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

WP10197

Future Water Reuse and other Marginal Water Use Possibilities

Original

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December 2011

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Report no.: P WMA 04/B50/00/8310/4

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Glossary of Terms

Allocable Water
Water that is available to allocate for consumptive use.

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.

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.

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.

Acid Mine Drainage
Decanting water from defunct mines which have become polluted and acidic and that reach the resource.

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

Internal Strategic Perspective (ISP)
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 is established.by a CMA.

List of Abbreviations & Acronyms

AMD	Acid Mine Drainage
CEDI	Continuous Electron Deioniser
CMA	Catchment Management Agency
CMC	Catchment Management Committee
CME	Compliance Monitoring and Enforcement
DPLG	Department of Provincial and Local Government
DWA	Department of Water Affairs
DWAF	Former Department of Water Affairs and Forestry
ED/EDR	Electrodialysis and Electrodialysis Reversal
EMF	Environmental Management Framework
EMP	Environmental Management Plan
EWR	Ecological Water Requirements (Ecological Component of the Reserve)
GDP	Gross Domestic Product
GIS	Geographical information System
IB	Irrigation Board
IDP	Integrated Development Plan
IAP	Invasive Alien Plants
ISP	Internal Strategic Perspective
IWRM	Integrated Water Resources Management
IWRMP	Integrated Water Resources Management Plan
LNW	Lepelle Northern Water Board
MAR	Mean Annual Runoff
MED	Multiple Effect Distillation
MINWAC	Mining & Industry Water Action Committee
MSF	Multi-Stage Flash
NPV	Nett Present Value
NRF	National Research Foundation
NWA	National Water Act (Act 36 of 1998)
NWRS	National Water Resource Strategy
OWAAS	Olifants Water Availability Study
RO	Reverse Osmosis
RWQO	Resource Water Quality Objectives
SALGA	South African Local Government Association
SDF	Strategic Development Framework
UF	Ultra-Filtration
URV	Unit Reference Value
VAC	Visual Absorption Capacity
VAPS	Vaal Augmentation Planning Study
WAAS	Water Availability Assessment Study
WCDM	Water Conservation /Demand Management
WFGDS	Water for Growth & Development Strategy
WMA	Water Management Area
WMP	Water Management Plan

WQMP	Water Quality Management Plan
WQT	Water Quality Time Series Model
WSDP	Water Services Development Plan
WUA	Water User Association
WWTW	Waste Water Treatment Works

Measurements

ℓ/uso	litres per unit sent out (electricity)
million m^3	million cubic metres
mg/ℓ	milligrams per litre
mS/m	milli-Siemens per metre (electrical conductivity)

EXECUTIVE SUMMARY

INTRODUCTION

The Olifants River Catchment is located within the provinces of Gauteng, Mpumalanga and Limpopo and covers an area of approximately 54 550 km^2. The catchment has been divided into three sub-catchments, namely the Upper Olifants, Middle Olifants (incorporates the Steelpoort River), and the Lower Olifants.

The study area consists of the Olifants River Catchment and its immediate supply zone. Hence, the urban areas of Polokwane and Mokopane have been included in the study area. This study area is collectively referred to as "the catchment" in this report.

The catchment is considered a stressed catchment. In order to contribute towards improving the water balance situation in the catchment and the livelihood of people in the catchment, measures to reuse water in the catchment must be considered. This report focuses on the existing use of non-conventional water and identifies future potential use of- non-conventional water within the Olifants River Catchment. The objective is to improve water efficiency and recycling and where possible contribute towards the yield in the catchment.

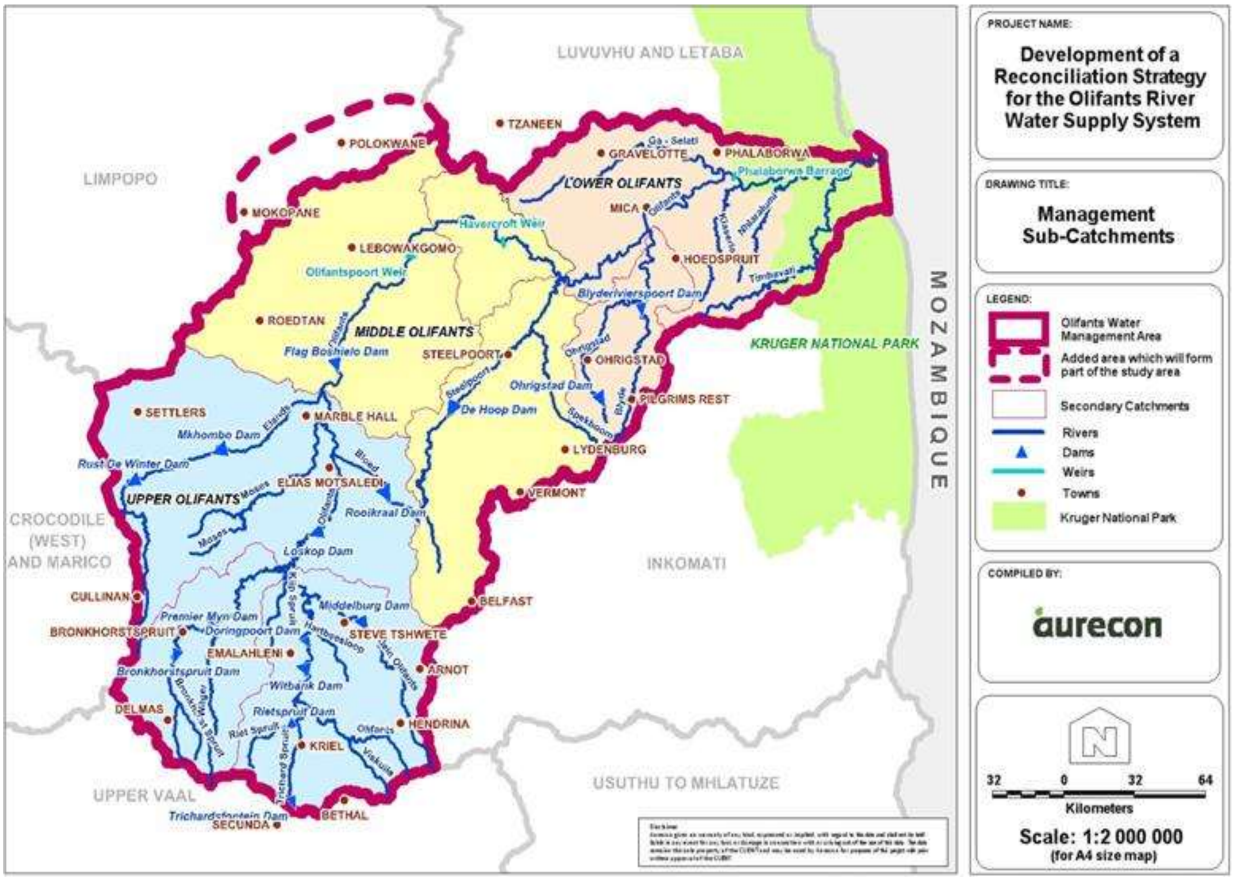

***Figure E1:** Map indicating the location of the Olifants River Catchment*

WATER REUSE

The reusing and recycling of water provides greater utilisation of water and improves water quality in the system. Non-conventional water, together with Water Conservation and Water

Demand Management (WC/WDM) are tools to improve water efficiency and reduce demands on freshwater resources. Non-conventional waters in many instances are used in conjunction with water conservation practices and technologies. By implementing these methods and processes, there is the added benefit of reducing waste discharge to water resources and thereby improving water quality within the catchment.

The key sources of non-conventional water include rain water, groundwater (brackish, sodic and sweet), waste water (domestic and industrial), mine water and seawater. For the purpose of this report and application in the Olifants catchment, seawater has not been considered because of the long distance which such water will have to be transported and associated high cost thereof. The role these sources of water play within the water cycle are illustrated in ***Figure E2****. Like conventional water, non-conventional waters are both impacted, e.g. health and environmental impacts. These impacts are discussed in this report.*

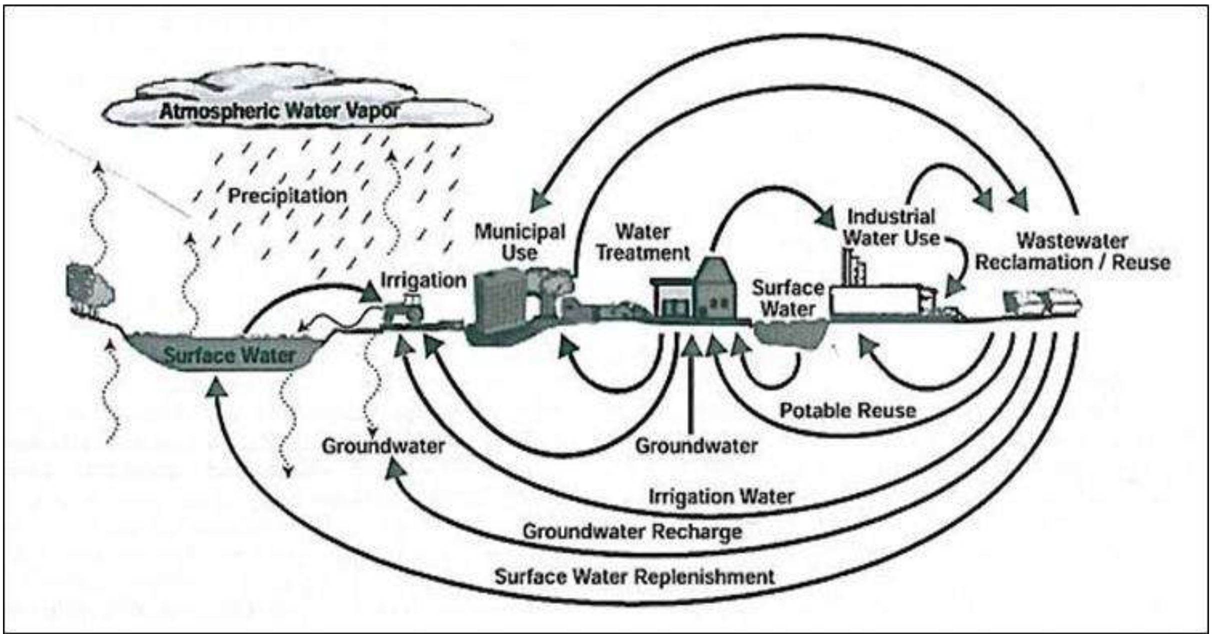

Figure E2: *The role of engineered treatment, reclamation, and reuse facilities in the multiple uses on non-conventional water through the hydrological cycle. (Source: Asano, 1995)*

Acid Mine Drainage (AMD) is the number one environmental problem facing the mining industry, and together with industrial wastewater, the biggest environmental problem in the Olifants Catchment. ***Figure E3*** *illustrates the mining effects on drainage.*

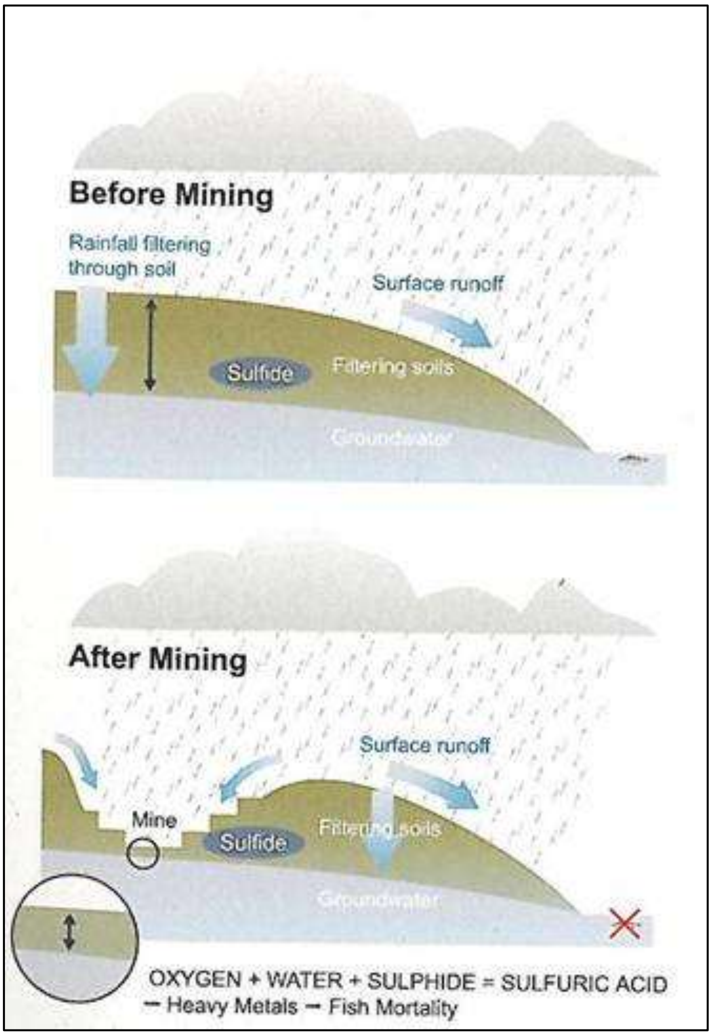

Figure E3: *Mining effects on drainage. (Source: UNEP, 2004)*

CURRENT EXTENT OF REUSED WATER IN THE STUDY AREA

While rainfall indirectly contributes to water supply, i.e. collects in rivers and dams from which abstraction then takes place, rainwater harvesting and enhancement can be an attractive alternative solution to water availability shortages. In particular, rainwater harvesting through its decentralised nature, enables people at household and community level to manage their own water.

*There are a number of water users in the study area that already reuse water in the form of domestic waste water reused for process water or for irrigation, as listed in **Table E1**.*

Table E1: *Water users reusing domestic waste water*

Company Name	Volume (Mℓ/day)	Type	Use
Bethal WWTW	*13.70*	*N/A*	*N/A*
Middelburg Mine Services	*2.74*	*N/A*	*N/A*
Middelburg WWTW	*2.74*	*N/A*	*N/A*
Steve Tshwete Local Municipality	*20*	*Reuse*	*Industrial*
Columbus Stainless Pty Ltd	*2*	*Reuse*	*Process water make-up*
Govan Mbeki Local Municipality	*7.25*	*Reuse*	*Irrigation*
Thaba Chweu Local Municipality	*8*	*Reuse*	*Mine water (70%)*
Witbank Prison WWTW	*2.74*	*N/A*	*N/A*

These is an agreement in place to reuse some 8 million m^3/a of waste water of Polokwane at a mine for industrial purposes.

*There are a number of water users that reuse their industrial waste water as shown in **Table E2**.*

Table E2: *Water users reusing industrial waste water*

Company Name	Volume (Mℓ/day)	Type	Use
Eskom	*Not available*	*Recycle*	*Process water*
Anglo Platinum	*69.32*	*Recycle & Reuse*	*Process water*
Columbus Stainless Pty Ltd	*5*	*Recycle & Reuse*	*Process water*
Phalaborwa Mining Company	*130*	*Reuse*	*Ore process water*
SAB Miller	*Not available*	*Recycle & Reuse*	*Process water*

Apart from those listed above, Acid Mine Drainage is reclaimed in the Middelburg and Emalahleni areas and used for domestic and process water.

POTENTIAL FOR REUSE OF WATER AND THE USE OF MARGINAL WATER IN THE STUDY AREA

Further potential areas for sources of and use of non-conventional waters were identified:

- ***Rainfall Enhancement***

  Cloud seeding is most effective in mountainous regions. The Drakensberg escarpment runs through the Lower Olifants catchment and provides suitable opportunity for cloud seeding to be implemented. This area is already a high rainfall area. In order to have longer lasting benefits from rainfall enhancement, a storage scheme for this area would be necessary.

- ***Rain Water Harvesting***

  In South Africa, disadvantaged families in rural and urban areas (if located on big enough stands) can reduce their poverty situation through subsistence gardening in their stands. Harvested rainwater can be used for domestic use and to irrigate vegetable crops and offer an opportunity for a household to save on food expenditure and in so doing, to release cash for other needs. According to Mwege Kahinda, et al, (2008), rainwater harvesting is suitable in areas with rainfall from 200 mm to 1 000 mm, deep soils (0.2 – 0.3 m) and slopes less than 3%. Rainfall across the catchment falls within these limits.

- ***Groundwater***

  There is extensive (registered not verified) use of groundwater within the Olifants Catchment. For the purposes of determining sources of non-conventional water, only groundwater with a TDS of 1 200 mg/ℓ or higher, which is called brackish groundwater, is considered. Water with a lower TDS is considered part of the conventional yield of the system.

Figure E4 *illustrates the electrical conductivity of registered boreholes in the catchment. All purple, red and some yellow dots fall into the brackish water limit. Verification of these boreholes regarding their utilisation, sodium and chloride content and recharge rate will be required before considering the utilisation of the water.*

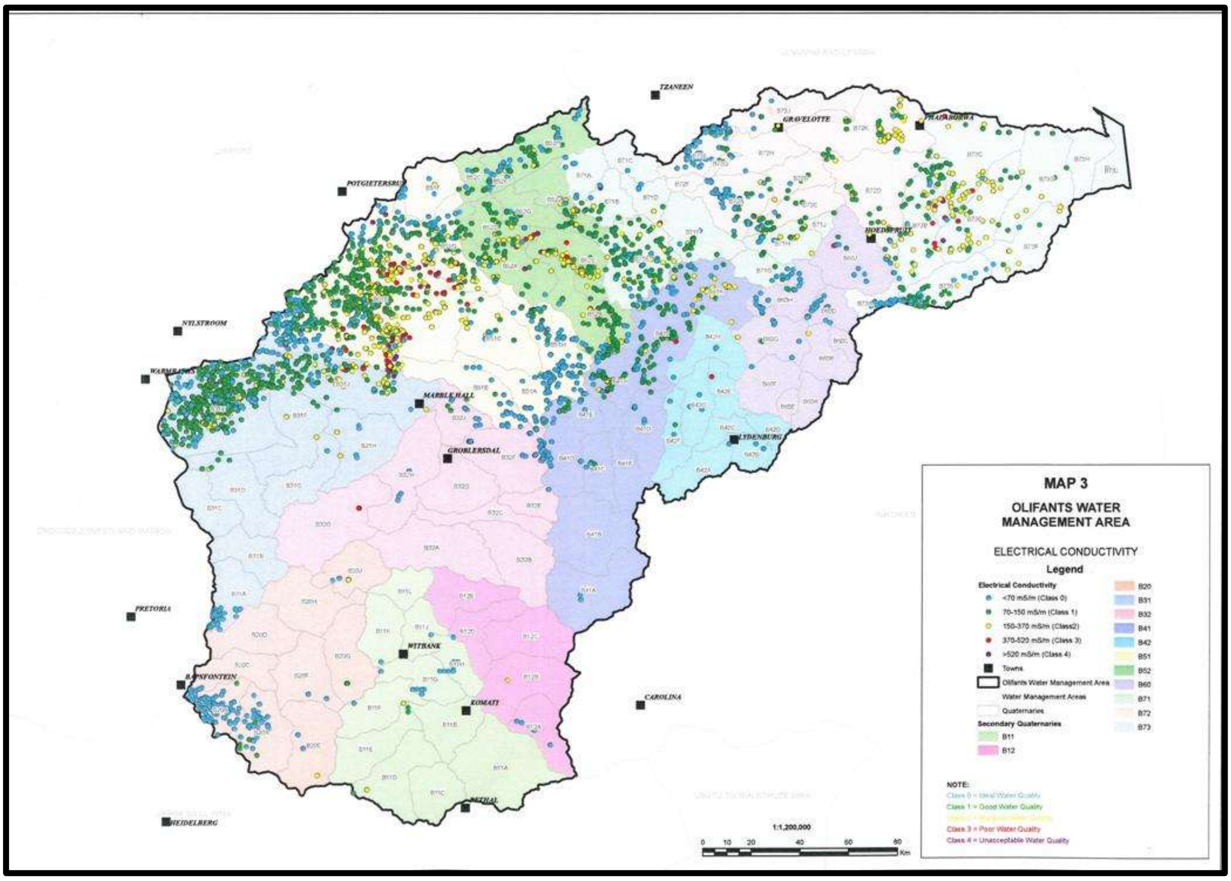

Figure E4: *Electrical conductivity of registered boreholes in the catchment. (Source: Africon, 2007)*

The sustainable availability of groundwater is dependent on the annual recharge from rainfall. In order to increase the yield of the groundwater system, improvements could be *achieved through artifically recharging of the aquifers. Aquifers with a yield greater than or equal to 5 ℓ/s would be suitable for direct/artificial aquifer recharge applications.* ***Figure E5*** *illustrates aquifers with their potential utilisation of recharge, i.e. areas identified as Class 4 are aquifers not utilised to their full capacity, whereas areas identified as Class1 are over-utilised. The areas of Class 1 and 2 aquifers should be investigated further for direct / artificial recharge application in order to speed up recharge timeframes and thus reduce stress on the aquifer.*

Applications for artificial groundwater recharge include utilising rainwater, reclaimed mine water, and treated waste water as source. The water quality of the water used for the artificial recharge would need to comply with DWA standards. The utilisation of artificial recharge to increase the yield and thus the higher utilisation of these Class 1 and 2 aquifers, must be considered carefully. The option of implementing the Godwinton Weir can recharge the dolomites close to the escarpment.

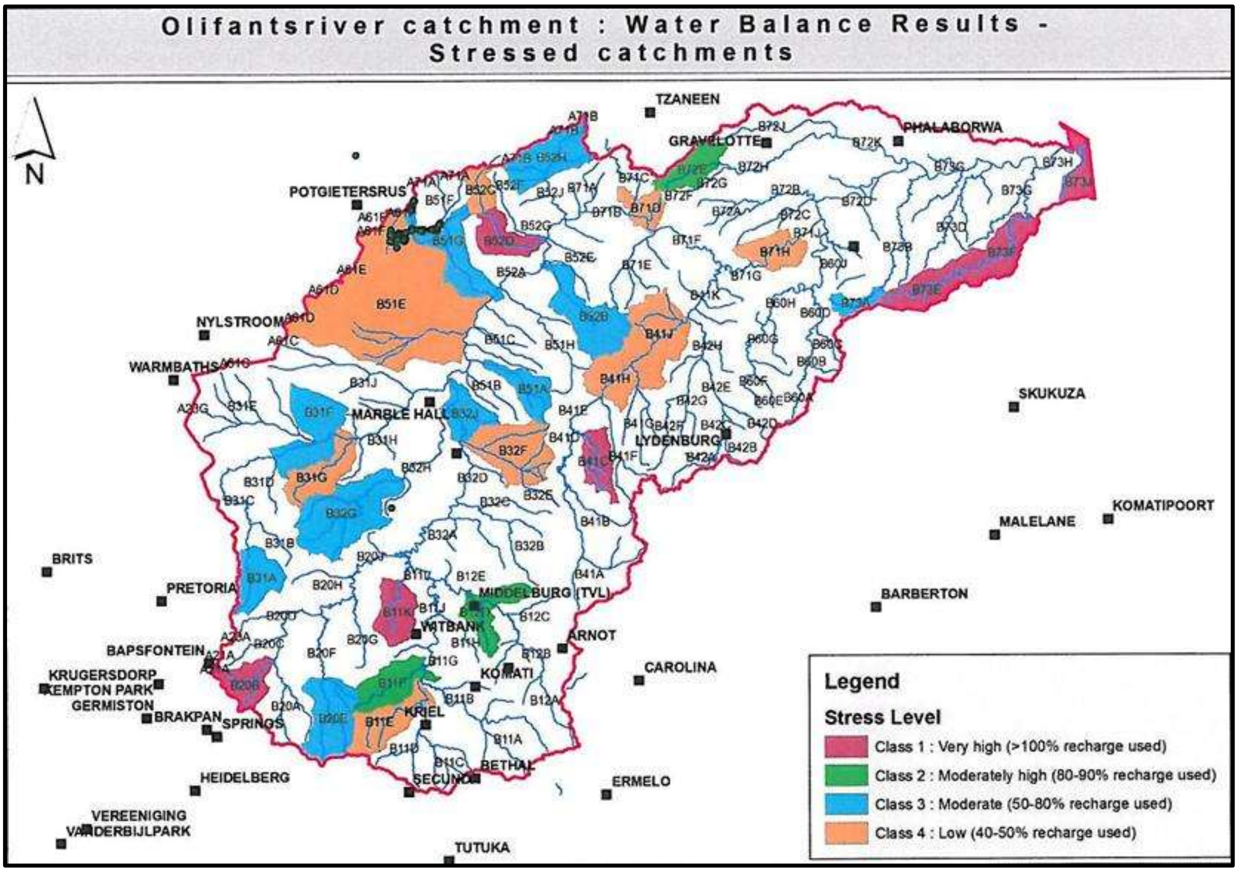

Figure E5: *Map indicating stressed quaternary catchments. (Source: AGES, 2007)*

- ***Waste Water***

  Due to the scattered nature of the urban centres and the limited treatment offered by the waste water works, irrigation of crops is not feasible. Localised reuse of treated effluent for urban use, and the reclaiming of domestic effluent for the direct recharge of aquifers should be further investigated.

*Power stations in the catchment do not utilise water directly from the Olifants system, but rather water from adjacent catchments by means of inter-basin transfers. Implementation of water recycling technology at the plants will reduce their freshwater demand, and in turn, should reduce the inter-basin transfers, thus making more water available in those catchment systems. The potential savings at Eskom plants, using WC/WDM and water reuse technology, are shown in **Table E3**.*

Table E3: *Potential savings at Eskom plants using WC/WDM and water reuse technology*

Power Station	Average water efficiency (2001-2006) (ℓ/use)	Potential Operational Savings (million m^3/a)	WC/WDM and Reuse Savings (million m^3/a)
Arnot	2.05	0.25	4.2
Duvha	1.99	0.00	6.3
Hendrina	2.30	2.37	5.2
Kriel	1.95	5.84	5.4
Matla	1.94	0.00	7.6
Kendal (dry-cooled)	0.11	0.84	n/a
	Total Savings	**9.3**	**28.7**

- ***Mine Water Reclamation***

According to Anglo-Coal, the Emalahleni Coalfields produce excess water of 123 250 Mℓ per day (45 million m^3/a) at 97% recovery rate this equates to about 119 000 Mℓ/day. Currently 25 Mℓ/day (design capacity of the Emalahleni plant) of mine water is treated to potable standard and supplied to Emalahleni Municipality. This plant is to be expanded by a further 25 Mℓ/day. The nett additional yield to the catchment as provided by the existing plant is estimated to be approximately 5 million m^3/a. Although the abstraction and treatment is in excess of the 5 million m^3/a, this is due to a reduction in runoff that also takes place and reduces the yield.

A further 15 Mℓ/day plant (design capacity of the Optimum plant) has recently been commissioned to treat water from the Middelburg North Mine.

*Four additional water reclamation plants have been identified by Anglo-Coal, as illustrated in **Figure E6**, to cater for the future expected decant of up to 45 million m^3/a in 2035. This additional yield could also be considered for new allocations such as for the expansion of operations of the platinum mines in the catchment downstream of the AMD treatment point(s). However, in the Integrated Water Resources Management Plan for the Olifants Catchment (2009), this additional water was earmarked for Emalahleni Municipality.*

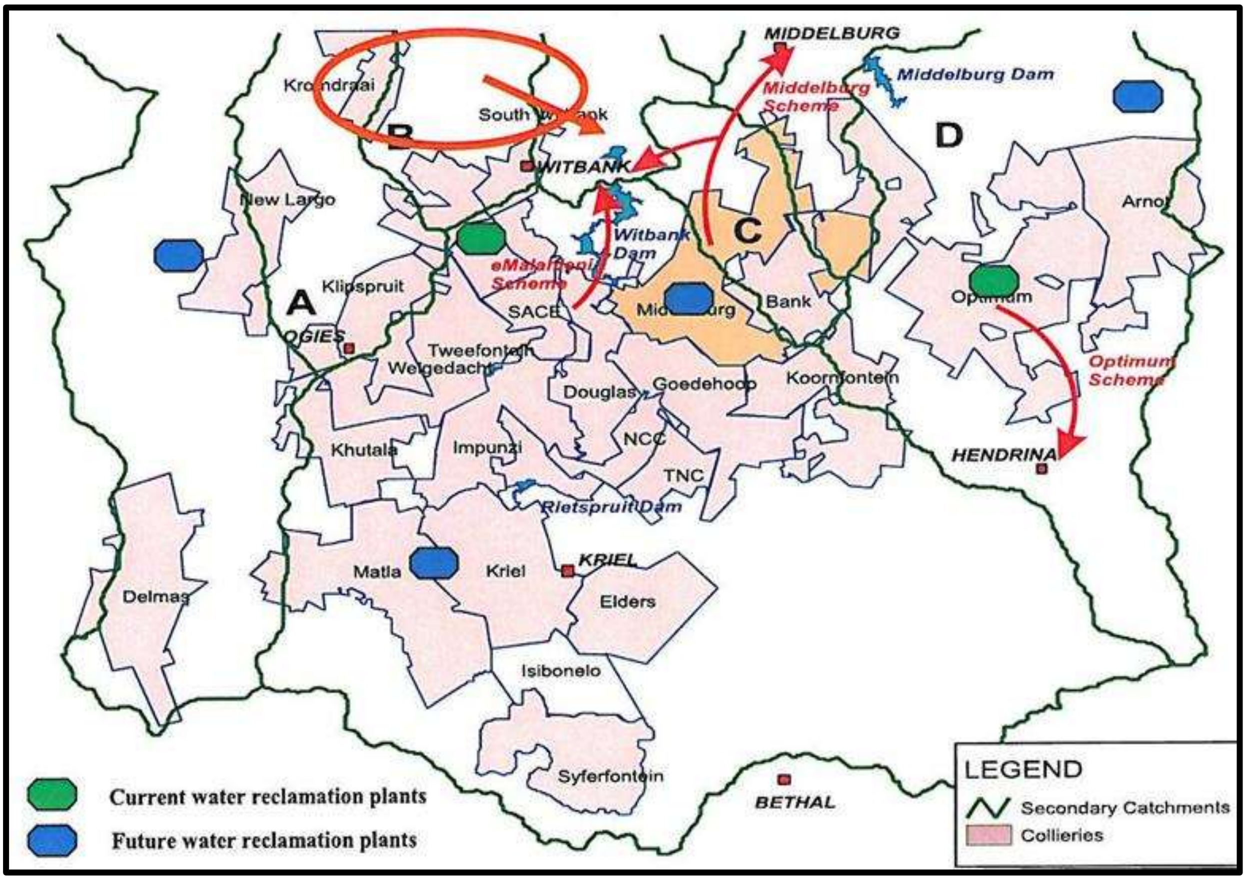

Figure E6: *Locality map indicating current and proposed future water reclamation plants. (Source: Anglo-Coal)*

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

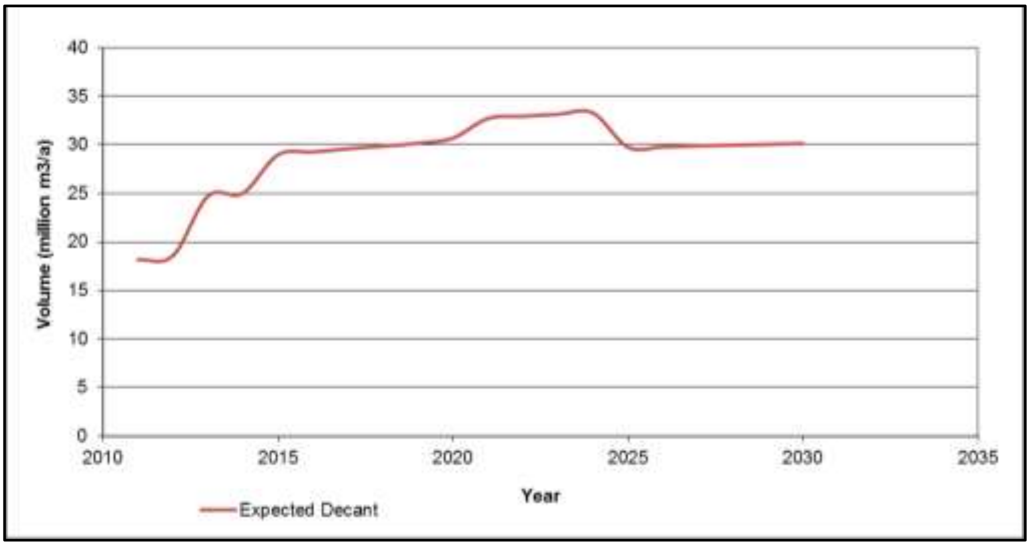

Figure E7: *Decant water from coal mines in the Witbank catchment*
Source: *Golder Associates, 2011*

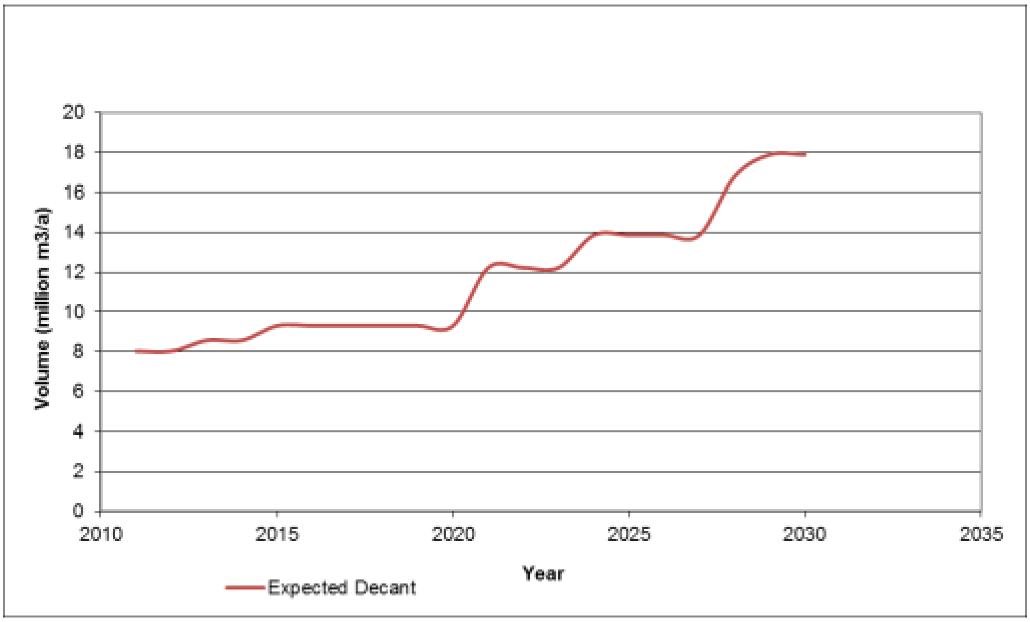

Figure E8: *Decant water from coal mines in the Middelburg Dam Catchment*
Source: *Golder Associates, 2011*

The current excess water decant in the catchments of Witbank and Middelburg Dams can be read off the graphs of ***Figure E7*** *and* ***Figure*** 4.7 ***E8*** *as 18 million m^3/a and 8 million m^3/a respectively. It was assumed that the additional yield of 4.2 million m^3/a as a result of the Emalahleni Water Reclamation Plant and the Optimum plant comes from this excess water decant and that the rest (i.e. 21.8 million m^3/a) is part of the current system runoff in any event. The incremental future decant can then be regarded as direct additional yield. In the case of the Witbank Dam catchment this value is approximately 12 million m^3/a, and of the Middelburg Dam catchment 10 million m^3/a, i.e. approximately 22 million m^3/a, in total over a period of 20 years.*

POTENTIAL IMPACTS

The potential impacts, both positive and negative, that must be considered with the utilisation of non-conventional water sources, have been grouped into Management, Social, Health and Environment. There are, however, also impacts or implications of not utilising the non-conventional sources. With regard to the management related inputs it is concluded that the PPP route of managing AMD reclamation is the preferable option, and should receive maximum political support. Social impacts are more severe on the non-supply of water and the reuse of water is generally acceptable as long as it complies with health standards to ensure compliance to standards. With regard to health standards, there is adequate opportunity to use poorer quality ground water and reuse for irrigation. Care needs to be taken and monitoring systems should be in place to ensure proper management of processes. The reuse of water generally has a positive impact on the environment as it reduces fresh water demand and makes water available for the environment. Contamination of sources by untreated effluent should be avoided.

Possible Options for Reuse of Non-Conventional Water

The possible options for using non-conventional water in the Olifants River catchment are described briefly below.

- ***Option 1: Rainfall Enhancement***

  The possible scheme involves cloud seeding in the escarpment region of the catchment. Cloud seeding is carried out by air dispersal (by plane) of condensation nuclei, in order to trigger cloud formation and increased storm events.

- ***Option 2: Rainwater Harvesting***

  Rainwater harvesting provides immediate access to water by homesteads, especially those not located near to reticulation networks at basic level. The rainwater is collected from roofs and stored in tanks mainly for domestic use and production farming. Simple community built rainwater tanks provide the skills within the community to build and to carry out maintenance works on the tanks. It will also pass on the skills to neighbouring communities. Access to rainwater tanks is therefore unrestricted and not limited to qualifying for subsidy schemes.

- ***Option 3: Water Reclamation***

  The Emalahleni Mine Water Reclamation Plant, a joint initiative between the mining houses such as Anglo Coal, BHP Billiton and Emalahleni Municipality treats mine water to potable standards to augment the domestic water supply. The plant currently produces 25 Mℓ/day of potable water at 97% recovery. Similarly, the Optimum plant near Middelburg produces 15 Mℓ per day. The treated mine water could be used for power generation, potable supply or aquifer recharge. The additional yield that can be achieved is 10 million m^3/a in the catchment of the Middelburg Dam and 12 million m^3/a in the Witbank Dam catchment.

- ***Option 4: Importing treated effluent from the East Rand***

  There are several waste water treatment works in the Ekurhuleni municipal area in relative close proximity to the Olifants River Catchment. These WWTW's currently 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 to be reused by Eskom in power generation activities. The envisaged scheme involves the pumping of treated effluent from one WWTW to the next, with a central collection point at Daveyton (where a potential tertiary treatment process could be applied). From here, the effluent will be pumped over the divide to a point about 10 km north of Delmas.

Conclusions

The catchment is in a stressed situation. Numerous instances and examples of sources of non-conventional water in the Olifants catchment are dealt within in this report. Whilst the catchment is in a stressed situation, even the smaller contribution by some sources, need to be considered. Some can only make a difference to the position of local users, but it may not make a significant contribution towards creating a positive water balance in the total system.

The component that can make a significant difference to the water balance in the catchment and is to be considered as a major resource is the utilisation of the AMD in the Upper Olifants sub-catchment. It needs to be utilised more effectively.

RECOMMENDATIONS

The following actions are recommended:

- *Proceed with the utilisation of AMD and implementation of further AMD initiatives as indicated in this and the other reports of this series.*
- *Promote the utilisation of PPP's for the utilisation of AMD in order to unlock the required investment and operational management capacity of industry.*
- *Extend the current reuse of effluent by the mines, at Mokopane and Polokwane.*
- *Develop a clear policy, strategy and guidelines for the use and application of all components of non-conventional waters.*
- *Legislative and implementation tools for the regulating and implementing the use of marginal waters should be established and made available. This should cover aspects such as: water reuse and recycling, implementation of water efficient technology in different industrial sectors, improving water efficiency, etc.*
- *The Water Conservation and Water Demand Management initiatives identified in the DWA Report "The Development of a Comprehensive Water Conservation and Water Demand Management Strategy and Business Plan for the Olifants and Inkomati WMA's. Industrial component: Power Generation. Situation Assessment", (Prepared by VWG Consulting on behalf of the Directorate: Water Use Efficiency) – should be considered for implementation.*
- *Rainwater harvesting in the catchment should be promoted and expanded. The subsidy for households for rainwater tanks in the rural areas should be continued and expanded. The use of such harvesting in cities should be promoted and can be even made compulsory for any new town development.*
- *Opportunities for groundwater recharge should be considered and the approach generally promoted. The feasibility of the implementation of the Godwinton weir to recharge the dolomite aquifer on the escarpment should be investigated further.*
- *The application of water recycling and internal reuse in industrial process should be continuously be required, promoted, advanced and implemented.*
- *The possible future implementation of rainfall enhancement should be taken further with a specific project to take the existing research knowledge to the next level and prepare it for possible future implementation.*
- *The transfer into the catchment of sewage from the Vaal River catchment for reuse in the Olifants catchment need to be considered in conjunction with the strategic constraints of water requirements in the Vaal River catchment itself.*

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1. INTRODUCTION

The study area consists of the Olifants River Catchment and its immediate supply zone. Hence, the urban areas of Polokwane and Mokopane have been included in the study area. This study area is collectively referred to as “the catchment” in this report.

1.1 BACKGROUND

The Olifants River Catchment is located within the provinces of Gauteng, Mpumalanga and Limpopo and covers an area of approximately 54 550 km^2. The catchment has been divided into three sub-catchments, namely the Upper Olifants, Middle Olifants (incorporates the Steelpoort River), and the Lower Olifants. In the western part of the catchment the topography is characterised by gently sloped hills before the Olifants River cuts through the Drakensberg mountains to enter the relatively featureless lowveld region. As a consequence of the topography, the climate experienced differs distinctly throughout the catchment, varying from cool in the highveld region of the catchment, through temperate in the central parts to sub-tropical east of the escarpment and lowveld region. The mean annual precipitation falls within the range of 700 mm in the highveld region, reaching 1 000 mm in the mountains and reducing to 500 mm in the lowveld region. The potential evaporation is well in excess of the rainfall.

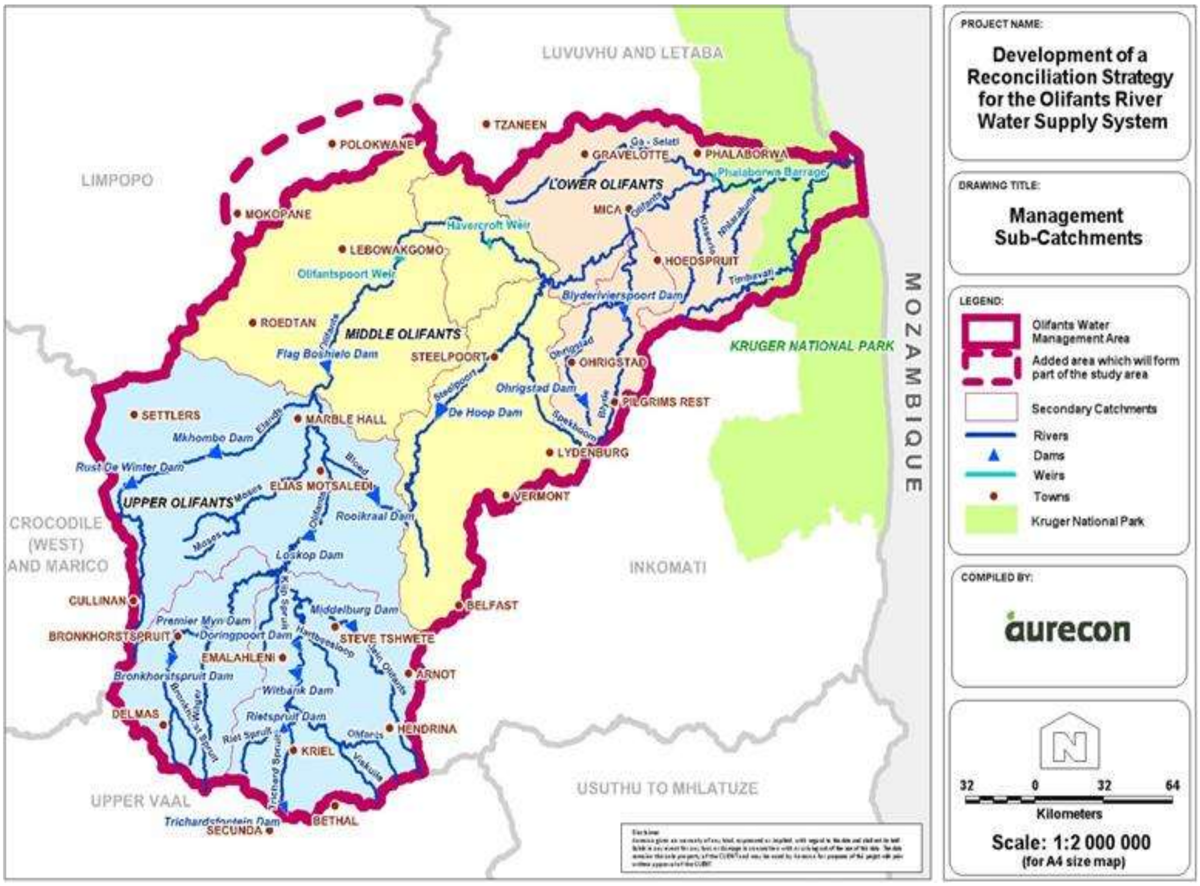

Figure 1.1: Map indicating the location of the Olifants River Catchment

The Olifants River is fed by a number of tributaries of which the most significant on the left bank are the Wilge, Elands and Ga-Selati Rivers and the Steelpoort, Blyde, Klaserie and Timbavati Rivers on the right bank. The Olifants River flows directly from South Africa into

Mozambique where it joins the Limpopo River. Developments in South Africa directly impact upon the water quality and quantity of the water flowing across the border into Moçambique.

The geology consists mainly of hard rock formations where Bushveld Igneous Complex is the most prominent occurring feature in the catchment. In the Upper Olifants Sub-catchment, in the vicinity of Emalahleni and Steve Tshwete Local Municipalities, lie extensive coal reserves. Along the Blyde River a large dolomitic intrusion extends along the river, curving westwards along the northern extremity of the catchment. Minerals such as copper in the Phalaborwa area, chrome and vanadium in the Steelpoort Valley occur in the lower portions of the catchment. Platinum reefs are found along the Dilokong Corridor (the Lebowakgomo to Burgersfort axis).

Economic activity in the Olifants catchment is diverse and ranges from mining, power generation, metallurgic industries and irrigation in the Upper sub-catchment, to irrigation, dry land, subsistence agriculture and ecotourism in the middle and lower sub-catchments. Approximately 5% of the Gross Domestic Product (GDP) of South Africa is generated within the Olifants catchment with the largest economic sectors inclusive of mining, manufacturing, power generation, government and agriculture. Coal is the dominant mineral mined in the catchment.

The Upper Olifants sub-catchment is predominately urbanised with the majority of the urban population concentrated in the Emalahleni (formerly Witbank) and Steve Tshwete areas. The land is extensively mined for its rich coal deposits which are exported through Richards Bay and also used locally in the coal-fired power stations. Much of the central and north western areas of the sub-catchment are largely undeveloped, with scattered rural settlements. The predominant land uses in the Middle Olifants sub-catchment include agriculture and extensive irrigation exploits. A number of platinum and chrome mines have also been developed in this area. Agriculture is the predominant land use, although vanadium and chrome mining also occur along the rural Steelpoort River. The Lower Olifants sub-catchment is rural in character, with the main urban centre being Phalaborwa. Eco-tourism is a prominent industry in the sub-catchment with a number of game parks and the Kruger National Park in the area. The main mining activities in this sub-catchment consist of copper and phosphorus excavations.

The Olifants River Catchment is currently one of South Africa’s most stressed catchments as far as water quantity (due to high demand) and water quality is concerned.

1.2 PURPOSE OF THIS REPORT

The catchment is considered a stressed catchment. In order to contribute towards improving the water balance situation in the catchment and the livelihood of people in the catchment, measures to reuse water in the catchment must be considered. This report focuses on the existing use of non-conventional water and identifies future potential use of- non-conventional water within the Olifants River catchment. The objective is to improve water efficiency and recycling and where possible contribute towards the yield in the catchment.

2. THE CONCEPT OF WATER REUSE

2.1 GENERAL

Article 26 (a) of the World Summit on Sustainable Development (WSSD), Plan of Implementation (2002), is quoted as follows: "Develop and implement national/regional strategies, plans and programmes with regards to integrated river basin, watershed and groundwater management and introduce measures to improve the efficiency of water infrastructure and reduce losses and increase recycling of water" (own italics). Non-conventional water refers to the process of 'recycling' water for direct reuse or utilising water sources not conventionally used, e.g. brackish groundwater. Non-conventional water together with Water Conservation and Water Demand Management (WC/WDM) are tools to improve water efficiency and reduce demands on freshwater resources. Non-conventional waters in many instances are used in conjunction with water conservation practices and technologies, such as decreased water pressure outside of peak-time periods, closed systems in industrial processes, improved process technology e.g. from sprinkler- to drip–irrigation techniques, and from wet- (water intensive) to dry-cooling in power generation. By implementing these methods and processes there is the added benefit of reducing waste discharge to water resources and thereby improving water quality within the catchment.

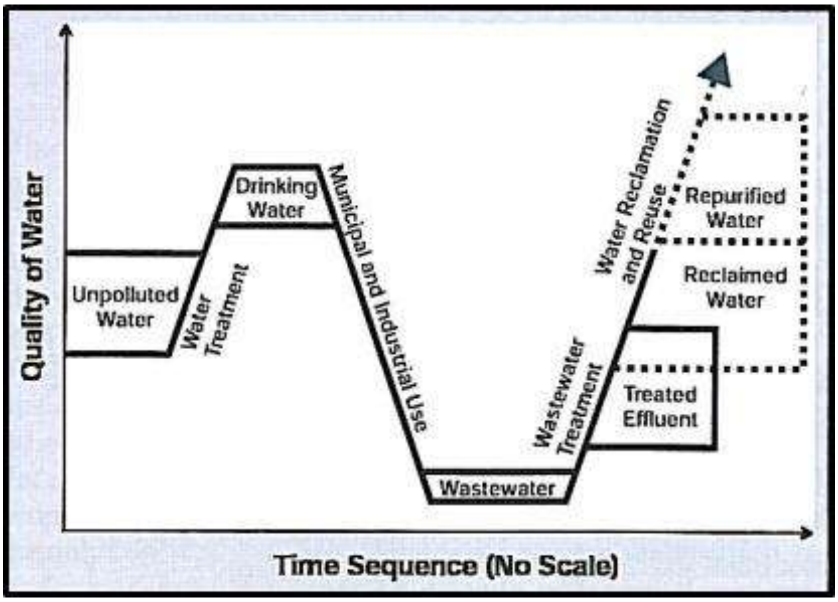

Figure 2.1: Water quality changes during municipal and industrial uses of water in a time sequence

(Source: Asano, 2002)

Asano, 2002, explains that the reusing and recycling of water, as illustrated in **Figure 2.1**, provides greater utilisation of water in the system, as well as improves water quality in the system. It must be remembered that non-conventional water does not always provide "new" or additional water into the catchment, but rather improves water utilisation of unused water within the catchment thereby reducing the demand on potable water for non-potable uses. There are exceptions such as rainfall enhancement, rainwater harvesting and sea water desalination, that will provide additional yield to a system.

2.2 DEFINITION OF "NON-CONVENTIONAL WATER"

For the purpose of this study non-conventional waters will be defined as:

"Water that can be recycled, reused or reclaimed, including naturally occurring un-potable water, such as sea water, brackish water, saline and sodic water, un-potable groundwater, rainwater and fog harvesting."

2.3 NON-CONVENTIONAL WATER TYPES: RECYCLE, REUSE AND RECLAIM

There are three types of non-conventional water, recycle, reuse and reclaim. Water sources and utilisation is categorised into these types based on the level of treatment the water receives and what purpose the water is used for.

2.3.1 Recycle

When water is used in a process and then reused in the same process with or without any purification / treatment or improvement of the water quality.

2.3.2 Reuse

When water is used and the return flow is then used again for another purpose. This may include purification (treatment) to some acceptable level for the secondary use, but the water is not treated to potable standard.

2.3.3 Reclaim

Water that was previously used for potable or any other purposes is treated up to potable quality standards so that it can again be used for potable purposes.

2.4 PROCESS OF INVESTIGATION

Information gathered for this report was garnered from the Department of Water Affairs WARMS database of registered water users; a questionnaire was also circulated to Local Authorities and companies in various sectors within the catchment, as well as information searches on the internet and research reports. **Appendix A** provides a table indicating the responses to the questionnaires. This information was compared with known measures in other catchments and options that can be successful is considered and reported on.

2.5 SOURCES OF NON-CONVENTIONAL WATER COVERED IN THIS REPORT

The key sources of non-conventional water include rain water, ground water (brackish, sodic and sweet), waste water (domestic and industrial), mine water and sea water. These are then further broken into types of application or use (e.g. irrigation for agriculture or landscape, urban, environmental and recreational uses); technology used (e.g. desalination; dual reticulation) and type (i.e. recycled, reused or reclaimed). For the purpose of this report and application in the Olifants catchment, seawater has not been considered because of the long distance which such water will have to be transported and the associated high cost thereof. The role these sources of water play within the water cycle are illustrated in **Figure 2.1**. Like conventional water, non-conventional waters are both impacted on e.g. by social paradigms and themselves impact on the receiving environment e.g. health and environmental impacts. These impacts will also be discussed in this report.

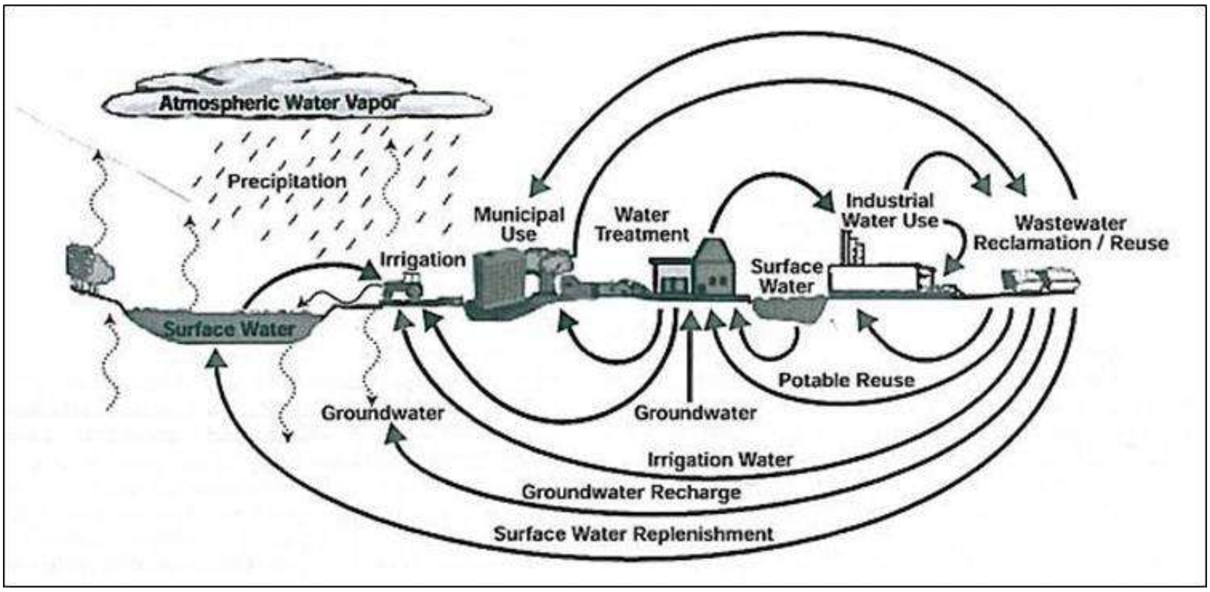

Figure 2.2: The role of engineered treatment, reclamation, and reuse facilities in the multiple uses of non-conventional water through the hydrological cycle
(Source: Asano, 1995)

Based on the information gathered, the types of non-conventional water and their potential impacts covered in this report include the following:

- Rainwater
- Groundwater
- Effluent Water (domestic and industrial effluent)
- Mine Water
- Desalination

2.5.1 Rainwater

Rainfall Enhancement:

In South Africa, research was carried out in the field of cloud seeding between 1997 and 2001, South African Rainfall Enhancement Programme (SAREP). SAREP developed hygroscopic flare-seeding technology and was monitored by radar-based storm climatology. The programme found that seeded storms on average produced twice the radar-determined rainfall that their controls produced.

The radar-based storm climatology for the 10 000 km^2 target area was compiled using storm lifetime of 15 min and 30 dBZ radar reflectivity as the TITAN storm-tracking thresholds. It was found that more than 2 000 of these radar storm tracks affected the target area during the seven months from October 2000 to April 2001. By comparing these radar storm tracks with those that were seeded, it was possible to identify the 290 radar storm tracks that could have been regarded as legitimate candidates for seeding. Based on the preliminary findings of this study, it is suggested that if 75 of the legitimate candidate storms in the specific target area are seeded, a marked (~10%) increase in area rainfall over the target area could be realised.

Rain Harvesting:

By collecting and storing rainwater, the dependence on less reliable water sources, such as open ponds and fluctuating rivers, decreases. Rainwater is collected from rooftops or surface catchments and is stored in different storage systems. Through its decentralised nature, the collection and storage of rainwater enables people at household and community level to manage their own water.



(i) (ii) (iii)

Figure 2.3: (i) Construction of a rainwater harvesting tank,
(ii) Finished tank, and
(iii) Tank utilisation, in West Africa (Source: RAINetwork)

In India, *Kundi* is known as rain harvested on an artificially created piece of land, which slopes towards a well to store the water. As little as 100mm of rainwater harvested on 1 ha of land collects 1 million litres of water in this structure. The water in turn can then be used for domestic use, to recharge groundwater aquifers and for irrigation or other productive uses. (Narin, S. Water for Food. Formas, 2008).

2.5.2 Groundwater

Groundwater has emerged as the most important source of drinking water supply in the world. In both the developed and developing world, there has been a manifold increase in the use of groundwater among the populations in the rural areas, as well as in the rapidly expanding urban areas. Due to the inadequate availability of surface water and its continuous deterioration in quality, dependence on groundwater will increase even further in the future. Conventional groundwater use is covered in Report No. P WMA 04/B50/00/8310/10 of this study. This report, however, focuses on the non-conventional methodologies to exploit groundwater to its maximum potential such as direct aquifer recharge and sand dams, as well as use of groundwater that would normally have been discarded because of its quality such as brackish groundwater (for stock watering).

Sub-surface dams, see **Figure 2.3** and **Figure 2.4**, are concrete or masonry barriers built in the river bed, perpendicular to the flow direction. A dam constructed across the width of the valley and down to an impermeable layer to effectively obstruct the groundwater flow in an aquifer becomes a sub-surface dam (Borst and de Haas, 2006). Behind these dams the river bed fills up with sand, enlarging the natural aquifer. Sub-surface dams trap groundwater where it flows close to the surface in valleys or dried-up river beds. The water is stored as a shallow aquifer beneath the surface. Very little water is thus lost through evaporation and there is also a natural purification of the water as it filters through the ground. The water is accessed by wells, preferably combined with infiltration galleries, constructed upstream of the dam. In sediment systems, the flow of sediment is not completely halted. The accumulation of sediment behind the “dam walls” can also be accessed for crop growing.

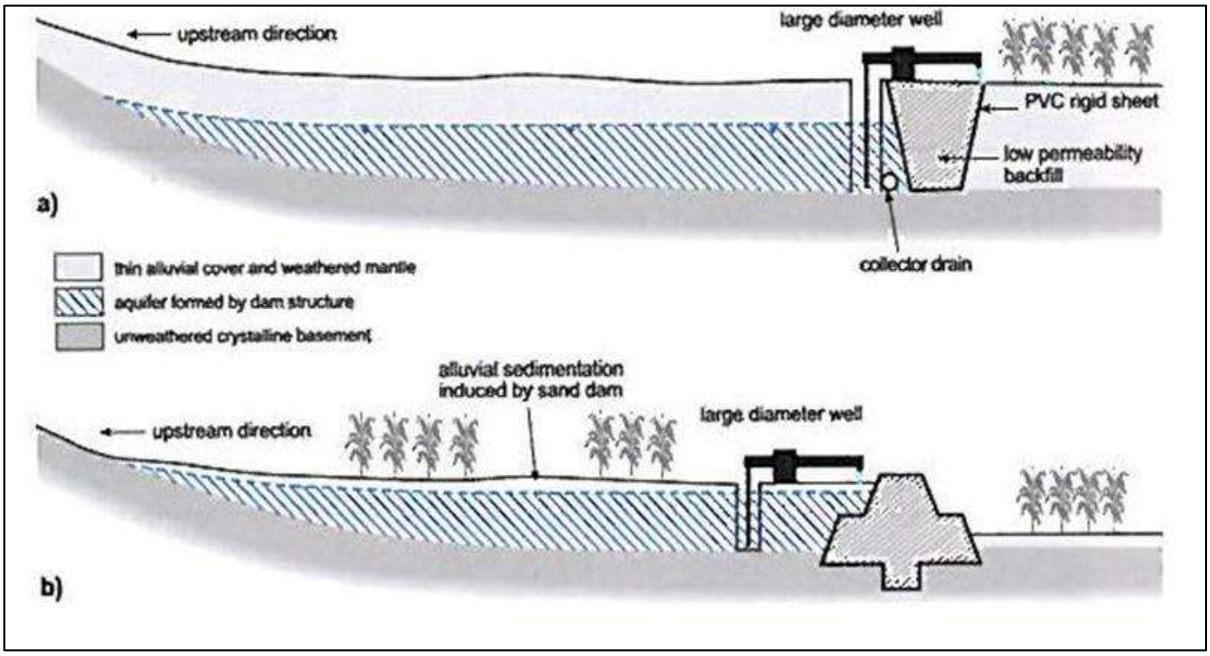

Figure 2.4: Diagram of a sub-surface dam

(Source: van Steenbergen and Tuinhof, 2010)

(i)

(ii)

Figure 2.5: (i) Construction of a sub-surface sand dam wall, Kenya; and
(ii) Completed and storage dam, Kenya. (Source: van Steenbergen and Tuinhof, 2010)

Sub-surface storage has several advantages including low (if any) evaporation losses, relative protection against water pollution, and improved water quality. Suspended solids are absorbed by the soils, temperatures are moderated and with sufficient detention time in warm aquifers many pathogenic bacteria, viruses and unicellular micro-organisms (protozoa) are removed (Dillon, *et al.* 2009). Furthermore, the soil can reduce acidity, remove inorganic and organic compounds through absorption, and chemicals as well as biological processes can change and neutralise hazardous compounds. In addition, underground storage of surface waters and the purification potential of capturing rainwater where it falls have the advantage of providing a clean safe source of water, thus avoiding the need to purify water in the first place – provided abstraction of groundwater is upstream of anthropogenic activities such as towns and villages, landfill and industrial sites, and sanitation or ablution areas.

With respect to the increased use of poor quality, non-potable groundwater, the most common quality problems in natural groundwater in the catchment includes excessive iron, salinity (EC), Nitrate from fertilisers and poor sanitation, and fluoride in some areas. Removal of iron from groundwater is normally an uncomplicated process, however other minerals may require more complex removal processes e.g. fluoride. Groundwater quality suffers significantly due to several anthropogenic fluxes such as land use practices upstream of groundwater reserves; heavy metal contamination from discharge of industrial wastes and mines, excessive use of fertilizers and irrigation seepage. The *South African Water Quality Guidelines* compiled by the Department of Water Affairs should be consulted to determine acceptable levels of constituents in both ground and surface water for various water uses, including livestock watering. In the Groundwater Report the conjunctive use of high fluoride boreholes with other boreholes or surface water in certain spots where it occurs, is recommended. Stock (except horses) is more resistant to higher fluorides than humans. Thus, such water can be utilised for stock watering and irrigation.

2.5.3 Waste Water

Domestic effluent:

The applications for reuse and recycling of domestic waste water include irrigation for agriculture and for landscaping, urban reuse such as for irrigation of sports fields and recreational uses, fire hydrants and pavement-garden watering, and for domestic reuse such as garden watering, car washing and toilet flushing. Further application involves reclamation of wastewater to potable standard for direct augmenting of drinking water supply or aquifer recharge.

Wastewater treatment and reuse in agriculture can provide benefits to farmers in conserving freshwater resources, improving soil integrity, preventing discharge to surface and ground waters, and improving economic efficiency. In the US State of California, 31% of re-used wastewater is used for crop or landscape irrigation. Untreated wastewater is often used in the informal, unregulated sector and directly benefits poor farmers who would otherwise have little or no access to water for irrigation.

Untreated wastewater can improve soil fertility and reduce water contamination downstream, since the wastewater is not fed directly into the water flow but is first filtered through the soil during irrigation. The problem arises from runoff on the surface of the soils. Typical nutrients in treated wastewater effluent from conventional sewage treatment processes are: 50 mg/ℓ of nitrogen, 10 mg/ℓ of phosphorus, and 30 mg/ℓ of potassium. The effluent would supply all of the nitrogen and much of the phosphorus and potassium normally required for agricultural crop production. However, excessive phosphorous accumulation leads to eutrophication of water resources. Therefore, runoff from waste water irrigation must be managed appropriately. There are two key contaminants that can significantly affect soil health: salts (especially sodium) and carbonate ions (contributing to alkalinity). These contaminants are directly related to households chemical use, particularly the use of cleaning products such as soaps and detergents. Grey water tends to be moderately saline, with values up to 1,400mSm (Christova-Boal et al. 1996). Laundry water in particular can contain varying levels of salts arising from the residue of laundry detergents (Misra and Sivongxay, 2009). Salts can affect plants either by osmotic stress or by direct toxicity. Increasing concentrations of salts in the soil lead to a decrease in osmotic potential of the soil-water solution resulting in reduced plant uptake of water. Where the domestic water supply is low in magnesium and calcium, the sodium adsorption ratio (SAR) of grey water is often high, which can lead to adverse effects on soil structure and permeability, which result in restricted water entry, poor root growth, and diminished soil aeration.

A key concern associated with the reuse of domestic effluent is the contamination of crops or users, as well as potable water supplies by bacteria, viruses and other pathogens. Any effluent used as a non-conventional source of water should be treated to the appropriate water quality standards for that use prior to utilisation.

Industrial Effluent:

Water is an important requirement in many industrial processes, for example, heating, cooling, production, cleaning and rinsing. The biggest users of water in the Olifants catchment include irrigation, power generation and mining activities. Once used industrial discharge can contain a wide range of contaminants and originate from a myriad of sources. Some of the biggest generators of toxic industrial waste include mining, pulp mills, tanneries, sugar refineries, and pharmaceutical production. In many instances wastewater from industry not only drains directly into rivers and dams, it also seeps in the ground contaminating aquifers. Cooling towers used in industrial processes like steel manufacture and coke production not only produce discharge with an elevated temperature which can have adverse effects on biota, but can also become contaminated with a wide range of toxic substances, including cyanide, ammonia, benzene, phenols, cresols, naphthalene, anthracene and complex organic compounds such as polycyclic aromatic hydrocarbons (PAH). Water is also used as a lubricant in industrial ‘machinery’ and can become contaminated with hydraulic oils, tallow tin, chromium, ferrous sulphates and chlorides and various acids. The recycling and reuse of industrial water, especially in closed systems, reduces the demand of the industry on freshwater supplies, as well as reduces the discharge of pollutants into the environment.

2.5.4 Mine Water

Acid Mine Drainage (AMD) is the number one environmental problem facing the mining industry, and together with industrial wastewater, the biggest environmental problem in the Olifants Catchment. AMD occurs when sulphide-bearing minerals in rock are exposed to air and water, changing the sulphide to sulphuric acid. AMD can devastate aquatic habitats; is difficult to treat with existing technology; and once started, can continue for centuries, e.g. Roman mine sites in Great Britain continue to generate acid drainage 2000 years after mining ceased (Mining Watch Canada, 2006). **Figure 2.6** illustrates the mining effects on drainage. Extraction decreases groundwater depth and natural filtration leading to increased oxidation of the Sulphide in the exposed rock which together with groundwater and natural filtration creates sulphuric acid.

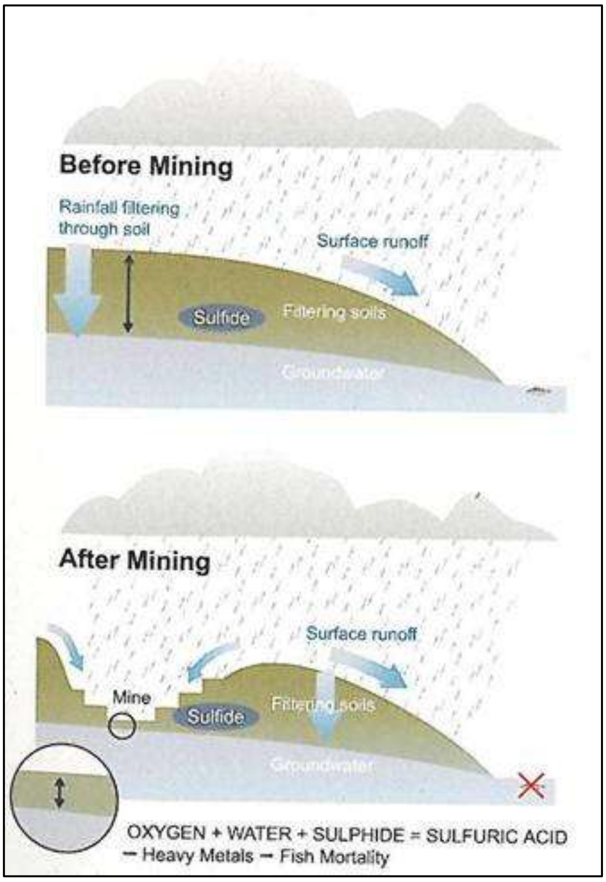

Figure 2.6: Mining effects on drainage

(Source: UNEP, 2004)

Impacts:

Mining has traditionally been a major source of unregulated wastewater discharge in developing countries. Tailings from mining operations can contain silt and rock particles. Depending on the type of ore deposit being mined, tailings can also contain heavy metals like copper, lead, zinc, mercury and arsenic. The contaminants in mine waste may be carcinogenic or neurotoxic to people (e.g. lead and mercury) or extremely toxic to aquatic organisms (e.g. copper). Common minerals mined within the catchment include coal, platinum, copper, chrome, vanadium and phosphorus.

2.5.5 Seawater and Brackish Groundwater

Desalination is a treatment process commonly used in treating non-conventional water for further use. Desalination (also called “desalinization” and “desalting”) is the process of removing dissolved salts from water, thus producing fresh water from sea or brackish water. The most common use of desalination is to produce potable water for domestic consumption. However, desalinated water, including wastewater, may also be used for agricultural and or industrial purposes. Desalination technologies employ membrane and/or thermal technologies. Reverse Osmosis (RO) is the predominant membrane processes. Thermal process includes multi-stage flash (MSF). Other processes include multiple effect distillation (MED), electrodialysis and electrodialysis reversal (ED/EDR).

As with any infrastructure and treatment process, the cost of desalination involves capital costs associated with construction, and the costs of operation. The expensive costs associated with desalination are the cost of energy required for the operation. Developments in technology and the introduction of energy recovery devices in RO desalination plants have assisted in reducing energy costs. For example, in 2006, energy consumption in the core RO process of a demonstration plant in Southern California was measured at just 1.58 kWh/m^3, and the overall energy consumed by this plant was 3.1 kWh/m^3 – comparable with the power required to convey surface water to Los Angeles and treat it, approximately 2.4 kWh/m^3. Thermal MED plants use less than 3kWh/m^3 of electrical power per m^3 of desalinated water in addition to the steam input required. Most facilities, in the *Water Desalination Report* 2008, reported water costs in the R5.00 – R11.00/m^3 range. (L, Henthorne. 2009. Drinking water- sources, sanitation and safeguarding. Formas)

The desalination process results in the discharge of waste in the form of a concentration of brine. This need to be managed well, sometimes it may end up in the receiving waters and may have serious adverse effects. Temperature and salinity are two factors that determine the composition and distribution of species in the marine environment affecting water density and causing stratification (Miri and Chouikhi, 2005; Lattermann and Hoepner, 2008) changes to primary production and turbidity. Changes in these parameters over sustained periods could lead to local ecological changes, resulting in shifts in species diversity, opening the potential for colonisation of exotic and potentially invasive species, and changing ecosystem function. The process requires the use of descaling and anti-fouling products, which can contain heavy metals and toxic chemicals, although the impact of these can be managed with good practice and plant maintenance. The waste streams from desalination can be further ‘harnessed’ by chemical precipitation and other means and the waste could sometimes be turned into a resource for other uses or managed more appropriately. For example gypsum is produced from the Emalahleni Water Reclamation plant and can be used in pre-fabricated construction materials. For the safe design of a seawater desalination facility, the intake needs to be designed appropriately in order to prevent entrapment of aquatic fauna.

3. CURRENT EXTENT OF REUSE OF WATER AND THE USE OF MARGINAL WATER IN THE STUDY AREA

3.1 RAIN WATER

While rainfall indirectly contributes to water supply i.e. collects in rivers and dams from which abstraction then takes place, rainwater harvesting and enhancement can be an attractive alternative solution to water availability shortages. In particular, rainwater harvesting through its decentralised nature, enables people at household and community level to manage their own water.

3.1.1 Rainfall Enhancement

Currently there is no cloud seeding or other rainfall enhancement activities within the catchment.

3.1.2 Rain Water Harvesting

The **Columbus Stainless Company** has made use of rainwater harvesting, by collecting the water of approximately 3 Mℓ per day, during high rainfall seasons. The water is purified using reverse osmosis (RO) the purified water is then reused during various processes at the company.

3.2 GROUND WATER

Groundwater's role in South Africa is often underestimated. Large volumes of water users rely on surface water, whereas there is suitable potential of groundwater to meet or contribute towards meeting those needs. Similar to surface water, groundwater must be managed in a reasonable and sustainable manner. The Groundwater Options Report, a supporting report to this project, indicates the potential of groundwater within the Olifants Catchment. This report describes non-conventional uses of groundwater only.

3.2.1 Brackish groundwater

Several brackish boreholes in the upper catchment provide water for stock watering, agricultural irrigation and some domestic uses. The exact quantity of water pumped is not monitored. Many of the boreholes are pumped by wind pumps and hand pumps.

The company Mokoena Mahlare is abstracting 26 Mℓ/day groundwater which is used for domestic purposes. This water is then reused by the company in their industrial processing.

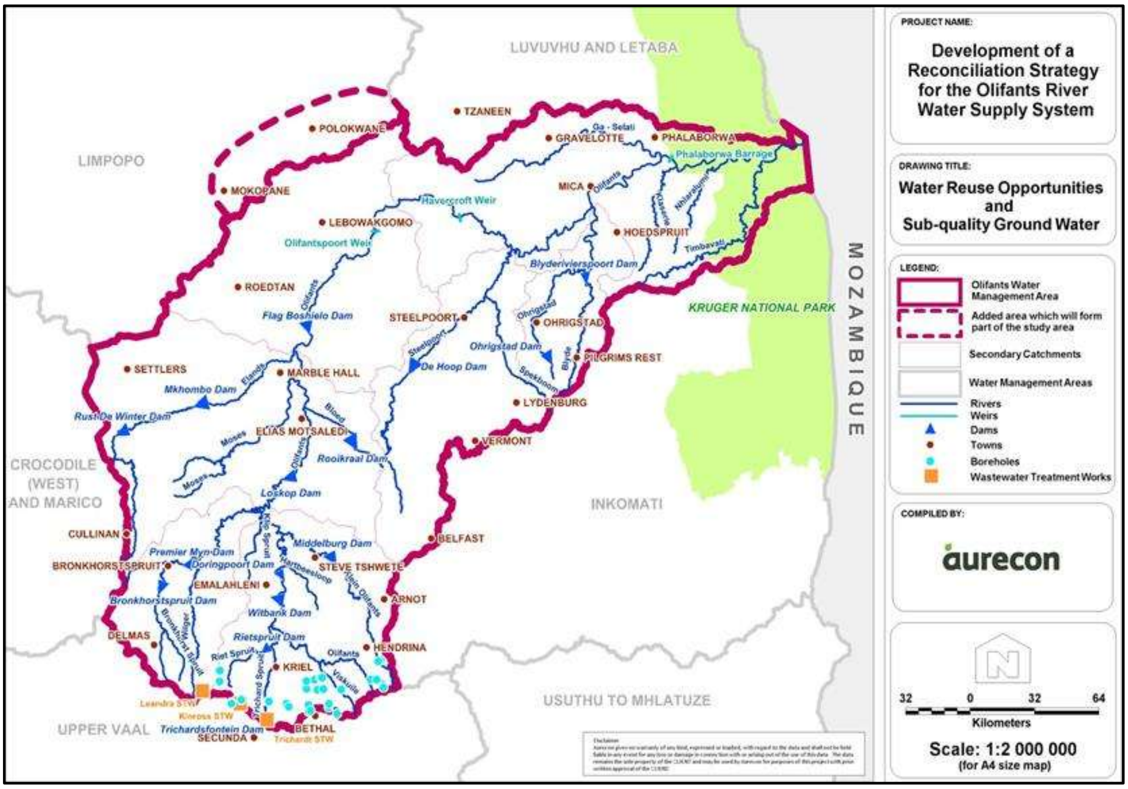

Figure 3.1: Locality of existing brackish boreholes in the catchment

3.2.2 Direct Aquifer Recharge

No information was found regarding the direct recharge of aquifers utilising freshwater supplies or recharge utilising treated waste water supplies in the catchment.

It must be noted that Cholera outbreaks were reported in the Delmas area over the past several years. This has been alleged to be due to contaminated groundwater through poor sanitation practices. It is known that at least one instance of actual contamination were recorded. The possibility of such contamination in the future still remains a threat.

3.3 WASTE WATER

3.3.1 Domestic Waste Water

There are a number of water users in the study area that already reuse water in the form of domestic waste water as listed in Table 3.1.

Table 3.1: Water users reusing domestic waste water

Company Name	Volume (Mℓ/day)	Type	Use
Bethal WWTW	13.70	N/A	N/A
Middelburg Mine Services	2.74	N/A	N/A
Middelburg WWTW	2.74	N/A	N/A
Steve Tshwete Local Municipality	20	Reuse	Industrial
Columbus Stainless Pty Ltd	2	Reuse	Process water make-up
Govan Mbeki Local Municipality	7.25	Reuse	Irrigation
Thaba Chweu Local Municipality	8	Reuse	Mine water (70%)
Witbank Prison WWTW	2.74	N/A	N/A

3.3.2 Re-using Sewage Effluent Polokwane and Mokopane

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

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

The future expected return flows for Polokwane (excluding the 8 million m^3/a referred to above), and Mokopane are shown in **Figure 3.2.** The curves in this figure must, however, be used with caution. If WC/WDM initiatives were to be launched in Polokwane and Mokopane, the return flows will be affected. An amount of losses can also be expected in the treatment process. It is therefore recommended that the curves in **Figure 3.2** are reduced by 20% to make provision for these uncertainties.

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

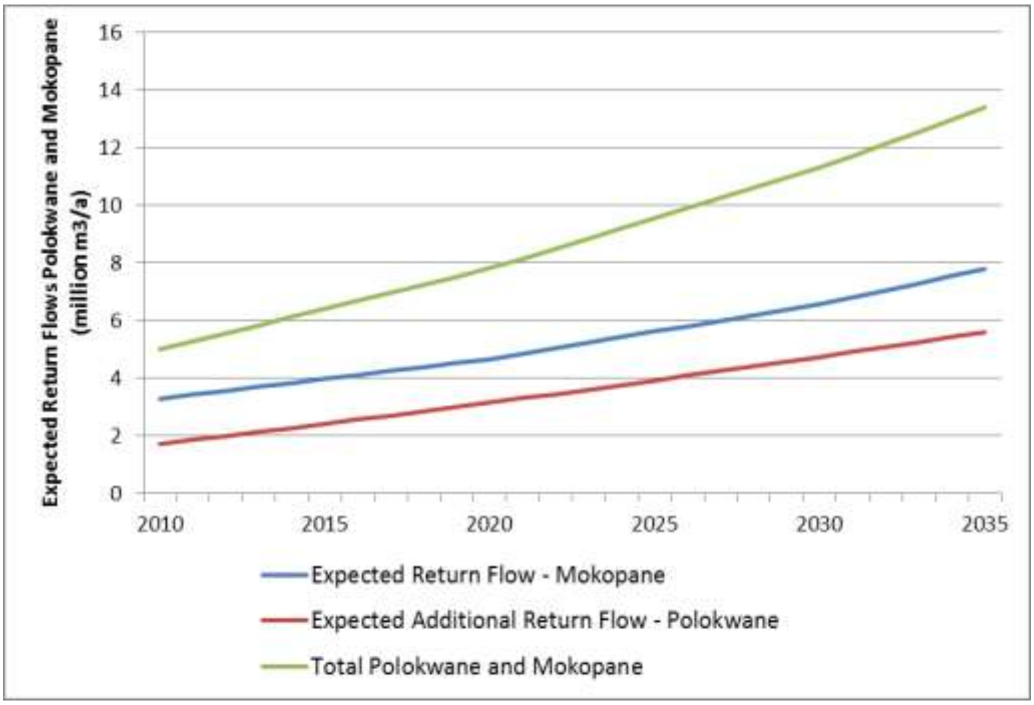

Figure 3.2: **Expected Available Return Flows in Polokwane and Mokopane**

3.3.2.1 Agricultural irrigation

A few scattered examples of agricultural irrigation utilising domestic waste water were found within the catchment.

SAB Miller plant's waste water is carefully cleaned and filtered before being used to irrigate the neighbouring apple orchards.

3.3.2.2 Landscape Irrigation

No examples of landscape irrigation with treated waste water were identified within the catchment.

3.3.2.3 Environment and Recreational Reuse

No specific examples were found in the catchment. However, in terms of industrial reuse for environmental purposes, the Emalahleni Mine Water Reclamation Plant releases a small volume of reclaimed water into the water resource in order to contribute to meeting environmental flow requirements.

3.3.2.4 Household Reuse

No specific examples were found in the catchment.

3.3.2.5 Urban reuse

Currently no urban reuse of domestic wastewater is implemented.

3.3.2.6 Domestic Reclamation

Currently there is no reclamation of domestic wastewater for direct potable supply augmentation. However, indirect reuse occurs by the nature of downstream abstraction of river water.

3.3.2.7 Industrial Reuse

Many of the waste water treatment works supply treated domestic effluent to nearby industries for use as process water, see Table 3.1 above.

3.3.3 Industrial Waste Water

There are a number of water users that reuse their industrial waste water as shown in **Table 3.2**.

Table 3.2: Water users reusing industrial waste water

Company Name	Volume (Mℓ/day)	Type	Use
Eskom	Not available	Recycle	Process water
Anglo Platinum	69.32	Recycle & Reuse	Process water
Columbus Stainless Pty Ltd	5	Recycle & Reuse	Process water
Phalaborwa Mining Company	130	Reuse	Ore process water
SAB Miller	Not available	Recycle & Reuse	Process water

SAB Miller, one of the world's largest breweries, has taken the pledge to reduce the amount of water used to make a litre of beer, which at present is four litres of water. They have implemented anaerobic digester treatment plants, which treat effluent, at five of their seven breweries in South Africa; this was not implemented at the Polokwane Brewery as SAB Miller have built a water treatment for the municipality more than 20 years ago from where the waste water is now re-used for industrial purposes.

At the breweries, they use secondary recycled water for non-product related tasks such as cleaning, floor washing and garden watering. Waste water at the plant's manufacturing process is carefully cleaned and filtered before being reused to irrigate the neighbouring apple orchards (for Appletiser production) or returned to the nearby river.

A project is currently under construction to install water treatment facilities that would reduce water consumption as well as effluent discharge in the steeping phase of malting, i.e. the production of malt for brewing or distilling. The treatments use membrane bio-reactor and reverse osmosis technologies to treat and purify process water to national potable standards.

Eskom operate a number of coal-fired power stations in the Olifants Catchment, and have implemented different types of water reuse. All Eskom power stations have to abide by a 'Zero Liquid Effluent Discharge' policy so that no effluent waste water will be released into the environment; rather the effluent from the power stations is purified and reused. The six current operational stations in the catchment are: Arnot, Hendrina, Duvha, Kriel, Matla and Kendal. The Kendal Power Station in Mpumalanga is the largest indirect dry-cooled power station in the world with an installed capacity of greater than 4100 MW, with the water consumption in the order of 0.08 litres per kWh of electricity sent out. Indirect dry-cooling entails the cooling of the water through indirect contact with air in a cooling tower, a process where virtually no water is lost in the transfer of the waste heat.

Water used in the power generation process has to meet strict water quality standards in order to prevent corrosion and scaling in the process equipment. The effluent passes through an oil skimming plant to remove oil using skimming ropes and is then purified in a desalination plant with ultra-filtration (UF) and reverse osmosis (RO) and continuous electron deioniser (CEDI). The recycled water produces demineralized water and water acceptable for cooling water use. The effective use of this practice allows the company to introduce polluted mine-water from the tied collieries in the catchment for reuse at the power stations. This assists with the prevention of negative environmental impacts on surface and ground waters in the catchment.

The **Columbus Stainless Company** in the Olifants Catchment area reuses approximately 5Mℓ per day of industrial water by purifying it using settling tanks, filtration, cooling towers, ion exchange and activated carbon to cleanse the water which is then reused during company processes. The treatment of effluent water, to be able to be reused, goes through a neutralization process, metal and salt precipitation and evaporation; the amount of water used is approximately 5 Mℓ per day at the cost of about R3.00 per cubic metre. The purified water is then reused during their production processes.

The **Anglo Platinum** mines and plants in the Olifants River Catchment receive all their water from different water sources and different quality levels, so that no water wastage occurs. Anglo Platinum acquires waste and second-class water from municipal sewage plants to supply process water to some operations. Reported intake of waste or second-class water in 2008 increased by 43% from the reported intake in 2007. The reason for this was the increased usage of such water from the Mokopane and Polokwane municipalities. At Mogalakwena, the usage of waste or second-class water in 2008 almost doubled from that in 2007, owing to the ramp-up of the new concentrator at that operation. The Group wants to use as much of this type of water as possible, as it reduces the need for potable water.

Water recycled from internal sewage plants, tailings return-water dams, underground operations and other internal surface water sources is not included in water used for primary or non-primary activities. The total recycled water reported was 25.3 million m^3 in 2008 compared with 24.0 million m^3 in 2007. The recycled water used volume is approximate and includes mostly water recycled from internal sewage treatment plants. Total excess water discharged decreased from 4.6 million m^3 in 2007 to 3.7 million m^3 in 2008. The average discharge for 2008 was 10 Mℓ per day. The mine constructed a dam during 2008 to contain some of the excess water. It is also planning to use some of the excess water for the gardens of the mine village. Infrastructure to facilitate this is being installed.

The water discharged typically has a neutral pH and elevated nitrate, sulphate and chloride concentrations, but at current discharge concentrations these do not pose a danger if consumed by livestock or humans.

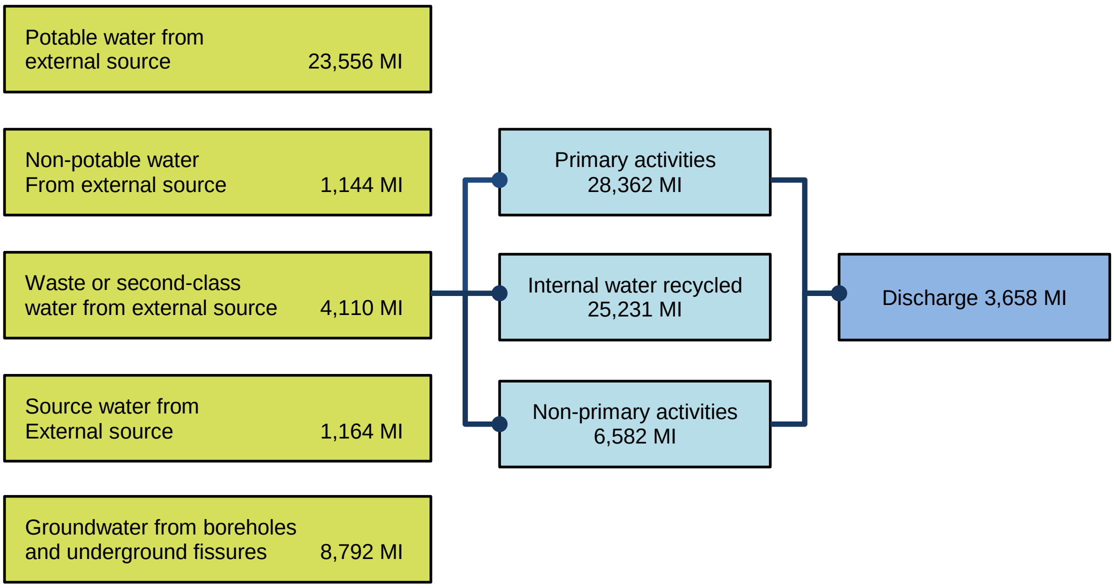

Figure 3.3: Source of water at Anglo Platinum mines

(Source: Anglo Platinum 2008 Materials Issue Report. Water Chapter)

In the Phalaborwa region, the **Phalaborwa Mining Company** which operates one of the largest copper mines in the world, have established the Phalaborwa Water Management programme where they import 20 Mℓ per day of industrial water and 3 Mℓ per day of potable water from the Lepelle Water Board. The industrial water is used in the various processing plants, mainly as a transport medium to transport mining residues (tailings) to the tailings dams. The tailing dam water is then recycled back into the processes. This system is called the Phalaborwa’s ‘Zero Discharge’ policy, where all water is stored and recycled to various plants for reuse. With the use of this policy the Phalaborwa Mining Company recycles approximately 130 Mℓ per day of water; this water is then returned and reused in their ore processes. Over the years, Phalaborwa Mining Company has managed to reduce its fresh water consumption from over 70 Mℓ per day to just over 20 Mℓ per day as indicated in **Figure 3.4**.

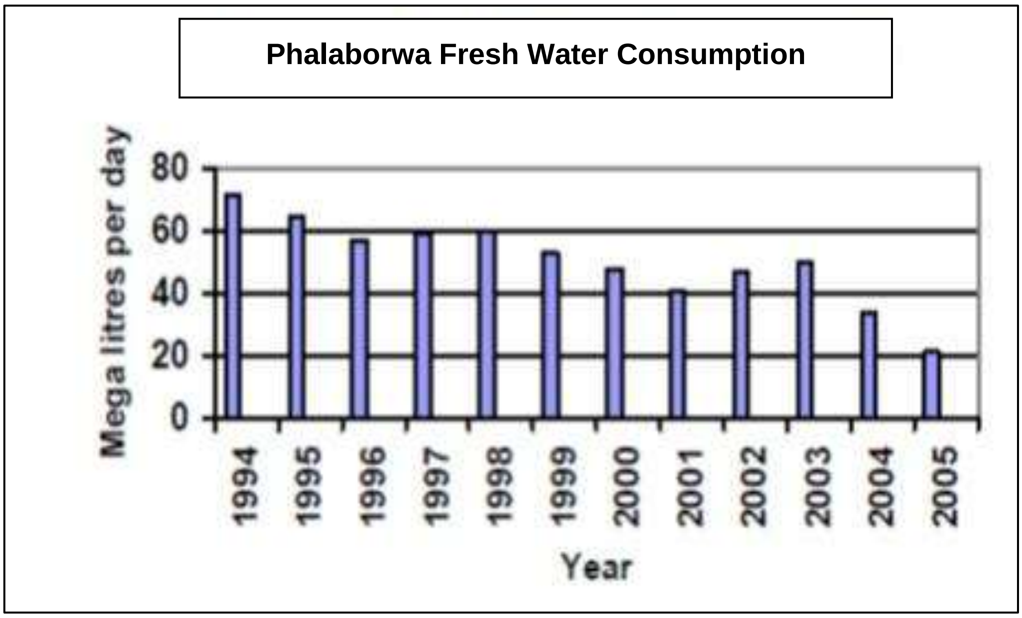

Figure 3.4: Reduced consumption of fresh water by Phalaborwa Mining Company

3.4 MINE WATER

Mining activities contribute process water through mining activities as well as decanted water from filling mine chambers and closed or abandoned mines. Although decanted water is contaminated with heavy metals and has a low pH, developments in treatment processes have provided for the reclaiming of mine water as a source of non-conventional water.

3.4.1 Mine water reclamation

One of **South Africa's** primary industries is mining. There is a potential of approximately 440 000 m^3 per day of mine water available for reuse and reclamation in South Africa.

In the catchment, mine drainage from existing and closed coal mines poses a serious challenge (and an opportunity). As the mines fill up with water; oxygen and sulphides in the shaft and tunnel walls react and form sulphuric acid, which causes a drop in pH to as low as 2.0. The acidic water can also dissolve heavy metals and this poses a huge threat to the receiving environment when such water decants to, or is discharged to the streams.

The Emalahleni Water Reclamation Plant at Emalahleni is an initiative driven by Anglo Coal and in partnership with BHP Billiton and in Public-Private Partnership (PPP) with the Emalahleni Local Municipality.

The plant reclaims AMD to potable standards and produces 25 Mℓ per day. The plant is currently being expanded to produce up to 50 Mℓ per day (with a maximum capacity of 60 Mℓ per day). Of the 25Mℓ treated water per day, 18Mℓ is supplied to the Local Authority for domestic water augmentation, 2.5 Mℓ is bottled as '4Life' bottled water, a small proportion is released for environmental flow requirements, and the rest is reused in the various mining operations in the area for mining processes, potable use etc.

Figure 3.5: 4Life, bottled water from the Emalahleni Water Reclamation Plant

The mining operations utilising water from the plant are now self-sufficient in terms of their water requirements. This reduces the supply problems faced by the Municipality. The Acid Mine Drainage is kept in a closed system and not released into the environment, which has a positive impact on the water quality of the river systems.

Further, the plant operates at a 99% water recovery rate and the ultimate goal is to be a zero waste facility through 100% utilisation of its by-product - approximately 100 tonnes per day of gypsum. Anglo-Coal has launched several research studies co-funded by the NRF and the local banking sector respectively. Due to the rapid growth in the construction sector, construction supplies such as bricks and cement have been in short supply which in turn has increased construction costs. As part of the studies, Anglo-Coal has built a three-bedroom house constructed almost entirely of gypsum-based building materials. It is currently undergoing a range of tests to prove its quality and social acceptance. If successful, it will be rolled out *en mass* to assist with South Africa's housing backlog.

Figure 3.6: Emalahleni Water Reclamation Plant

The **Optimum Coal** mine near Middelburg in Mpumalanga, an initiative driven by BHP Billiton, has installed a 15Mℓ/day water reclamation plant as part of their company's long-term water management strategy. The Optimum Coal Water Reclamation Plant is "a licence to operate" project and is crucial for the mine to continue its operation. The total capital cost of the plant is about R600 million. Treating costs of the water is covered by the mine. Operating costs is catered for by revenue generated from the sale of potable water to the Steve Tshwete Local Municipality. Once the mine has closed, the operational costs will be funded by the Optimum Collieries' Environmental Trust provisions and from revenue generated from the selling of potable water.

The quality of treated effluent is safe for human consumption. About 95% of the treated water will be available for the surrounding communities, while the remaining 5% will be given back to the environment by discharging it into the Klein Olifants River to meet ecological flow requirements, as required by Department of Water Affairs. In effect, Optimum Coal is a zero discharge mine and by limiting their raw and potable water use has successfully implemented responsible mining and land use practices.

4. POTENTIAL FOR REUSE OF WATER AND THE USE OF MARGINAL WATER IN THE STUDY AREA

The previous chapter identified current examples of non-conventional water utilisation in the Catchment. This Chapter identifies further potential areas for sources of- and use of- non-conventional waters.

4.1 RAINFALL ENHANCEMENT

Cloud seeding is most effective in mountainous regions. The Drakensberg escarpment runs through the Lower Olifants catchment and provides suitable opportunity for cloud seeding to be implemented. This area is already a high rainfall area. In order to have longer lasting benefits from rainfall enhancement a storage scheme for this area would be necessary.

4.2 RAIN WATER HARVESTING

In South Africa, disadvantaged families in rural and urban areas (if located on big enough stands) can reduce their poverty situation through subsistence gardening in their stands. Harvested rainwater can be used to irrigate vegetable crops and offer an opportunity for a household to save on food expenditure and in so doing, to release cash for other needs.
The Department of Water Affairs and Forestry adopted a policy for Historically Disadvantaged Individuals (HDI) and groups, through which certain government subsidies can be granted in terms of Sections 61 and 62 of the National Water Act (Act 36 of 1998). The policy opens up six possible opportunities (subsidy products) for resource poor farmers. One of these subsidy products is a grant on a rainwater tank for family food production and other productive uses.

Currently DWA subsidies are for the installation of Jojo type tanks. Rainwater harvesting projects throughout East Africa have focused on supplying building materials and training in the construction of the tanks. This results in skills transfer between communities, and the communities themselves being capable of carrying out any maintenance on tanks. The current DWA subsidy scheme for Jojo tanks could be reconsidered to include the East Africa method of community constructed tanks. This latter method would not save more water but may have an additional socio economic benefit to communities.

The potential of utilising gypsum products from the Emalahleni Water Reclamation Plant for constructing rainwater tanks should be investigated further.

According to Mwege Kahinda et al. (2008), rainwater harvesting is suitable in areas with rainfall from 200mm to 1 000mm, deep soils (0.2 – 0.3m) and slopes less than 3%. Rainfall across the catchment falls within these limits as illustrated in **Figure 4.1**. (The local situation regarding the soil and slope will have a bearing on the potential for groundwater recharge.) The whole catchment is suitable for rain water harvesting, provided harvesting and storage techniques cater for the high evaporation rates.

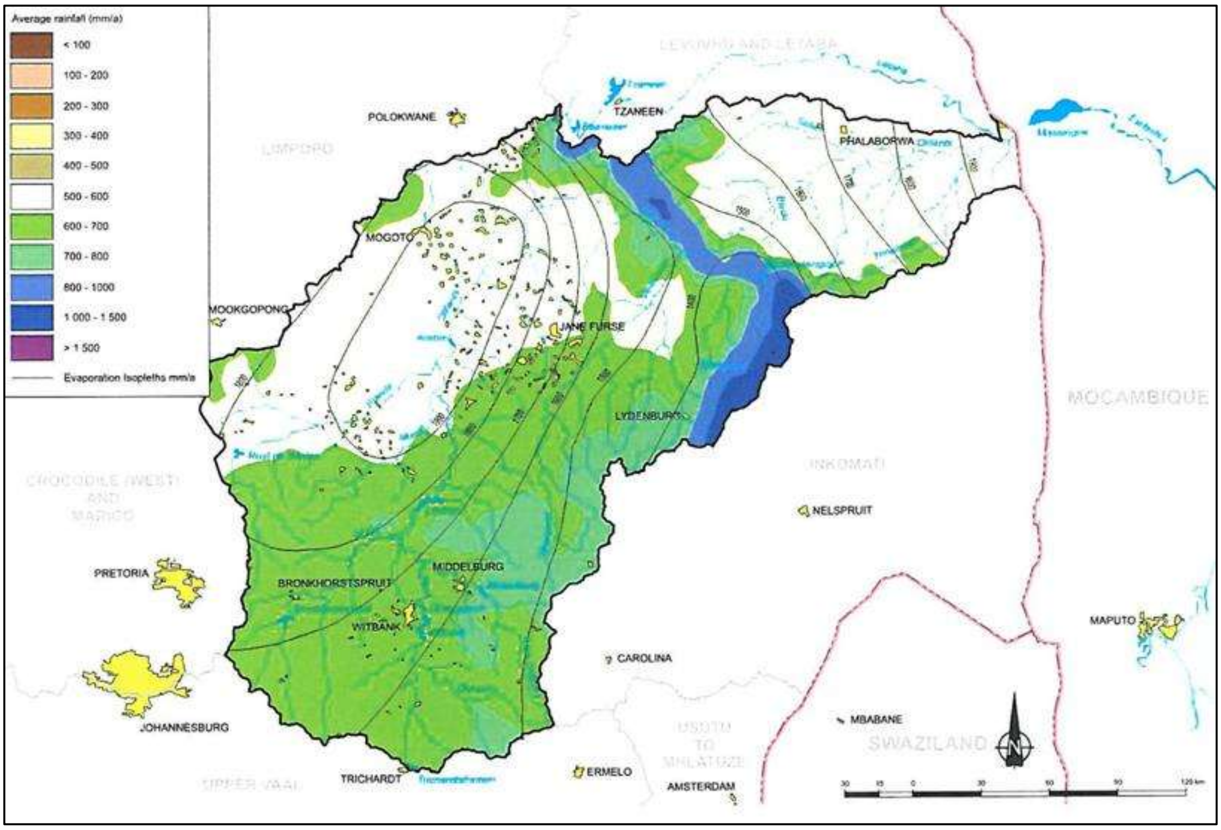

Figure 4.1: Mean Annual Rainfall across the Olifants Catchment.
(Source: Olifants WMA ISP)

4.3 GROUNDWATER

There is extensive (registered not verified) use of groundwater within the Olifants catchment, as illustrated in **Figure 4.2**. For the purposes of determining sources of non-conventional water, only ground water with a TDS of 1 200 mg/ℓ or higher, which is called brackish groundwater, is considered. Water with a lower TDS is considered part of the conventional yield of the system.

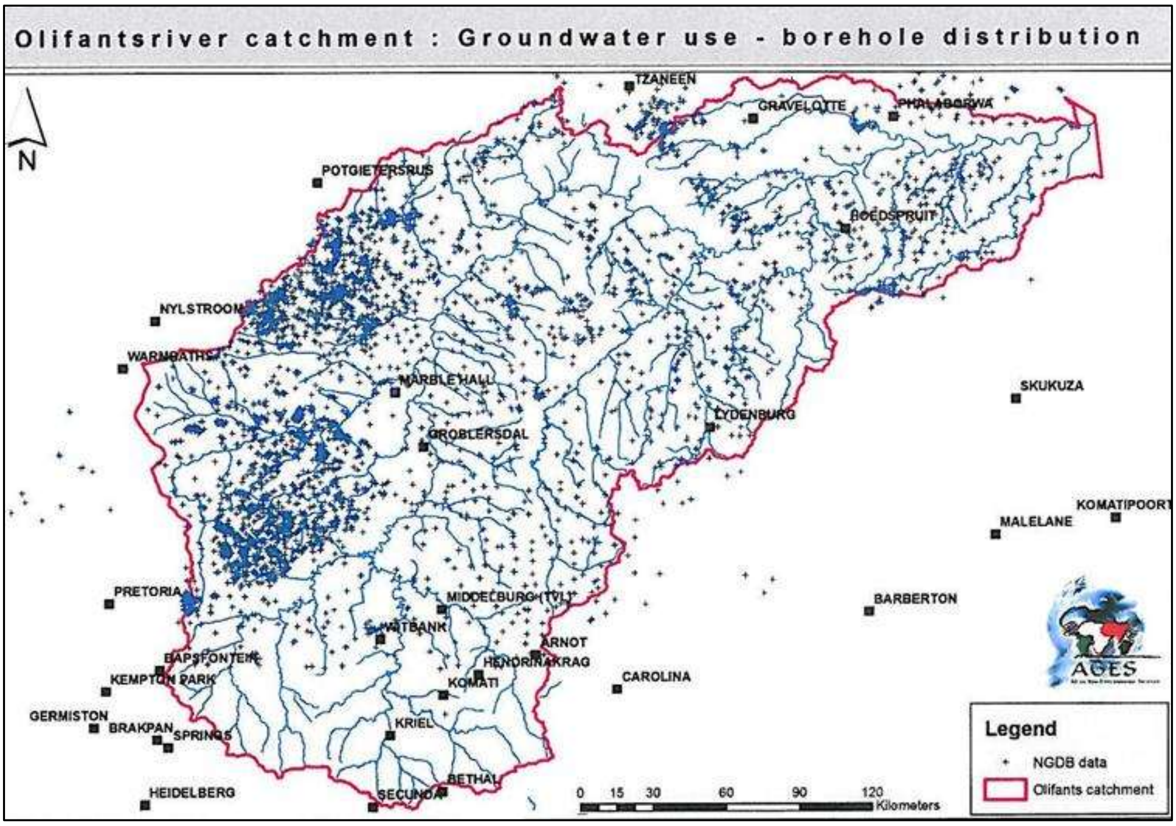

Figure 4.2: Distribution of boreholes throughout the Olifants catchment

(Source: AGES 2007)

According to the Groundwater Options Report of this project, the availability of groundwater resources for abstraction is controlled by the aquifer characteristics of permeability and storage. The aquifers in the Olifants River Catchment are 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 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 yielding in the order of 0.5 ℓ/s.

The report indicates that only 25% of the aquifers in the Olifants River Catchment are stressed. At least 70 million m^3/annum of additional groundwater resources are estimated to be available for development in the quaternary catchments that are not stressed. This is especially true for the dolomite aquifers in the northern escarpment area where the resources can be used for future development as a regional groundwater resource. This resource must receive attention in the new strategy for groundwater development in the Olifants River Catchment.

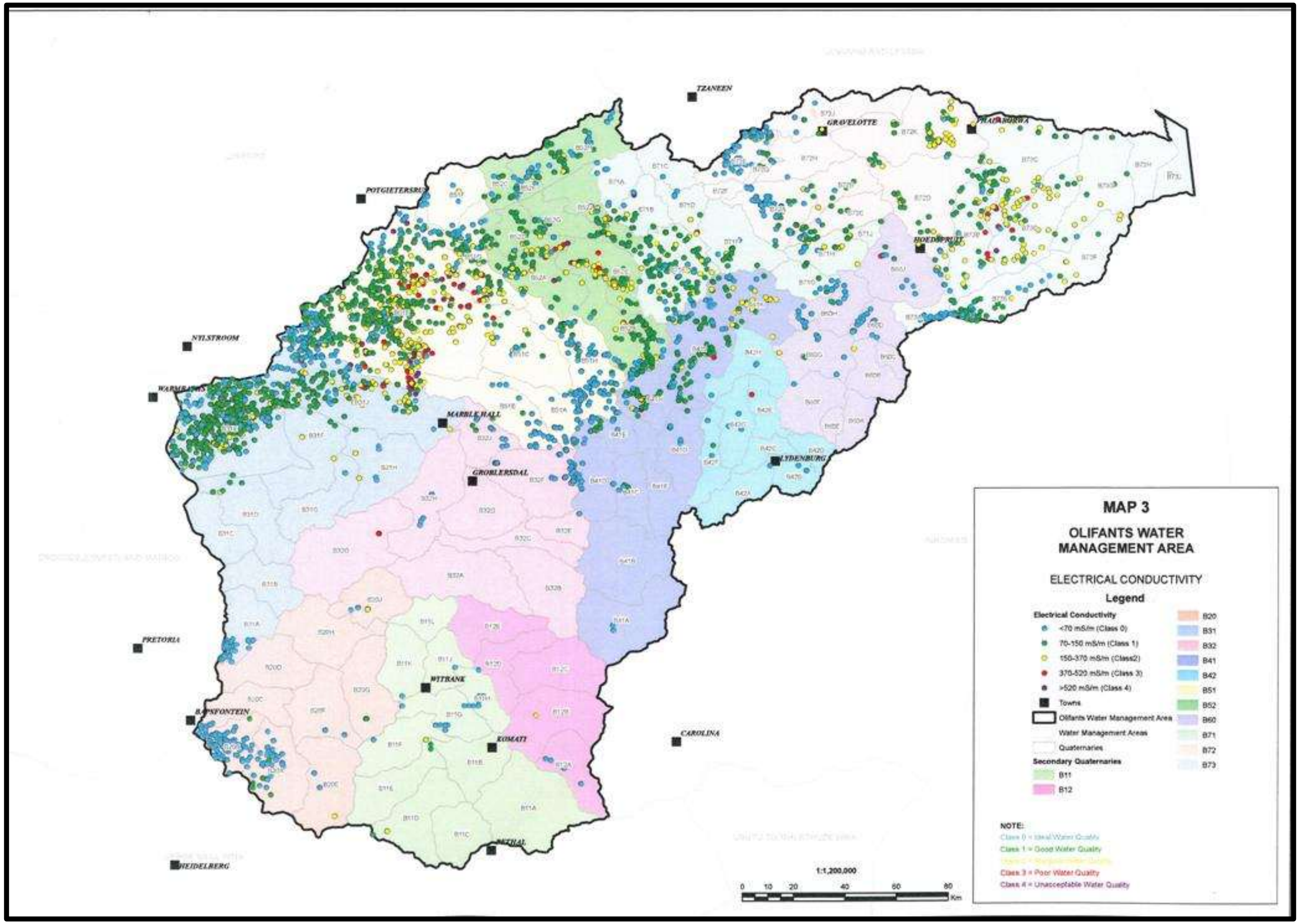

Figure 4.3: Electrical conductivity of registered boreholes in the catchment

(Source: Africon, 2007)

4.3.1 Brackish Groundwater

A TDS load of 1 200 mg/ℓ roughly equates to 190 mS/m electrical conductivity. Error! Reference source not found. illustrates the the electrical conductivity of egistered boreholes in the catchment. All purple, red and some yellow dots fall into the brackish water limit. There is potential for brackisch groundwater use in the Springbok Flats area, dispersing easterly across the catchment.

Verification of these boreholes regarding their utilisation, sodium and chloride content and recharge rate will be required before considering the utilisation of the water.

4.3.2 Direct Aquifer Recharge

The sustainable availability of groundwater is dependent on the annual recharge from rainfall. The calculated recharge across the Olifants River Catchment is in the order of 860 million m^3/annum (SATAC Joint Venture of SSI and Africon in association with Knight Piesold Consulting Sigodi Marah Martin and Ages, 2008). The recharge to the Middle and Lower Olifants Catchments is in the order of 700 million m^3/annum. The Groundwater Yield Model (SATAC, 2008) results showed that 500 million m^3/annum is lost due to groundwater evapo-transpiration losses. This means that large groundwater resources are available if it can be economically utilised before it is lost to groundwater evapo-transpiration losses. In order to increase the yield of the groundwater system, improvements could be achieved through artifically recharging of the aquifers. This could be achieved through the use of treated effluent or treated AMD for the artificial recharging of the aquifer. This will apply only in the case where the direct re-use of treated effluent or treated AMD is not feasibile of preferable. Such a system could be considered as a utilisation of a non-conventional source of water.

Aquifers with a yield greater than or equal to 5 ℓ/s would be suitable for direct/artificial aquifer recharge applications. **Figure 4.4** illustrates aquifers with their potential utilisation of recharge, i.e. areas identified as Class 4 are aquifers not utilised to their full capacity, whereas areas identified as Class1 are over-utilised. The areas of Class 1 and 2 aquifers should be investigated further for direct / artificial recharge application in order to speed up recharge timeframes and thus reduce stress on the aquifer. This should be considered in conjunction with the groundwater management plans as recommended in the groundwater report (SATAC, 2008). The utilisation of artificial recharge to increase the yield and thus the higher utilisation of these Class 1 and 2 aquifers, must be considered carefully. In some instances the acquifer stress, or the over utilisation of the source, cannot be relieved through artificial recharge only. In such cases artificial recharge should be carried out in conjunction with water demand management strategies.

Applications for artificial groundwater recharge include utilising rainwater, reclaimed mine water, and treated waste water as source. The water quality of the water used for the artificial recharge would need to comply with DWA standards.

Potential areas for application of groundwater recharge need to be identified and considered. The Groundwater Options Report suggests the construction of a weir at Godwinton as a potential aquifer recharge project. This can recharge the dolomitic aquifer along the escarpment. The water quality of the water supplies for the recharge would need to comply with DWA standards. Water then accessed from these aquifers would need to comply with the SANS 241 Drinking Water Standards if utilised for potable purposes.

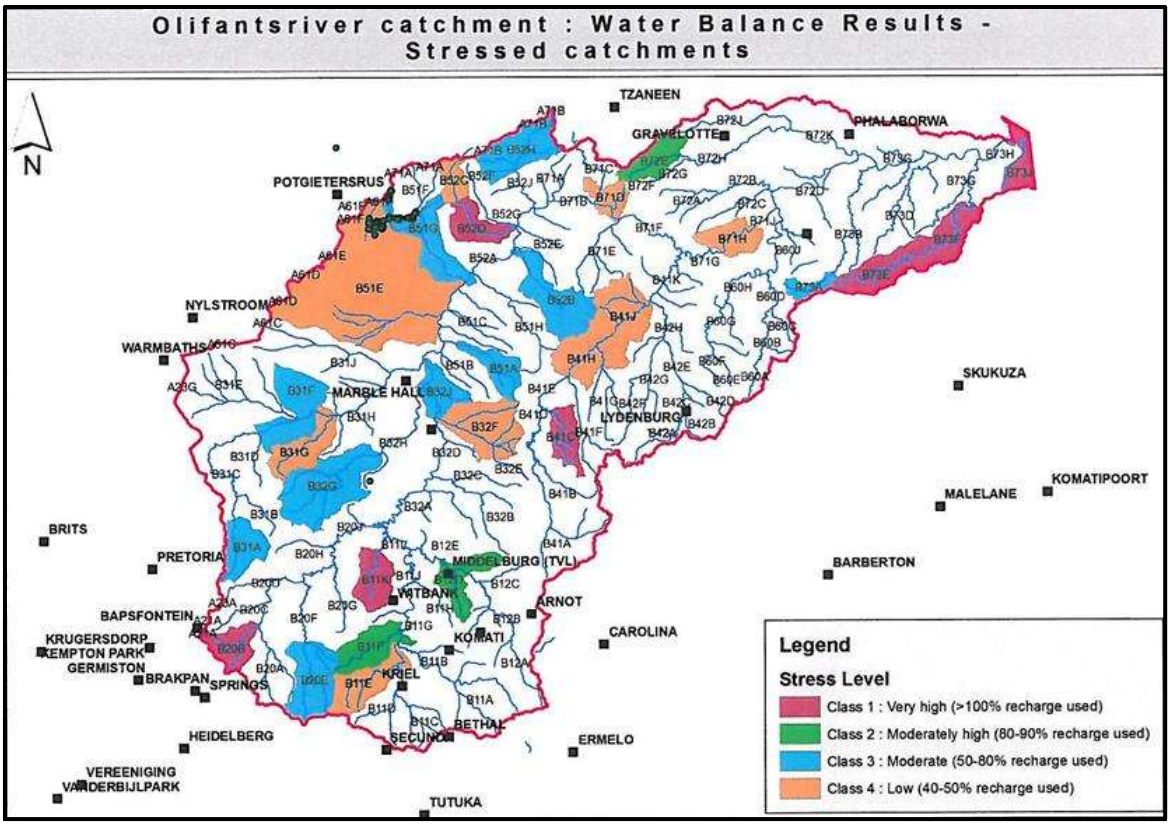

Figure 4.4: Map indicating stressed quaternary catchments
(Source: AGES 2007)

Other potential areas for further investigation into direct/artificial aquifer recharge should include underground storage at mines, where AMD water is currently being pumped out for purification and reuse purposes, with proper consideration of the potentially very serious water quality issues.

4.3.3 Sand Dams

Ephemeral rivers in the low lying dry parts of the catchment could be suitable for the use of this technique by small rural communities. The water sources are not difficult to manage in small communities and require minimum capital if the community provides the labour. Sand dam techniques are suitable for areas prone to flash flooding, and very absorptive soils. Similar to direct groundwater recharge, utilising of the aquifers must be responsible and reasonable.

4.4 WASTE WATER

4.4.1 Domestic

Due to the scattered nature of the urban centres and the limited treatment offered by the waste water works, irrigation of crops is not feasible. However, localised reuse of treated effluent for urban use, such as irrigation of landscapes, pavement-gardens, and sports fields; water supply for car washes, fire hydrants and garden watering etc., should be further investigated. Reclaiming of domestic effluent for the direct recharge of aquifers should also be investigated further.

4.4.2 Industrial

Eskom

Power stations in the catchment don't utilise water directly from the Olifants system, but rather water from adjacent catchments by means of inter-basin transfers. Implementation of water recycling technology at the plants will reduce their freshwater demand, and in turn should reduce the inter-basin transfers thus making more water available in those catchment systems.

In addition to plant specific investments such as improved thermal efficiency, all the wet-cooled stations would benefit from the installation of a dry ash handling system. This will require installing a desalination plant to ensure compliance with the "Zero liquid effluent discharge" policy. The desalination plants will increase the ability to reuse and recycle water more times (up to 15 times) per cycle and thus reduce fresh water demand. The approximated savings would range between 7.6 Mℓ/day and 21 Mℓ/day across the power stations. However, retrofitting will cause operational disruption to the grid. (DWA, 2007).

The potential savings at ESKOM plants using WCWDM and water reuse technology are shown in **Table 4.1**.

Table 4.1: Potential savings at Eskom plants using WC/WDM and Water reuse technology

Power Station	Average water efficiency (2001-2006) (ℓl/uso)	Potential Operational Savings (million m^3/annum)	WC/WDM and Reuse Savings (million m^3/annum)
Arnot	2.05	0.25	4.2
Duvha	1.99	0.00	6.3
Hendrina	2.30	2.37	5.2
Kriel	1.95	5.84	5.4
Matla	1.94	0.00	7.6
Kendal (dry-cooled)	0.11	0.84	n/a
	Total Savings	**9.3**	**28.7**

Recommendation: to implement the water efficiency WC/WDM and water reuse options identified and recommended in the DWA 2007 report.

4.5 MINE WATER RECLAMATION

According to Anglo-Coal, the Emalahleni Coalfields produce excess water of 123 250 Mℓ per day (45 million m^3/a) at 97% recovery rate this equates to about 119 000 Mℓ/day. Currently 25 Mℓ/day (design capacity of the Emalahleni plant) of mine water is treated to potable standard and supplied to Emalahleni Municipality. This plant is to be expanded by a further 25 Mℓ/day. The nett additional yield to the catchment as provided by the existing plant is estimated to be approximately 5 million m^3/a. Although the abstraction and treatment is in excess of the 5 million m^3/a, this is due to a reduction in runoff that also takes place and reduces the yield. A further 15 Mℓ/day plant (design capacity of the Optimum plant) has recently been commissioned to treat water from the Middelburg North Mine.

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

Four additional water reclamation plants have been identified by Anglo-Coal, as illustrated in **Figure 4.5**, to cater for the future expected decant of up to 45 million m^3/a in 2035. This additional yield could also be considered for new allocations such as for the expansion of operations of the platinum mines in the catchment downstream of the AMD treatment point(s). However in the Integrated Water Resources Management Plan for the Olifants Catchment (2009) this additional water was earmarked for Emalahleni Municipality. It now seems that the additional water will exceed the requirements of Emalahleni Municipality and some of it could be utilised for the expected shortage downstream.

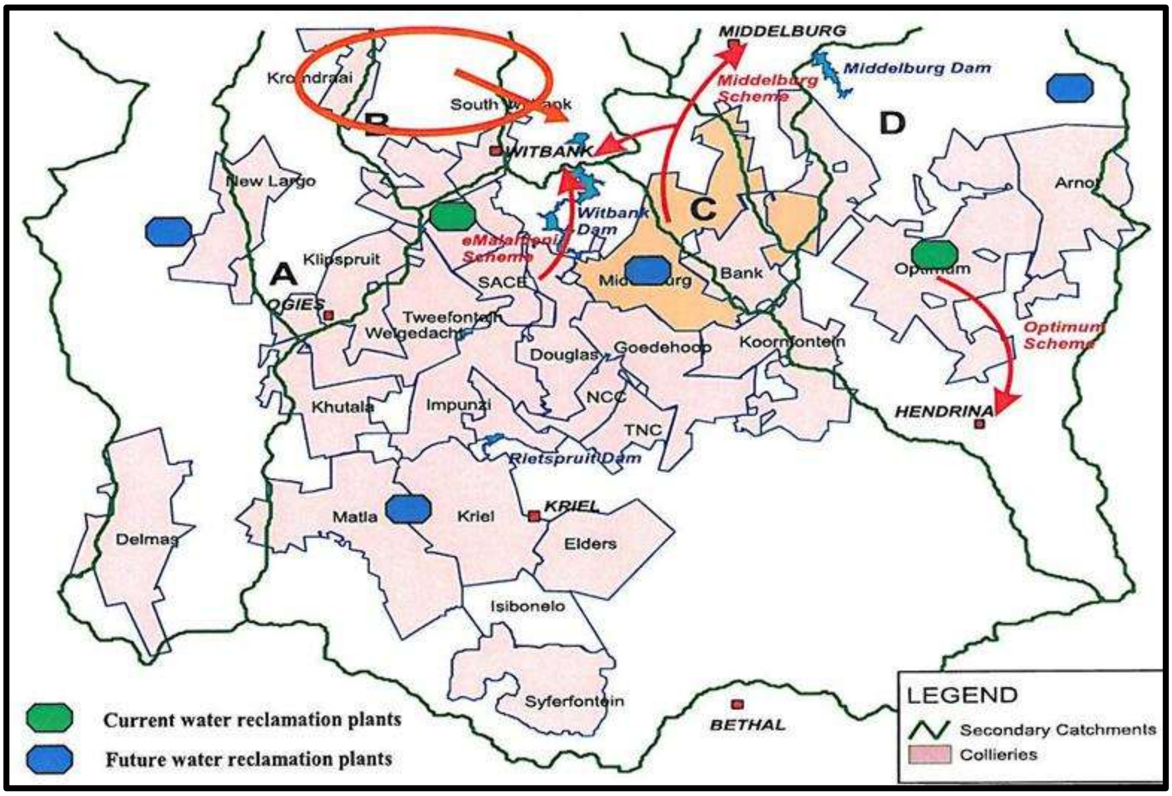

Figure 4.5: Locality map indicating current and proposed future water reclamation plants

(Source: Anglo-Coal)

A study by the WRC, (Report No 1628/1/11 "*Prediction of How Different Management Options Will affect Drainage Water Quality and Quantity in the Mpumalanga Coal Mines Up To 2080)*, made the following findings and recommendations, *inter alia*:

- The water demands of the Steve Tshwete and Emalahleni Local Municipalities exceed the yields of the Witbank and Middelburg Dams. There is no further surface water resources that can be developed in the catchment to meet the growing water demands. The mine water is the only local source of water that can be used to meet the demands. The treatment of mine water and supply as potable water is already being undertaken by South African Coal Estates with a 20 Mℓ/day plant operating capacity of the Emalahleni plant (with peak capacity of 25 Mℓ/day) and 11 Mℓ/day operating capacity at the Optimum plant (with peak capacity of 15 Mℓ/day). Based on the available data, there is believed to be still a further 65 Mℓ/day to 100 Mℓ/day available for treatment and supply.
- The use of storage to delay the expansion of treatment capacity showed that there was some merit in it but the cost of the piping to convey the water for storage in the workings was expensive and offset the savings in treatment costs.
- The intermine flow is a promising mine closure scenario. The water can relatively cheaply be transferred to a low point close to Emalahleni. A treatment plant can be constructed at the low point for supply to Emalahleni.
- The intermine flow option however requires cooperation between the mines and planning to control the flows between the workings. Issues of liability would also have to be addressed if intermine flow is to be considered as a feasible option.

- Income derived from the water supply to the town has a significant impact on the financial viability of the scheme as a portion of the operating costs can be recovered.
- The closure of the mines is still some years off. The NPV analysis show that although there are immediate management issues on some of the mines, relatively small sums of money can be provided now to cover the closure costs in 40 or 50 years' time.
- The mines must keep the monitoring of their water balances current so that all achieve a similar level of accuracy and confidence in the data available.
- Not all the mines were included in the study. There are a number of smaller mines and mining companies whose information should be collated and included in the modelling and long term planning.
- The mines must co-operate and continually update the life cycle costs and seek the most economical solution for the management of water in the long term. This includes incorporating intermine flow as a closure solution.
- The treatment and supply of mine water for potable use is an important component of the strategy to achieve a balance between water demand and supply in the catchment. However the long term changes in the recharge rates need to be assessed to consider the effects of the opencast mine workings consolidate and the effect there of on the "water table" or the perched aquifer.
- One of the significant impacts and expenses in treatment is the disposal of brine. Consideration should be given to the storage of brine in the underground workings to reduce the costs of the treatment process.
- Impact of electricity costs on viability should be reviewed.

The question that has been addressed in this Study is how much additional water can be sourced from mine water decant in the future? Some work on this was carried out as part of the IWRMP study (DWA, 2009), and the conclusion is that as much as 45 million m^3/a will decant by 2035. The WRC report No 1628/11/11 "Prediction of how different Management Options will affect Drainage Water Quality and Quantity in the Mpumalanga Coal Mines up to 2080" by Coleman et al, April 2011 gives lower values up to 36.5 million m^3/a. The graphs of Error! Reference source not found. and **Figure 4.7** how the latest information available.

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

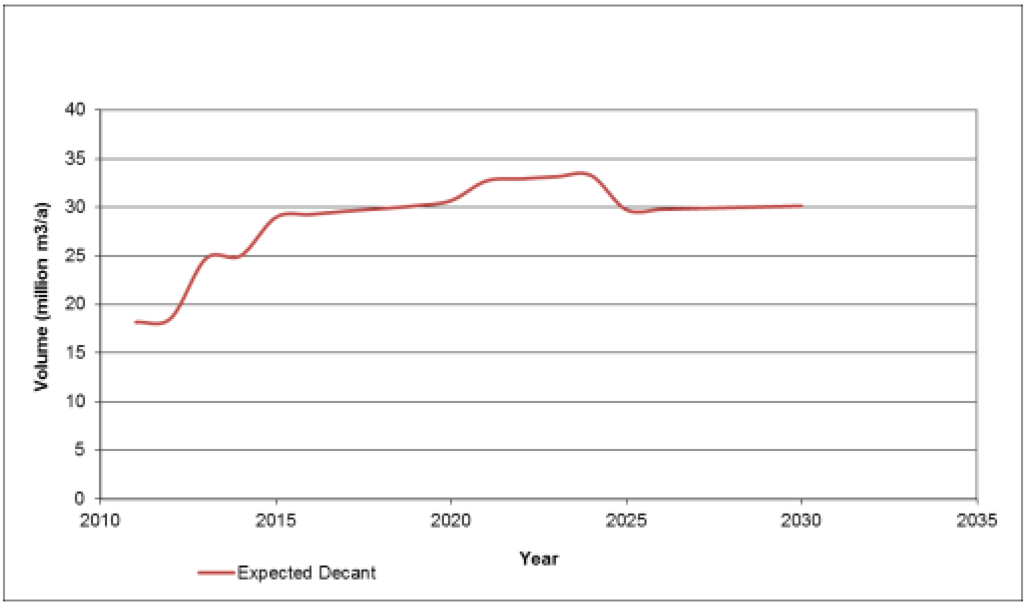

Figure 4.6: Decant water from coal mines in the Witbank catchment
Source: Golder Associates, 2011

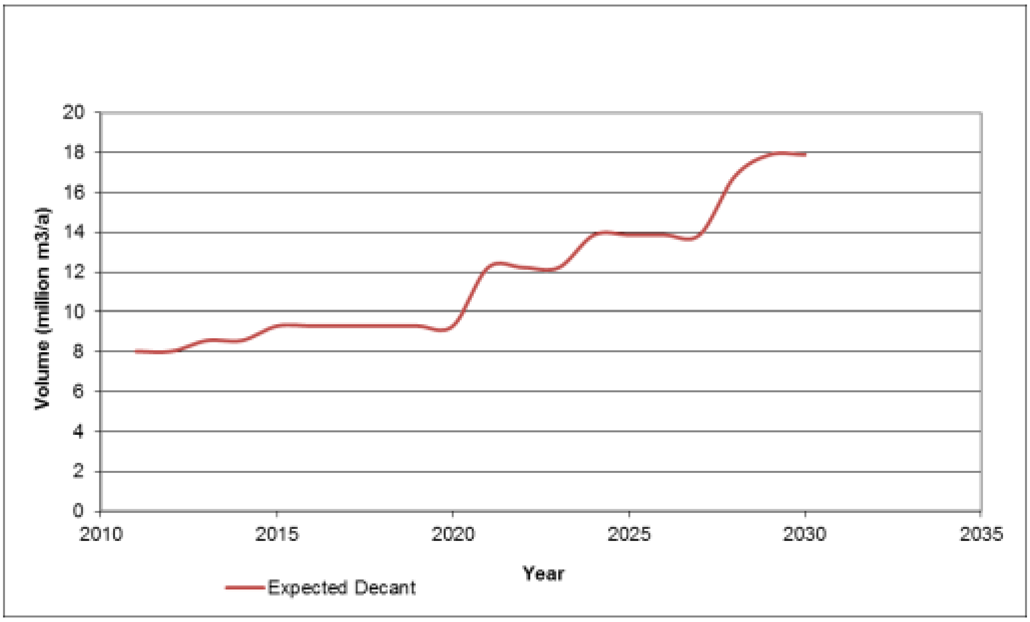

Figure 4.7: Decant water from coal mines in the Middelburg Dam Catchment
Source: Golder Associates, 2011

In July 2011 Anglo Platinum appointed a consultant to look into this possible additional water resource in more detail. The results of this detailed analysis were not available at the time of compiling this report. For the purpose of this study therefore, the decant information of **Figure 4.6** and **Figure 4.7** has been used. This possible future water resource can be considered as option to be factored into the reconciliation strategy. However because of the divergence of opinion on whether it will realise and also because this additional water is linked to expensive treatment costs it cannot be regarded as an unconditional additional yield.

The current excess water decant in the catchments of Witbank and Middelburg Dams can be read off the graphs of **Figure 4.6** and **Figure 4.7** as 18 million m^3/a and 8 million

m^3/a respectively. It was assumed that the additional yield of 4.2 million m^3/a as a result of the Emalahleni Water Reclamation Plant and the Optimum plant comes from this excess water decant and that the rest (i.e. 21.8 million m^3/a) is part of the current system runoff in any event. The incremental future decant can then be regarded as direct additional yield. In the case of the Witbank Dam catchment this value is approximately 12 million m^3/a, and of the Middelburg Dam catchment 10 million m^3/a, i.e. approximately 22 million m^3/a, in total over a period of 20 years.

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

Water demand in the area includes: Municipal supply at 60 Mℓ/day, Eskom power generation of 90 Mℓ/day and Platinum mining at 70 Mℓ/day. Current demand is approximately 220 Mℓ/day in the area. The potential exists for the development of further water reclamation plants; however, the institutional arrangements should enable the effective and efficient use the AMD water. In this regard it is important that an enabling environment is created at all spheres of government for the successful implementation of works through PPP's. The institutional issues that have arisen regarding the Emalahleni plant as well as financial support for such development must be addressed. The reclamation plants not only address water supply issues, but remediate the environmental problem of Acid Mine Drainage. Closed and Abandoned mines in the area are the responsibility of the State and should be included into these future proposed plants as a means of managing them.

5. POTENTIAL IMPACTS

There are several potential positive (and negative) impacts related to the use of non-conventional water sources.

The potential impacts, both positive and negative, that must be considered with the utilisation of non-conventional water sources, have been grouped below into Management, Social, Health and Environment. There are however also impacts or implications of not utilising the non-conventional sources. These impacts provide the impacts, driving force, motivation for the use of non-conventional sources. The most obvious in this category are water shortages and cost of transfer of water from far afield other implications in this category are also dealt with below.

5.1 MANAGEMENT

From a Water Resources Management perspective the use of non-conventional water should be properly managed and controlled. Appropriate guidelines for water recycling, reuse and reclamation should be developed together with a clear policy and strategy. The utilisation of non-conventional sources of water requires monitoring and regulation, as well as clear institutional roles and responsibilities. Currently the reuse of effluent streams require environmental authorisation in terms of the National Environmental Management Act, Act 107 of 1998 (And its amendments and SEMAs), and in some cases, depending on the intended use requires water use licences in terms of the National Water Act, (Act 36 of 1998). However, there are no formal guidelines in place to assist potential users or decision makers in this regard. In terms of water availability assessments and water service delivery plans, sources of non-conventional water are not given sufficient weighting in order to reduce freshwater demand, as there is no legislation or regulatory requirement in place requiring them to do so. In order to change the current paradigm of excessive water consumption towards a paradigm of water efficiency, all alternatives need to be considered. Many of the examples given in this report are own initiatives by companies and industries to reduce their operating costs. Initiatives like these should be encouraged and regulated by the state in the spirit of good environmental practice, efficient water use and sustainable resource utilisation.

5.1.1 Political

The Emalahleni Local Municipality is involved in the Public-Private Partnership of the Emalahleni Water Reclamation Plant. The plant provides drinking water, and soon will provide housing (or at least material for housing). The success of the current project and the potential to achieve service delivery objectives (through both for the water reclamation and the gypsum building material manufacturing) can be supported more by Government Institutions. These positive results can be achieved through acceptance and continuous support to Public Private Partnership projects within the Local Authority area of jurisdiction.

5.1.2 Technical

From a technical perspective, water use efficiency can increase through the management and implementation of effective water reuse methods. The applicable methods vary according to the process’s function.

Cooling Water:
In heavy industry, 50-90% of onsite water is used for cooling and it is common to use approximately 90% of the recycled water for cooling makeup. The use of recycled water for cooling could cause corrosion and scaling.

- To decrease the rate at which corrosion occurs, the recycled water used should maintain low levels of ammonia which is achieved through the process of nitrification. Nitrification will simultaneously produce acid thus reducing alkalinity too. Cooling towers should ideally be constructed of watertight concrete and reinforcement protected against the presence of chlorides that will accelerate the corrosion process of the structure. In general, the chloride content is controlled by adjusting the blow-down rate.
- The scaling is managed through the control of the salt concentration. Once the concentrations of the salt have reached its solubility limit a precipitate from the solution will form scale. The presence of scale results in blockage of the cooling system, increasing fouling which effectively causes poor heat exchanges as their surface is coated. The scale formed is dependent on the composition of the feed water. The presence of scale is best combatted through control of the pH levels of the recycled water, use of anti-scalants and control of the type of salt in solution.

In general, previous studies have shown that cooling systems are rarely optimised. Technology advances make it possible to optimise the system and thus reduce water use.

Boiler Feed Water:
Steam generation is the second largest water user, after cooling, in power stations. The purity of the steam is imperative as to avoid deposition and corrosion. In the presence of steam carbon dioxide, sulphur dioxide and hydrogen sulphide are severely corrosive. To avoid corrosion a pH level above neutral must be maintained (to prevent acid corrosion) and a moderate level of alkalinity should be achieved. A common approach is to use sodium hydroxide and anime buffers to achieve the desired chemical levels. The implications of utilising the best quality water for this use need to be considered in the optimisation of the total water cycle in the specific industrial process.

5.1.3 Carbon Emission Tax

The current trend to manage climate change is through the monitoring and regulation of carbon emissions. This is to be done through Carbon Emission Taxes but it is not implemented in SA as yet. The electricity levy announced in 2008 was the first step towards a carbon tax in South Africa and for the purpose of this report reference to the Environmental Levy and Carbon Tax are considered to be de facto, the same. When calculating the unit reference value (URV) for pumped water supply the carbon emission tax, which is implemented through Eskom's Environmental Levy, should also be considered (as long as it is not double accounted for). This tax is calculated on the tonnage of carbon / megawatt hour. For bulk water supply the estimated tax is R50 per tonne of carbon, at 1 tonne carbon / megawatt hour. This tax is assumed to be an effective method of motivation to industry to limit the carbon emissions, and should be considered in any such process. The savings that can be achieved through more effective processes are considered as the incentive to limit the carbon emission.

Similar to the above example the following relevant environmental taxes to non-conventional waters are being investigated further by the Department of Water Affairs and Treasury:

- A waste water discharge levy; and
- Levies on the waste streams of various products.

This kind of charge or tax has the objective to firstly apply the “polluter pay” principle and secondly to provide incentives to industry to maximise the re-use of water and the recovery of waste products from the return flows. This can be a useful mechanism to manage the waste and re-use more effectively and thus achieve better utilisation of the water resources available.

5.1.4 Public-Private Partnerships

One of the major impacts or hurdles to water reuse is the cost of treatment of waste streams. Government owned wastewater treatment works do not receive the necessary priority in terms of budget allocations for their upgrading, maintenance and operations. A potential solution to this could be that the ownership of these plants is vested in large corporations operating in the area through Public-Private Partnerships (PPP) and thus provide the required capital investment. For example, a large industry taking responsibility for the maintenance and operating of the works could be responsible to meet its pollution control obligation and to operate the works sustainably. The industry in turn benefits from utilising the water produced and complying to license conditions. In terms of regulating the works and the roles of Government; it is also more effective and easier for government to regulate a water treatment works operated by an industry than a works operated by another government body.

5.2 SOCIAL

Social issues influence choosing the source of non-conventional water or application thereof, its potential uses, design of the system and management administration. Naji and Lustig (2006) suggest as a principle for social sustainability to promote people’s sense of self-control over their lives as people need to feel they are self-organising and self-actuating individuals. People are more likely to use resources effectively if they feel they are in control. Hence; the degree of people’s control over their water management systems would have to increase as does their confidence in the reliability of the water recycling systems. Making people aware of their day to day water utilisation, similar to the electricity consumption awareness system, may improve people’s choice in non-conventional water options. This aspect applies to the individual level for rain water harvesting and the local authority and industry level for the reuse of grey or process water.

5.2.1 Religious Aspects

There are no evident religious objections to the potable reuse of marginal waters. Though it is necessary to note the importance of educating the public, allowing them to fully comprehend their decision to accept or reject the use of reclaimed water as a potable resource. Although the Muslim religion requires purification with clean water (i.e. not recycled water), there are means of achieving this via rainwater harvesting, and borehole water. Further the water used after the cleansing process, can be re-used within the Mosques for flushing toilets and watering the gardens.

5.3 HEALTH

PCPP's (pharmaceutical and hormones) accumulate in water, with increased concentration in treated waste water (as treatment techniques do not address these). Certain plants absorb PCPPs. Therefore irrigation using treated waste water should be limited to identify suitable crops (i.e. not fruits).

The contamination of water sources, where no treatment is implemented before it is released into any water source, could affect the well-being of human, animal and plant life that make use of such water source.

In the Olifants River System, the upper catchment is dominated by domestic, industrial and potable uses, while in the middle and lower catchments the water is reused for irrigation purposes. **Table 5.1** indicates the recommended limits for constituents in treated waste water for irrigation purposes. The table includes the United States long term limits, as well as the Victoria (Australia) limits, compared to the RSA guideline limits applicable within the Olifants Basin. **Table 5.2** indicates the level of acceptability for different "classes" of water quality.

Table 5.1: Recommended limits for constituents in treated waste water for irrigation purposes – Comparison of limits applicable in the USA, Australia and South Africa

Constituent	US EPA Long-term use (mg/ℓ)	Australia EPA-Vic Long-term use (mg/ℓ) (1)	South African guidelines limits (mg/ℓ)(4)
Heavy metals			
Aluminium	5.00	5.00	5.0
Arsenic	0.1	0.1	1.0
Beryllium	0.1	0.1	-
Boron	0.75	0.75	5.0
Cadmium	0.01	0.01	0.01
Chromium	0.1	0.1	0.1 (Chrome VI)
Cobalt	0.05	0.05	1.0
Copper	0.2	0.2	0.5
Fluoride	1.0	1.0	2.0
Iron	5.0	5.0	10.0
Lead	5.0	5.0	0.1
Lithium	2.5	2.5	-

Constituent	US EPA Long-term use (mg/ℓ)	Australia EPA-Vic Long-term use (mg/ℓ) (1)	South African guidelines limits (mg/ℓ)(4)
Manganese	0.2	0.2	10.0
Molybdenum	0.01	0.01	0.01
Nickel	0.2	0.2	1.0
Selenium	0.02	0.02	0.05
Vanadium	0.1	0.1	1.0
Zinc	2.0	2.0	1.0
Other parameters			
pH	6.0	6.0–9.0 (2)	6.5 – 8.5
TDS	500 - 2000	Refer below (3)	1000
Chlorine residual	1.0	1.0	1.0

Sources:

(1) From EPA Victoria, Guidelines for Waste water Irrigation, 1991 (unless specified otherwise)

(2) EPA Guidelines for Environmental Management: Use of Reclaimed Water

(3) Guidelines for Waste water Irrigation, Table 4: Salinity Class of Irrigation Waters (Class based on soil drainage properties)

(4) South African Water Quality Guidelines, Volume 4, Agricultural Water Use – Irrigation (DWAF, 1996), in Department of Water Affairs and Forestry, 2006.

It is important to note that the South African standard for agricultural irrigation are more lenient in most of the constituents than the US or Australia Standards. Only the lead and zinc indication are stricter in the South African guidelines. That provides an opportunity for increased utilisation of poorer quality water for reuse for irrigation in the catchment. The level of acceptability for irrigation is indicated in **Table 5.2**.

Table 5.2: General water quality limits for Agricultural Use: Irrigation (DWAF, 2006)

Water Quality Guidelines For Agricultural Use: Irrigation					
Variable	**Units**	**Ideal**	**Acceptable**	**Tolerable**	**Unacceptable**
Physical Requirements					
Total Suspended Solids	mg/ℓ	50	75	100	>100
Chemical Requirements					
Chloride	mg/ℓ	100	137.5	175	>175
Electrical Conductivity	mS/m	40	90	270	>270
Fluoride	mg/ℓ	2.0	8.5	15.0	>15.0
pH (upper)		8.4	8.4	8.4	>8.4
pH (lower)		6.5	6.5	6.5	<6.5
Sodium Absorption Ratio	mmol/ℓ	2.0	8.5	15.0	>15.0

Water Quality Guidelines For Agricultural Use: Irrigation					
Variable	**Units**	**Ideal**	**Acceptable**	**Tolerable**	**Unacceptable**
Sodium	mg/ℓ	70.0	92.5	115.0	>115.0
Aluminium	mg/ℓ	5.0	12.5	20.0	>20.0
Arsenic	mg/ℓ	0.1	1.05	2.0	>2.0
Beryllium	mg/ℓ	0.1	0.3	0.5	>0.5
Boron	mg/ℓ	0.5	0.75	1.0	>1.0
Cadmium	mg/ℓ	0.01	0.03	0.05	>0.05
Chromium VI	mg/ℓ	0.1	0.56	1.0	>1.0
Cobalt	mg/ℓ	0.05	2.75	5.0	>5.0
Copper	mg/ℓ	0.2	2.6	5.0	>5.0
Iron	mg/ℓ	5.0	12.5	20.0	>20.0
Lead	mg/ℓ	0.2	1.1	2.0	>2.0
Lithium	mg/ℓ	2.5	2.5	2.5	>2.5
Manganese	mg/ℓ	0.02	5.1	10.0	>10.0
Molybdenum	mg/ℓ	0.01	0.03	0.05	>0.05
Nickel	mg/ℓ	0.2	1.1	2.0	>2.0
Selenium	mg/ℓ	0.02	0.04	0.05	>0.05
Uranium	mg/ℓ	0.01	0.06	0.1	>0.1
Vanadium	mg/ℓ	0.1	0.56	1.0	>1.0
Zinc	mg/ℓ	1.0	3.0	5.0	>5.0
Biological					
Faecal coliforms	per 100mℓ	1	500	1 000	>1 000

Water obtained from a waste stream is seldom fit to be used for all purposes. The re-use of water or the use of inferior quality water inhibits the opportunities for the utilisation of such water without impacting on the receiving environment. Such impact and opportunity should be carefully evaluated. It is important that water that is fit for the purpose, is utilised to make more water of a higher quality available for other uses, such as for domestic use for e.g.

5.3.1 Groundwater Water Quality

While naturally occurring groundwater is free from pathogenic bacteria and viruses, there is a number of naturally occurring inorganic contaminants in the ecosystem such as arsenic, lead, zinc, copper, cadmium, radium, radon, uranium, selenium, barium, thallium, iron, manganese, fluoride, sulphate, chloride, boron, microbial contaminants, and many others which are potentially toxic for humans. Some examples are presented in **Table 5.3**.

Table 5.3: Common inorganic contaminants in groundwater environment indicating the possible effects on health and the ecosystem

Origin	Contaminant Type	Sources	Health and ecosystem effects
Natural Origin	Arsenic	Natural occurrence in sediments aggravated by overexploitation of groundwater seepage from inundated paddy fields and over irrigation.	Arsenicosis primarily as skin disorders such as skin lesions, keratosis, melanosis and carcinoma, disorder in the nervous system and kidneys.
	Fluoride	Natural occurrence	Dental and skeletal fluorosis, crippling and bone damage.
	Salinity	Sea water intrusions due to overexploitation of groundwater from coastal aquifers.	Degradation of fresh water unsuitable for drinking or irrigation.
Anthropogenic Origin (Human induced)	Nitrate	Fertilizer runoff, manure from livestock and septic systems, pit-latrines, etc.	Infant deaths due to "blue-baby syndrome".
	Heavy metals Arsenic, chromium, copper, zinc, thallium, lead, selenium, cadmium, mercury, etc.	Mine waste and tailings, landfills, hazardous waste dumps, ammunition, electroplating, wood preservation, paper/pulp industries and others.	Diverse metabolic disorders, damage to nervous and endocrine systems, retarded brain development, carcinogenic at high levels of exposure.

(Source: adapted and modified from Sampat, 2000, US EPA, 200a).

The determining level of 1 200 mg/ℓ of Total Dissolved Solids (TDS) distinguishes between water that is suitable for human consumption, and brackish water. It does however depend on the make-up of the salts. High levels of sulphates (300 – 400 mg/ℓ) could have a laxative effect while chloride concentrations above 250 mg/ℓ will give water an unpalatable, salty taste. (Water Quality and Treatment, 5th Ed, AWWA, 1999).

5.4 ENVIRONMENT

The use of non-conventional sources of water has both positive and negative impacts on the environment. Firstly, the reuse and reclamation of effluent streams reduces the discharge of these wastes into the environment thereby improving the general water quality of the system. The reduced demand on fresh water supplies also “unlocks” more freshwater within the applicable catchments. However, non-compliance to water quality objectives, which needs to be regularly monitored and enforced, may lead to the concentrated contamination of receiving water bodies.

6. POSSIBLE OPTIONS FOR REUSE OF NON-CONVENTIONAL WATER

The DWA commissioned a study "Assessment of the Ultimate Potential and Future Marginal Cost of Water Resources in South Africa" prepared by BKS (Pty) Ltd, Report No.: P RSA 000/00/12610. The only option contained in that report that is also presented in this report is the acid mine drainage reclamation. The cost figures utilised in this report are up dated from that shown in the BKS report. The BKS report does not include the Carbon Emission Tax in the cost calculations of each of the alternatives. In the calculation of costs and URVs, care must be taken to ensure that the Carbon Emission Tax or Levies are not double counted as it is currently included in the electricity tariffs of Eskom.

The possible options for using non-conventional water in the Olifants River catchment are described briefly below.

6.1 OPTION 1: RAINFALL ENHANCEMENT

6.1.1 Description

The possible scheme involves cloud seeding in the escarpment region of the catchment. Cloud seeding is carried out by air dispersal (by plane) of condensation nuclei, in order to trigger cloud formation and increased storm events.

6.1.2 Volume Water to be added

Approximately an additional 10% increase in rainfall over the target area can be expected. The current rainfall in the escarpment area ranges between 600mm to over 1000m, and an estimated MAR of 500 million m^3/annum in the escarpment region (MAR WR90). However, without detailed catchment modelling it is conservatively estimated that the increase in this region would only add an additional 20 million m^3/annum to the yield. Ideally the rainfall enhancement should be supported by creating additional storage in the catchment in order to make the additional rainfall available as yield. This aspect was not investigated in much further detail.

6.1.3 Cost

The cost for the additional water that can be made available through rainfall enhancement is estimated to be R 0.50/m^3 to R1,00/m^3 without consideration of the additional storage required. It will require significant initial capital expenditure and will have a fairly high operating cost.

6.1.4 Possible Impacts

- Such rain fall enhancement will/may have impacts such as increased rainfall in an already high rainfall area where it may affect the flooding regime of the affected rivers.

- Although the technology has proved that rain fall can be enhanced the perception persists that the impact on the rainfall pattern in the greater cycle may be affected though there is no information available on this type of impact. The fear is that rain that would have fallen elsewhere on the escarpment from these storm events will no longer fall on these areas, as it already fell within the target area. That means that claims can be expected that the rain fall enhancement in this area will reduce precipitation in surrounding areas.

6.2 OPTION 2: RAINWATER HARVESTING

6.2.1 Description

Rainwater harvesting provides immediate access to water by homesteads, especially those not located near to reticulation networks, at basic level. The rainwater is collected from roofs and stored in tanks mainly for domestic use. Simple community built rainwater tanks provide the skills within the community to build and to carry out maintenance works on the tanks. It will also pass on the skills to neighbouring communities. Access to rainwater tanks is therefore unrestricted and not limited to qualifying for subsidy schemes.

The rainfall within the catchment varies from high to low in an easterly direction and will serve the households with a reasonable supply of water.

6.2.2 Volume Water to be saved

A 10 m x 10 m roof will have a gross run-off of 1 000 litre for a 10 mm precipitation that can be captured in the tanks and utilized. The use of the water from the tanks will not only be much more convenient to the inhabitants but can also save the use of other sources, normally groundwater. The normal practice is to have a 5 000 litre tank constructed or to have a 5 000 litre Jojo tank installed.

6.2.3 Cost

A 5 000 litre Community Constructed tank = R7 500.00 (incl. cement, sand, stone, pipework, tap, transport, labour).

5 000 litre Jojo Tank Subsidy = R18 000

6.2.4 Possible Impacts

The utilisation of this option has the following impacts:

- Increased access by households to potable water and water for gardening.
- The cost of a community constructed tank will provide more than 2 tanks per 1 subsidy equivalent.
- Increased skills and onsite maintenance capability
- Saving on the utilization of the alternate water resource, normally groundwater resources are used and it is often over utilized.

- Reduction in runoff into river system is also an affect that need to be considered in the hydrology once a large percentage of households have installed these tanks.

6.3 OPTION 3: WATER RECLAMATION

6.3.1 Description

The Emalahleni Mine Water Reclamation Plant, a joint initiative between Anglo Coal, BHP Billiton and Emalahleni Municipality treats mine water to potable standards to augment the domestic water supply. The plant currently produces 25 Mℓ/day of potable water at 97% recovery. Similarly, the Optimum plant near Middelburg produces 15 Mℓ per day. The treated mine water could be used for power generation, potable supply or aquifer recharge.

6.3.2 Volume Water to be saved

- According to Anglo Coal, excess mine water of 200-300 Mℓ per day is potentially available. Currently the two plants can supply a peak capacity of 25 and 15 Mℓ/day respectively and after the upgrade; the total will be 65 Mℓ/dag.
- Four other potential plants have been identified for the Upper Olifants catchment.
- As indicated in **section 4** the additional yield that can be achieved is 10 million m^3/a in the catchment of the Middelburg Dam and 12 million m^3/a in the Witbank Dam catchment.

6.3.3 Cost

Capital costs vary between R247 million – R600 million depending on desalination technology used, availability of existing infrastructure, and construction of infrastructure to the point of use or the reticulation. Operating costs on existing plants ranges from R8.00 /m^3 to R12.00 /m^3 and has been carried by the mines, with some recovery from the sale of water to the local authorities

Other possible costs include environment levy (carbon tax): included in the Eskom tariffs of R50 / ton carbon / MW hour

The Environmental Levy on AMD based on the expected recovery of R119 000 m^3/day (see **section 4.5**) is estimated as follows:

- The Emalahleni plant runs at approximately 2.5 kWh/m^3
- 2.5 kWh / m^3 at 119 000m^3 per day = 297.5 MWh = 297.5 tonnes of carbon
- The Environmental Levy could amount to: R14 875.00 per day (R5 429 375.00 per annum)

6.3.4 Possible Impacts

- The higher infiltration of rainwater on the rehabilitated areas of decommissioned mines will increase the yield of the system. Increases in yields of 30 million m^3/a, for the Witbank Dam catchment and 15 million m^3/a for the Middelburg Dam catchment are expected.
- The reclaiming and reuse of mine water reduces the discharge of acid mine drainage into the environment, thereby improving the water quality in the river.

6.4 OPTION 4: IMPORTING TREATED EFFLUENT FROM THE EAST RAND

6.4.1 Description

There are several waste water treatment works in the Ekurhuleni municipal area in relative close proximity to the Olifants River Catchment. These WWTWs currently 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 to be reused by Eskom in power generation activities. The seven most suitable works are included in this option and shown below.

The concept of the project is shown on the map

Figure 6.1 and details are given in **Table 6.1**.

While the water is assumed to comply with the "general standard", this is considered to be unacceptably high in nutrients for discharge into the Olifants System, so provision has been made for tertiary treatment (potentially reverse osmosis) of the effluent so as to have a maximum phosphate content of 0.1 mg/ℓ. The treated water could then be used to augment the supplies for power generation by Eskom, thereby reducing demands on both the Olifants and Inkomati catchments.

The effluent will, as far as possible, be pumped from one Waste Water Treatment Works (WWTW) to another, with a central collection point at Daveyton. There the effluent will be treated before being pumped over the divide to the Olifants catchment to a point about 10 km north of Delmas. The discharge points have 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.

Figure 6.1: Waste Water Treatment Works in Ekurhuleni

6.4.2 Cost

Table 6.1 suggests the cost at about R7,30 per m^3 of water via this scheme. It must be noted that the main cost in the scheme is the construction of the tertiary treatment facility.

Table 6.1: Potential cost of importing treated effluent from Vaal catchment

		Capacity	Assumed Yield[1]		Pipeline							Pumps	Dam	Cost	URV
WWTW	Location	(Ml/d)	($x10^6$ m^3/a)	(m^3/s)	Destination	(m^3/s)	km	Start El	High pnt	End El	Diam	(kW)	(Ml)	(R Million)	(R/m3)
Daveyton	Daveton	16	4.7	0.148	Discharge pt	1.213	21.6	1590	1633	1536	900	650	17	301	0.81
JP Marais	Benoni	15	4.4	0.139	Daveyton	0.445	9	1597	1629	1590	600	310	6	96	0.67
Rynefield	Benoni	13	3.8	0.120	JP Marais	0.120	3.9	1605	1608	1597	300	62		35	1.05
Benoni	Benoni	10	2.9	0.093	JP Marais	0.093	9.7	1653	1657	1597	300	27		65	2.32
Jan Smuts	Brakpan	10	2.9	0.093	JP Marais	0.093	7.2	1602	1605	1597	400	48		53	1.25
Welbedacht	Springs	35	10.2	0.324	Daveyton	0.620	7	1577	1607	1602	700	424	9	96	0.62
Ancor	Springs	32	9.3	0.296	Welbedacht	0.296	12.5	1573	1601	1577	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

Further, the Vaal River raw water tariff (R6,14) will apply to the water pumped out of the Vaal catchment.

Carbon tax will be levied on both the tertiary treatment plant and the bulk water pump station.

- The pump station alone at 0.4 kWh/m^3 at 104 110m^3 per day = 41.6 MW = 41.6 tonnes of carbon at R50/ton of carbon.
- Environmental Levy: R2082.20 per day about (R760 000 per annum)

6.4.3 Volume Water to be saved

The proposed scheme produces 38.3 million m^3 per annum.

6.4.4 Possible Impacts

- The General Authorisation standards for waste water discharge into the Olifants River upstream of the Loskop dam is 10 mg/ℓ phosphates. The treated effluent from the WWTW is assumed to comply with the “general standard”, however to prevent eutrophication of water resources in the Olifants system improved treatment of the water is necessary. Improved treatment could either be by tertiary treatment (potentially reverse osmosis) or improved discharge quality standards at each individual WWT works. The benefit of the latter is that minimum discharge into the Vaal River will be of a better quality.
- The effluent from theses WWTWs has already been accounted in the Vaal system yield analysis. Therefore, water used in this scheme must be replaced with water from another scheme.
- This scheme has the potential to be implemented in phases, and thus lends itself to being used as an interim solution until other longer term schemes are implemented.

7. CONCLUSIONS

The catchment is in a stressed situation. There are a number of initiatives and examples of the utilisation of existing non-conventional water sources within the Olifants River Catchment. Not all of the options discussed in this report will contribute significantly towards creating a positive water balance in the system through significant contributions to the yield of the Olifants River System. However, utilising the smaller contribution by some sources of non-conventional water, it can make a difference to the position of the local users and specifically the livelihood of poor people in the rural areas. These options can assist in reducing the poverty and have an impact on the urgency and need for capital investment for regional infrastructure. It can reduce the total water demand somewhat.

The component that can make a significant difference to the water balance in the catchment and is to be considered as a major resource is the utilization of the AMD in the upper Olifants River sub catchment, and it needs to be utilised more effectively.

8. RECOMMENDATIONS

It is recommended to follow the actions described below:

- Proceed with the utilisation of AMD and implementation of further AMD initiatives as indicated in the other reports of this series.
- Promote the utilisation of PPP's for the utilisation of AMD in order to unlock the required investment and operational management capacity of industry.
- Extend the current reuse of effluent by the mines, at Mokopane and Polokwane
- Develop a clear policy, strategy and guidelines for the use and application of all components of non-conventional waters.
- Legislative and implementation tools for the regulating and implementing the use of marginal waters should be established and made available. This should cover aspects such as: water reuse and recycling, implementation of water efficient technology in different industrial sectors, improving water efficiency, etc. There are examples of own initiatives by industry that are successfully implemented in various catchments in the country.
- The Water Conservation and Water Demand Management initiatives identified in the DWA Report "The Development of a Comprehensive Water Conservation and Water Demand Management Strategy and Business Plan for the Olifants and Inkomati WMA's. Industrial component: Power Generation. Situation Assessment", (Prepared by VWG Consulting on behalf of the Directorate: Water Use Efficiency) – should be considered for implementation.
- Rainwater harvesting in the catchment should be promoted and expanded. The subsidy for households for rainwater tanks in the rural areas should be continued and expanded. The use of such harvesting in cities should be promoted and can be even made compulsory for any new town development.
- Opportunities for groundwater recharge should be considered and the approach generally promoted. The feasibility of the implementation of the Godwinton weir to recharge the dolomite aquifer on the escarpment should be investigated further.
- The application of water recycling and internal reuse in industrial process should be continuously be required, promoted, advanced and implemented.
- The possible future implementation of rainfall enhancement should be taken further with a specific project to take the existing research knowledge to the next level and prepare it for possible future implementation.
- The transfer into the catchment of sewage from the Vaal River catchment for reuse in the Olifants River catchment need to be considered in conjunction with the strategic constraints of water requirements in the Vaal River catchment itself.

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APPENDIX A

A questionnaire was sent to various District and Local Municipalities, as well as various industries within the Catchment. Responses were received from the following:

Questionnaire Sent to:	Response received:
INSTITUTION	
GERT SIBANDE District Municipality	Yes
GOVAN MBEKI Local Municipality	
EHLANZENI District Municipality	
NKANGALA District Municipality	
POLOKWANE Local Municipality	
STEVE TSHWETE Local Municipality	Yes
Emalahleni Local Municipality	Yes - meeting
CAPRICORN District Municipality	
MOKOENA MAHLARE Local Municipality	Yes
MOPANI District Municipality	
WATERBERG District Municipality	
GREATER SEKHUKHUNE District Municipality	Yes
THABA CHWEU Local Municipality	Yes
VHEMBE District Municipality	
INDUSTRY	
Anglo-Coal – Emalahleni Water Reclamation Plant	Yes - meeting
Columbus Stainless Pty Ltd	Yes
Phalaborwa Mining Company Limited	Yes

QUESTIONNAIRE FOR WATER USERS

Please fill in the answers to the questions below in the given space. For questions with multiple choices, please indicate the preferred answer with an x.

Questionnaire Nr.: *For office use only*	

A. Contact Details:

Sub-Catchment: Upper Olifants [ ] Middle Olifants [ ] Lower Olifants [ ] Steelpoort [ ]

Company/Association Name: ______________________________

Name of person who completes the questionnaire: ______________________________

Contact details: **E-mail:** ______________________________

Telephone Nr.: ______________________________

Cell phone Nr.: ______________________________

Sector: Domestic [ ] Agriculture [ ] Mining [ ] Industry [ ] Other [ ]

For purposes of this study, "Marginal Waters" will be defined as:

"Water that can be recycled, reused or reclaimed, including naturally occurring un-potable water, such as brackish water, saline water, un-potable groundwater and rainwater (for household harvesting)."

Is there anything you would like to add or exclude from this definition?

____

____

____

Note:

- **Re-cycle** – when water is used in a process and then re-used in the same process without any purification/ treatment or improvement of the water quality.
- **Re-use** – when water is used and is then used again for another purpose with or without purification to some acceptable level (not yet potable).
- **Re-claim** – water is used and treated to potable quality.

B. Sources, treatment and use of marginal water

Sources	Location in the Sub-Catchment	Re-cycled / Re-used / Re-claimed	What technology is used to treat the marginal water? *E.g. reverse osmosis, desalination, reed beds, etc.*	Is the water potable?	How much water is inputted to the treatment process?	How much marginal water is actually used?	How much water is released for return flow?	What is it used for?	What was the original source of water?	How much does the water cost you (R/cubic metre)?	Is there potential to use marginal water? Where / how?
Brackish water											
Groundwater											
Saline water											
Rainwater (Household consumption)											
Mine water											
Industrial water											
Effluent water											
Others											

If you aren't using marginal water, why not? Not applicable

a) Not aware of the possibility ☐

b) Adequate supply from conventional sources ☐

c) Too expensive ☐

d) Technology inadequate ☐

e) Environmentally unacceptable ☐

f) Socially unacceptable ☐

g) Other *(Please specify)* ____________________

C. Environmental Impacts and Social Stigmas

1. Have any environmental impacts been identified in using marginal waters?

2. How will the recycling / re-use / reclaiming of marginal water affect the return flows of downstream users?

3. Are there any social stigmas attached to using marginal waters? E.g. in relation to the quality of water, the mind set of re-using water, or in the location of the treatment works?

....
Signature Date

Thank you very much for your time.

Please fax the completed questionnaire to fax number +27 12 663 3257 or e-mail a scanned copy of the completed questionnaire to Janette.VanZyl@af.aurecongroup.com; and chumadc@vodamail.co.za; before xx June 2010.