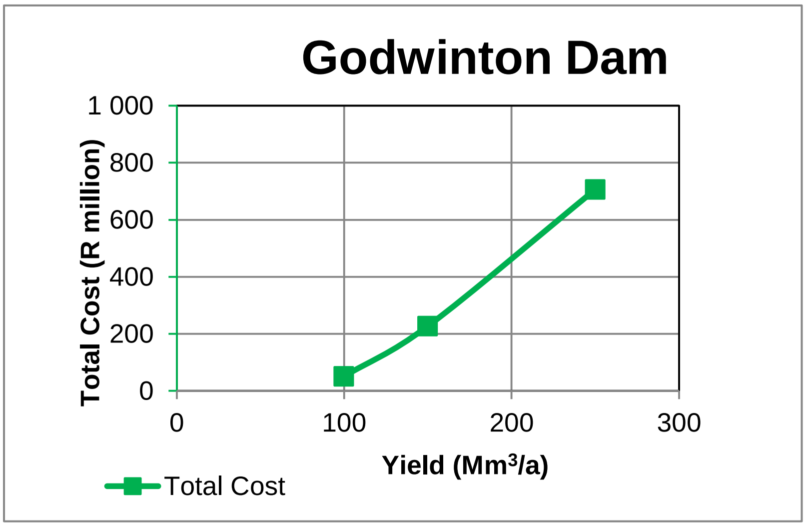


Figure 3.6: Godwinton Dam

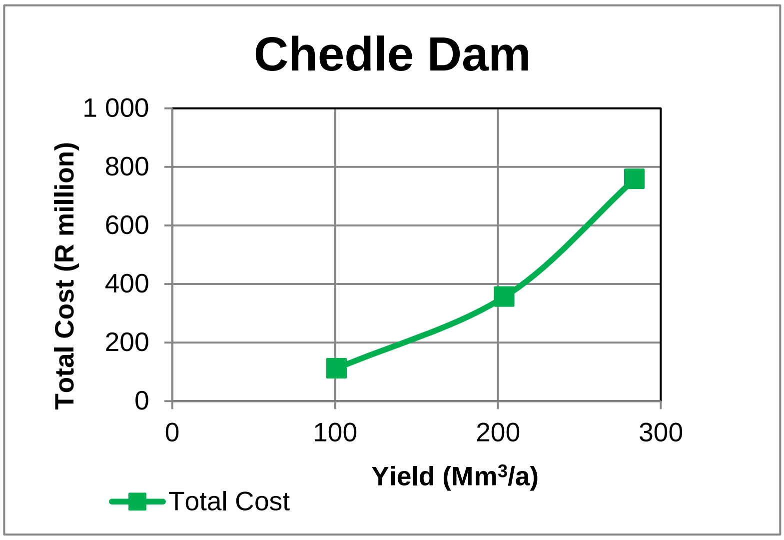


Figure 3.7: Chedle Dam

- **Unit Reference Value**

  The unit reference values of the 100 million m^3/a sizes is as follows:

Godwinton	R 0.14 /m^3
Chedle	R 0.20 /m^3

3.4.1.3. New Dams in the Lower Olifants River

- **Site Description**

  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, as illustrated in **Figure 3.1**, namely:

  i) Epsom
  ii) Mica
  iii) Madrid

  The Epsom site is located immediately downstream of the Blyde/Olifants confluence, which makes it favourable in that water will be stored up 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 (FSL 440 masl) 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.

  Figure 3.8 illustrates the relationship between full supply height, dam capacity and yield of the Epsom Dam Site.

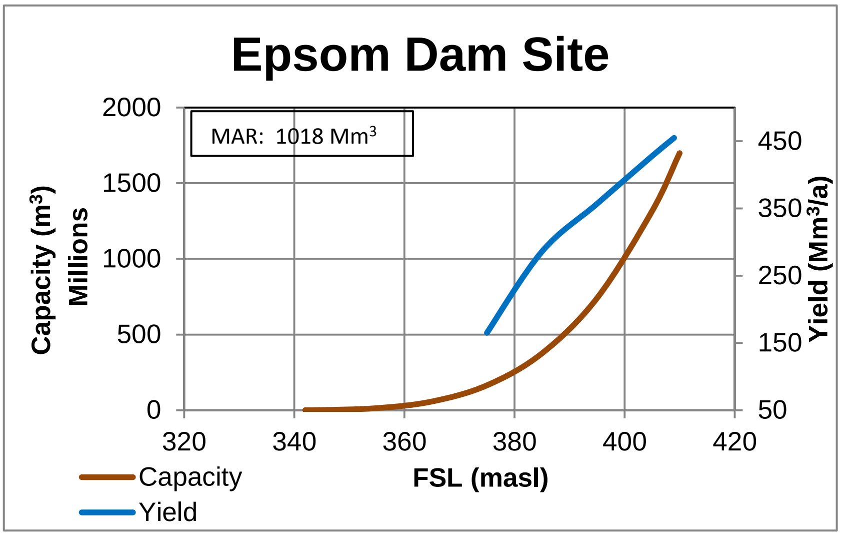


Figure 3.8: Epsom Dam Site

The **Mica** site is located 8 km downstream of the Blyde river confluence, and the Madrid site is some 20 km further downstream. Neither site is topographically very suitable, being in a flat valley, and both will require long dam structures. Both sites are limited to a maximum FSL of about 410 masl, 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 will be inundated and which will 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, with some 3.5 km of the R530 being inundated.

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

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 effected. However, the height restriction of 410 masl limits the storage capacity of the Mica site to only 514 million m^3, which is equivalent to 0.5 MAR, while at the same level the Madrid site can store 1 700 million m^3 or 1.5 MAR.

The full supply height/capacity/yield curves for the Madrid Dam site are very similar to those of the Epsom Dam site as can be seen in **Figure 3.9.**

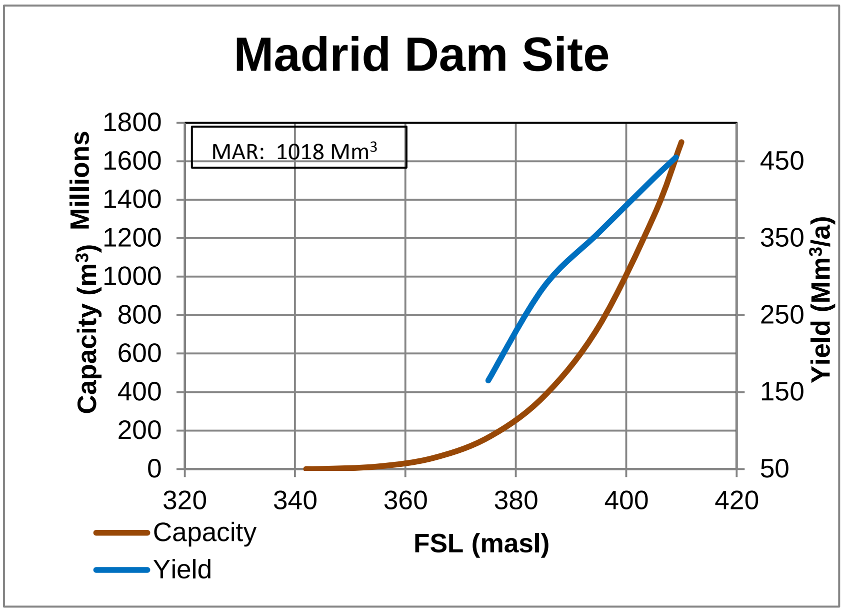


Figure 3.9: Madrid Dam Site

- **Cost**

  The costs of the three dam sites are very similar and vary between R5 billion and R9 billion depending on the chosen yield. These relationships are illustrated in Figure 3.10 and Figure 3.11.

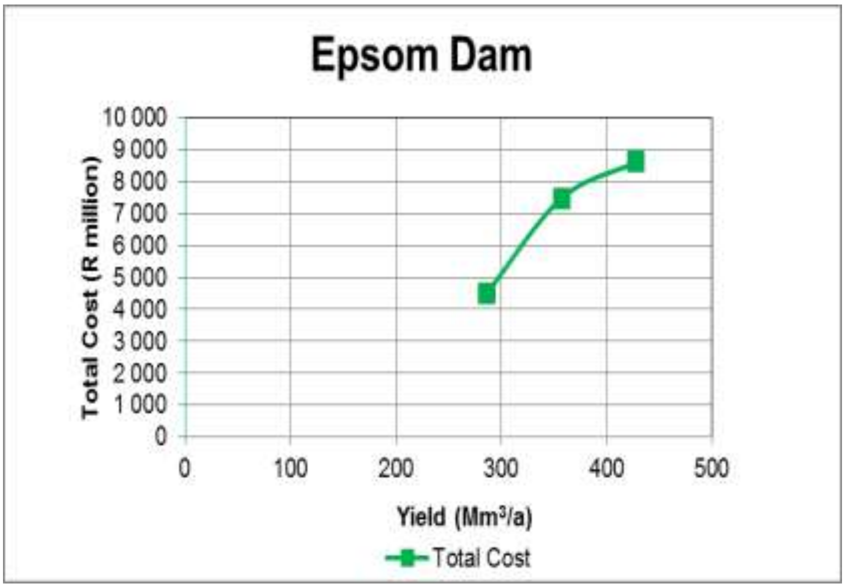


Figure 3.10: Epsom Dam

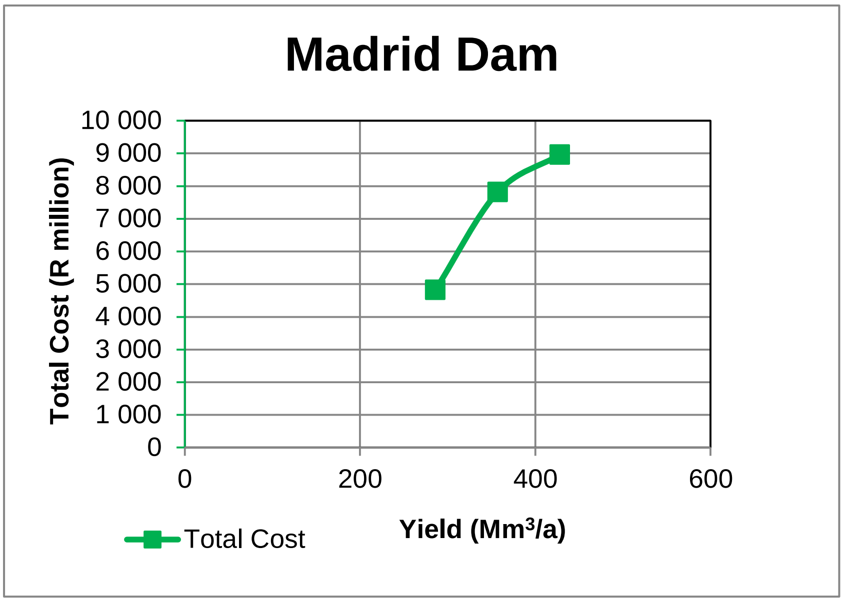


Figure 3.11: Madrid Dam

- **Unit Reference Value**

  The unit reference values of the dams are as follows:

  Epsom (yield 286 Mm^3/a) R 1.58 $/m^3$
  Madrid (yield 440 Mm^3/a) R 1.71 $/m^3$

3.4.1.4. Raising of Blyderivierspoort Dam

- **Site Description**

  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, only 17.4% of the MAR, suggesting that there is plenty of scope for raising. A site visit showed that the site is ideal for the height of the existing dam however 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.

  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 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 stresses in the foundation and can ameliorate this problem.

The stability and perviousness 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. Capacity and yield curves are shown in

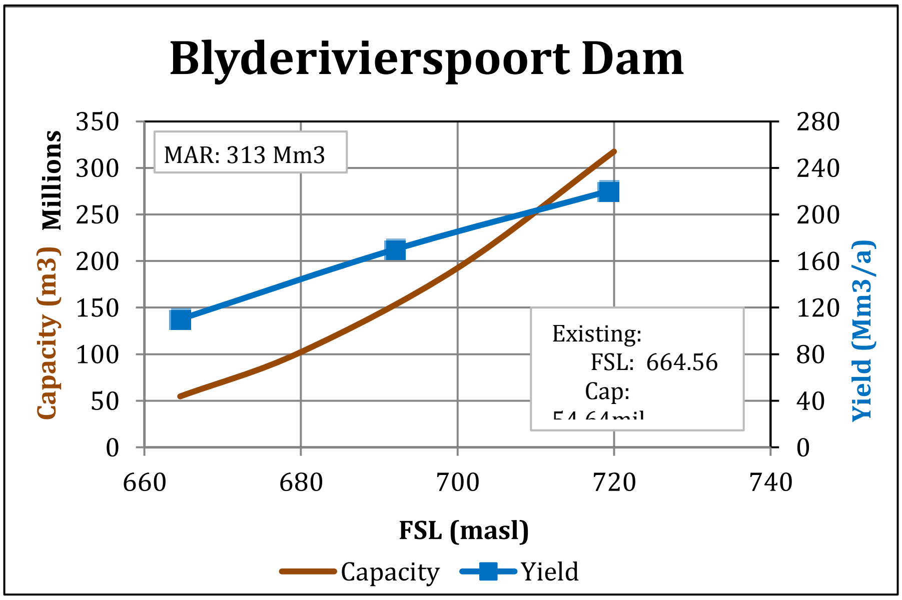
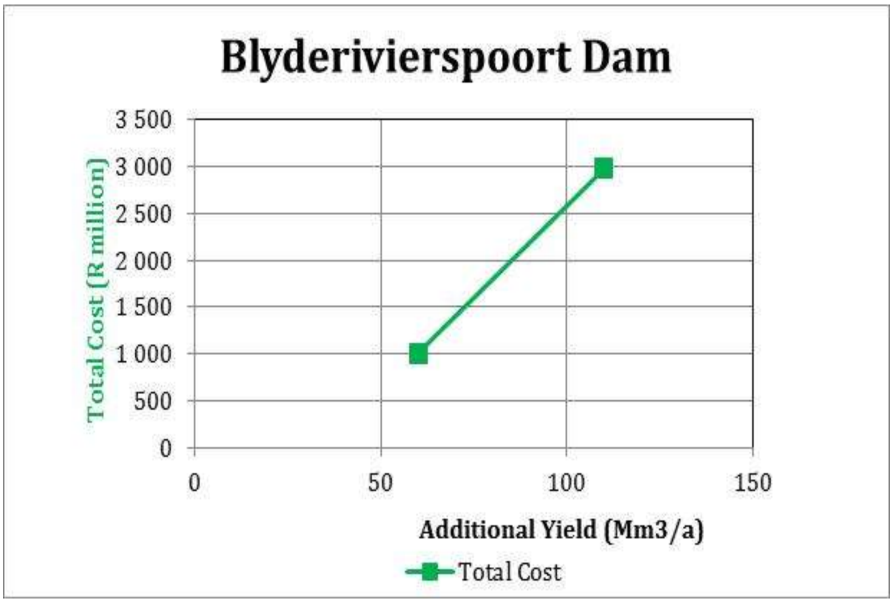


Figure 3.12.

Figure 3.12: Capacity and yield curves for raising of Blyderivierspoort Dam



(Units: million m^3/annum)

Figure 3.13: Cost Estimates for Raising of Blyderivierspoort Dam

The 55 m raising will increase the yield of the dam by 110 million m³/a. The estimated cost of such a project will be R2,98 million with a URV of R2,99/m^3.

- **Cost**

  The cost of the Blyderivierspoort Dam raising is shown in **Figure 3.13**, and varies between one billion and three billion rands, depending on the height of the raising.

- **Unit Reference Value**

  The URV for a dam raising of 55m will be R2.77/m^3. 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 3.4.1.2.

3.4.2 Possible transfer schemes

3.4.2.1. Transferring Treated Effluent from the East Rand

- **Option Description**

  There are a total of 12 waste water treatment works in Ekurhuleni, which discharge their treated effluent into various tributaries of the Vaal River. It is possible to pump this water over the catchment divide into a tributary of the upper Olifants River. For this assessment the seven most suitably located works were selected. The concept of the project is shown on the map in **Figure 3.14.**

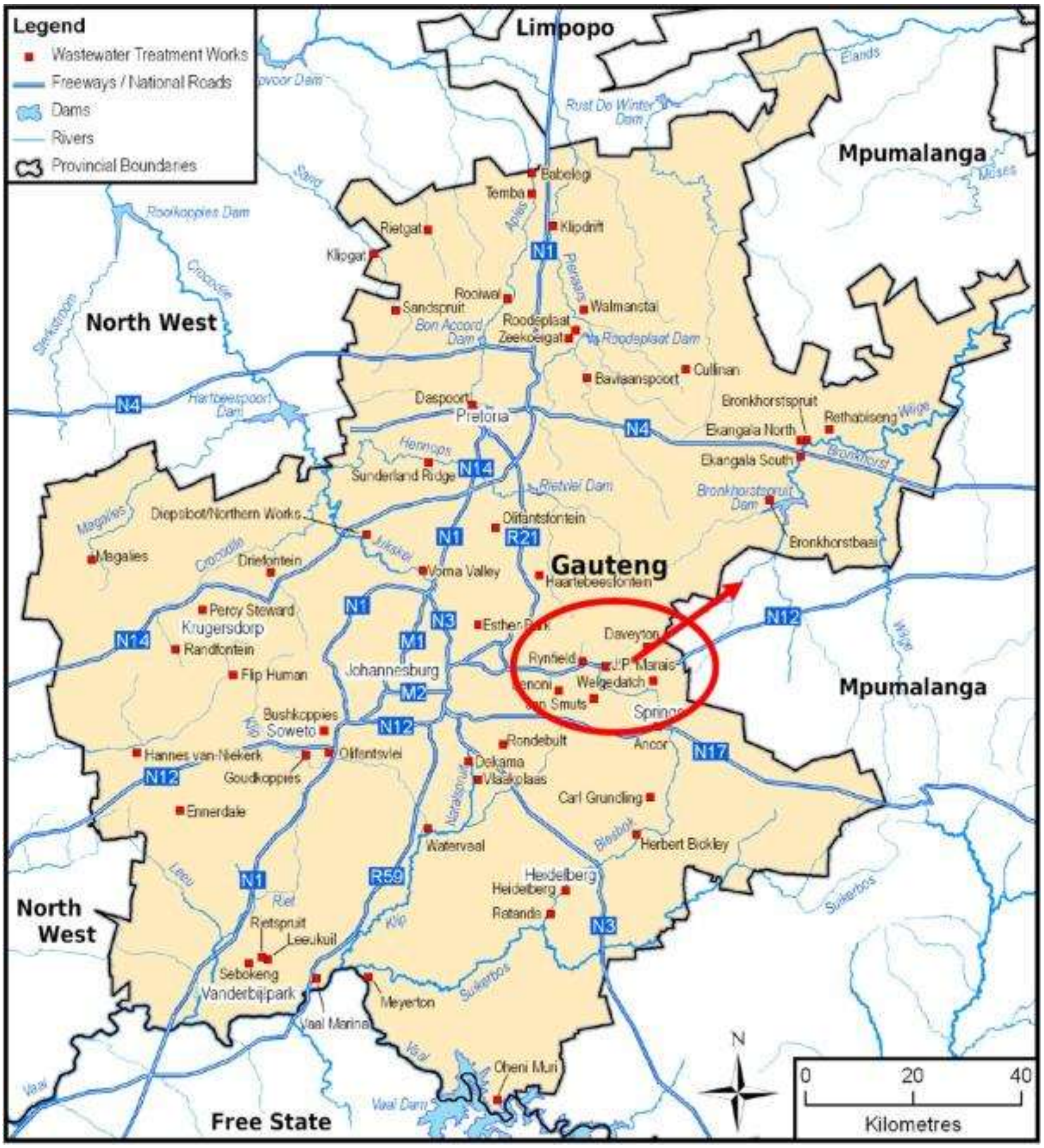


Figure 3.14: Waste Water Treatment Works in Ekurhuleni

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

The location of the envisaged scheme is shown in **Figure 3.14.** 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.

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. This is based on the estimated cost of the Lesotho Highlands Water Project Phase II.

The seven treatment works have been selected based on their capacities and their location relative to the Olifants catchment. They are listed in **Table 3.6.** 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.

Table 3.6: Details of Assumed Treated Effluent Scheme

WWTW	Location	Capacity (Ml/d)	Assumed Yield[1]		Pipeline							Pumps (kW)	Dam (Ml)	Cost (R Million)	URV (R/m^3)
			(million m^3/a)	(m^3/s)	Destination	(m^3/s)	Length (Km)	Start Elevation	High point	End Elevation	Diameter				
Daveyton	Daveton	16	4,7	0,148	Discharge pt	1,213	21,6	1 590	1 633	1 536	900	650	17	301	0,81
JP Marais	Benoni	15	4,4	0,139	Daveyton	0,445	9	1 597	1 629	1 590	600	310	6	96	0,67
Rynefield	Benoni	13	3,8	0,120	JP Marais	0,120	3,9	1 605	1 608	1 597	300	62		35	1,05
Benoni	Benoni	10	2,9	0,093	JP Marais	0,093	9,7	1 653	1 657	1 597	300	27		65	2,32
Jan Smuts	Brakpan	10	2,9	0,093	JP Marais	0,093	7,2	1 602	1 605	1 597	400	48		42	1,25
Welbedacht	Springs	35	10,2	0,324	Daveyton	0,620	7	1 577	1 607	1 602	700	424	9	96	0,62
Ancor	Springs	32	9,3	0,296	Welbedacht	0,296	12,5	1 573	1 573	1 601	500	260		121	1,44
		131	38,3	1,213			70,9							466	3,83[2]
Tertiary Treatment Works at Daveyton WWTW: Capacity 136 Ml/day														657	3,48
													TOTAL (Excluding VAT)	**1 123**	**7,31**

1 Assumed equal to 80% of capacity

2 Weighted averages accumulated along the route

- **Costs and URVs**

  Preliminary estimates of costs and Unit Reference Values (URVs) based on 2010 cost levels, for this option is also given in **Table 3.6.**

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

3.4.2.2. Transferring More Water from Vaal Dam

- **Option Description**

  DWA has recently commissioned a scheme (the VRESAP scheme) to pump 160 million m^3/annum raw water from Vaal Dam to the Vaal-Olifants watershed. This water is fully committed to Sasol at Secunda in the Vaal catchment and Eskom in the upper Olifants catchment. This scheme comprises a 1 900 mm pipe 110 km long 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.

- **Cost**

  The costs of the VRESAP scheme, escalated to 2010, amount to about R3.5 billion.

- **Unit Reference Value**

  The NPV of operational and maintenance costs amounts to R4 923 million which gives a URV of R 3.60 /m^3. It should, however, be noted that the Vaal river raw water tariff must be paid for all water supplied from that area. Considering that the water will only be available after the construction of the next phase of the Lesotho Highlands Water Project (LHFP), this tariff will be significant. While the tariff after construction of the LHFP is not yet known, it is assumed for the purposes of this report that it will be of the order of R 4.50 /m^3.

3.4.2.3. Transfer of Water from Crocodile (West) River System

- **Option Description**

  Flows in the Crocodile (West) river are continuously increasing as a result of increasing discharges from numerous waste water treatment works (WWTW) which discharge into various tributaries of the main stem river. These works collect effluent from the whole of the City of Tshwane and the northern half of Johannesburg, totalling a considerable volume. However, much of this water enters the Crocodile (West) River relatively far downstream of the westward flowing river, and the cost of pumping the furthest water to the Olifants River would be exorbitant.

In other studies for DWA, the increase in the yield as a result of the inflows of all dams in the Crocodile (West) and its tributaries.

This study focuses on the available increasing yield of the closest dams, as listed in **Table 3.7.**

Table 3.7: Water Available from Selected Crocodile (West) River Dams (million m^3)

Dam	2015	2020	2030
Hartebeespoort dam	24,0	29,0	58,5
Klipvoor Dam	0	4,7	17,0
Roodeplaat dam	26,5	36,0	33,0

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

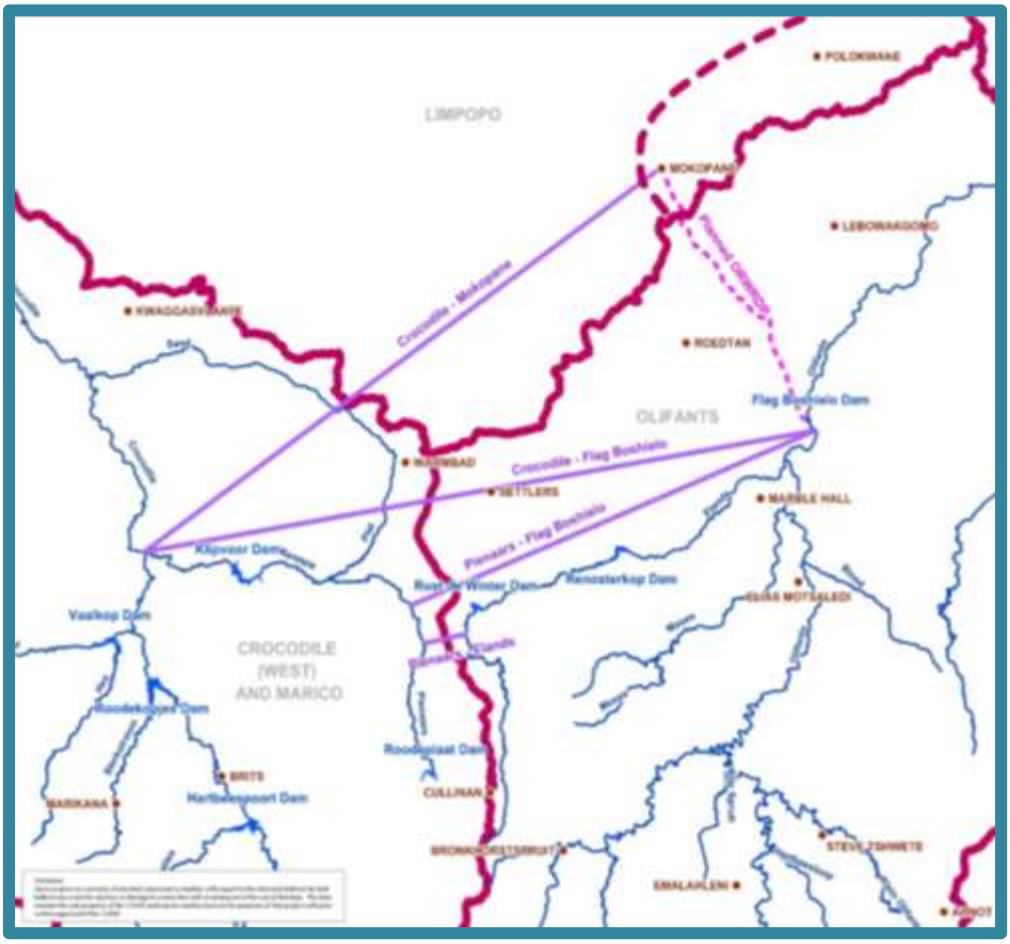


Figure 3.15: Crocodile (West) - Olifants Transfer Options

As shown in **Figure 3.15** four options have been considered, namely:

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

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

iii) To abstract water from the Crocodile River just downstream of the confluence of the Moretele river confluence and to discharge it just upstream of the Flag Boshielo Dam.

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

- **Costs and URVs**

  The estimated cost of each of the four options is set out in **Table 3.8,** as well as the URVs. The Pienaars-Elands option is by far the cheapest, but the transmission losses along the Elands River are appoint of great uncertainty.

Table 3.8: Details of Crocodile (West) Transfer Options

Transfer Option	Pipe Length (km)	Supply (million m^3/a)	Cost (R $x10^6$)	URV (R/m^3)
i) Pienaars - Elands	12	30/15	213	1,57
ii) Pienaars – Flag Boshielo Dam	115	30	1 268	3,82
iii) Crocodile – Flag Boshielo	180	60	3 926	6,43
iv) Crocodile - Mokopane	180	25	3 728	14,51
ORWRDP-2B: Flag Boshielo - Mokopane	72	25	1 034	5,37

An important observation is that the Pienaars-Flag Boshielo Dam (Option ii) added to the planned ORWRDP-2B pipeline from Flag Boshielo Dam to Mokopane, is actually cheaper than the pipeline from the Crocodile (West) River directly to Mokopane. Was this not the case, the ORWRDP-2B pipeline would have to be reconsidered.

3.4.2.4. Transfer of Water from Massingir Dam

- **Option Description**

  It has been suggested that because the biggest shortfall in water supplies is that required to meet the EFRs through the KNP, that this water could be pumped from Massingir Dam to just upstream of the KNP. Because this water is effectively circulated continuously, the only reduction in flow to Massingir would be the river losses through the KNP. This is a significantly lower effect on Massingir than any of the dam options. It has been assumed that the pumps would be located downstream of the Massingir Dam wall and the scheme would discharge into the existing Phalaborwa Barrage. The storage available in the barrage could possibly be used to provide elevated flows, although this would impact on the yield of the Barrage, which would have to be replaced from elsewhere. Details of the scheme are summarised in **Table 3.9.**

Table 3.9: Massingir Pipeline Details

Assumed Yield		Pipeline Details					Pumps	Cost	URV
(million m^3/a)	$(m^3/s)^1$	km	Start El	High pnt	End El	Diam	(MW)	(R Million)	(R/m^3)
175	5.55	115	310	375	344	1900	29.7	4 000	3.18
100	3.17					1600	15.7	2 900	3.72
50	1.59					1200	8.2	2 000	4.85

(1) Assumes pumping 24 hours per day

- **Cost and URVs**
  The cost and URV values are also shown in **Table 3.9.**

3.4.3 Development of non-conventional water sources

3.4.3.1. Desalination of Sea Water

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

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

Table 3.10: Details of Desalination Options

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

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

3.4.3.2. Utilising the Acid Mine Drainage in the Upper Olifants

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

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

It is important to note that much of this water, from dewatering of presently operating mines and decant from decommissioned mines, would have returned to the river as base flow even without any mining. The increase in reliable yield has been quantified in a detailed study by Golder, and is relatively small at present, but will reach a peak of 12 million m^3/a in approximately 5 years (2015) for the Witbank Dam Catchment and of 10 million m^3/a in approximately 2030 for the Middelburg Dam catchment.

The treatment and re-use of acid mine drainage water has already been implemented with a reverse osmosis plant, the Emalahleni Water Reclamation Plant, with a capacity of 9 million m^3/a. (25 Mℓ/d) and another one near Steve Tshwete LM, namely the Optimum Plant with a capacity of 5.5 million m^3/a (15 Mℓ/d). To provide additional capacity to meet the final expected yield of 22 million m^3/a is expected to cost approximately R86 million with a URV of R7.26 /m^3.

It should be noted that the mines are legally obliged to treat all AMD, not just the additional yield, before returning it to the river. This water, if treated to potable standards, can be used to supply domestic users, but the capital cost will be substantially more than that quoted above.

3.4.4 Groundwater Development

The study's report on Groundwater Options, PWMA 04/B50/00/8310/10, describes the availability of groundwater. This resource can fruitfully be utilised by the rural areas and many villages in the area. The groundwater availability map should be used as guideline to determine whether there is a good chance of finding groundwater at a given location.

No specific groundwater schemes have been assessed, but it has been assumed that 35 million m^3/a out of the available 70 million m^3/a will be developed over the next 16 years. For this purpose approximately R3 million per year is needed, giving a URV of R0.13/m^3.

3.4.5 Environmental Screening of Options

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

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

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

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

The construction of bulk water supply infrastructure such as dams and pipelines require the environmental authorisation impact assessment process that includes a public participation process.
Potential impacts on adjacent groundwater using landowners, surface flow and riverine ecology and groundwater dependent ecosystems could potentially be affected by groundwater development if it is not implemented sustainably.

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

The use of treated acid mine drainage can increase the system yield and improve the water quality. No significant impacts are expected.

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

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

The raising of the Blyderivierspoort Dam or construction of any of the possible five new large dams identified will have potentially significant social and ecological impacts which will require a full environmental and social impact assessment and to which the hierarchy of mitigation measures (enhance, avoid, reduce, restore compensate, offset) will have to be applied.

Rainfall enhancement could increase the size and frequency of floods.

The increase on utilisable yield from removal the of the invasive alien vegetation is expected to be negligible, but this option will have a positive impact on biodiversity.

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

4. COMPARISON OF COST AND URV'S

For easy reference and comparison purposes, the cost and unit reference values are repeated under this section.

Table 4.1: Management Options

Option	Yield/Water Saving (million m/a)	Cost as NPV (R million)	URV (R/m^3)
Eliminating Unlawful Irrigation use	8.7	12	0.12
Removal of Alien Invasive Plants	15	120	0.76
WC/WDM: Urban	20	285	1.48
Compulsory Licensing	35	32	0.07
Purchasing Water Entitlements	35	175	0.35

Table 4.2: Development Options

Option	Yield (million m^3/a)	Capital Cost (R million)	URV (R/m^3)
Rooipoort Dam	59	1 140	2.14
Dam in Olifants Gorge:			
Godwinton	100	132	0.14
Chedle	100	200	0.20
Dam in Lower Olifants:			
Epsom	286	4 820	1.58
Madrid	440	8 800	1.71
Raising of Blyderivierspoort Dam	110	2 977	2.77
Transfer from ERWAT ∗	38.3	1 123	7.31
Transfer from Vaal Dam ∗	160	3 500	3.60
Transfer from Crocodile (West):			
Pienaars – Flag Boshielo Dam	30	1 268	3.82
Crocodile – Flag Boshielo Dam	60	3 926	6.43
Crocodile – Mokopane	25	3 728	14.51
Transfer from Massingir Dam	50	2 000	4.85
Groundwater Development	35	48	0.13
Utilising Acid Mine Drainage	22	75	6.31
Desalination of Sea Water	100	12 970	44.45

∗ *Excludes cost of LHFP (URV R6.14/m^3)*

5. CONCLUSIONS AND RECOMMENDATIONS

The selection of options for possible further consideration is discussed further in the Final Reconciliation Strategy Report. The following comments are made to assist the selection process.

5.1 The Rooipoort Dam has high social costs and is located on a stretch of river whose flow is already much reduced. Much of its yield would therefore be allocated to meeting the EFR.

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

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

5.4 Transferring treated effluent from the ERWAT WWTW or raw water from Vaal Dam would both exacerbate water shortages in the Vaal river basin, for which Phase 2 of the Lesotho Highlands Water Project is currently being planned. The URV of that scheme is currently estimated at R6.14 /m^3, which must be added to the cost of transferring the water to the Olifants River.

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

5.6 Transferring water from Massingir Dam would benefit only the KNP, and there is no certainty that the scheme would be considered to have positive environmental impacts. The necessary negotiations with Mozambique would also be a serious complication. This alternative is not considered to be a viable option.

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

5.8 The reducing of assurances of supply for the irrigation sector from the current 80% should be investigated and a consultation process should be initiated.

6. REFERENCES

Ninham Shand, 1994. *Olifants-Sand Water Transfer Scheme Feasibility Study*

Ninham Shand, 2001. *Olifants-Sand Water Transfer Scheme: Feasibility of Further Phases*

BKS, 2010. *Assessment of the Ultimate Potential and Future Marginal Cost of Water Resources in South Africa (Draft)*