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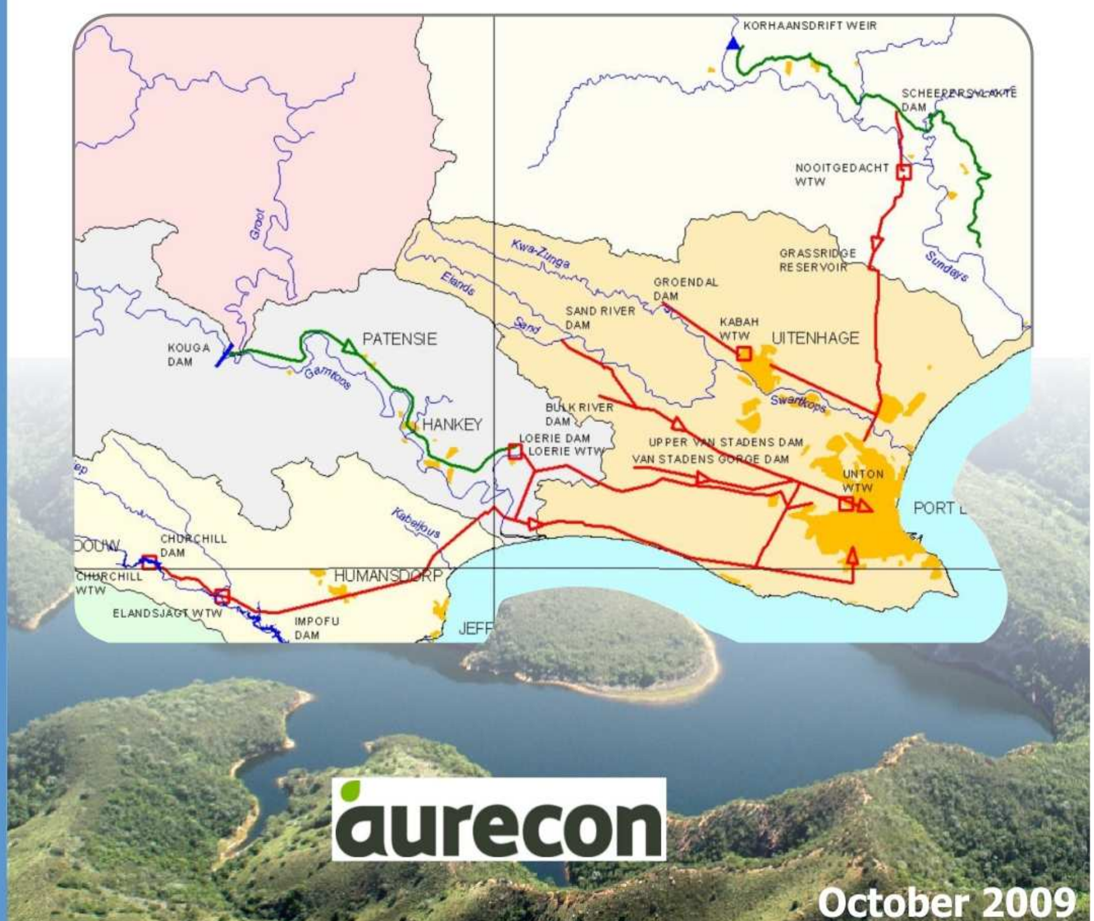
Water Reconciliation Strategy Study for the Algoa Water Supply Area

Annexure A
Interventions Workshop



October 2009

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Department:
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REPUBLIC OF SOUTH AFRICA

Directorate: National Water Resource Planning

Aurecon Project No. 402448

Water Reconciliation Strategy Study for the Algoa Water Supply Area

ANNEXURE A: INTERVENTIONS WORKSHOP

October 2009

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Department of Water Affairs
Directorate National Water Resource Planning

Water Reconciliation Strategy Study for the Algoa Water Supply Area

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APPROVAL

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Water Reconciliation Strategy for the Algoa Water Supply Area

Study Reports

Report Name	DWA Report Number	Aurecon Report number
Impact of Changed Crops on Water Quality in the Great Fish River	WMA 15/M00/00/1409/01	5004
Preliminary Reconciliation Strategy	WMA 15/M00/00/1409/02	5005
Inception	WMA 15/M00/00/1409/03	5006
Algoa Reconciliation Strategy	WMA 15/M00/00/1409/04	5007
Annexure A: Interventions Workshop	WMA 15/M00/00/1409/04	5007A
Annexure B: Public Participation	WMA 15/M00/00/1409/04	5007B

EXECUTIVE SUMMARY: ANNEXURE A: INTERVENTIONS

The following potential augmentation interventions are described in this document:

SECTION A: Agricultural Water Conservation and Demand Management

- A1: Compulsory licensing for NMBM

SECTION B: Urban Water Conservation and Demand Management

- B1: Introduction to urban water demand management intervention options
- B2 WC and WDM downstream of consumer meters
- B3 WC and WDM upstream of consumer meters
- B4 Rainwater harvesting for household use
- B5: Rainwater harvesting for gardening

SECTION C: Trading of water use authorisations

- C1: Water trading – Baviaanskloof
- C2: Water trading – Upper Great Fish River

SECTION D: Land use changes

- D1: Watershed management – Kromme, Kouga and Baviaanskloof

SECTION E: Re-use of water

- E1: Treatment of effluent to industrial standards
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SECTION F: Desalination

- F1: Desalination – Coega IDZ supply option
- F2: Desalination - Lower Sundays River return flow
- F3: Desalination of seawater by NMBM

SECTION G: Surface Water Augmentation Schemes

- G1: Maximising yield of existing Kouga/Loerie Scheme (updated)
- G2: ORP / Nooitgedagt Low Level Scheme (updated)
- G3: Diversion of lower Gamtoos River flows
- G4: Tsitsikamma River diversion
- G5 Guernakop Dam
- G6 Kouga Dam replacement and raising

SECTION H: Groundwater

- H1: Jeffreys Arch (Jeffreys Arch hydrogeological domain)
- H2: Van Stadens River Mouth (Pre-Cape Horst hydrogeological domain)
- H3 Bushy Park (Elands-Winterhoek Arch hydrogeological domain)
- H4 South-eastern Coega Fault (Algoa Basin hydrogeological domain)

Appendix A describes the urban water demand forecast for the Algoa Water Supply System.

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APPENDIX B: Current and Potential Future Capacities of Water Treatment Works and Pipelines of the AWWS

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Annexure A: Interventions

1. BACKGROUND AND INTRODUCTION

1.1 THE ALGOA RECONCILIATION STRATEGY STUDY

1.1.1 The need for a strategy

The NMBM is regarded as the economic hub of the Eastern Cape Province contributing more than 40% of the Gross Geographic Product of the Province. Over the next ten years, economic growth potential could exceed 5% per annum, given the establishment of the Coega Industrial Development Zone (IDZ) and the international deep harbour at Ngqura. The proximity of extensive commercial agriculture contributes to growth in the NMBM, providing permanent and seasonal jobs and value-added activities for communities both within and on the fringe of the NMBM.

In order to address the imminent requirement for more water, the NMBM and the DWA have initiated a number of planning studies to optimise existing water supply systems, to better manage water use activities and to explore water sources that can augment the water supply system. The culmination of these studies is the **Reconciliation Strategy for the Algoa Water Supply System (AWSS)**, which will consolidate the planning process into an implementation plan of action to ensure that the supply of water can meet present and future requirements. The Strategy will establish a programme of studies and other investigations to be undertaken so that the necessary interventions are investigated at the appropriated level of detail, and the NMBM is provided with suitable options for implementation in a progressive and phased manner.

1.1.2 Strategy objectives

The purpose of the Strategy is to achieve reconciliation of the available water supply with the water requirements of water services authorities, mainly the NMBM, as well as industrial and agricultural water users in the area served by the AWSS. The Strategy aims for adequate levels of assurance of supply within the constraints of affordability and at appropriate levels of service to users, whilst ensuring protection of current and possible future resources, and efficiency of operation and management of the AWSS, in an integrated and sustainable manner. The Strategy will address the water requirements up to 2035.

1.2 THE ALGOA WATER SUPPLY SYSTEM (AWSS)

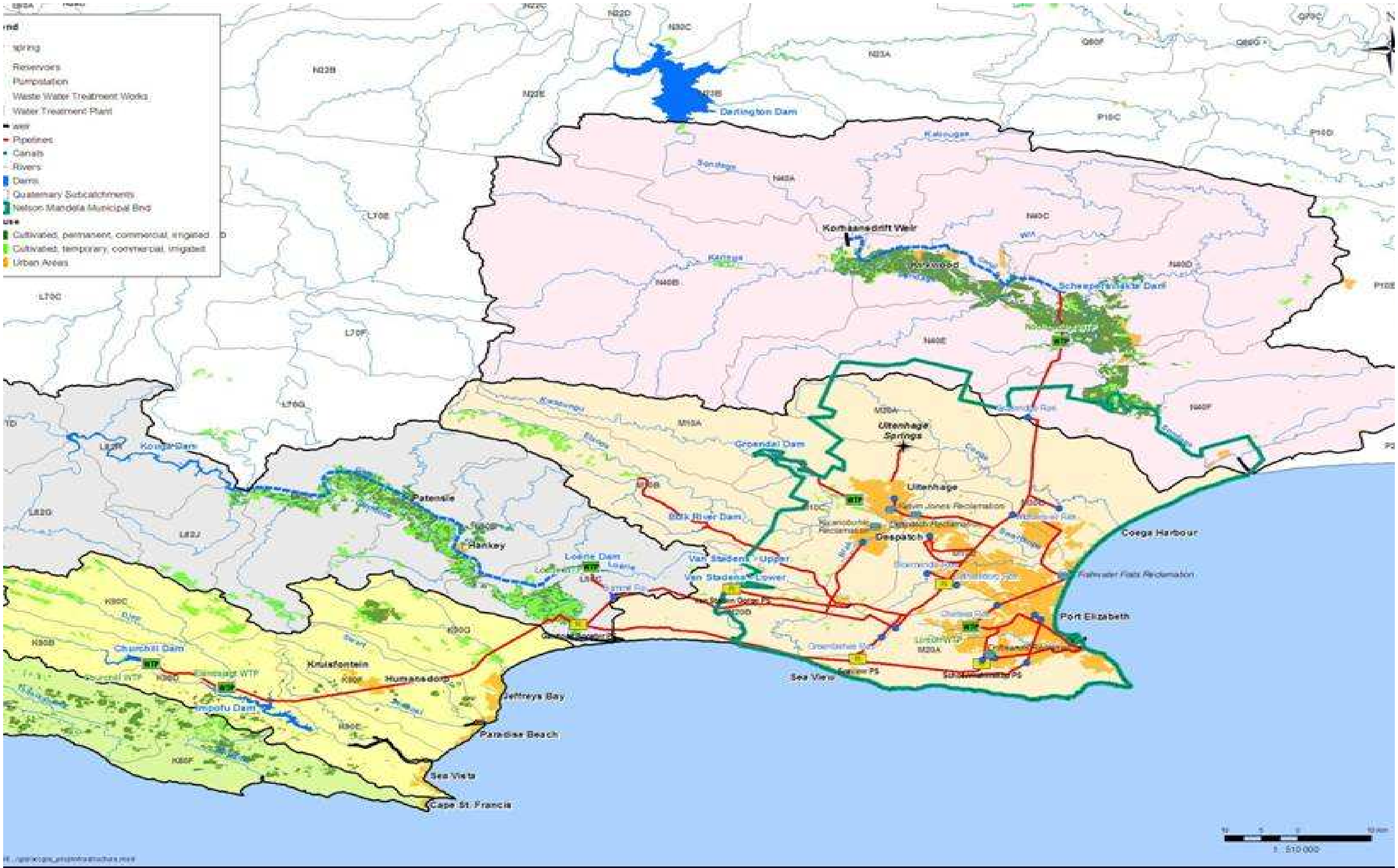
1.2.1 Overview of the AWSS

The AWSS (Figure 1) provides water to the Lower Sundays River Water User Association (LSRWUA), the Gamtoos Irrigation Board (GIB), the Nelson Mandela Bay Municipality (NMBM) and several smaller towns in the Kouga Municipality and the Sundays River Municipality.

Western System

The western system provides water to the NMBM from the Churchill and Impofu Dams on the Kromme River, Kouga Dam on the Kouga River and Loerie Balancing Dam on the Loerie Spruit, a tributary of the Gamtoos River. Bulk water provided to NMBM from the combined western system amounts to about 57 million m^3/a.

Figure 1 Algoa Water Supply System



Eastern System

The eastern system receives water transferred from the Gariep Dam on the Orange River via the Orange-Fish Tunnel, the Fish River and the Fish-Sundays Canal to augment the supply from the Sundays River. The current quantity of bulk water provided to NMBM from this system is 31 million m^3/a, although the registered use is only 17 million m^3/a.

Secondary System

The secondary system consists of dams on the Sand, Bulk, Van Stadens and Swartkops rivers and the Uitenhage groundwater aquifer. The quantity of water abstracted by NMBM from this secondary system is around 10 million m^3/a.

1.2.2 Operation of the AWSS

The AWSS system consists of bulk infrastructure components which are owned and operated by the DWA, the LSRWUA, the Gamtoos Irrigation Board and the NMBM. Irrigation requirements from the AWSS peak in the summer months from October to January. Domestic supply requirements to NMBM also peak over the summer season, when around 300 000 visitors also impose additional demands on the system.

The municipal supply is optimised for cost of operation, however, the storage capacity of some dams cannot be fully utilised due to limits in the capacities of pipelines and treatment works. There is also treated wastewater capacity at the six largest wastewater treatment works, which is currently not fully utilised.

Unaccounted-for water losses were around 20%, reaching up to 40% in some municipal areas, which represented significant potential for saving in the existing water supply system. While the operation and management of the AWSS can be modified to improve operation and reduce water wastage, it is clear that existing sources will not be able to provide for the expected growth in water requirements.

The inter-basin transfer from the Gariep Dam on the Orange River (ORW) contributes about 560 million m^3 per year to the Fish and Sundays Rivers, mainly for the purposes of irrigation and to dilute the salinity levels in these rivers. Current water supply for irrigation from the Orange River is about 99 million m^3 per year to the Lower Sundays River WUA which is not served by the AWSS.

1.2.3 Current and Potential Future Capacities of Water Treatment Works and Pipelines

The existing and possible future peak week capacities of the main components of the existing AWWS water treatment and bulk pipeline infrastructure were evaluated for a peak week demand factor of 1.3 in order to assess whether this existing infrastructure would have the capacity to supply the peak week requirements of additional future supply interventions. The analyses presented in the Appendix show that the peak conveyance capacity of the existing infrastructure is adequate to supply the present day peak week demand and that by boosting the Churchill/Impofu and the Kouga/Loerie systems the conveyance capacity of the existing infrastructure could be increased.by about 20%.

1.3 YIELD OF THE AWSS

The 1 in 50 year and 1 in 20 year long-term stochastic yields of the various sources of supply, available for urban, industrial and agricultural use are shown in **Table 1**. These yields are largely based on the 1996 Algoa Water Resources Stochastic Analysis Study, but also on the Algoa Prefeasibility Study and the latest available yield determinations for the Uitenhage Springs. The Algoa Operational Analysis Study has confirmed the yields for the Kouga/Loerie and Churchill/Impofu sub-systems shown in Table 1.

Table 1 Long-term stochastic yields or allocations of the Algoa Water Supply System

Sources of supply	1 in 50 year yield or existing allocation/use (Mm^3/a)	1 in 20 year yield or existing allocation/use (Mm^3/a)
NMBM older dams	3.3	4.0
Groendal Dam	6.5	6.5
Uitenhage Springs	2.4	2.4
Churchill/Impofu Dams	44.4	51.0
Kouga/Loerie Dams	75.5	86.0
Sundays River GWS	25.6	25.6
Re-use	1.7	1.7
Combined Total Yield	**159.4**	**177.2**

Bulk water planning generally assumes a 1 in 50 year assurance of supply, for urban water supply. For the AWSS, the urban water use is more than 60% of the total use, and is expected to increase. The evaluation and planning for this study has been based on a 1 in 50 year assurance of supply. Should some or all of the AWSS water users be supplied at a 1 in 20 year assurance of supply, an increased yield would be available for use, but at a much higher risk.

An additional 1 in 50 year system yield of 26 million m^3/a and a 1 in 20 year system yield of 17 million m^3/a could be accommodated by the existing pipeline infrastructure if this is upgraded by boosting, for a peak week demand factor of 1.3, relative to the current system yields (see Appendix).

An Ecological Water Requirement (EWR) of 2 million m^3/a has been taken into account for the lower Kromme River. However, the Preliminary Kromme Estuary EWR of 5 million m^3/a, as determined in the Kromme/Seekoei Comprehensive Reserve Determination Study, has not been taken into account in the determination of the system yield.

1.4 WATER USE FROM THE AWSS

1.4.1 Urban water use

The AWSS provides water for domestic use and more than 200 industrial users in the NMBM. Several other smaller towns within the Kouga Municipality and the Sundays River Valley Municipality are also reliant on the AWSS.

The job opportunities within the NMBM have led to a rapidly increasing population through in-migration and growth in peri-urban settlements. This has exacerbated the backlog in services, which were inherited when the NMBM amalgamated four separate municipalities in 2000. At present the housing backlog is around 50 000 units, most of which fall within the low-cost categories. In addition to the backlog, it is estimated that the need for new residential erven could be as high as 28 000 per annum. Of the current 300 000 households within the NMBM, around 27 000 do not have in-house water supplies and 32 000 do not have sanitation services. A further 25 000 are on the bucket system, which the NMBM is committed to eradicate and replace with reticulated sewage systems.

The water demands of the NMBM have increased steadily over the past few years, due to the in-migration, increased service levels and industrial activity. The 2007/2008 urban and industrial water use was 98.3 million m^3/a, which includes the water use of NMBM, Uitenhage, Despatch and the coastal towns in the Jeffreys Bay/St Francis Bay area.

Urban use by the small inland towns of Hankey, Patensie and Loerie is estimated to be 0.6 million m^3/a from the Kouga/Loerie sub-System.

It is anticipated that the Coega Industrial Development Zone (IDZ) and the Ngqura harbour could become significant water users in future, although expectations of growth have recently been lowered. Figure 1 shows the current area supplied from the AWSS, the main sub-systems serving the NMBM and the infrastructure within these sub-systems.

1.4.2 Agricultural water use

The Gamtoos Irrigation Board (GIB) farmers appear to have slowly increased their water use. This apparent increase may arise from the slow expansion of the irrigated areas over the last few years (mainly citrus), or from the replacement of old water meters with new ones. As a result, some hitherto unaccounted-for-water/losses have been identified as water use.

It was therefore decided amongst the delegates at the Operations Workshop for this study, held in October 2008 that, for future yield or planning analyses for the Algoa Water Supply System, a use of 46 million m^3/a by the GIB, supplied from Kouga Dam, should be modelled (as opposed to the 42 million m^3/a previously used). The full allocation of the GIB is 59.36 million m^3/a (742.2 ha at 8 000 $m^3/ha/a$), but inadequate yield is available from Kouga Dam to make full use of this allocation.

The allocated quota for irrigation, below Groendal Dam, is 2.4 million m^3/a. This use was not previously included as use from the AWSS, but for completeness, has been taken into account in this analysis. Irrigation usage from Impofu Dam is about 2 million m^3/a.

Total agricultural use from the current AWSS is therefore estimated to be 50.4 million m^3/a. This excludes agricultural use from rivers above dams that supply water to the AWSS.

1.4.3 Canal losses

Estimated losses of the conveyance canal from Kouga Dam to Loerie Balancing Dam has decreased from previous estimates to 8.4 million m^3/a, mainly due to improved operation and metering.

1.4.4 Total current use from the AWSS

For the determination of the current water balance of the AWSS, it is recommended that the urban water requirements, EWRs, and the losses/unaccounted-for-water from the Gamtoos Canal be assessed at a 1 in 50 year assurance of supply, whilst water for irrigated agriculture is assessed at a 1 in 20 year assurance of supply. The exception would be the 2.4 million m^3/a supplied to the irrigators below Groendal Dam, which receives preference above the urban water supply from Groendal Dam, in terms of a Court Order, and is therefore assessed at a 1 in 50 year assurance of supply. The equivalent 1 in 50 year system water requirement is **153.2 million m^3/a**. Total urban and industrial use from the system is estimated to be 98.3 million m^3/a.

1.4.5 Future Water Requirements including Coega Industrial Development Zone

The water demands on the Algoa Water Supply System (AWSS) of all sectors other than urban/industrial water use have been assumed to be constant. The following revised scenarios have been developed for growth in urban/industrial use by NMBM and other urban users from the AWSS (without taking account of the likely future requirements of the Coega IDZ described below):

- Baseline equal to the actual water supplied in 2008/2009 (i.e. up to June 2009);
- Long-term (next 25 years) Low water requirement scenario : 1.0% growth/a;
- Long-term (next 25 years) High water requirement scenario : 3.5% linear growth from baseline.

Based on recent changes in the industries that are likely to be established in the Coega IDZ, the scenarios for the growth in the potable and industrial water requirements of the IDZ (which will be additional to those described above) are assumed to be as follows:

- Potable Requirements :
    - o 2010 to 2014 6 to 10 Ml/d
    - o 2015 40 Ml/d (assuming that the PetroSA refinery comes on line)
    - o 2015 to 2030 40 to 55 Ml/d
    - o 2030 to 2035 55 Ml/d

- Industrial Requirements :
    - o 2010 to 2014 5 to 10 Ml/d
    - o 2015 20 Ml/d (assuming that the PetroSA refinery comes on line)
    - o 2015 to 2030 20 to 30 Ml/d
    - o 2030 to 2035 30 Ml/d

The report describing this "Urban Water Demand Forecast for the Algoa Water Supply System" is provided in Appendix A.

1.5 WATER BALANCE

It is concluded that the supply and demand on the AWSS were approximately in balance in 2008/2009 and that any increase in use would put the system at risk. The higher the growth in water requirements, the higher the risk would be, especially if the large users in the Coega IDZ are established within the next five years. It is clear that measures to solve this problem must be proceeded with immediately on account of the lead times necessary for the implementation of any augmentation scheme.

1.6 WORKSHOPS

A specialist group Workshop was held with wide representation by members of the Steering Committee3the interventions which may be appropriate for the Algoa Reconciliation Strategy, in order to consider the interventions in terms of timing, cost and yield. Combinations of different interventions will also be considered in order to devise the set of best possible alternatives to meet the water requirements of the NMBM in the 25-year time frame. Specific objectives are:

- Present the selection criteria which have been used to select the interventions;
- Invite comment on the selection of interventions for the Strategy;
- Present selected potential interventions;
- Invite comment on and contributions to interventions;
- Make recommendations on possible actions (e.g. feasibility studies) and responsibilities, and a programme for such actions.

Following the workshop the Programme and Action Plan will be documented and circulated for comment and refinement.

2. INTERVENTIONS SELECTED FOR EVALUATION

2.1 SELECTION CRITERIA

A significant number of interventions for the AWSS were initially identified. From this list, interventions that could be implemented within the medium-term were selected and evaluated, according to a standard template. A few additional interventions have been evaluated, mainly to have a range of types of interventions and to be able to compare these across the board. The descriptions of these interventions are included in this starter document.

2.2 EVALUATION OF INTERVENTIONS

The information on the intervention described in this document is drawn from various existing reports, as well as expert knowledge. Some of the interventions had been studied only very superficially, or not at all. Additional evaluation was done at desktop level for such interventions to provide sufficient information for this preliminary evaluation. Whilst the base information differs in extent and reliability, it should nevertheless be sufficient for this evaluation.

2.2.1 Costing

Where possible, capital costs have been based on costs available from previous studies. These costs were escalated based on Contract Price Adjustment (CPA) indices to be representative of the base year costs (June 2009). In some cases, costs had to be estimated from basics, as some options had never been costed.

An evaluation period of 25 years was selected for all water augmentation schemes, for determination of unit reference values (URVs). Discount rates of 0%, 3%, 6% and 8% were used for the URV calculations, to cater for funding by both NMBM and the DWA.

Multiplication factors were applied to allow for additional costs as follows:

- Preliminary and General costs of 25% were first added to the capital costs.
- A 15% Contingency sum was then added to the previous sub-total.
- A 15% Professional fees/site supervision sum was further added to the previous sub-total, to get the total construction cost estimate.
- The total construction cost estimate was spread over the first two financial years in the URV calculation.

Equipment replacement periods for e.g. pumps (mechanical and electrical) and desalination membranes were not considered.

2.2.2 Programming

Implementation programmes for interventions were based on the template previously developed in the Reconciliation Planning Support Tool (RPST).

2.2.3 Yields

Yields of interventions were mainly drawn from existing reports. In some cases, no yields had been determined and best estimates of available yields were made.

3. SELECTED POTENTIAL AUGMENTATION OPTIONS

The following potential augmentation options are presented in this document:

SECTION A: Agricultural Water Conservation and Demand Management

A1: Compulsory licensing for NMBM

SECTION B: Urban Water Conservation and Demand Management

B1: Introduction to urban water demand management intervention options
B2 WC and WDM downstream of consumer meters
B3 WC and WDM upstream of consumer meters
B4 Rainwater harvesting for household use
B5: Rainwater harvesting for gardening

SECTION C: Trading of water use authorisations

C1: Water trading – Baviaanskloof
C2: Water trading – Upper Great Fish River

SECTION D: Land use changes

D1: Watershed management – Kromme, Kouga and Baviaanskloof

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F3: Desalination of seawater by NMBM

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H4 South-eastern Coega Fault (Algoa Basin hydrogeological domain)

SECTION A

AGRICULTURAL WATER CONSERVATION AND DEMAND MANAGEMENT

A1. Verification, validation and abstraction control in the Kouga/Gamtoos, Orange-Fish-Sundays and other catchments of the AWSS

1. SCHEME LAYOUT

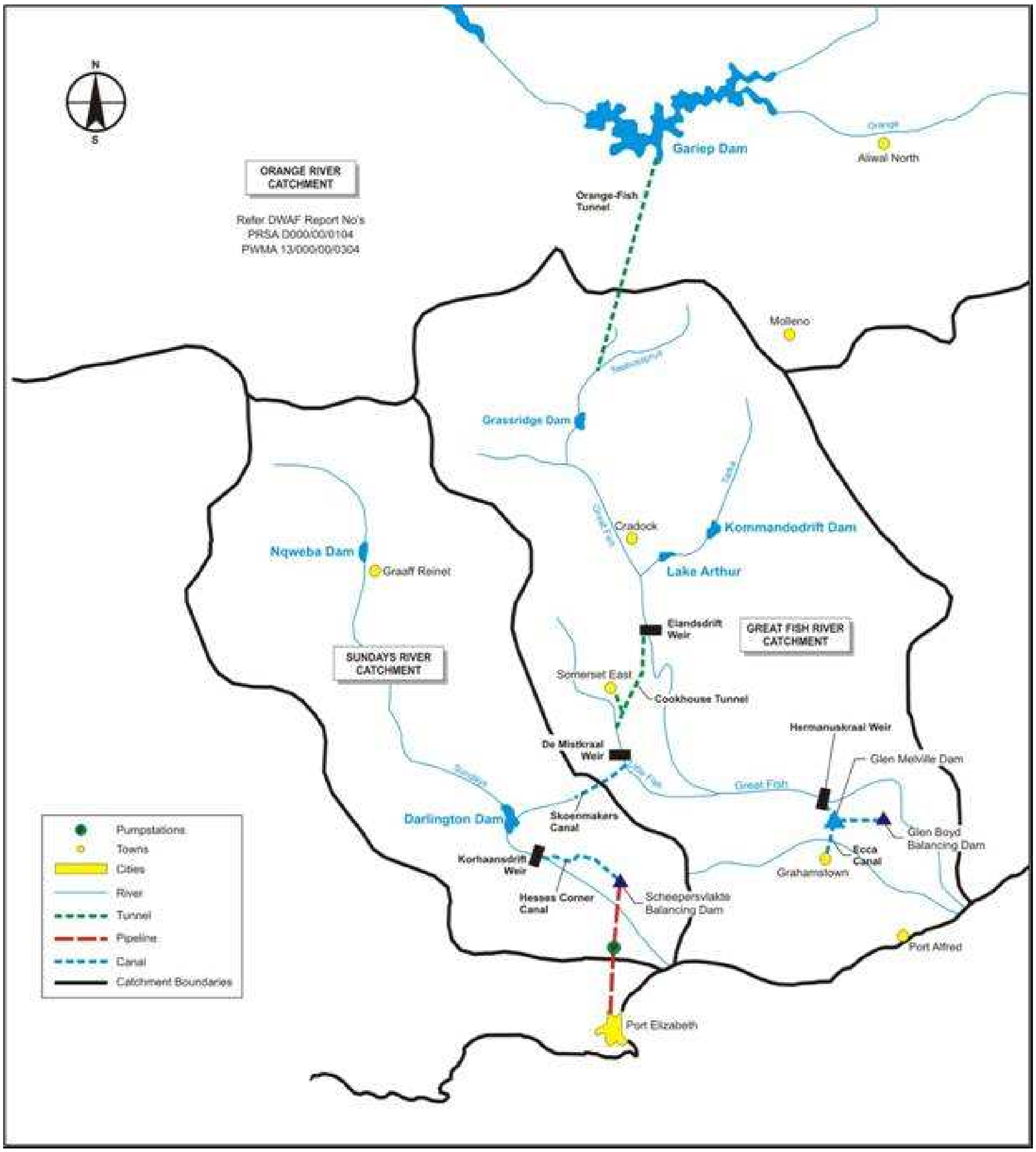


Figure 1 Schematic layout of the Orange-Fish-Sundays Transfer Scheme

Figure 2 The Kouga/Gamtoos Rivers catchments

2. SCHEME DESCRIPTION

Verification and validation of abstraction rights is the process that would be followed to determine compliance with existing agricultural and urban abstraction and storage rights. Many of these abstraction rights stem from earlier Water Court rulings, as well as Agreements (usually included on the Title Deeds) between irrigators sharing a common source, and the storages and abstraction rates from the issue of permits in terms of Section 9B of the Water Act (Act 54 of 1956). Many water users in the Langkloof area also lay claim to water entitlements through assumed prescriptive rights, but the DWA and the local Irrigation Boards are not aware of any such prescriptive rights ever having been proven.

The process would involve the following :

- Obtaining all Water Court rulings, 9B permits and the dates of other rulings such as the 9B(1C) ruling in the upper part of the catchment of the Kouga River which limited the construction of additional farm dams and also limited abstraction rates for any new waterwork.
- In addition, actual usage as at 26 August 1998 (the date of promulgation of the National Water Act, Act 36 of 1998) would need to be determined based on aerial photography or satellite imagery at that time. As a lawful right is also based on the water use for the 2 year period leading up to the date of promulgation, any aerial photography during this period would also be of value in this exercise.
- Thereafter, field surveys would be conducted to verify that the existing diversion and storage infrastructure complies with all the relevant legal stipulations, in order to determine the extent of legal irrigation in 1998.
- Anomalies would be identified, measures to correct the anomalies would be determined as well as long-term monitoring measures.

This process will ensure that water within the catchment areas is allocated and used in accordance with the existing legal rights of the users.

Catchments of the AWSS

The catchments upstream of the dams in the AWSS are practically fully developed with existing land and water resources fully allocated and under stress to meet demand. The Gamtoos Irrigation Board is concerned about the perceived decline in the yield of Kouga Dam on account of upstream irrigation. This apparent decline appears to have resulted in reduced availability of water for the Gamtoos Irrigation Board and NMBM with increasing need for restrictions.

In the Langkloof, the fertile soil in the valleys of the upper tributaries of the Kouga River catchment is intensively cultivated. Large areas of deciduous fruit orchards and some pasture are grown under irrigation, using water stored in a large number of farm dams. The valley upstream of Churchill Dam is an extension of the Langkloof and is intensively cultivated. Areas of deciduous fruit orchards, pasture, and vegetables are irrigated from farm dams and from water abstracted directly from the river.

Although many studies have been done, there remains uncertainty regarding the extent of irrigation usage in the Langkloof upstream of the Kouga Dam. It is generally accepted that the Kouga/Loerie sub-system is over-allocated, that the confidence in the water balance of this sub-system is low, and that the water balance of this sub-system must be revisited. Only a very detailed evaluation of the Kouga catchment could provide clarity.

In order to provide greater certainty on the availability of water from Kouga Dam, it is proposed that existing legal water usage is verified as described above, and that the hydrological model of the catchment is recalibrated accordingly. Thereafter, abstraction control will be necessary to ensure that legal abstraction rights are complied with.

The Orange-Fish-Sundays GWS

Large quantities of water are transferred from the Gariep Dam on the Orange River via the Orange-Fish Tunnel, the Fish River and the Fish-Sundays Canal to the fertile valleys of the Eastern Cape. Most of the water supplied through the tunnel is used for irrigation purposes. The volume of water transferred fluctuates on an annual basis according to local catchment yield and crop mix, areas irrigated, requirements for freshening, local rainfall and availability of Orange River water to be transferred.

Transferred water released from the Grassridge Dam is used by the various sub-areas of the Great Fish River WUA for irrigation along the Great Fish River, down to the confluence with the Little Fish River. Irrigation along part of the lower Tarka River also falls under this scheme. Riparian owners downstream of the confluence with the Little Fish River abstract water on an opportunistic basis. Grahamstown and the Tyhefu Irrigation Scheme along the lower Fish River are supplied with water of suitable quality through pulse releases from the Elandsdrift Weir, but with significant losses on account of the need to first scour the saline return flows and there is potential for alternative schemes to reduce water losses. At the Elandsdrift Weir about 163 million m^3/a is diverted for eventual use in the lower Sundays River valley. All along the way water is used for irrigation.

The inter-basin transfer from the Gariep Dam on the Orange River contributes about 560 million m^3 per year to the Fish and Sundays Rivers, mainly for irrigation and to dilute the salinity levels in these rivers when there is surplus water in the Orange River system. Current water supply for irrigation from the Orange River to the Lower Sundays River Water User Association is about 99 million m^3 per year, with an allocation of 155 million m^3/a (424 Ml/day).

A total of 4 000 ha of additional allocations of Orange River water, involving an estimated 38 million m^3/a, has been reserved for resource-poor farmers in the Fish and Sundays Rivers catchments. This will mainly involve new licensing, but small quantities of this water allocation have already been licensed.

Inefficiencies in irrigated agriculture are generally significant, although the irrigation in the Lower Sundays Irrigation Board area is regarded as very efficient. Canal losses in the Fish River catchment are significant. Serious attention should be paid to the option of lining earth canals. River losses of transferred Orange River water are also significant. Potential exists for the intensification of irrigated agriculture in the Fish and Sundays River catchments, through conversion to higher value crops, along with the establishment of an associated agricultural processing industry, as well as a move towards more efficient irrigation methods.

3. SCHEME YIELD

It is not possible to estimate the yields that will be "freed up" through verification of existing water use and improved abstraction control.

4. UNIT REFERENCE VALUE

No URV can currently be calculated.

5. ECOLOGICAL

The overall ecological implications of abstraction control in accordance with verified and validated water use are uncertain, but are likely to have a positive impact on the riverine environment. However, any changes to the existing freshening release regimes into the Lower Fish River may be perceived to be detrimental to the ecology, although this is not a natural flow regime.

6. SOCIO-ECONOMIC

Verification and validation of existing legal water use and abstraction control thereafter should have no socio-economic impacts. However, the additional allocations to be made in the Lower Sundays River valley provide an important opportunity to catalyse redress of water allocation and water reform in terms of race and gender, and improve equity in water use. Water may also have to be freed up from existing users to meet targets for HDI use. Because of the fragile balance between existing water use and the economic vulnerability of the predominantly agricultural users, it seems that the most suitable approach to reform will be one of adaptive management, over time, to allow for adaptation and gradual managed reforms in water use practices.

7. OTHER ISSUES

Specific strengths and weaknesses of verification and validation of existing lawful use and abstraction control include:

- **Strengths**
  - o This is seen as a fair and even handed process that will focus on ensuring that the legal abstraction rights of existing users are adhered to.
  - o Existing infrastructure could potentially be used to abstract such additional yield.

- **Weaknesses**
  - o The processes to be followed are slow and the farming community may show resistance to the process.
  - o The potential yield is unknown.

SECTION B

URBAN WATER CONSERVATION AND DEMAND MANAGEMENT

B1. Introduction to Urban Water Demand Management Intervention Options

The information presented on urban water conservation and demand management is based on the outcomes of the Algoa Water Supply Pre-Feasibility Study (1999/2000) by BKS Acres (Volume – "Development of as Water Demand Management Programme") and the Algoa Water Resources Bridging Study" (2007/2008) by WRP (Pty) Ltd (Draft Volume – "Draft Water Conservation and Water Demand \Management Strategy", Oct 2007).

As water is a scarce resource, it needs to be used in an efficient and effective manner. Legislation has been put in place in South Africa to ensure that this requirement is met.

The objective of water conservation and water demand management (WC/WDM) is to minimise water wastage and to ensure the optimal use of water, which often requires a fundamental shift in the perception of users of the value of water. This can be achieved through a number of initiatives as listed below, and is presented in more detail in this document:

- Leakage detection and repair;
- Leakage repair beyond the meter;
- Pressure management;
- Use of water efficient fittings;
- Elimination of automatic flush urinals (AFUs);
- Adjustment of water tariffs, metering and credit control;
- User education.

Although not necessarily direct water demand management initiatives, the following supply augmentations could potentially also be considered under WC/WDM, but have not been considered here:

- Grey water usage;
- Use of private well points and boreholes.

The elimination of AFUs will have limited water saving benefits in the NMBM area of supply. During the severe drought of 1989 to 1992, water rationing was implemented on two occasions and, due to the serious situation, a major drive towards the eradication of AFUs was launched at all hotels and businesses. Since then, approved building plans did not permit the use of AFUs.

Water wastage is generally attributed to distribution losses (leakages) and wastage by users, e.g. leaks within properties and indiscriminate wastage (e.g. taps left open).

Inefficient water usage is attributed to the fact that water is often used for the service that is derived from it, rather than for the water itself. As gardening and toilet flushing represent approximately 35% and 30% respectively of the total domestic water requirements, they are key focus areas for targeting inefficiencies. Certain industries and large bulk users would also be sectors to target.

The various WC/WDM options have not been presented as individual interventions in this document, due to a lack of up-to-date and in-depth evaluation data. The WC/WDM intervention has therefore been presented as two main interventions, as described below.

INTERVENTION 1: WC/WDM DOWNSTREAM of USER METERS

- Retrofitting of inappropriate plumbing and sanitation fittings;
- Leakage repair beyond the meter;
- Pressure management;
- Use of water efficient fittings;
- Elimination of automatic flush urinals;
- Adjustment of water tariffs;
- User education.

INTERVENTION 2: WC/WDM UPSTREAM of USER METERS

- Leakage detection and repair;
- Pressure management;
- Staff training & motivation;
- Improved meter reading & billing system/credit control;
- Meter replacement programme (domestic & industrial).

As part of the Algoa Water Supply Pre-Feasibility Study (Volume – "Development of a Water Demand Management Programme"), an analysis was undertaken to determine the potential water savings based on specific reservoir supply zones, interrogation of meter reading data bases, water balances and staffing strengths/ weaknesses. It was concluded that up to 22 Ml/day could be cost effectively saved.

The Algoa Water Resources Bridging Study summarised the NMBM key performance Indicators (KPIs) for WC/WDM as shown in the following Table:

Table 1 : Basic System Data and Performance Indicators for WC/WDM

Parameter	KPI
Number of connections (communication with S Groenewald: Nov 2007)	191 000
Length of mains (communication with S Groenewald: Nov 2007)	3 600 km
Density of connections (communication with S Groenewald: Nov 2007)	53 conn/km
Average pressure (communication with S Groenewald: Nov 2007)	45 m
System input volume (m^3 /a): value supplied by NMMM	90.0 million m^3/annum
System input per connection	1 290 litres/conn/day
Billed consumption (m^3/a): value supplied by NMMM	57.3 million m^3/annum
Total Water Losses (m^3/a) = input – billed consumption	32.7 million m^3/annum
Apparent losses (estimated to be 15 % of total losses)	4.9 million m^3/annum
Real Losses (= total losses – apparent losses) in m^3 per year	27.8 million m^3/annum
Real Losses in litres /conn/day =ARL	399 litres/conn/day
Unavoidable Annual Real Losses (UARL) from BABE***** in m^3 per year	3.6 million m^3/annum
Unavoidable Annual Real Losses (from BABE) in litres/conn/day	51 litres/conn/day
Non revenue water as % of system input (i.e. 32.7 / 90.0)	± 36 %
Apparent Losses as % of System Input (poor indicator – use with caution)	± 5%
Real losses as % of System Input (poor PI to be used with caution)	± 31%
Infrastructure leakage index (ILI) = ARL / UARL	± 7.8

** Burst and Background Estimate methodology*

Based on this information (indicated in Table 1), the following is stated in the Draft WC/WDM Strategy (October 2007):

- "Less than two thirds of the water supplied to the system is sold (i.e. 57.3 million m^3/a compared to 90.0 million m^3/a).

- The percentage real losses are relatively high at over 30% although it must be noted that this is a poor performance indicator and can often be misleading.

- The Infrastructure Leakage Index is approximately 8, which indicates that the actual physical losses (leakage) from the system are 8 times higher than the minimum level of leakage that would normally be expected from such a system. It should be noted that it is rarely possible to reduce the leakage to the minimum level, however an ILI value of between 3 and 4 should be possible in most South African systems. A value of 8 is relatively high and suggests that significant reductions in wastage are possible. It would obviously be necessary to undertake more detailed water balances at a District level, to help identify the pockets of high leakage/wastage so that efforts can be concentrated where they will yield the highest savings."

Based on the above comments, it can be assumed that opportunities do exist within the NMBM water supply system to bring about water savings.

B2. WC and WDM upstream of consumer meters

1. BACKGROUND TO INTERVENTION

The Algoa Water Resources Bridging Study Report is being compiled on a broad-based assessment and not on field measurements, in-depth interrogation of data, and previous studies, as originally indicated in the Study's Inception Report.

Detailed system analysis for zone and sub-zone water balances is not yet available. The Draft WC/WDM Strategy Report (from the Algoa Bridging Study) however indicated that for the NMBM water supply system as a whole, "*the Infrastructure Leakage Index is approximately 8, which indicates that the actual physical losses (leakage) from the system are 8 times higher than the minimum level of leakage that would normally be expected from such a system."*

A value of 8 is considered high (most SA systems should be able to achieve an Infrastructure Leakage Index (ILI) of 3 to 4) and is indicative of significant savings being possible.

2. INTERVENTION DESCRIPTION

The Bridging Study (Draft Water Conservation and Water Demand management Strategy (2007)) reported that the NMBM has performed as follows on the various activities related to this intervention:

- Water Balance - Monthly detailed analysis of "water purchased" and "water sold" and an annual water balance;
- Sectorisation of reticulation system: of a total 162 zones, zone meters have been installed in 140 zones;
- A leakage reporting and repair system is in place but can be improved on.

The Report has also indicated that in 2007 the following shortcomings still existed within the NMBM water management:

- No formal WC/WDM section is in place;
- A WC/WDM Manager should be appointed;
- No active leakage control system is in place; a passive leakage repair system (reaction to visible leaks reported only) is in operation.

This option entails the roll-out of an active WC/WDM Section within the NMBM Silo for Water and Sanitation, controlled by a full-time WC/WDM Manager. The WC/WDM Section should perform the following activities:

- Monthly readings of all zone meters;
- The conducting of monthly water balances to identify zones and sub-zones with leakage problems;
- The locating and repair of those leaks within the system as part of an active leakage control system.

The WC/WDM Section should agree on all relevant KPIs and constantly evaluate the WC/WDM programme against these KPIs.

3. OPTION YIELD

The potential savings due to leakage repair is linked to the unaccounted-for water (UAW) for a specific area, where UAW is the difference between the bulk input into the area and the measured usage within that area.

As it is generally accepted that UAW cannot economically be reduced to below 15% of the annual average daily demand (AADD) due to the high costs of identifying and repairing background leakage (small leaks). The potential saving is therefore the difference between actual UAW and the 15% of AADD target (provided the actual UAW is above the 15% level).

It is estimated that between 5 Ml/day (1.83 million m^3/annum), as a Low Scenario, and 10 Ml/day (3.65 million m^3/annum), as a High Scenario, could be achieved as a saving from this intervention.

It is assumed that this saving will materialise over 3 to 5 years at savings of approximately 2 Ml/day per month.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows :

Table 1 : WC/WDM upstream of consumer meters URVs

ITEM	Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Capital cost (R mill)	4.6	4.6	4.6	4.6
Annual operating cost (R million/annum)	5.0	5.0	5.0	5.0
NPV Cost (R million)	134.6	95.9	72.2	61.3
Unit Reference Value (R/m^3)	1.68	1.80	1.95	2.06

No operating and maintenance costs have been accounted for in the estimated capital costs, as it has been allowed for under the NMBM's existing budget.

5. ECOLOGICAL

Degradation of riverine environment and catchments has a direct impact on the quality, quantity and ecological integrity of surface and groundwater resources. Despite the fact that water is a scarce resource in South Africa, large volumes are wasted on a daily basis while the demand for it increases.

By implementing the intervention measures mentioned in this section, management of this scarce resource would improve. This would also help to reduce the current pressure that the environment and water resources are experiencing, to meet the increasing demand for water. It is very important to manage this resource correctly and use it wisely to manage the ecological integrity of alternative potential water resources, and to ensure sustainable use thereof.

6. SOCIO-ECONOMIC

Should the current pattern of wastage continue, the price for water could increase to such levels that it will affect all users and the economy negatively. WC/WDM therefore helps to keep water affordable. It further extends the outlay of high capital costs for expensive water resource and purification infrastructure.

The proposed interventions are labour-intensive and would provide an increasing number of semi-skilled and skilled employment opportunities. This would also assist in reducing the current unemployment rate (27%) in the Eastern Cape and improve the livelihoods and earnings of the people in the area.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include :

- **Strengths**
  - Relatively quick to implement for short-term benefits.
  - Has certain socio-economic benefits, e.g. can create employment opportunities.

- **Weaknesses**
  - It requires ongoing team inputs and assessments to remain effective.
  - Needs continuous involvement i.e. it can’t be a once-off initiative for sustainable benefits.
  - It would have an institutional impact on the authority.

B3. WC and WDM downstream of consumer meters

1. BACKGROUND TO INTERVENTION

The Bridging Study Report is being compiled on a broad-based assessment and not on field measurements or in-depth interrogation of data and previous studies as per the Study's Inception Report.

Detailed analysis of night flows for all reservoir supply zones within the NMBM water supply area, is therefore not available to this study. Based on the historic supply system performances noted in the Algoa Water Supply Pre-Feasibility Study, an update was obtained for the Motherwell Zone, to have some verification of previous data. The results confirmed that major night flows still exist in this reservoir zone.

2. INTERVENTION DESCRIPTION

From available information, the NMBM has implemented the following programmes and actions to date:

- A *domestic meter replacement programme*. In 2006/07 about 18,000 meters were replaced at a cost of R4.5 million, and in 2007/08 about 12,000 meters were replaced at a cost of R3.5 million.

- An *industrial meter replacement programme*. In 2006 a total of 460 industrial meters were replaced, which represents 17.5% of the 2 622 industrial meters.

- A *leak repair programme* for households registered under the ATTP programme. Over a period of about 3 years, more than 7 000 on-site leaks have been repaired, of which about 90% were leaking cisterns (Beta Type). The current programme at present repairs between 700-1 000 on site leaks per month (meter readings > 12 kl/month).

- A *three-stepped water tariff* is in use throughout the Metro. For the 2007/08 financial year, the 0-30 kℓ/month water use scale was at R4.49/Kℓ, whereas the >60 Kℓ/month water use scale was R6.75/kℓ.

- An investigation was undertaken into water use in 35 *schools* in the NMBM supply area. The report confirmed huge water wastages and poorly maintained water and sanitation systems. The six highest consumers were using about 260 ℓ/s (22 Ml/day). Part of this high use could potentially be attributed to meter malfunctioning or reading errors.

- Consumer education through informative prints with monthly billing

This intervention is based on the continued roll-out of the previously-mentioned programmes and the addition of the following activities to the WC/WDM programme:

a) A public awareness/ user education programme;
b) A schools (educators and learners) awareness programme;
c) Retrofitting of inappropriate plumbing and sanitation fittings ;

d) Pressure management;

e) Use of water-efficient fittings;

f) Elimination of automatic flush urinals.

3. YIELD

It is estimated that between 5 Ml/day (1.83 million m^3/a), as a Low Scenario, and 10 Ml/day (3.65 million m^3/a), as a High Scenario, could be achieved as a saving from this intervention.

It is assumed that this saving will materialise over 3 to 5 years, at approximately 2 Ml/day saving achieved per year.

4. UNIT REFERENCE VALUE

The URV for an option such as this is difficult to determine as the costs and savings will vary from area to area and will be dependent on the efficiency of the implementation initiative. Once the saving has been achieved, the programme and financial expenditure must be continued to sustain the saving. The estimated costs are tabulated below:

Table 1 WC/WDM downstream of consumer meters URVs

ITEM	Discount Rate 0 %	Discount Rate 3 %	Discount Rate 6 %	Discount Rate 8%
Capital cost included in operating costs				
Annual operating cost (R million/annum)	7.7	7.7	7.7	7.7
NPV Cost (R million)	201.3	142.6	106.7	90.3
Unit Reference Value (R/m^3)	2.51	2.67	2.88	3.03

No direct capital costs have been included in these URV calculations. Capital is included in the annual budget amounts as an ongoing project operating cost.

5. ECOLOGICAL

Degradation of riverine environment and catchments has a direct impact on the quality, quantity and ecological integrity of surface and groundwater resources. Despite the fact that water is a scarce resource in South Africa, large volumes are wasted on a daily basis while the demand for it increases.

By implementing the intervention measures mentioned in this section, management of this scarce resource would improve. This would also help to reduce the current pressure that the environment and water resources are experiencing, to meet the increasing demand for water. It is very important to manage this resource correctly and use it wisely to manage the ecological integrity of alternative potential water resources, and to ensure sustainable use thereof.

6. SOCIO-ECONOMIC

Should the current pattern of wastage continue, the price for water could increase to such levels that it will affect all users and the economy negatively. WC/WDM therefore helps to keep water affordable. It further extends the outlay of high capital costs for expensive water resource and purification infrastructure.

The proposed interventions are labour-intensive and would provide an increasing number of semi-skilled and skilled employment opportunities. This would also assist in reducing the current unemployment rate (27%) in the Eastern Cape and will improve the livelihoods and earnings of the people in the area.

7. OTHER ISSUES

Specific strengths and weaknesses of the intervention include:

- **Strengths**
    - o Short implementation period.
    - o Positive socio-economic, environmental and financial impacts.
    - o Ongoing capital costs are funded through savings after about three years.
    - o Increases the longevity of both water and wastewater infrastructure.
    - o Delays capital expenditure on augmentation infrastructure.

- **Weakness**
    - o Household leak repairs are limited to ATTP households only; other on-site leaks are not addressed
    - o Has large institutional implications; schools e.g. suffer due to lack of support from Provincial Government.
    - o Often fails because of political support at local government level.
    - o The sustainability of the benefits over the long-term is unknown.

B4. Rainwater harvesting for household use

1. SCHEME LAYOUT

The potential for rainwater harvesting is applicable throughout the study area.

2. OPTION DESCRIPTION

Background information was obtained from the Western Cape Water Reconciliation Study Report (Interventions - 2007) and the WRP Study Proposal Document for rainwater harvesting aspects of the Water Reconciliation Strategy Study for the KwaZulu Natal coastal metropolitan areas.

This option, which is in fact a supply augmentation option as opposed to a demand management option, entails the collection of rainwater from roofs, primarily for toilet flushing. The collection of rainwater for supplementing of garden water use is deemed as an extension of this option and would be applicable mostly to the high income group which is the largest gardening water users. The latter extension, in turn, could be supplemented by the phasing in of grey water use.

Storage tanks available in the market have been designed to add special feature value to properties and not to deface and devalue when put into practice.

Figure 1 Rainwater storage tanks

The costs of the infrastructure required to implement this option vary significantly from installation to installation, depending on the roof configuration and the location of the toilets.

3. OPTION YIELD

A sensitivity analysis was done for Port Elizabeth daily rainfall figures for the period 1992-2008, based on 100 m^2 roof area and 5% evaporation/absorption losses.

Table 1 Average annual rainwater harvested from rainwater tank

Storage tank volume (*l*)	Annual Average Rainwater harvested from tank / 100 m^2 roof (*l*/yr)						
	Daily water consumption from tank (*l*/d)						
44,205	50	100	200	300	400	600	800
1,000	16,457	24,411	30,585	34,029	36,417	39,739	42,268
2,000	17,827	29,785	37,748	40,898	42,732	45,043	46,818
3,000	18,175	32,438	41,702	44,799	46,372	48,314	49,656
5,000	18,234	34,838	46,088	49,016	50,422	51,939	52,918
7,500	18,234	35,964	49,282	52,147	53,336	54,361	55,102
10,000	18,234	36,396	51,533	54,157	54,948	55,694	56,190
15,000	18,234	36,396	54,318	55,985	56,362	56,811	56,916
20,000	18,234	36,396	55,748	56,811	57,123	57,172	57,172
30,000	18,234	36,396	57,172	57,172	57,172	57,172	57,172

Percentage rainwater used

Storage tank volume (*l*)	Rainwater consumed / Rainwater falling on roof (%)						
	Daily water consumption from tank (*l*)						
77.3%	50	100	200	300	400	600	800
1,000	28.8%	42.7%	53.5%	59.5%	63.7%	69.5%	73.9%
2,000	31.2%	52.1%	66.0%	71.5%	74.7%	78.8%	81.9%
3,000	31.8%	56.7%	72.9%	78.4%	81.1%	84.5%	86.9%
5,000	31.9%	60.9%	80.6%	85.7%	88.2%	90.8%	92.6%
7,500	31.9%	62.9%	86.2%	91.2%	93.3%	95.1%	96.4%
10,000	31.9%	63.7%	90.1%	94.7%	96.1%	97.4%	98.3%
15,000	31.9%	63.7%	95.0%	97.9%	98.6%	99.4%	99.6%
20,000	31.9%	63.7%	97.5%	99.4%	99.9%	100.0%	100.0%
30,000	31.9%	63.7%	100.0%	100.0%	100.0%	100.0%	100.0%

Percentage days needing supplement with potable water

Storage tank volume (l)	Percentage of days needing supplement with potable water						
	Daily water consumption from tank (*l*)						
42.9%	50	100	200	300	400	600	800
1,000	10.5%	35.9%	62.3%	74.4%	81.2%	88.6%	91.5%
2,000	2.6%	20.0%	52.3%	68.1%	76.4%	85.8%	90.1%
3,000	0.5%	12.1%	46.6%	64.1%	73.9%	84.1%	89.1%
5,000	0.2%	5.0%	40.1%	60.0%	70.9%	82.4%	87.9%
7,500	0.2%	1.7%	35.4%	56.9%	68.8%	81.2%	87.1%
10,000	0.2%	0.4%	32.0%	55.0%	67.6%	80.5%	86.7%
15,000	0.2%	0.4%	28.0%	53.2%	66.6%	80.0%	86.4%
20,000	0.2%	0.4%	25.9%	52.3%	66.0%	79.8%	86.3%
30,000	0.2%	0.4%	23.8%	52.0%	66.0%	79.8%	86.3%

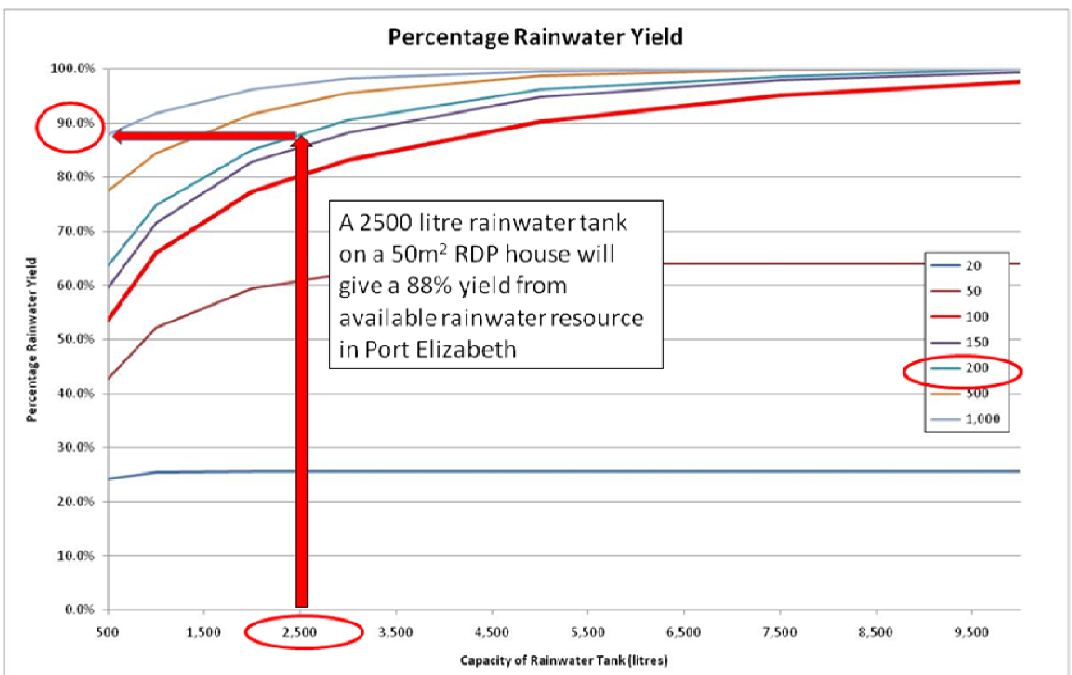
The potential yield for this option is affected by the combination of rainfall patterns, roof areas utilised and storage volumes supplied. The following conclusions can be made from the above sensitivity analysis :

- Per 100m^2 roof area, a 20 Kl storage tank could maximise storage by capturing 100% runoff from the roof area in the amount of 57 Kl/annum.
- In order to maximise storage capturing, the draw must be more than 400 L/day
- Draws of 400 L/day will require supplement from municipal system 66% of the time and 500 L/day will require supplement 80% of the time.
- In order to economize (per 100 m^2 roof) the variables of tank size (capital) and percentage time supplementing from municipal system, the following "scheme" size appears to be appropriate:

Roof Drainage Area [Port Elizabeth]	= 100 m^2
Tank storage capacity	= 5 m^3
Yield (draw off)	= 200 L/day (basic demand)
Annual Yield (volume harvested)	= 46.3 m^3 [63% x Basic demand]
Efficiency	= 80% run-off collected
Average Supply from Municipal	= 26.7 m^3 [37% x basic demand]

The self supply option, due to its initial direct capital layout requirements, will be limited to middle and high income groups.

The similar optimisation exercise was **based on 50 m^2 roof** for a low cost housing unit with Port Elizabeth daily rainfall figures over some 40 years as demonstrated below.



Roof Drainage Area	= 50 m^2
Tank storage capacity	= 2.5 m^3
Yield (draw off)	= 200 L/day (basic demand)
Annual Yield (volume harvested)	= 25.2 m^3 [35% x Basic demand]
Efficiency	= 88% run-off collected
Average Supply from Municipal	= 47.8 m^3 [65% x basic demand]

4. UNIT REFERENCE VALUE

The URVs for this option (**100 m^2 roof**) is based on an assumption of the capital costs to be incurred for supply & installation of 5 m3 tanks and connector works to ensure a pressurised supply for normal household applications. The URV calculation per household is based on social discount rates of 0%, 3%, 6% and 8% applied for a 25 year period and annual maintenance cost of R 150.00/annum.

ITEM	Discount Rate 0 %	Discount Rate 3 %	Discount Rate 6 %	Discount Rate 8 %
Total capital cost (R)	13,500	13,500	13,500	13,500
Annual operating cost (R /annum)	150	150	150	150
NPV Cost (R)	16,950	15,573	14,581	14,055
Unit Reference Value (R/m^3)	15.4	20.6	26.8	31.3

Note: To opt for a smaller storage tank, will yield less water per annum, will increase the URV values and increase the time of dependence on the municipal water supply system.

Similarly, the URVs were determined for the (**100 m^2 roof area**) supply & installation of 5m^3 tanks and basic tap & overflow for basic usage for a maintenance cost of R100 per every second year.

ITEM	Discount Rate 0 %	Discount Rate 3 %	Discount Rate 6 %	Discount Rate 8 %
Total capital cost (R)	7,800	7,800	7,800	7,800
Annual operating cost (R /annum)	50	50	50	50
NPV Cost (R)	9,000	8,568	8,196	7,976
Unit Reference Value (R/m^3)	8.1	11.3	15.1	17.8

Finally, the URVs were determined for the **(50 m^2 roof area)** supply & installation of 2.5m^3 tanks and basic tap & overflow for basic usage at a maintenance cost of R80 per every second year.

ITEM	Discount Rate 0 %	Discount Rate 3 %	Discount Rate 6 %	Discount Rate 8 %
Total capital cost (R)	4,740	4,740	4,740	4,740
Annual operating cost (R /annum)	50	50	50	50
NPV Cost (R)	5,940	5,597	5,310	5,142
Unit Reference Value (R/m^3)	9.8	13.5	17.8	20.9

5. ECOLOGICAL

Water used from rainwater tanks would help to relieve current pressure on the natural systems and local municipalities to provide water, which would have an overall positive impact on the ecological environment.

6. SOCIO-ECONOMIC

Due to the high costs of rainwater tanks and the installation thereof, poor and middle income groups would most likely be unable to afford this option. In addition, due to the current economic conditions and trends, the size of these two groups would most likely increase over the next few years, potentially hampering the effectiveness of this scheme. Also, changes in weather systems due to climate change could result in droughts occurring more frequently, increasing requirements and pressure on water resources, making this a more attractive option to consumers. Material can be obtained from small business enterprises which will support job opportunities.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

- **Strengths**
  - Quick to implement.
  - Recent reductions in the costs of rainwater tanks have made it more affordable.
  - Recent improved aesthetics of tank designs, has made it more attractive for implementation by high income groups, particularly for garden watering and swimming pool top-up, etc..
  - Drought conditions and water restrictions could result in more than the expected number of tanks to be implemented.

- **Weaknesses**
  - The use of unsterilised rainwater from rainwater tanks for domestic purposes has been prohibited since 1972, however this bylaw will be changed in the near future.
  - The option would largely be driven by the property owner.
  - Limited potential savings.
  - Expensive to implement.
  - The use of simple rainwater tanks in low income areas for vegetable garden watering may provide socio-economic benefits, provided that this does not lead to increased water usage during periods of low inflow into the dams (see B5).

SECTION C

TRADING OF WATER USE AUTHORISATIONS

C1. Water trading - Baviaanskloof

1. BACKGROUND

The National Water Act (Act 36 of 1998) (hereafter "NWA") was promulgated in the Government Gazette of 26 August 1998. Section 25 (2) of this Act, titled "Transfer of Water Use Authorisations" makes provision for the trading of water entitlements, and reads as follows:

"A person holding an entitlement to use water from a water resource in respect of any land may surrender that entitlement or part of that entitlement:

(a) in order to facilitate a particular licence application under Section 41 for the use of water from the same resource in respect of other land; and
(b) on condition that the surrender only becomes effective if and where such application is granted."

The availability of some 150 ha of irrigation entitlements in the Baviaanskloof, upstream of Kouga Dam, has been noted. The Study Management Committee Meeting of the Pre-Feasibility Study of Water Supply Options for the Algoa Region (5 August 1999) minuted that DEAE&T wished to consolidate the two mountain wilderness areas by buying the 21 farms in the Baviaankloof Valley. It was minuted that 9 of the 21 farmers have then offered to sell their farms.

2. SCHEME DESCRIPTION

This option entails the negotiating and purchasing of irrigation entitlements on some 150 ha of land within the Baviaanskloof Valley to possibly supplement the NMBM allocation of water supply from the Kouga Dam.

There is no history of past trading in this area and unit rates for similar transactions in the upper Great Fish River, has thus been applied. Based on historical transactions elsewhere, this trading could be achieved at a cost of some R25 000/ha for undeveloped entitlements and some R68 000/ha for developed entitlements. For this intervention, a 100% developed entitlement was assumed.

3. OPTION YIELD

There are no established water entitlements in the area. It is not even known by DWAE whether all the water uses have been registered. A programme of validation and verification of water entitlements will have to be completed before any transfer to the NMBM can take place.

Based on an irrigation water requirement of 800 mm per annum, the water entitlements to be transferred to NMBM, could amount to 18 Ml/annum/ha, i.e. 1.2 million m^3/annum (3.3 Ml/day) at source. Evaporation losses from source to Loerie Dam are estimated to be some 25%. Net yield of this intervention could thus amount to **0.9 million m^3/annum (2.5 Ml/day)**

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

Table 1 Baviaanskloof Water Trading URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Capital cost	**(R million)**	10.2	10.2	10.2	10.2
Annual operating cost	**(R million/annum)**	0.49	0.49	0.49	0.49
NPV Cost	**(R million)**	21.5	17.5	15.0	13.8
Unit Reference Value	**(R/m^3)**	1.02	1.24	1.50	1.70

1) Present O&M charged by the Gamtoos Irrigation Board amounts to R726,289 for 23,5 million m^3/a (3.1c/m^3) (2009/2010).
2) Present DWA charges for water abstracted by NMBM at Loerie is 50.93c/m^3 (2009/10)
3) No other operating and maintenance costs are involved.

5. ECOLOGICAL

This option will have no significant implications for the natural environment.

6. SOCIO-ECONOMIC

This option has minimal socio-economic effects as it is focused on farmers who have been scaling down on farming activities for some years.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include :

- **Strengths**
  - Relatively quick to implement for short-term benefits.
  - Additional supply from this source can be accommodated within existing spare capacities along main canal, Loerie WTW and rising pipeline.

- **Weaknesses**
  - Could reduce a minimal number of jobs on farms.
  - No established water entitlements exist for this area. A programme of validation and verification of water entitlements will have to be completed before any transfer to NMBM can be made.
  - Potential yield may be very much less than assumed.

C2. Water trading – upper Great Fish River

1. BACKGROUND

The National Water Act (Act 36 of 1998) (hereafter "NWA") was promulgated in the Government Gazette of 26 August 1998. Section 25 (2) of this Act, titled "Transfer of Water Use Authorisations" makes provision for the trading of water entitlements, and reads as follows:

"A person holding an entitlement to use water from a water resource in respect of any land may surrender that entitlement or part of that entitlement –

(c) in order to facilitate a particular licence application under Section 41 for the use of water from the same resource in respect of other land; and

(d) on condition that the surrender only becomes effective if and where such application is granted."

The availability of irrigation entitlements in the Upper Fish River is unknown.

The present economic recession in RSA together with ever increasing farming input costs have put many farmers under financial pressure and it is anticipated that land and/or irrigation rights could become available for Water Trading as permitted within the National Water Act.

2. SCHEME DESCRIPTION

DWA Eastern Cape Cradock office advised as follows:

"A total of 50 068 ha using 531,4 million cubic metres per annum (losses excluded) are presently irrigated in the Fish-Sundays system using Gariep Dam water. This total of 50 068 ha remains in the Eastern Cape after 2 254,2 ha was transferred to outside the Eastern Cape since 26 August 1998 (when the NWA came into force). The total of irrigated area traded in the Eastern Cape since August 1998 stands at 3 228 ha, of which the 2 254,2 ha was transferred outside of the EC borders, *leaving 973,8 ha which changed ownership within the borders of the EC."*

This option entails the identification (through agents and advertising), negotiating and purchasing of irrigation entitlements on less than 5% (1 500-2 000 ha) of land within the Fish-Sundays system, focussing on the upper reaches of the Great Fish River, to supplement the NMBM allocation of urban water use, supplied from the ORP.

Based on historical transactions elsewhere, this could be achieved at a cost of some R35 000/ha for undeveloped entitlements and some R88 000/ha for developed entitlements. For this intervention, a 10/90 division was assumed.

3. OPTION YIELD

Based on an irrigation water requirement of 12 500 m^3/ha/annum, the water entitlements to be transferred to NMBM for 1 800 ha, could amount to 22.5 million m^3/annum (61.6 Ml/day).

Evaporation losses from source to Scheepersvlakte Dam (Sundays River Water User Association) are estimated to be some 30%.

Net yield of this intervention could thus amount to **15.75 million m^3/annum (43.1 Ml/day).**.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

Table 1 Upper Great Fish River URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Capital cost	(R million)	147.8	147.8	147.8	147.8
Annual operating cost	(R million/annum)	19.4	19.4	19.4	19.4
NPV Cost	(R million)	577.2	423.8	330.9	288.3
Unit Reference Value	**(R/m^3)**	1.66	1.84	2.06	2.24

Notes :

1) Present maintenance and transfer fees charged by DWA to NMBM at Scheepersvlakte Dam amounts to R0.98 / m^3 (2009/2010).
2) Transfer operating costs to Olifantskop reservoir site has been taken into account.
3) No other operating and maintenance costs are involved.

5. ECOLOGICAL

The purchasing of water rights from holders of undeveloped entitlements would lead to an increase in the overall utilisation of that particular source, as the entitlement would not have been exercised to date. This could have an impact on the ecological functioning of the riverine environment. However, since this scheme is based on obtaining 10% of undeveloped entitlements, the overall impact is considered to be of low significance. This option would therefore not have any significant additional impacts on the environment or the ecological functioning of the riverine system.

6. SOCIO-ECONOMIC

Should water rights be purchased from farmers for the NMBM, future agricultural expansions and developments could be limited, affecting food production and agriculture-related employment. However, the provision of water to the NMBM is likely to have positive spin-offs for the region, which could include the provision of additional jobs in various sectors.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

- **Strengths**

- Relatively quick to implement for short-term benefits.
- Will improve quality of water flowing into the lower OFS system (poor quality irrigation land and poor irrigation techniques to be targeted for buying out water entitlements).
- Existing or planned abstraction and transfer infrastructure can be used.
- Cost-effective.

- **Weaknesses**
  - It could reduce a number of jobs on farms.
  - The availability of water entitlements for trading are not known.
  - Potential agricultural food production would be reduced.

SECTION D

LAND USE CHANGES

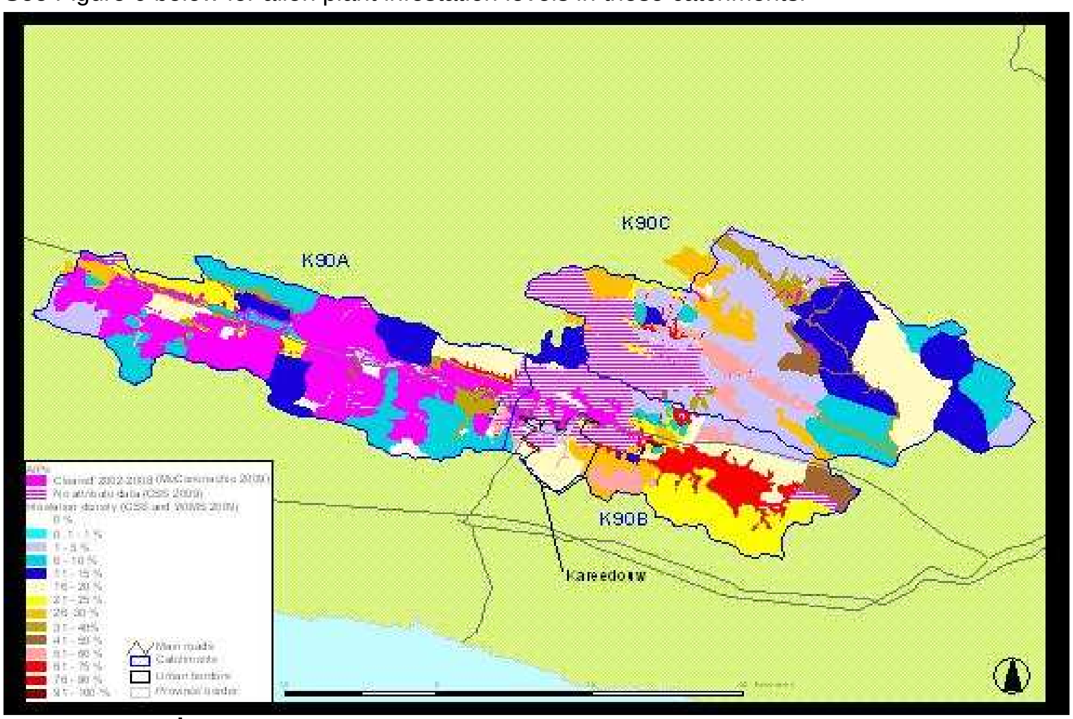
D1. Catchment management in the Kromme, Kouga and Baviaanskloof catchments

1. SCHEME LAYOUT

Preliminary research results for discussion, dated October 2009, and compiled by Mander, Blignaut, Schulze, Horan, Cowling, Powell, Mills and Van Niekerk, have been used to compile this intervention text.

The restoration of natural capital has not yet been considered as an intervention. It has been shown, however, that the restoration and subsequent maintenance of natural capital can improve baseflow, water quality and yield (Blignaut *et al,* 2007, Blignaut *et al,* 2008, Turpie *et al,* 2008, and Bel *et al,* 2009).

The scheme involves the removal of invasive alien plant species (IAPs), especially wattle, in the Kromme and Kouga catchments more specifically, management of the riparian zones of the Kromme and Kouga Rivers, and restoration of denuded land cover in the Baviaanskloof, Kromme and Kouga systems. The aim would be, through restoration of the watersheds and the management of natural capital, to seek an increase in the water licence for the NMBM. See Figure 6 below for alien plant infestation levels in these catchments.



catchments

2. SCHEME DESCRIPTION

The Working for Water programme independently and in conjunction with partners such as the Gamtoos Irrigation Board, has a long-standing history of clearing invasive alien plants. In the past most of the activities have been funded by DWA. Recently, however, private and public sector entities wishing to either obtain or increase their water use licence can do so by paying for the clearing of the invasive plants in the now developing market for ecosystem services.

The objective is to :

- clear the riparian zones of the Kromme and Kouga Rivers,
- to restore land cover in the Baviaanskloof, and
- to remove invasive alien plants and to keep them out of farmland and natural areas in the three watersheds.

The impact of invasive alien riparian vegetation is most pronounced on the low flows. This, in turn, impacts on the run-of-river yield and consequently, on the yield of storage dams on those rivers. Irrigation releases are also reduced by invasive alien vegetation.

The prevention of further spread of invasive alien plants is to be encouraged. From a water resource perspective, clearing activities should continue to focus on those areas in which maximum benefit from increased surface water runoff will be achieved.

3. SCHEME YIELD

See the tables below for preliminary results. A maximum yield of 7.5 million m^3/a is predicted,

4. UNIT REFERNCE VALUE

The URVs for water only, based on a term of 25 years, social discount rate of 4%, and price of carbon of R60/t, is R3.82, as shown in Table 1.

The preliminary URVs for this option are based on the design and costing done by Mike Powell, Christo Marais and James Blignaut, who are members of a larger study team investigating the option to use Restoration of Natural Capital and the management of natural capital as a conduit to develop a market for ecosystem services in the Baviaanskloof, Kouga and Kromme catchments.

Comments on URV calculations

The URV excludes the following:

- Escalation
- Cost of land and servitudes – but that is not a requirement since the land can still be privately owned
- Water treatment chemicals – this intervention will reduce the cost of treatment by also improving the quality of the water.

The URV includes the following:

- Capital costs for restoring the natural capital, phased in over a 10-year period
- Operating costs to manage the water catchment over the entire period.

5. ECOLOGICAL

Currently, the river systems proposed for restoration are considered to be critically endangered (Biodiversity GIS website). From an ecological point of few, the removal of alien invasive species would restore ecosystem functions and services that are currently impacted on and/or stressed. In addition, riparian habitats (including those of red data list species) would improve significantly, positively impacting biodiversity. These changes may in turn have numerous positive impacts such as reduced sedimentation and erosion, and increased water quality, as well as reduced impacts of flood and drought events.

6. SOCIO-ECONOMIC

The socio-economic environment is dependent on the health of ecosystems and the services and functions it provides. Consequently there is a direct link between human wellbeing and environmental health. Thus, by improving the condition of the riverine ecosystems through the removal of alien vegetation, not only human wellbeing of local communities would improve, but also the economic environment, should further water be available to the Municipalities and other water users. Furthermore, the restoration programme would require a large work force to remove alien vegetation, thereby creating numerous job opportunities, or sustaining those organisations that are already engaged in the Working for Water programme. In addition, the alien vegetation material that has been removed can have additional value by providing material for handcraft products such as baskets or wood carvings.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include:

- **Strengths**
    - The project can be linked to the development of a nature-based economy and the extension of the Baviaanskloof mega-reserve.
    - The wood extracted can also be used to generate electricity by means of biomass gasification. This powerplant could be between 10 and 20 MW in capacity using the IAPs.
    - This project could be linked to the ongoing Working for Woodlands and Spekboom restoration project in the Baviaanskloof.
    - There would be a slight reduction in the sedimentation of dams.

- **Weaknesses**
    - There is concern that additional baseflows generated will be intercepted by other catchment users upstream of the dams and will not be available for NMBM to use;
    - Costs do not account for additional required infrastructure. It is assumed that the yield can be realised by utilising spare capacity in existing transfer infrastructure.
    - Operational costs of existing bulk transfer infrastructure have not yet been accounted for.
    - Results must be regarded as preliminary.

Table 1 Catchment Management URVs

Term = 25 years; discount rate = 4%; price of carbon = R60/t

Based on actual restoration and management cost, hydrological modelling (by Schulze) using the ACRU model, accounting for site-specific (quinary-wide) differences

Management objective	Indicator	Kromme	Kouga	Baviaans	Total	Notes
Maximising yield	Change in yield: m^3	4 893 751	1 372 641	1 267 183	7 533 575	**Under this option, each quinary is individually assessed to determine which intervention (clearing of IAPs or restoration of areas denuded of vegetation) will maximise yield and the quinary is managed towards this objective**
	Change in baseflow: m^3	8 079 786	826 220	2 781 529	11 687 535	
	Sediment reduction: t	19 275	-	12 495	31 770	
	URV: Water only	2.09	25.95	2.26	3.82	URV calculated only considering additional water (based on the conventional method)
	URV: Water and above ground carbon	1.68	22.43	2.97	2.04	URV calculated based on water and the value of above ground carbon (treated as a negative cost by subtracting it from the cost of the intervention above the line)
	URV: Water, above ground carbon, land use change and sediment	1.48	17.92	8.55	0.26	Ditto, but adding the value of land use change (tourism and continuing sustainable farming practises) and the value of sediment reduction in dams
Management objective	**Indicator**	**Kromme**	**Kouga**	**Baviaans**	**Total**	**Notes**
Control and clearing of IAPs	Change in yield: m^3	3 348 494	1 372 641	-	4 721 135	**Under this option only the impact of controlling and clearing IAPS are considered**
	Change in baseflow: m^3	1 552 762	826 220	-	2 378 983	
	Sediment reduction: t	-	-	-	-	
	URV: Water only	8.48	26.50	-	15.50	URV calculated only considering additional water (based on the conventional method)
	URV: Water and above ground carbon	8.48	26.50	-	15.50	URV calculated based on water and the value of above ground carbon (treated as a negative cost by subtracting it from the cost of the intervention above the line)
	URV: Water, above ground carbon, land use change and sediment	7.48	21.98	-	6.78	Ditto, but adding the value of land use change (tourism and continuing sustainable farming practises) and the value of sediment reduction in dams

Management objective	Indicator	Kromme	Kouga	Baviaans	Total	Notes
Revegetation of denuded areas	Change in yield: m^3	-1 931 146	-10 599 850	-1 708 949	-14 239 945	**Under this option only the impact of revegetating areas denuded of vegetation are considered**
	Change in baseflow: m^3	20 028 219	15 861 808	5 649 308	41 539 335	
	Sediment reduction: t	130 745	160 990	63 674	355 408	
	URV: Water only	0.88	1.34	2.01	1.21	URV calculated only considering additional water (based on the conventional method)
	URV: Water & above ground carbon	0.52	0.24	-2.05	0.06	URV calculated based on water and the value of above ground carbon (treated as a negative cost by subtracting it from the cost of the intervention above the line)
	URV: Water, above ground carbon, land use change & sediment	0.42	-0.03	-4.83	-0.47	Ditto, but adding the value of land use change (tourism and continuing sustainable farming practises) and the value of sediment reduction in dams

Management objective	Indicator	Kromme	Kouga	Baviaans	Total	Notes
Baseflow maximisation	Change in yield: m^3	-1 931 146	-9 227 209	-1 708 949	-12 867 304	**Under this option, each quinary is individually assessed to determine which intervention (clearing of IAPs or restoration of areas denuded of vegetation) will maximise baseflow and the quinary is managed towards this objective**
	Change in baseflow: m^3	20 028 219	16 688 029	5 649 308	42 365 556	
	Sediment reduction: t	130 745	160 990	63 674	355 408	
	URV: Water only	0.88	1.71	2.01	1.36	URV calculated only considering additional water (based on the conventional method)
	URV: Water & above ground carbon	0.52	0.88	2.05	0.32	URV calculated based on water and the value of above ground carbon (treated as a negative cost by subtracting it from the cost of the intervention above the line)
	URV: Water, above ground carbon, land use change & sediment	0.42	0.62	4.83	-0.20	Ditto, but adding the value of land use change (tourism and continuing sustainable farming practises) and the value of sediment reduction in dams

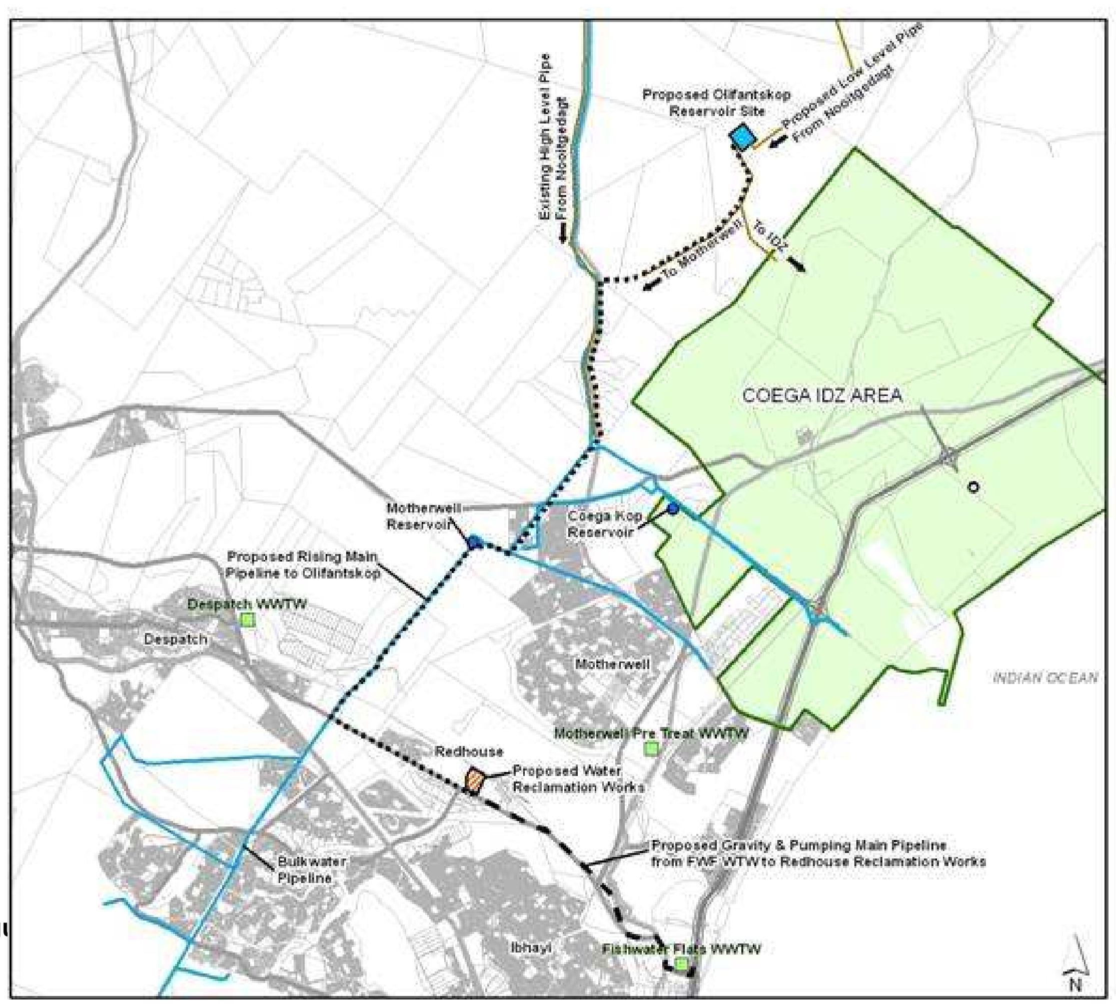
SECTION E

RE-USE OF WATER

E1. Treatment of effluent to industrial standards

1. SCHEME LAYOUT

Unless otherwise stated, information presented herein has been taken from the Coega Development Corporation's Inception Report for a *"Water and Return Effluent Masterplan, IDZ Bulk Water, Return Effluent and Sewers Planning and Implementation"*, dated August 2007. The report discusses the concept of utilising secondary treated effluent of a consistent quantity and quality from the Fish Water Flats Wastewater Treatment Works (FWF WWTW) for the initial supply of treated effluent to a proposed Low Pressure, Low Rejection reclamation system capable of delivering a product of steady quality and quantity to users, whether it be for industrial or commercial usage.



Fig

Further information presented herein, has been added from recent planning undertaken by Afri-Coast Engineers to meet the increased demand for industrial quality water within Zone 6 of the Coega IDZ.

A site near Redhouse was selected for the following reasons:

- Land constraints in and around Fish Water Flats (FWF) WWTW;
- Redhouse site is close to existing potable water pipeline servitudes which can be followed up to Olifantskop Reservoir site;
- The site is close to the existing main electricity grid;
- The site is well positioned to supplement yield in future, by the addition of final effluent from the Uitenhage and Despatch WWTW;

2. SCHEME DESCRIPTION

This option entails pumping secondary treated effluent, subjected to flocculation and rough screening, from a dedicated balancing tank located off the discharge point into the seawater outfall at the FWF WWTW, via a pipeline to the proposed post-treatment site.

A post-treatment site has been provisionally identified adjacent to the Redhouse/Perseverance industrial area, currently zoned as 'unidentified and commercial 3 zoning' with a total area of approximately 25ha. Possible limiting factors influencing the finalisation could include rezoning as well as environmental and public concerns.

At the treatment site, the effluent will, due to high variability of FWF WWTW effluent, and to optimise utilisation rates, be passed through a 24-hour artificial reed bed system (3.5 Ha /10 Ml/day). Thereafter the water will make a full (100%) pass through a treatment train, as a required minimum, before being considered suitable for distribution into the existing water infrastructure system. The treatment train comprises the following:

- Flocculation;
- Rough screening (Pile Cloth Filtration);
- Pumped to Redhouse post treatment site;
- Biological post treatment (artificial reed beds);
- Sanitation (UV and Ozone);
- Ultra Filtration;
- Reverse osmosis;
- Stabilisation and pH correction;
- Final sanitation;
- Brine discharge into the ocean (return pipeline Redhouse – FWF to follow same route as pumping main from FWF WWTW).

The available land at FWF WWTW can accommodate the initial screening process and balancing tank with pump station, all to be located off the existing sea outfall at FWF WWTW.

The scheme will have high capital and operational costs. The unit cost of industrial water sold to end users is therefore largely dependent on the benefit of scale, i.e. maximise the amount of water for supply and minimise the amount of water discharged back into sea.

A blended stream of RO and ultrafiltration filtrates must therefore be evaluated in more depth for the preliminary and design stages of the project.

3. SYSTEM YIELD

Based on 65 Ml/day domestic discharge stream available at FWF WWTW and a process recovery rate of 60% (based on 100% RO pass) from a complete RO system, the final volume for industrial use is approximately 39 Ml/day.

Should improved removal of polysaccharides be achieved (purpose of artificial reed beds) and/or the by-pass and blended option for the RO process be acceptable, then a 65-70% recovery rate could be achieved.

The treated effluent supply can in future be supplemented from Despatch WWTW with an additional 6 - 8 Ml/day.

A total yield of approximately 45 Ml/day has been assumed for this intervention. However, since this intervention was analysed, the projected industrial demand of the Coega IDZ in 2030 has been reduced to 30 Ml/d.

4. UNIT REFERENCE VALUE

The URVs for this option are based on costing performed by Afri-Coast Engineers during the month of September 2008.

Table 1 Industrial effluent URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	680.0	680.0	680.0	680.0
Annual operating cost	**(R million/annum)**	23.9	23.9	23.9	23.9
NPV Cost	**(R million)**	1209.4	1002.3	867.8	802.4
Unit Reference Value	**(R/m^3)**	3.33	4.15	5.17	5.95

N

Note that the URV calculations exclude escalation and the capital for supply and distribution from Olifantskop. This to be provided by Coega Development Corporation.

The URV includes all infrastructure from Fish Water Flats WWTW to Olifantskop, brine discharge infrastructure to FWF WWTW site and operating costs (chemical treatment excluded).

5. ECOLOGICAL IMPACT

The proposed site is located on disturbed land that is characterized by Valley Bush and would probably not be significantly impacted by the development. Furthermore, the proposed pipeline would be routed adjacent to the existing pipeline, road and rail reserves in areas that are already disturbed. This would reduce the extent of new areas of disturbance.

The reuse of sewage effluent could possibly have a negative impact on the environment to which the treated effluent was previously discharged into, as a result of the reduction in the flow in that system.

6. SOCIO-ECONOMIC IMPACT

Additional water provided by this scheme would contribute to the development of the IDZ, which is likely to create more jobs and income for the region. In addition, this water resource is not dependent on rainfall, providing the Municipality with a strategic advantage.

Visual impacts associated with the development would be minimal since the plant would be located opposite an existing industrial area. Furthermore, the plant would not release odours or gases that could be a nuisance or have any other negative social impacts on the public.

7. GENERAL

Possible positive impacts of this system include:

- Utilisation of a potential water source previously "lost" by being discharged into the sea at FWF WTW;
- Reduced demand on natural resources by industrial users;
- Augmentation of the Municipality's potable water resources through a source capable of producing a constant reliable output, irrespective of drought cycles.
- Improvement in the ecological state of the Swartkops River estuary.

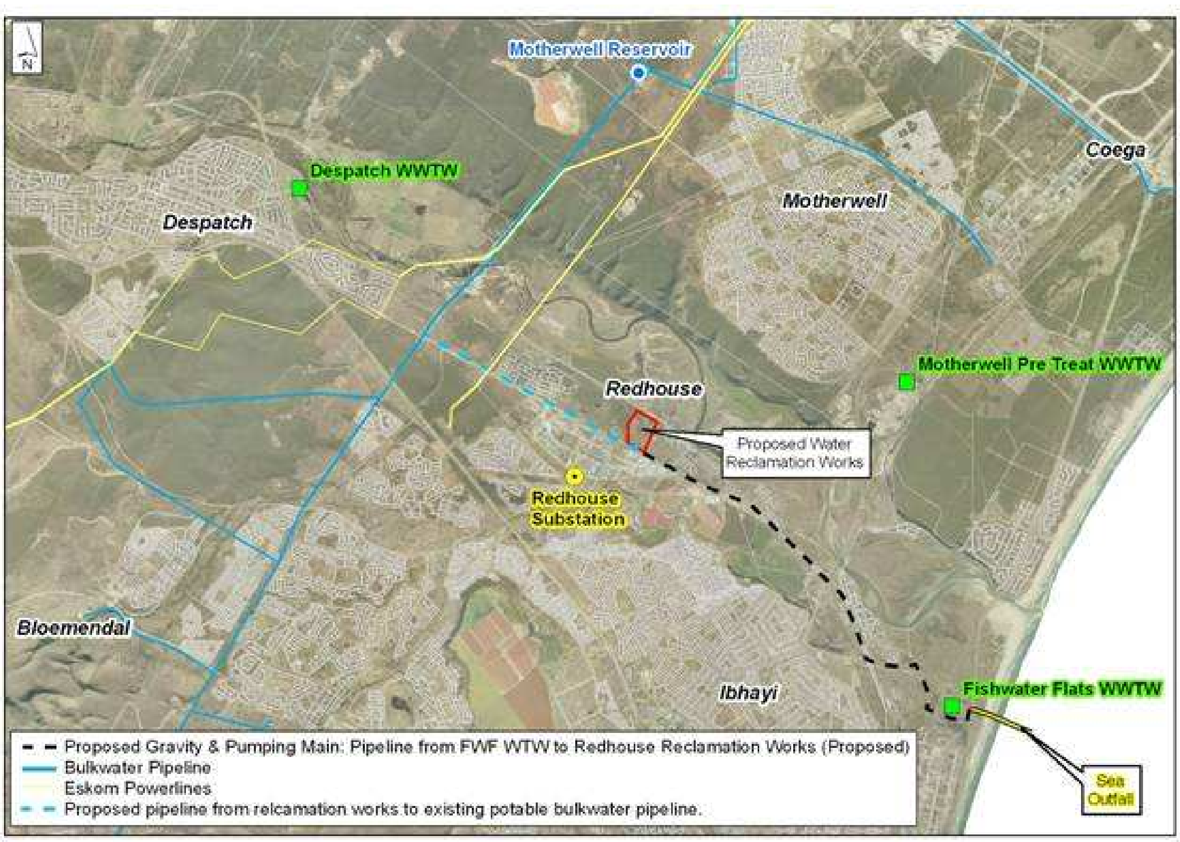
Possible negative impacts include:

- High concentrations of reject water/brine disposal into the sea and/or local Swartkops river;
- Impacts related to the construction of the scheme;
- Institutional implications regarding the operation and maintenance of FWF WWTW and the reclamation plant;
- High variability in quality of effluent from FWF WWTW could have negative impacts on RO system operations;
- A large component of the project requires the importation of specialist equipment. The cost of equipment is thus dependent on the Rand exchange rate.

E2. Treatment of effluent to potable standards

1. SCHEME LAYOUT

To date the application of post-treated secondary effluent as a source of potable water supply has not been a consideration for the NMBM or for RSA. The direct use of secondary effluent treated for potable use worldwide, has only been practiced by Windhoek Municipality over a period of 40 years (1968 – 4.8 Ml/day, 2008 – 21 Ml/day).



F

A site near Redhouse was selected for the following reasons –

- Land constraints in and around FWF WWTW;
- Redhouse site is close to major bulk water infrastructure pipelines;
- The site is close to the existing electricity main grid;
- The site is well positioned to include effluent from Uitenhage and Despatch WWTW.

2. SCHEME DESCRIPTION

The Western Cape Water Supply System: Reconciliation Strategy Study (June 2007) Volume 5 of 7 titled *Treatment of Effluent to Potable Standards for supply from the Faure Water Treatment Plant* considered the use of treated sewage effluent for post treatment to potable standards. .

This intervention for the NMBM water supply system, was not considered any further due to the following reasoning –

a) About 75 Ml/day is available from FWF WWTW domestic stream.
b) Where RO systems are applied for treated sewage effluents, low recovery rates (60%) are experienced due to the nature of sewage effluents which gives high risk of membrane clogging.
c) The net yield of recovery is thus about 45 Ml/day of potable water.
d) At the time that the description of this intervention was prepared, the latest information from the Coega IDZ is that Zone 6 industries (including PetroSA) will require some 85 Ml/day of water supply (30 Ml/day of industrial quality and 55 Ml/day of potable quality).
e) The proposed Coega WWTW will always lag behind in industrial return effluent supply capacity, since water use within the Coega IDZ must grow to create effluent.
f) It makes sense to treat sufficient effluent for industrial water requirements (with less health risks) than to treat effluent to potable standards and use potable water to supplement industrial requirements in the Coega IDZ.

3. SYSTEM YIELD

Not determined.

4. UNIT REFERENCE VALUE

Not determined.

5. ECOLOGICAL IMPACT

Reuse of effluent would have the positive effect of limiting the development of new groundwater or surface water schemes.

The reuse of sewage effluent could possibly have a negative impact on the environment to which the treated effluent was previously discharged into, as a result of a reduction in the flow in that system.

6. SOCIO-ECONOMIC IMPACT

Some people have an aversion to the notion of drinking treated sewage effluent. There may also be objections to this practice on the basis of religion. The treated effluent would be blended with water from other surface or groundwater sources, which is likely to reduce any health concerns related to the use of treated effluent. Nevertheless, an undetected failure of the treatment system could constitute a major health risk as there would be no major reservoir buffer between the treatment process and the users which is considered to be best international practice.

E3. Industrial Water Supply from Coega WWTW

1. SCHEME LAYOUT

The information presented is taken from the *Coega Development Corporation's (CDC) Final Report for "Coega IDZ 7 Water, Sewer and Return Effluent Master Plan Update" dated April 2009.*

The scheme would be implemented by the NMBM as the Water Services Authority developing a new industrial water supply source from the post treatment (including desalination) of treated effluent to be discharged from the planned Coega WWTW.

2. SCHEME DESCRIPTION

The scheme will consist of a post treatment plant located at the site of the planned Coega WWTW. Brine resulting from the post treatment process (which will include low pressure RO) will be discharged together with the surplus treated sewage effluent via a combined sea outfall pipeline.

Industrial quality water will be pumped from the WWTW site over a distance of some 13.7 km via an 800 mm diameter rising main pipeline to the industrial water supply balancing reservoirs at the Olifantskop reservoir site (TWL 140 m MSL).

The following factors influence the implementation of this potential source of supply:

- The year for commissioning of the Coega WWTW plant, has not been fixed yet.
- Major water demand centres – the Coega IDZ is a major future water demand centre of the NMBM and is ideally located for utilisation of this potential source.
- Implementation of the water re-use scheme will be in line with the ROD issued for the Coega IDZ, namely that effluent from sewage treatment must be used as a source of industrial water supply.
- Brine discharge to sea – It has been assumed that the return of final effluent to the sea could utilise the WWTW sea discharge pipeline and that the EIA for the Coega WWTW will cover this issue sufficiently.

3. SCHEME YIELD

The following table illustrates possible future flows to be discharged from the planned Coega WWTW. The NMBM and the Coega IDZ Sewage Master Plans have indicated that domestic streams from Motherwell and Motherwell North will be diverted into the planned Coega WWTW to improve the quality of sewage to be treated and to create spare capacity at the Fishwater Flats WWTW for growth of the metro sewage system along the right bank of the Swartkops River.

Table 1 Possible future flows from the planned Coega WWTW

Description	Estimated Sewage Flows (Ml/d)			Return Effluent Yield (Ml/d)		
	2015	2020	2040	2015	2020	2040
Motherwell North 1	-	19.4	19.4	-	10.1	10.1
Motherwell North 2	16.2	16.2	16.2	8.4	8.4	8.4
Motherwell	8.9	8.9	8.9	4.6	4.6	4.6
Coega IDZ: Zone 8 & 9	1.3	2.7	4.6	0.7	1.4	2.4
Coega IDZ: Zone 1 & 2	1.8	3.6	5.3	0.9	1.9	2.8
Coega IDZ: Zone 3, 4 & 5	2.6	4.0	5.5	1.3	2.1	2.9
Coega IDZ: Zone 6, 7 & 10	13.2	17.3	18.2	6.9	9.0	9.5
Coega IDZ. Zone 11, 12, 13 &14	6.6	12.7	18.8	3.4	6.6	9.8
	50.6	**84.8**	**96.9**	**26.3**	**44.1**	**50.4**

The Return Effluent available was estimated on the following assumptions:

- 80% of total flow will become available for re-use due to 24 hour variability
- 65% of available discharged flows will become actual re-use and the balance will be brine streams from pre-filtration and RO systems.

For the purposes of this assessment, a treated industrial water output of 50 Ml/d (18.25 million m^3/a) was considered for 2040, growing in demand from 25 Ml/d in 2015. Since this intervention was analysed the projected industrial demand of the Coega IDZ in 2030 has been reduced to 30 Ml/day.

4. UNIT REFERENCE VALUE

The URV calculation is based on social discount rates of 0%, 3%, 6% and 8% for a 25 year period.

Table 7 Industrial Water Supply from Coega WWTW URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	627.6	627.6	627.6	627.6
Annual operating cost	**(R million/annum)**	29.6	29.6	29.6	29.6
NPV Cost	**(R million)**	1272.8	1033.8	883.0	811.7
Unit Reference Value	**(R/m^3)**	3.2	3.93	4.84	5.57

Note that the URVs exclude escalation and capital cost for a brine sea outfall pipeline (brine to utilise sea outfall for WWTW)

The URVs include the following :

- Capital costs for the pump station and rising pipeline to Olifantskop and balancing storage.

- Operating costs including conveyance

For the surface and groundwater options, water treatment costs have been excluded in the URV calculation. This resulted in a reduced URV of between 20% and 30% for those options. Similarly, the desalination process (which supplies water to potable standard) was adjusted by 10% and no post treatment (water stabilization & disinfection) costs were added to this Intervention.

5. ECOLOGICAL

Based on the assumption that the proposed Coega WWTW would be located within the IDZ, no significant environmental impacts are anticipated as long as the associated infrastructure (i.e. pumping main to Olifantskop reservoir site) follow the existing Coega IDZ servitudes and are located outside conservation areas. This would reduce the extent of new areas of disturbance. Furthermore, the discharge of brine with effluent from the WWTW is unlikely to add any significant additional impact to that associated with the WWTW.

6. SOCIO-ECONOMIC

Social impacts are not likely to be significant (given the plant's location in the IDZ). Additional water provided by this scheme would contribute to the development of the IDZ which would create more jobs and income for the region, with the associated positive benefits. In addition, this water resource is not dependent on rainfall and would provide the Municipality with a strategic advantage, by having a source of water independent of the weather constraints.

7. OTHER ISSUES

The strengths and weaknesses of the re-use scheme are:

- **Strengths**
  - Source of supply is not drought /season related, thus reducing risk in supply to industry.
  - Complies with ROD condition, namely that waste flows must be re-used.
  - Site is located within the demand centre for the demand source.

- **Weaknesses**
  - Quality of effluent from proposed WWTW not known, which could increase or decrease the estimated process costs.

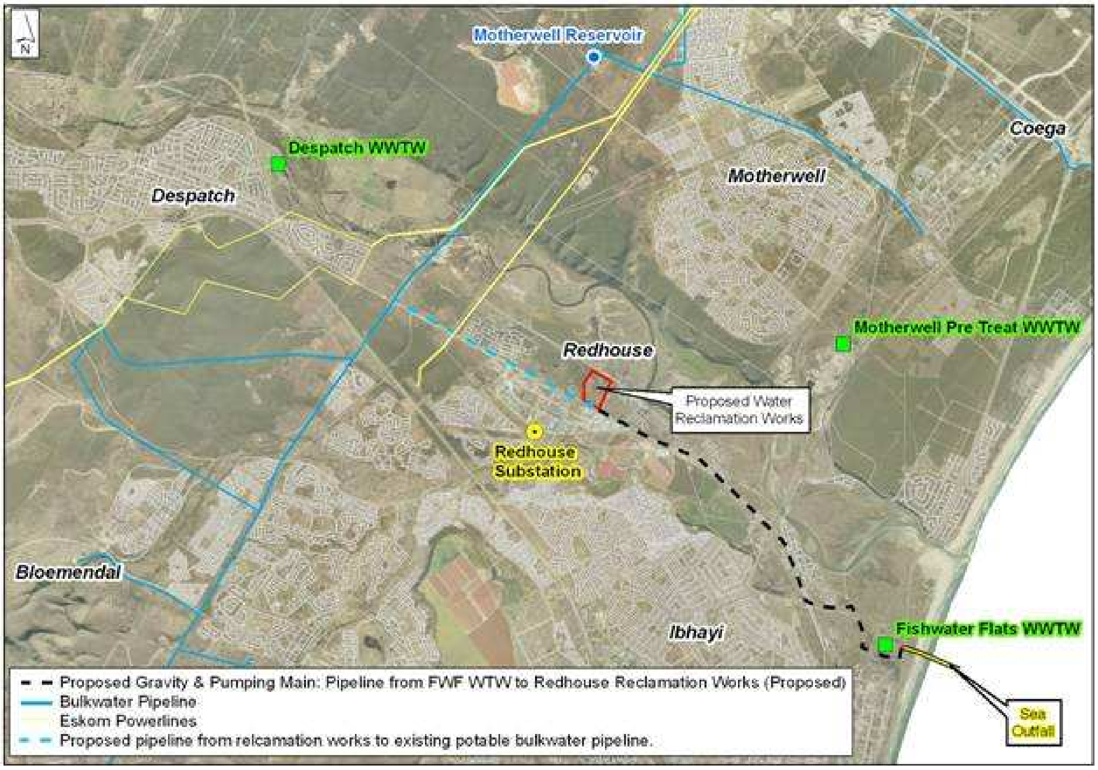
E4. Indirect Reuse of effluent treated to potable standards with storage in a new dam at Echodale

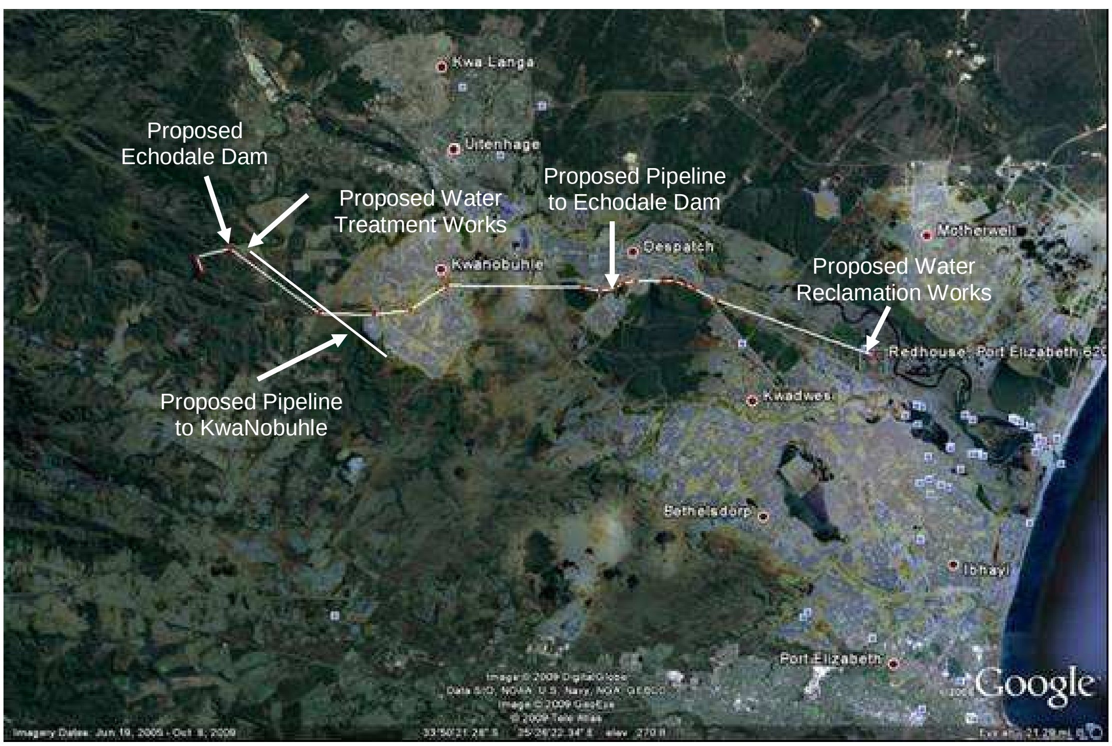
1. SCHEME LAYOUT

The accepted best international practice for potable reuse of treated effluent is that the effluent should preferably be treated by an RO process and thereafter should be stored in an impoundment before abstraction and treatment by a conventional potable water treatment processes. The purpose of storing the water in an impoundment is to avoid the "toilet to tap" perception of the public but also to provide a buffer so that in the event of a malfunction of the waste water treatment process contamination of the potable water supply would be minimised through the dilution and natural decomposition processes, followed by the conventional water treatment process.

It is also recommended that if possible an existing impoundment and water treatment and conveyance infrastructure should be utilised so as to minimise capital costs. In the case of the Algoa system the Groendal Dam and the Bulk and Sand River Dams are closest impoundments but have very small storages and existing pipeline capacities and are also located long distances from the Fishwater Flats WWTW, the main potential source of treated effluent for reuse. Therefore for the Algoa system it has been assumed that an indirect potable reuse scheme would require that a new dam to be constructed at Echodale as this appears to be the closest site for a dam of sufficient capacity. An alternative would be to utilise the Uitenhage Aquifer for storage, possibly by injecting the RO treated water into the aquifer via a series of boreholes close to the coast with a series of abstraction boreholes further inland.

The proposed Algoa indirect potable reuse scheme has been based on the RO schemes proposed for interventions E1 and E2 together with a dam at Echodale. **Figure 1** shows the location of the proposed RO treatment works at Redhouse and **Figure 2** shows the route of the pipeline from Redhouse to Echodale which would discharge into the reservoir approximately one kilometre upstream of the embankment dam. Water would be released from the dam, treated and then pumped via a rising main to discharge into the bulk connecting pipeline in the vicinity of KwaNobuhle.


Motherwell Reservoir
Coega
Despatch WWTW
Despatch
Motherwell
Motherwell Pre Treat WWTW
Redhouse
Proposed Water Reclamation Works
Redhouse Substation
Bloemendal
Ibhayi
Fishwater Flats WWTW
Sea Outfall
Proposed Gravity & Pumping Main: Pipeline from FWF WTW to Redhouse Reclamation Works (Proposed)
Bulkwater Pipeline
Eskom Powerlines
Proposed pipeline from relcamation works to existing potable bulkwater pipeline.


Kwa Langa
Uitenhage
Proposed Echodale Dam
Proposed Water Treatment Works
Proposed Pipeline to Echodale Dam
Kwanobuhle
Despatch
Motherwell
Proposed Water Reclamation Works
Redhouse, Port Elizabeth
Kwadwesi
Proposed Pipeline to KwaNobuhle
Bethelsdorp
Ibhayi
Port Elizabeth
Google

2. SCHEME DESCRIPTION

The scheme would comprise the following:

- A pipeline would convey approximately 75 Ml/d of the domestic treated wastewater stream from Fishwater Flats to Redhouse (which is well situated to also accept treated domestic effluent from Uitenhage and Despatch and is close to the main electricity grid – **Figure 1**).
- The treatment at Redhouse would be as described in Section 2 of Intervention E1 with a net recovery from the RO process of about 45 ML/day (16.4 million m^3/a). Stabilisation and pH correction would not be required.
- A return flow pipeline would deliver the brine to the existing sea outfall at Fishwater Flats.
- A pump station and 27 km long pipeline would transfer the treated water to Echodale Dam (**Figure 2**) which would have a capacity of about 20 million m^3.
- Water abstracted from the dam would be treated at a new 45 Ml/d water treatment works and then pumped via a new 7 km pipeline to discharge into the existing bulk pipeline system upstream of the KwaNobuhle Reservoir.

3. SYSTEM YIELD

It has been assumed that hydrological yield of the dam would only be sufficient to meet evaporation losses, abstractions to supply existing downstream irrigators and Reserve releases. Therefore together with the transfers the available yield will be approximately equal to the transfer of **45 Ml/d (16.4 million m^3/a)**.

4. UNIT REFERENCE VALUE

The URVs for this option shown in **Table 1** have been based on the costing for Intervention E1, together with the costs of the Echodale Dam, water treatment works and additional pipelines.

Table 1: Indirect Potable Effluent Reuse after RO, Storage in Dam and Treatment

ITEM	Discount Rate 0 %	Discount Rate 3 %	Discount Rate 6 %	Discount Rate 8%
Capital cost included in operating costs	1152	1152	1152	1152
Annual operating cost (R million/annum)	32	32	32	32
NPV Cost (R million)	1830	1547	1360	1269
Unit Reference Value (R/m^3)	5.25	6.77	8.69	10.21

5. ECOLOGICAL IMPACT

The site of the proposed treatment works at Redhouse is located on disturbed land that is characterised by Valley Bush and would probably not be significantly impacted by the development. The pipeline from Fishwater Flats to the treatment works would be routed adjacent to the existing pipeline, road and rail reserves that are already disturbed.

The majority of the pipeline to the Echodale Dam would also be routed adjacent to existing road reserves that are already disturbed. However the last four kilometres would be pass through indigenous Valley Bush and farmlands. The water treatment works would be sited on farmland and the pipeline to the vicinity of Kwanobuhle reservoir would also pass through farmlands and indigenous Valley Bush.

The Echodal Dam and its reservoir would cover or inundate approximately 10 km of river and 180 ha comprising the river channel, irrigated and dry agricultural lands and indigenous Valley Bush. The dam itself would interrupt the natural flows and floods in the Elands River which is one of two main tributaries of the Swartkops River and the important Swartkops Estuary. In particular the dam would attenuate the more frequent floods and it is likely that the Reserve would probably require that high flow releases are made, one of which might perhaps have a hydrograph peak similar to that of the annual flood. Reserve low flow releases would also have to be made.

6. SOCIO-ECONOMIC IMPACT

The indirect reuse of waste water treated by the RO process after storage in Echodale Dam would eliminate the potential health risks and the public perceptions associated with the potable reuse of treated effluent.

The scheme would deliver water to the bulk supply pipeline serving the KwaNobuhle reservoir. Some of the water would be pumped back to the Chelsea Reservoir however most of the water would be utilised by the areas served by this reservoir. This could result in the perception that one community only is indirectly receiving treated wastewater. Therefore it might be preferable to extend this pipeline to a trunk main that serves a much larger area.

On the other hand the scheme would provide a reliable supply of good quality water close to town and would not be subject to droughts.

The reservoir would inundate some farmlands with consequent loss of jobs.

The scheme could accommodate additional treated effluent without the need to increase the capacity of the Echodale reservoir which would reduce the cost of future phases.

The scheme would involve pumping for the RO process and for pumping the water and would therefore be affected by increasing electricity tariffs, however anticipated electricity cost increases have been taken into account.

SECTION F

DESALINATION

F1. Desalination: Coega IDZ supply option

1. SCHEME LAYOUT

The information presented is taken from the *Coega Development Corporation's (CDC) Inception report for "IDZ Bulk Water, Return Effluent and Sewers Planning and Implementation" dated July 2007* and the *Water Master Plan 2006 for NMBM*. Outdated information has been updated in line with latest outcomes of workshops and technical meetings between NMBM and CDC on the provision of industrial water supply infrastructure.

The scheme would entail the NMBM purchasing desalinated water for potable use from a potential Industrial Manufacturer of chlorine from sea salt (NaCl) within the Coega IDZ.

In order to start chlorine production, the Manufacturer (Straits Chemicals) will initially import salt through the Harbour of Ngura, until a seawater intake and supply is available from the CDC. The site of supply and integration with bulk water infra-structure system, is shown in the figure below.

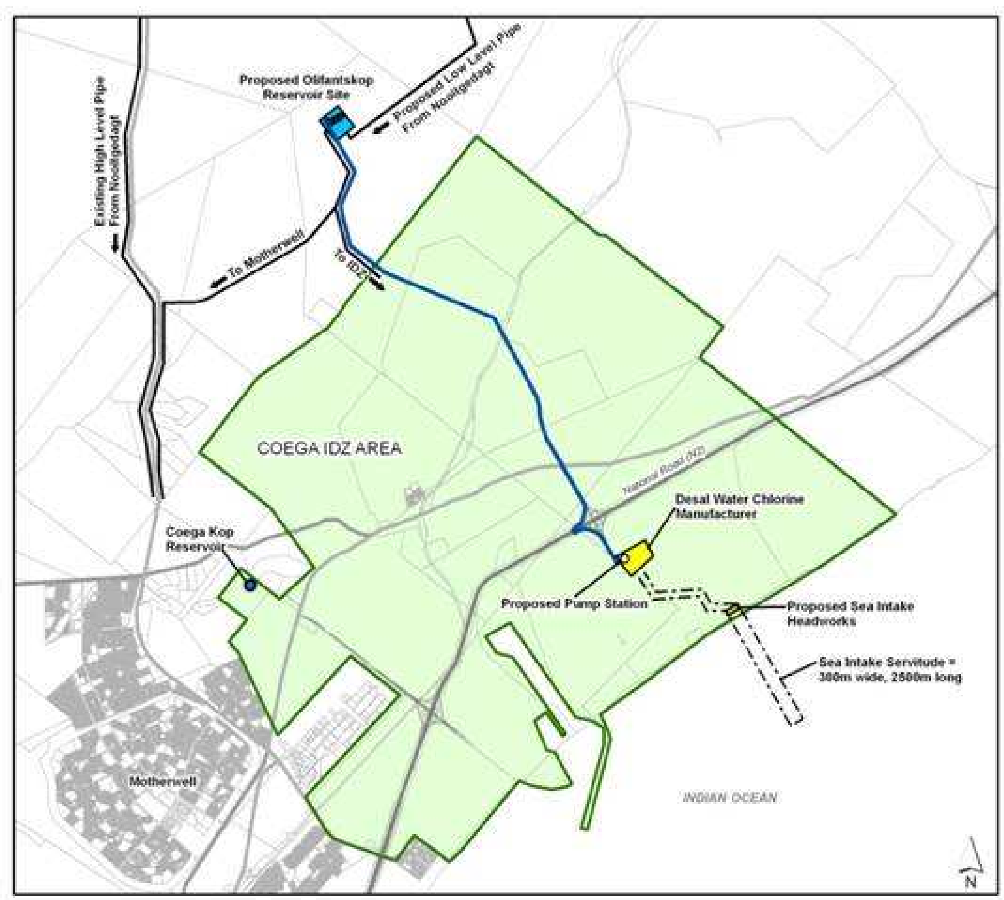


Figure 7 Coega IDZ desalination scheme layout

2. SCHEME DESCRIPTION

The scheme will consist of a bulk sea water intake system to be provided by the CDC for various potential sea water users within the Coega IDZ area. The Manufacturer will pump sea water from the onshore bulk head to the manufacturing site. The most probable intake system will be an underground collector pipe system installed by directional drilling (Neodren(p)), a more capital intensive intake than open sea intakes, but far more environmentally acceptable and thus to be approved in a shorter EIA timeframe.

The Manufacturer will extract NaCl from a brine resulting from a double pass RO system (First pass 60-65 Bar and second 100 Bar) with NaCl recovery from the brine, resulting in a final brine discharge slightly denser than seawater.

It appears from discussions to date that the final treatment for potable water supply from the Manufacturer will be an onsite stabilisation process (lime treatment) and balancing storage. A pump station (operated by NMBM or the Manufacturer) will lift the potable water to balancing storage along a 13.4 km long rising pipeline to the proposed Olifantskop reservoir site, north of the Coega IDZ area.

There is an added benefit in utilising potable water from RO, as the blending of this water with water supplied from Nooitgedagt WTW (both at Olifantskop and Grassridge reservoirs) will improve the final water quality supplied to end users.

The sea intake and desalination costs do not form part of the project capital costing, since the potable water will be sold off as a by-product of the chlorine manufacturing process. The unit cost for water supplied at Manufacturer's site, has been assumed to be R5.00/m^3 (initial offer made by the Manufacturer to NMBM based on the basic unit selling rate to consumers) with annual escalation built into the unit rates, which then form part of annual operating costs.

Factors influencing the implementation of this potential source of supply :

- Cost of sea intake infrastructure – This could amount to some R 300-R400 million (depending on the scale) which, if not implemented by CDC as part of its infrastructure plan, could delay the ultimate use of sea water as a NaCl source. The Manufacturer has recently obtained a ROD from DEADEA for the manufacture of chlorine but with a sea intake excluded.
- Uncertain energy supply – The operation of an RO plant is high in energy demand. Present energy shortage threats in SA could impact on the supply (start up and reliability of supply).
- Connecting to infra-structure – The availability of existing water balancing and conveyance infrastructure of the proposed Nooitgedagt Low Level Scheme will supplement the implementation plan for this source.
- Major water demand centres – The Coega IDZ is a major future water demand centre of the NMBM and is ideally located for utilisation of this potential source.
- Post treatment of RO water – The extent of post treatment necessary to adjust the pH and increase alkalinity will be significantly reduced if water from this source is blended with water from Nooitgedagt WTW.
- Brine discharge to sea – The return of final effluent to the sea will require a discharge pipeline provided by either CDC or the Manufacturer. The quality of the "brine" will, however, be a much better quality than that of standard RO/seawater systems.
- Implementation of source water by NMBM will simply be required to a purchase agreement with the Manufacturer.

3. SCHEME YIELD

Earlier correspondence with the Manufacturer during October 2007 indicated that the initial quantity of potable water available would be some 50 Ml/day which in the long term could increase to as much as 170 Ml/day.

A ROD was issued by DEDEA on 5 September 2008 to Straits Chemicals for the implementation of a chlor-alkali plant within the Coega IDZ. The ROD is based on the importation of coarse grade solar salt from overseas suppliers through the Port of Ngurha. Based on the most recent discussions with CDC officials, it seems to be likely that the sea intake will be constructed.

For the purposes of this assessment, a treated water output of 80 Mℓ/d (29.2 million m^3/a) was considered until more clarity on the long term plans of chlorine manufacturing within the Coega IDZ become available.

4. UNIT REFERENCE VALUE

The URVs for this option are based on preliminary design and costing performed by Afri-Coast Engineers as part of the NMBM Draft Preliminary Design Report for the Nooitgedagt-Olifantskop Low Level Scheme (2008). The URV calculations are based on a social discount rates of 0%, 3%, 6% and 8% per annum for a 25 year period.

Table 1 Desalination – Coega IDZ URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	(R million)	331.3	331.3	331.3	331.3
Annual operating cost	(R million/annum)	153.8	153.8	153.8	153.8
NPV Cost	(R million)	3331.1	2235.8	1582.9	1293.4
Unit Reference Value	(R/m^3) _a	5.85	6.14	6.51	6.83
Unit Reference Value	(R/m^3) _b	4.55	4.84	5.22	5.52

Comments on URV calculations

1) URV _a is calculated on an assumed price for desalinated water from Coega IDZ of R5.00/Kl, while URV _b is calculated on an assumed price of R3.70/Kl.

2) The URV excludes the following :
   - Escalation
   - Sea-intakes and pumping costs to site of Manufacturer
   - Desalination infrastructure and operating costs

3) The URV includes the following:
   - the Unit Sales Cost at which NMBM will purchase potable water from Manufacturer on site as a by-product

- Capital costs for the pump station and rising pipeline to Olifantskop and balancing storage, gravity pipeline to Motherwell Reservoir (the latter could be in place, should the Nooitgedagt Low Level Scheme go ahead).
- Operating costs including conveyance

4) For the surface and groundwater options, water treatment costs have not been included in the URV calculations. This resulted in a reduced URV of between 20% and 30% for those options. Similarly, no post treatment (water stabilisation costing) costs were added to this Intervention.

5. ECOLOGICAL

This desalination process differs from those normally considered for potable water supply:

(a) The brine is used to supply NaCl to the manufacturing process would result in a final brine solution slightly denser than seawater, which would have minimal ecological impact.
(b) The directional drilling technique to be used for seawater abstraction through perforated HDPE pipelines installed some 4-5m below seabed level will have no ecological impact on marine life (and would in any case be constructed for other schemes in the IDZ).
(c) No pre-treatment with anti-fouling chemicals would be required, resulting in a final discharge effluent with less impact on marine environment than other standard seawater desalination projects.
(d) The pumping main would follow existing Coega IDZ servitudes

Desalination of seawater uses considerable amounts of electricity and this has secondary environmental impacts associated with coal or nuclear power stations.

6. SOCIO-ECONOMIC

There would be minimal visual impacts associated with the underground intake system and a bulk head intake structure situated behind the front dune system without affecting it at all.

All other infrastructure forming part of the desalinated water supply, will blend in with other infra-structure of the IDZ and will follow service servitudes and ducts already planned for by the CDC.

7. OTHER ISSUES

The strengths and weaknesses of the desalination scheme are:

- **Strengths**
    - Source of raw water independent of drought cycles.
    - Unit cost /process costs will be reduced since potable water will be a by-product of the manufacturer
    - Direct environmental impacts can be minimal.
    - Potential to improve overall water quality supplied from Nooitgedacht.

- **Weaknesses**
  - No firm negotiations between Coega Development Corporation, Straits Chemicals and NMBM in place yet. Final purchase prices for potable water therefore a best estimate of cost.
  - Energy requirements result in secondary environmental impacts.
  - The supplier of potable water is an industrial manufacturer (not a water supply business) driven by market demands with associated risk for continuity of supply to the NMBM.

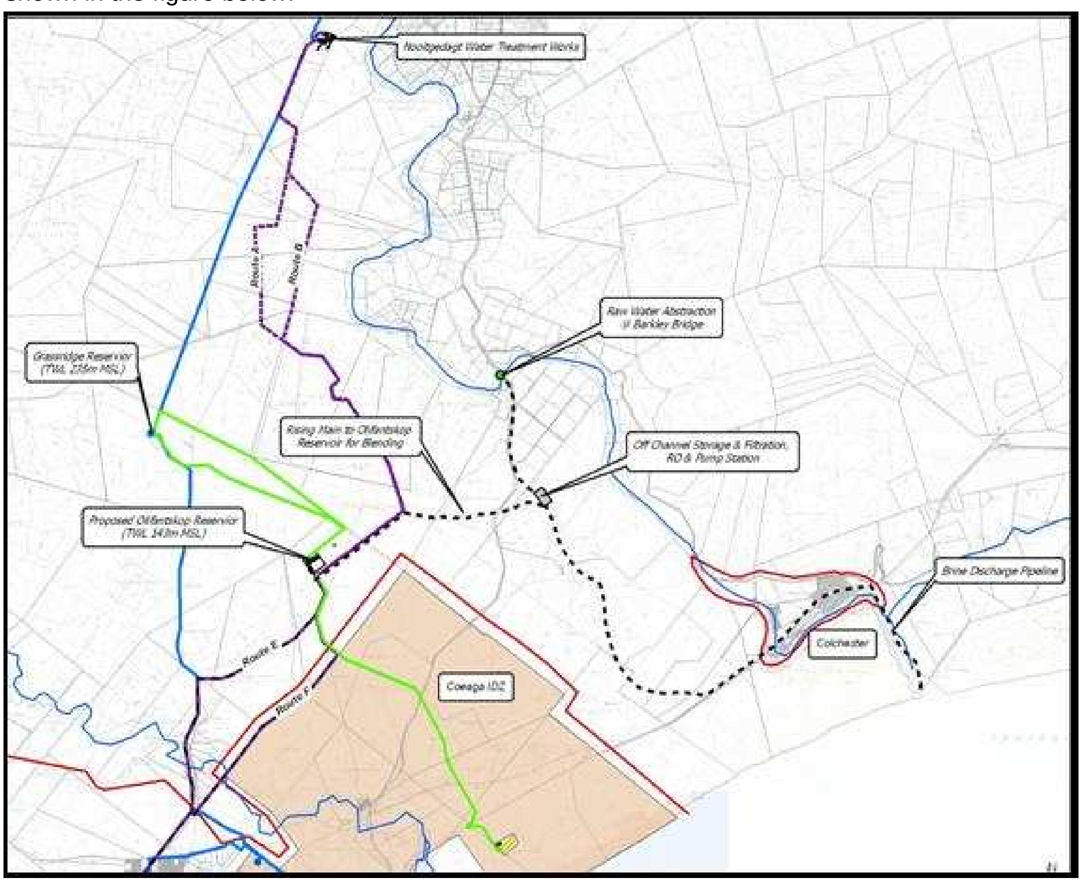
F2. Desalination of lower Sundays River return flows

1. SCHEME LAYOUT

This intervention was not previously considered as a possible source of water supply to NMBM. The information used was presented by Ninham Shand in October 2008 as a WRC Project, No. K8/780/2, titled “A Hydrological Study of the Sundays River Estuary”.

The scheme is aimed at the NMBM abstracting return flows downstream of the Sundays River Irrigation Board (upstream of the tidal river zone) and desalination of same before blending at Olifantskop reservoirs with water supplied from Nooitgedagt WTW [Alternatively, part of the RO stream could be supplied directly to the Olifantskop reservoirs as an industrial water supply to the Coega IDZ].

The proposed scheme and its integration with the future bulk water infra-structure system, is shown in the figure below.



2. SCHEME DESCRIPTION

The scheme will consist of a raw water abstraction pump station on the Lower Sundays River in the vicinity of Barkly Bridge. The raw water source is mostly return flow water from the Lower Sundays River irrigation scheme. Raw water will be pumped over some ..... km to an off-channel balancing dam.

The water will undergo micro filtration/ultra filtration to remove suspended solids as a pre-treatment to reverse osmosis (RO). Chemical addition of sulphuric acid and an antiscalant to minimise scale formation on the RO membranes will be required. This chemical treatment will support high operating recovery rates. Permeate water will be stabilised before being pumped away.

A pump station will deliver the desalinated water to Olifantskop reservoir site over a distance of some 9.0 km, where it will be blended with "normal" Orange River water (a moderately hard water) supplied from Nooitgedagt WTW or alternatively, will be supplied to the Coega IDZ as an industrial water supply.

The brine and ultrafiltration backwash streams (estimated at 20% of initial feed water volume) will be discharged with a gravity pipeline system from a balancing storage at the treatment site over a distance of some 20 km to the mouth of the Sundays River. The discharge will be released on 6 hour cycles on the outgoing tides to minimise the overall environmental impacts on the estuary.

Factors influencing the implementation of this potential source of supply:

- Details of pre-treatment prior to RO – Water quality information was based on that in the DWAWMS water quality database. Final process pre-treatment will be based on a more detailed analysis.
- Uncertainty in energy supply – The operation of an RO plant is high in energy demand. Present energy shortage threats in SA could impact on supply (start up and reliability of supply).
- Land availability – Land on both banks of the Sundays River is under irrigation. Therefore suitable land was identified on higher levels further away from the river.
- Connecting to infra-structure – The scheme will be implemented as a follow on to the proposed Nooitgedagt Low Level Scheme. The availability of existing infrastructure at Olifantskop and the transfer capacity to Motherwell, will support the implementation plan for this source.
- Brine discharge to sea – The return of the brine stream could be an environmentally sensitive issue which will require more debate and the final outcome could have major cost implications.

3. SCHEME YIELD

WRC Project No K8/780/2 reports that, based on multiple hydrological scenarios done, 45 Mm^3/a (123 Ml/day) of the "return flow" in the Lower Sundays River could be utilised while maintaining the ecological flow requirements.

The total area under irrigation from the Lower Sundays River Water User Association is some 17,300 ha. Based on an annual irrigation allocation of 900 mm and a return flow of 10%, one could expect a return base flow of some 15.6 Mm^3/a (42.6 Ml/day).

For this intervention (and until such time as more accurate flow measurements become available and Reserve requirements for estuary are known) an average river return flow of 18.2 Mm^3/a (50 Ml/day) is assumed (compared to 45 Mm^3/a previously assumed).

If 85% of the return flow is abstracted on average (on account of variable flows and small abstraction weir), the supply would be 15.5 Mm^3/a (42.5 Ml/day).

For the purpose of this assessment, a 13% waste stream is estimated for backwashing of filters (sand and or ultra) and a further 15% as a brine stream for RO.

A possible source yield of **11.4 Mm^3/a (31.4 Ml/day)** is thus assumed from this intervention option.

4. UNIT REFERENCE VALUE

The URVs for this option are based on preliminary design and rudimentary sizing and costing performed by Afri-Coast Engineers as part of this study. The URV calculations are based on social discount rates of 0%, 3%, 6% and 8% applied for a 25 year period.

Table 1 Desalination of Lower Sundays Return Flows URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	381	381	381	381
Annual operating cost	**(R million/annum)**	16.0	16.0	16.0	16.0
NPV Cost	**(R million)**	732.4	601.5	518.5	479.0
Unit Reference Value	**(R/m^3)**	2.9	3.6	4.5	5.2

Note that the URV calculations exclude escalation, cost of land & servitudes, transfer pipelines from Olifantskop (assumed that most of this supply will be for demand of IDZ) and water treatment chemicals

The URV includes the following :

- Capital costs for all infrastructure from river abstraction to balancing storage at Olifantskop
- Operating costs to treat water from raw to potable (no chemicals)
- Operating costs of all conveyance infrastructure up to Olifantskop site

For the surface and groundwater options, water treatment costs have been excluded in the URV calculation. This resulted in a reduced URV of between 15% and 25% for those options. Similarly, no treatment chemicals costs were added to this Intervention.

5. ECOLOGICAL

Intertidal salt marshes occur in large permanently open estuaries, such as the Sundays River estuary. This type of estuary is considered to be rare in South Africa and is threatened due to reduced freshwater input and residential and industrial developments (Mucina and Rutherford, 2006). However, due to irrigation activities in the Lower Sundays River, irrigation return flows exceed the ecological Reserve flow requirements and because the water quality has deteriorated to such levels that the present ecological status is considered to be Class D (largely modified).

The discharge of brine with a high salt concentration and traces of process chemicals could have an impact on the biophysical environment, especially in the vicinity of the discharge point.

Even though the Cape Estuarine Salt Marshes (AZe2) vegetation is considered to be least threatened, various endemic and/ or rare species could occur in the estuary. Many estuary organisms are dependent on temperature and salinity changes brought upon by the tides and could be negatively influenced should the general salinity levels and temperature increase.

Furthermore, during construction of the pipelines it will be necessary to destroy indigenous vegetation and future maintenance work may disturb this vegetation. The proposed pipeline would go through various vegetation types, including Albany Thicket (AT6 and AT7) and Sandstone Fynbos (FFs 28) that could contain endemic, rare and/or endangered species. Other construction phase impacts could include soil compaction which could lead to erosion.

6. SOCIO-ECONOMIC

From a social perspective, the Sundays River estuary is considered to be important. Ecological impacts on the estuary could negatively impact on recreational activities such as fishing as well as its aesthetic value. Furthermore, the Addo Elephant National Park is located near the Sundays River and should the ecological status and quality of the estuary deteriorate further, tourism could be affected negatively. Lastly, during the operation of the desalination plant, noise would be generated by the high-pressure pumps, which may be considered intrusive to tourists and residents in the vicinity. This could be partially mitigated through design and sound proofing of the structures associated with the plant.

7. OTHER ISSUES

The strengths and weaknesses of the return flow desalination scheme are:

- **Strengths**
  - The excess flows entering the Sundays River estuary will be reduced to be more representative of the naturally occurring flows by the planned abstraction rates.
  - The “waste stream” to the ocean will cost less than the DWA charges for water supplied directly from the ORP system.
  - The scheme would supply additional water to the northern side of the NMBM bulk supply system where future demand increases will be highest.
  - Potential to improve overall water quality supplied from the northern side of NMBM if blended at the Nooitgedagt WTW with (ORP/Fish River) water.

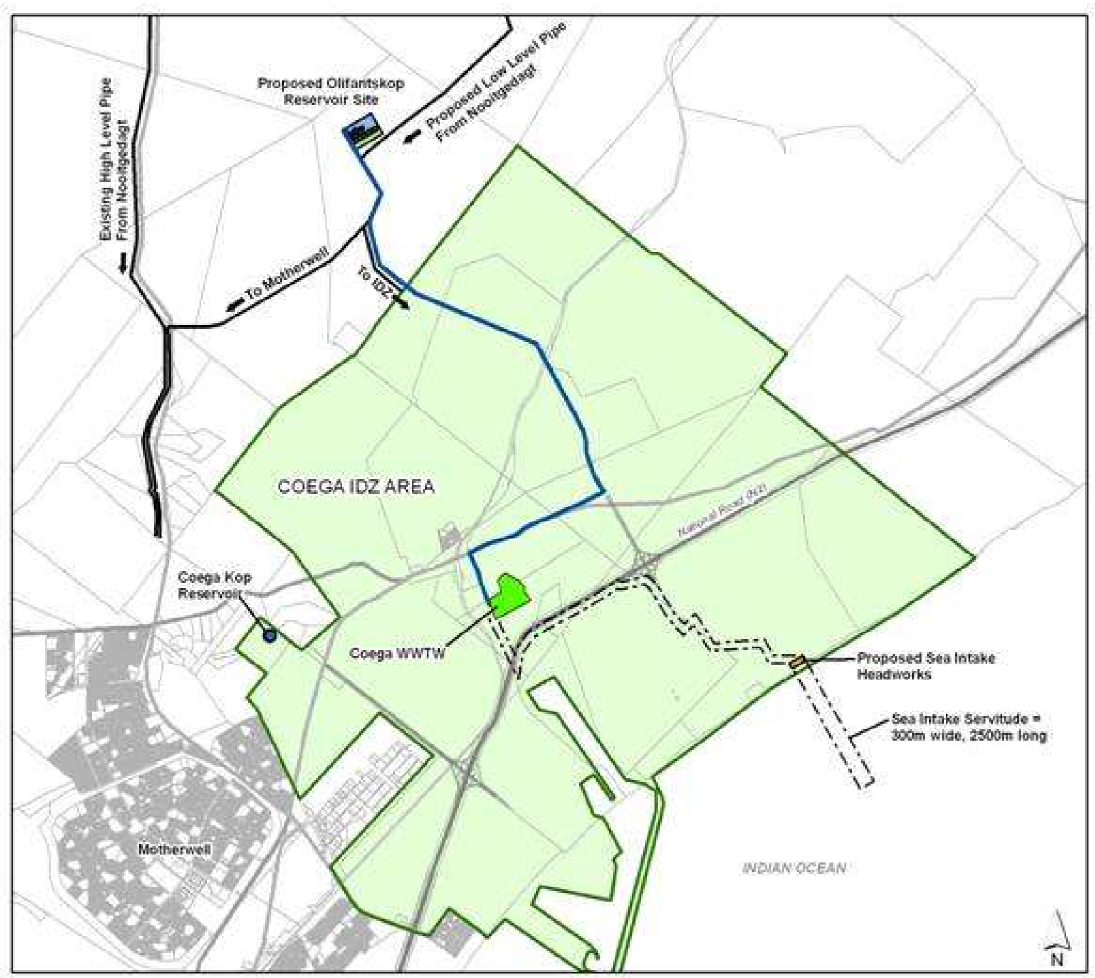
- **Weaknesses**
  - No fully representative water quality information is available. This information could have major impacts on the final treatment processes required to treat the water.
  - Variability in river flow and actual volumes to be abstracted, not accurately measured – this could minimise assumptions made on yield.
  - High energy requirements result in secondary environmental impacts.
  - Brine discharge pipeline over long distance is required.
  - Brine discharge into sea will require special environmental considerations.

F3. Desalination of seawater

1. SCHEME LAYOUT

The information presented is taken from the *Coega Development Corporation's (CDC) Inception report for IDZ Bulk Water, Return Effluent and Sewers Planning and Implementation* dated July 2007 and the *Water Master Plan 2006 for NMBM.* This outdated *i*nformation has been updated in line with latest outcomes of workshops and technical meetings between NMBM and CDC on the provision of industrial water supply infrastructure.

The scheme would be implemented by the NMBM as the Water Services Authority developing a new water supply source from the desalination of sea water to potable water standards, assuming that the Coega IDZ option for a desalinated water supply does not materialise.



2. SCHEME DESCRIPTION

The scheme will consist of a bulk seawater intake system to be provided by the CDC as a seawater intake for multiple potential sea water users within the Coega IDZ area (if this does not take place, then the NMBM will be required to implement this as an additional capital outlay). The NMBM scheme will pump sea water from the onshore bulk head via an 8.5km x 1.1m dia pipeline to the proposed RO plant site (to be shared with the planned Coega WWTW).

The most probable intake system will be an underground collector pipe system installed by directional drilling (Neodren[(p)]), a more capital intensive intake than open sea intakes, but far more environmentally acceptable and thus to be approved with less environmental mitigation factors and probably in a shorter EIA timeframe.

If the NMBM cannot find a downstream user for the brine discharge, then the brine stream will be discharged into the ocean, making use of the proposed Coega WWTW sea outfall sewer sea discharge pipeline.

Water will be lime stabilised at the treatment site before being pumped via a 13.7km x 1.0m dia pipeline to the proposed Olifantskop reservoir site north of the Coega IDZ area, where it will be blended with water supplied from the Nooitgedagt WTW (ORP supply source).

There is an added benefit in utilising potable water from RO, as the blending of this water with water supplied from Nooitgedagt WTW (both at Olifantskop and Grassridge reservoirs) will improve the final water quality supplied to end users.

Factors influencing the implementation of this potential source of supply:

- Cost of sea intake infrastructure – This could amount to some R 300-R400 million (depending on the scale) which, if not implemented by CDC as part of its infrastructure plan, will directly impact on the unit costs of water treated
- Uncertain energy supply – The operation of an RO plant is high in energy demand. Present energy shortage threats in SA could impact on supply (start up and reliability of supply)
- Connecting to infra-structure – The availability of existing water balancing and conveyance infrastructure of the proposed Nooitgedagt Low Level Scheme will supplement the implementation plan for this source.
- Major water demand centres – The Coega IDZ is a major future water demand centre of the NMBM and is ideally located for utilisation of this potential source.
- Post-treatment of RO water – The extent of post treatment to balance pH and increase alkalinity will be grossly reduced if source is blended with water from Nooitgedagt WTW.
- Brine discharge to sea – The return of final effluent to the sea could require a separate discharge pipeline to be provided by NMBM should the EIA for the Coega WWTW not permit a combined sea outfall pipeline.

3. SCHEME YIELD

Seawater could yield a limitless volume. The metropolitan water demand versus available sources at the time of implementation, will determine the yield of the scheme to be developed. For the purposes of this assessment, a treated water output of 100 Ml/d (36.5 million m^3/a) was considered.

4. UNIT REFERENCE VALUE

The URVs for this option are based on preliminary design and costing performed by Afri-Coast Engineers as part of the NMBM Draft Preliminary Design Report for the Nooitgedagt-Olifantskop Low Level Scheme (2008) and technical input by a membrane technology supplier. The URV calculation is based on social discount rates of 0%, 3%, 6% and 8% per annum for a 25 year period.

Table 1 Desalination of Seawater URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	1222.6	1222.6	1222.6	1222.6
Annual operating cost million/annum)	**(R**	134.0	134.0	134.0	134.0
NPV Cost	**(R million)**	3993.3	2973.0	2345.7	2048.5
Unit Reference Value	**(R/m^3)**	5.29	6.04	7.0	7.7

Note that the URV's exclude escalation, cost of supplying a sea-intake and any income stream for utilisation of the brine stream by others

The URV includes the following :

- An estimated Unit Cost of R1.50 /m3 at which NMBM will purchase seawater at the sea intake bulkhead (supplied by others)
- Operating costs including conveyance to the proposed Olifantskop Reservoir site and including balancing storage at the same site.
- A reduction of 10% on capital & operating costs for Desalination (refer to Point 2 below)

For the surface and groundwater options, water treatment costs have been excluded in the URV calculation. This resulted in a reduced URV of between 20% and 30% for those options. Similarly, the desalination process (which supplies water to potable standard) was adjusted by 10% and no post treatment (water stabilization costing) costs were added to this Intervention.

5. ECOLOGICAL

This desalination process differs from those normally considered for potable water supply for the following reasons:

(a) brine could be sold to industries for secondary products within the IDZ;

(b) the directional drilling technique to be used for seawater abstraction through perforated HDPE pipelines installed some 4-5m below seabed level, would have a very low to no ecological impact on marine life during the operational phase (and would in any case be constructed for other schemes in the IDZ).;

(c) no pre-treatment with anti-fouling chemicals is required, resulting in a final discharge effluent with less impact on marine environment than other standard seawater desalination projects; and

(d) the pumping main will follow existing Coega IDZ servitudes.

However, should there be no market for the brine, the discharged effluent would be at twice the salinity concentration of the intake water and with an elevated temperature. As a result, marine organisms in the vicinity of the discharge point that are intolerant to high salinity levels or fluctuations in salinity and temperature levels could be affected by the brine discharge.

Furthermore, the desalination processes would use considerable amounts of electricity and this would have cumulative secondary environmental impacts that are associated with the development of power stations for electricity generation. These impacts are not borne by the beneficiaries of the water, but are concentrated in the areas of abundant coal resources in *inter alia* the Free State, Mpumalanga, the Waterberg and elsewhere, giving rise to equitability issues.

6. SOCIO-ECONOMIC

Social impacts are not likely to be significant (given the plant's location in the IDZ). Additional water provided by this scheme would contribute to the development of the IDZ which would create more jobs and income for the region, with the associated positive benefits. In addition, this water resource is not dependent on rainfall and would provide the Municipality with a strategic advantage, by having a source of water independent of the weather constraints.

7. OTHER ISSUES

The strengths and weaknesses of the desalination scheme are:

- **Strengths**
  - Unlimited source of raw water independent of drought cycles.
  - Process costs can be reduced through integration with PetroSa (heated water).
  - Direct environmental impacts can be minimised.
  - Plants can be easily upgraded/phased to increased capacities.
  - Desalination processes are becoming less expensive and energy consuming (latest energy recovery technologies have reduced energy input required from 4.3 kWh/m^3 to some 2.1 kWh/m^3).
  - Potential to improve overall water quality supplied from the northern side of NMBM.

- **Weaknesses**
  - High energy requirements result in secondary environmental impacts.
  - Relatively more expensive option than surface water.
  - Proposed Eskom annual increases of 45% per annum for the next 3 years will make this Intervention expensive to operate.

SECTION G

SURFACE WATER AUGMENTATION SCHEMES

G1. Maximising the yield of existing Kouga/Loerie Scheme

1. SCHEME LAYOUT

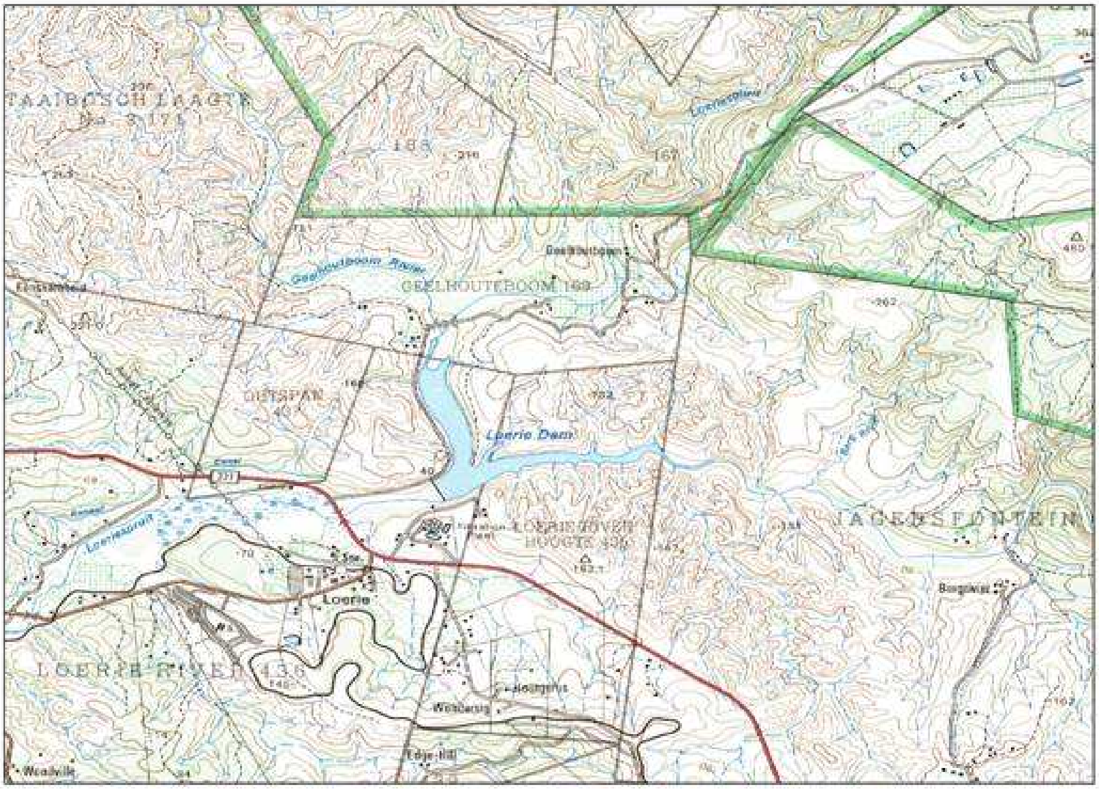


Figure 1 Loerie Dam

2. SCHEME DESCRIPTION

The existing Kouga/Loerie scheme comprises the Kouga Dam, the Gamtoos Canal and the Loerie Dam from which NMBM abstracts water for treatment at the 100 Mega litre per day (36.5 million m^3/a) Loerie Water Treatment Works. NMBM's current allocation from the Kouga Loerie scheme is 23.0 million m^3/a.

DWA's recent survey of the basin of Loerie Dam shows that siltation has reduced the capacity of Loerie Dam to about 2.9 million m^3. Information provided by NMBM indicates that the dead storage capacity of Loerie is about 0.8 million m^3 (27% of its current capacity) and that in addition, a reserve of about 0.4 million m^3 is required for periods when the Gamtoos Canal is out of service. Therefore, the capacity at the normal minimum operating level is about 1.2 million m^3 (40% of total capacity) and the corresponding available live storage about 1.8 million m^3, whereas until very recently the capacity at the minimum operating was about 2.35 million m^3 (80% of total capacity).

The MAR at Loerie is estimated to be about 25 million m^3/a (although this is uncertain as discussed in Section 3 below). The Gamtoos Irrigation Board currently experiences difficulty in controlling the flows from the Gamtoos Canal into Loerie Dam as there is only one balancing dam in the upper reaches of the canal near Patensie, whereas the original White Paper made provision for three balancing dams.

The results of the preliminary analyses to estimate the additional yields that can be obtained from Loerie Dam for various Target Operating Levels and inflows from the Gamtoos Canal are described in Section 3 below.

3. OPTION YIELD

This preliminary assessment of the yields that might be obtained from Loerie Dam in addition to those provided by the inflows from Kouga Dam have been based on the WR90 flow record from 1969 to 1989, with all runoffs reduced pro rata to provide a MAR of 25 million m^3/a for the period. The Loerie Dam yields have been estimated for the original target operating level of 80% of current capacity and for the recently introduced minimum operating level of 40% capacity, and for constant inflows from the Gamtoos Canal of 6, 12, 18 and 24 million m^3/a. The yields shown in the Table below were assumed to be equal to the minimum average annual yield over 36 months.

The Table indicates that if the Loerie WTW and pumps are operated at maximum capacity whenever the canal and natural inflows cause the level in the dam to rise, and the minimum operating level is reduced from 80% to 40% of current full capacity, then the yield of Loerie from its catchment runoff will increase by between about 4 and 6 million m^3/a over a prolonged drought period.

Table 1 Yields of Loerie Dam for Various Target Operating Levels and Canal Inflows

Loerie Dam	Storage Total – Minimum (% of 2.93 Mm^3/a)	Loerie Dam Yield (Mm^3/a) for Gamtoos Canal Inflow (Mm^3/a)			
		6.0	**12.0**	**18.0**	**24.0**
Existing	100% - 80%	5.4	5.4	5.4	5.4
Existing	100% - 40%	11.7	11.7	11.3	9.6
	Increase in Yield	6.3	6.3	5.9	4.2

The table also indicates that in order to supply NMBM's current allocation of 23.0 million m^3/a, releases from Kouga Dam should be as follows for the previous and current minimum operating levels (MOLs) of Loerie Dam:

- MOL (80%): Loerie 5.4 million m^3/a and Kouga 18.1 million m^3/a (23.5 minus 5.4)
- MOL (40%): Loerie 11.7 million m^3/a and Kouga 11.8 million m^3/a (23.5 minus 11.7)

The table also indicates that if the Gamtoos Irrigation Board is able to limit releases from the canal into Loerie Dam to about 12 million m^3/a (0.4 m^3/s) then an additional balancing dam on the canal would provide little or no benefit in yield but will almost certainly provide other operational benefits.

4. UNIT REFERENCE VALUE

No URV has been determined for the implementation of the reduced operating level as this would result in little or no additional cost.

5. ECOLOGICAL

The only ecological impact of operating Loerie Dam at lower levels is the reduction in the frequency and volumes of spillway overflows which might impact on the ecology of the river downstream.

6. SOCIO-ECONOMIC

There are no socio-economic impacts of operating Loerie Dam at lower levels.

7. OTHER ISSUES

Specific strengths and weaknesses of the rule to operate Loerie Dam at lower levels include:

- **Strengths**
  - The operation does not require additional infrastructure or operating staff.
  - The yield of Loerie Dam can be increased by about 6 million m^3/a during a prolonged drought.

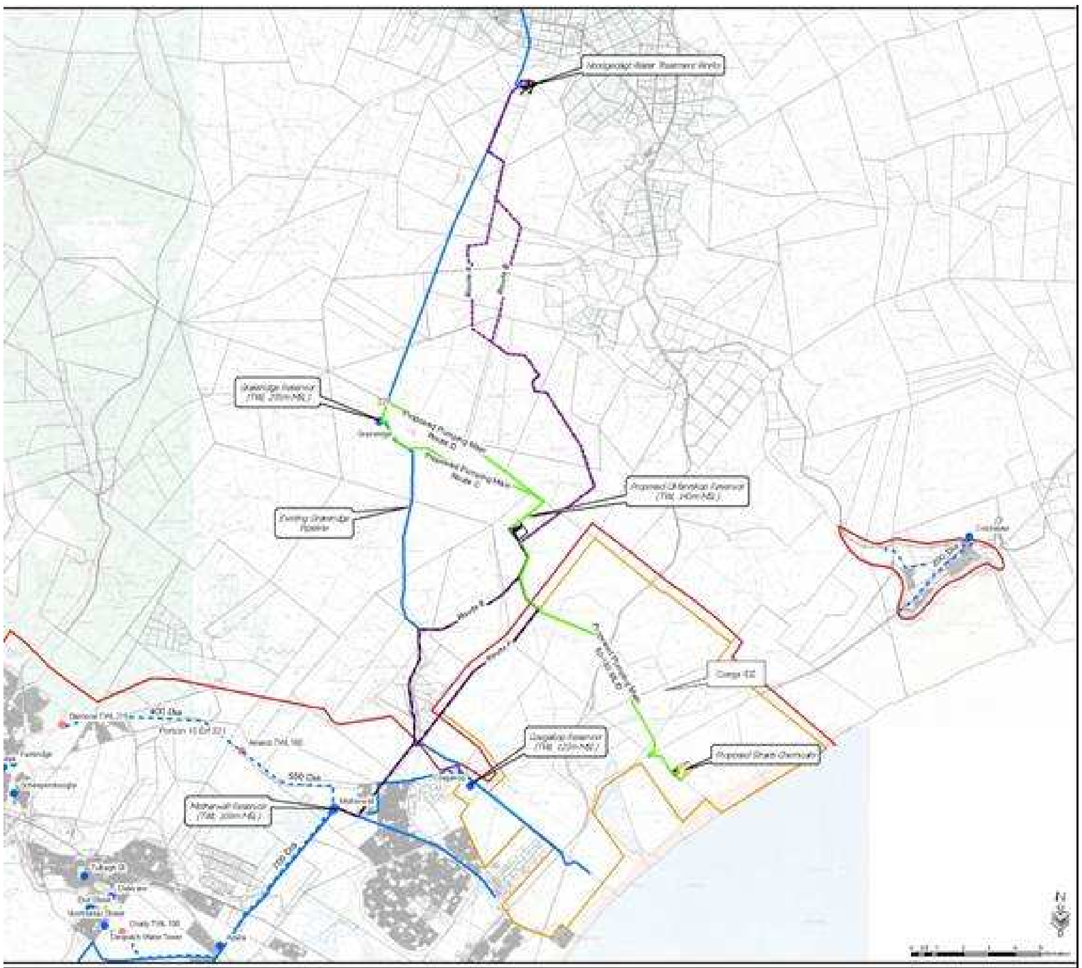
- **Weaknesses**
  - The frequency of spillway overflows will be reduced which may be detrimental to the ecology of the river downstream.
  - The yield results are uncertain on account of the uncertain record of inflows to Loerie Dam. This record should be reviewed.
  - Historically high manganese concentrations caused problems at the WTW when Loerie Dam was operated at low levels; however it has been found that no water quality problems have been experienced with the recent introduction of the minimum operating level of 40%.

G2. ORP / Nooitgedagt Low-Level Scheme

1. SCHEME LAYOUT

The information presented is taken from the *NMBM Water Master Plan 2006 (WMP).* The WMP recommended the scheme based on the outcomes of the *Algoa Water Supply Pre-Feasibility Study* conducted by BKS Acres in 1999/2001.

The scheme is aimed at NMBM receiving an increased water supply from the ORP and developing a low level scheme from the Nooitgedagt WTW on the right bank of the Lower Sundays River to a proposed reservoir site on the Farm Olifanstkop. The proposed scheme is essential for the future potable water supply (industrial water supply to be sourced from secondary sources) to the Coega IDZ, presently under development and will offer huge energy savings in terms of a reduced pumping head.



2. SCHEME DESCRIPTION

The Nooitgedagt WTW at present has an output capacity of 100 Ml/day and a final water pump supply capacity (High Level Scheme) to Grassridge reservoir (TWL 234 m MSL) of 90 Ml/day. Recent additions of a second pulsator clarifier and a fourth pump to the high-lift pump station increased the previous 70 Ml/day to 100 Ml/day.

The scheme will consist of the following elements :

- An extension of the treatment capacity of Nooitgedagt WTW from 90 Ml/day (Peak) to 210 Ml/day (Peak).
- A Low-Lift Pump Station at Nooitgedagt.
- A rising pipeline (22.7 km x 1 200 mm dia) from Nooitgedagt to Olifantskop reservoir.
- A first phase reservoir (40 Ml) at Olifantskop.
- A gravity pipeline from Olifantskop to Motherwell (15.7 km x 1 200/1 000 mm dia).

Factors influencing the implementation of this potential source of supply are:

- Infrastructure options – The project is already in its preliminary design phase with alternative pipeline routes and reservoir sites having been identified and initial soil testing and profiles completed.
- Environmental – The project has been registered for the EIA process which is in progress. This will shorten the implementation period of the project compared with other intervention options.
- Energy efficiency – The low-level scheme will pump some 40-50% of the present high-level requirement along the low-level route. This will bring about an immediate energy saving, however this saving will reduce over the medium term with the growth in the requirements of both the high and low-level schemes.

3. SCHEME YIELD

In formulating the Low-Level Scheme, the following have been taken into account:

- NMBM was allocated an exchange volume of 13.5 million m^3/a (37 Ml/day) from the ORP for an equivalent reduction in allocation from Kouga Dam in 1993.
- NMBM has a registered water use dated June 2005 of 17.0 million m^3/a (46.6 Ml/day) from the ORP system.
- NMBM water use from the ORP system over the 2007/08 period was 31 million m^3/a (69 Ml/day).
- At the time that this paper was prepared, it was envisaged that the Coega IDZ would have an additional estimated requirement of 21.9 million m^3/a (60 Ml/d) potable use and 65.7 million m^3/a (180 Ml/day) industrial water use, will require up to 25.6 million m^3/a (70 Ml/day) by 2016. These expectations of growth in especially industrial water requirements have since been reduced to industrial use of 30 Ml/day and potable use of 55 Ml/day by 2030.
- The DWAF ISP indicated that some 41.3 million m^3/a (113.2 Ml/d) is still available (reserved) for NMBM from the ORP system.

A scenario was assumed whereby the present registered water use of 17.0 million m^3/a (46.6 Ml/day) would be increased by the 41.3 million m^3/a unallocated water to a total allocation of 58.3 million m^3/a (159.7 Ml/day) from the ORP. Based on a current High Level Scheme capacity of 25.6 million m^3/a (70 Ml/d, with a peak of 91 Ml/d), the incremental yield of the Low Level

Scheme is estimated as 32.7 million m^3/a (89.7 Ml/d, with a peak of 115 Ml/d). The low level scheme could be extended in future, should NMBM obtain and purchase irrigation water rights in the Fish or Sundays rivers catchments.

An interim DWA allocation/licence for ORP water of 160 Ml/d was therefore assumed until more clarity on the actual DWA licensed supply becomes available. Based on a High Level Scheme with an average capacity of 70 Ml/day, the applied yield for this Intervention is 89.7 Ml/day.

4. UNIT REFERENCE VALUE

The URVs for this option is based on preliminary design and costing performed by the NMBM Project Team in 2008 for the proposed Nooitgedagt Low Level Scheme. The URV calculation is based on a social discount rates of 0%, 3%, 6% and 8% for a 25 year period.

Table 1 ORP/Nooitgedagt Low Level Scheme URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	457.6	457.6	457.6	457.6
Annual operating cost	**(R /annum)**	9.74	9.74	9.74	9.74
NPV Cost	**(R million)**	1578.9	1151.1	892.6	775.7
Unit Reference Value	**(R/m^3)**	2.53	2.90	3.40	3.80

Note that the URV calculations exclude escalation and watertreatment costs.

The URV includes the following :

- All capital works required to implement this intervention
- Operating costs including conveyance energy
- An assumed DWAE transfer tariff of R1.50/m^3 (present tariff = R1.002/m^3 for 2009/10) for ORP water supplied to the Lower Sundays River Scheme for urban use

For the surface and groundwater options, water treatment costs have been excluded in the URV calculation. This resulted in a reduced URV of between 20% and 25% for those options. Similarly, no treatment costs were added to this Intervention

5. ECOLOGICAL

SRK Consulting is currently in the process of conducting an Environmental Impact Assessment (EIA) for the proposed scheme. According to the EIA report, the proposed pipeline would, where possible, follow existing servitudes, thereby limiting the destruction of indigenous vegetation during the construction of the pipeline. However, the pipeline will cut through some indigenous vegetation that is currently in an excellent condition, and the more limited servitudes would remain cleared to facilitate inspection and maintenance activities. Vegetation types impacted by the proposed scheme may include Sundays Spekboom Thicket (Vulnerable[1]), Koedoeskloof Karroid Thicket (currently not vulnerable), Grassridge Bontveld (currently not vulnerable), Motherwell Karroid Thicket (Endangered) and the Sundays Doringveld Thicket (Vulnerable). In

[1] Conservation Status according to the Subtropical Thicket Ecosystem Plan (STEP)

addition, the pipeline would cross through river valleys and steep slopes that could result in further disturbance of sensitive ecosystems and could be subject to erosion into the future.

A positive impact associated with this scheme would be the immediate energy savings over the medium term that would contribute to lessening the pressure placed on Eskom to provide electricity. However, as the demand for water increases at both the high and low level schemes, energy savings will decrease over time.

6. SOCIO-ECONOMIC

The clearing of vegetation for the proposed pipeline could have a significant visual impact on the surrounding area, as the cleared areas may be visible to tourists and other visitors travelling to the Greater Addo Elephant National Park and other tourist attractions (especially along the R335), reducing the aesthetic value of the area.

On the other hand, the availability of sufficient water to commission major industries within the Coega IDZ is necessary to generate the socio-economic benefits related to the IDZ for the region. An increase in industries will create more job opportunities and expand livelihoods and earnings of people in the area, thereby having a positive economic impact.

7. OTHER ISSUES

The strengths and weaknesses of the ORP Supply scheme are:

- **Strengths**
  - The Low Level Scheme will supply water to Olifantskop, Coega Kop and Motherwell reservoirs at a reduced pumping energy demand compared to the present High Level Scheme. This will bring about an immediate energy and cost saving of some R110,000/month.
  - The scheme is already in its EIA phase with the Preliminary Design completed. This will shorten the time scale for implementation date compared to other interventions.
  - The power supply to the Eskom yard and the 22kV power supply line from Eskom to the Nooitgedagt Transformer yard, does not need any upgrading.
  - The water from a remote inland catchment results in a reduced risk factor to the NMBM bulk water supply system in periods when local resources experience drought conditions.

- **Weaknesses**
  - No firm allocation /licence has been issued by DWA for the increased water requirement.
  - The supply is from the Gariep Dam, an inland source.
  - The Scheepersvlakte Balancing Dam has a small storage capacity (815 Ml). This necessitates that during three months per annum, the NMBM bulk water supply system must be rezoned to draw less water from this source. Raising of the dam overflow level should be considered.

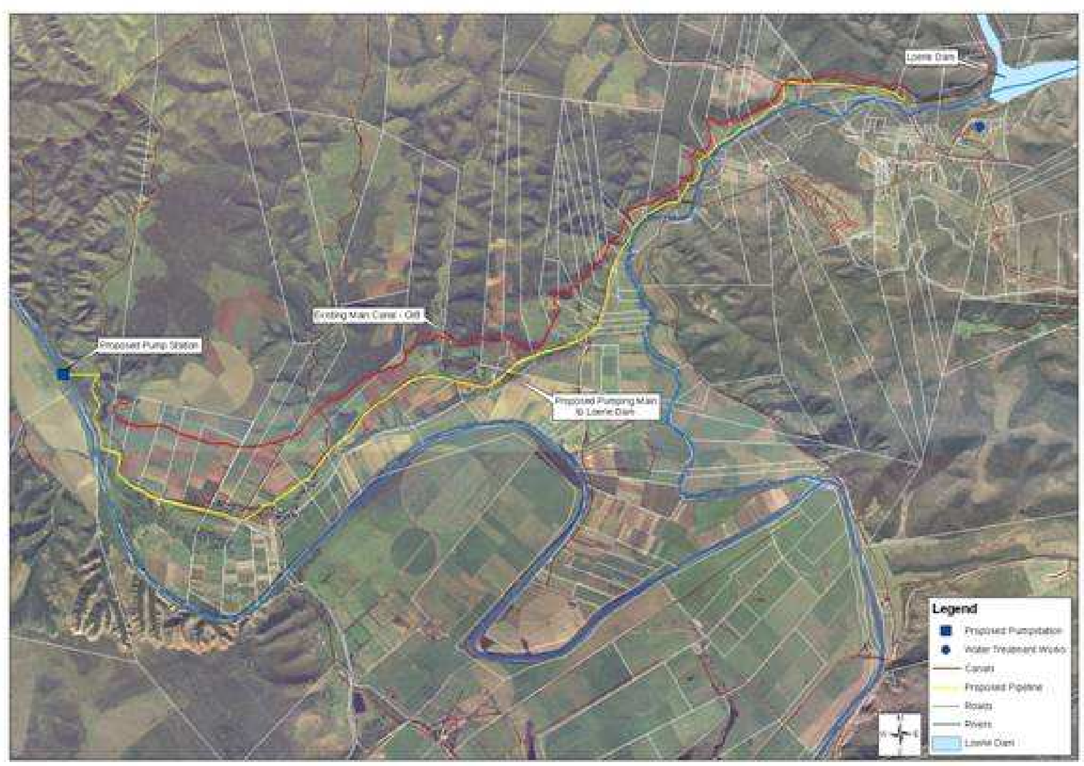
G3. Diversion of lower Gamtoos River flows

1. SCHEME LAYOUT

This intervention has not been considered or investigated by any previous study as a possible source of water supply to NMBM. The information used is based on assumptions of average return flows into the Lower Gamtoos River from the Kouga irrigation scheme (WRC Report No 503/1/97 – The effect of Land Use on Gamtoos Estuary Water Quality), a Reserve assumption and on water quality data obtained from the DWAE water quality database.

The scheme would comprise the abstraction of irrigation return flows from downstream of a significant proportion of the irrigation area supplied by the Gamtoos Irrigation Board (upstream of the tidal river zone) and pumping this water into the Loerie Dam for blending with water from Kouga Dam.

The proposed scheme and integration with existing water infra-structure, is shown in the figure below.



infra-structure

2. SCHEME DESCRIPTION

The scheme will consist of a raw water abstraction pump station on the Gamtoos River at a point some 25 km from the river mouth and upstream of the tidal zone which impacts on water quality at Boschhoek Railway Bridge some 20.4km upstream of the river mouth (WRC Report No 503/1/97). The raw water source is mostly return flow from the Gamtoos Irrigation Scheme (a portion of the scheme known as Mondplaas, is still downstream of this abstraction point) as well as contributions from the Groot River and Klein River, both which could be classified as perennial streams.

Raw water will be pumped over some 13.8 km and be discharged into the lower end of the Gamtoos canal immediately upstream of the tunnel leading to the Loerie Dam discharge point, thus without any interference with irrigation water quality standards.

Additional water pumped into Loerie Dam will be treated at Loerie WTW utilising the existing spare capacity and will be pumped to Summit reservoir by the existing final water pump station, also utilising spare pumping and transfer capacities (spare capacities resulting from DWA's exchange of water allocations from Kouga Dam to the ORP supply in 1989).

DWA water sampling (51 samples) at Station L9H004Q01 at the Boschhoek Bridge some 5 km downstream of the proposed abstraction point (period Sep 06 to Aug 07 and Sep 81 to Aug 06) was used to provide an indication of river water qualities. The data set showed promising water quality data.

A single sample was collected from the river in August 2009, blended in varying ratios and analysed to determine which blend of river and canal water would comply with potable water standards. 80/20 and 70/30 (canal/river) blended samples both showed acceptable water qualities in terms of SABS 241 Class 1 standards for potable water.

It is anticipated that, provided the blending of river and canal water is maintained below the threshold ratio, no additional treatment such as desalination or softening, will be required.

Factors influencing the implementation of this potential source of supply :

- The raw water quality variability has not been determined in sufficient detail to confirm the actual acceptable blending ratios and thus the scheme yield.
- The Reserve determination could alter and affect the scheme yield.

3. SCHEME YIELD

WRC Report No 503/1/97 reports that, the estimated inflow of freshwater into the estuary is approximately 1 m^3/s. In dry period this may sporadically drop to some 0.5-0.8 m^3/s.

It will, due to many unknowns (Reserve determination, irrigation return flow, gauging measurements) be too optimistic to assume an abstraction in excess of 20 Ml/day (7.3 million m^3/annum)

4. UNIT REFERENCE VALUE

The URVs for this option are based on preliminary design and rudimentary sizing and costing performed by Afri-Coast Engineers as part of this study. The URV calculation is based on discount rates of 0%, 3%, 6% and 8% for a 25-year period.

Table 2 Diversion of Lower Gamtoos River Flows URV

ITEM		Discount Rate 0 %	Discount Rate 3 %	Discount Rate 6 %	Discount Rate 8%
Total capital cost	**(R million)**	102.4	102.4	102.4	102.4
Annual operating cost	**(R million/annum)**	4.9	4.9	4.9	4.9
NPV Cost	**(R million)**	218.9	178.9	153.6	141.6
Unit Reference Value	**(R/m^3)**	1.26	1.51	1.81	2.04

Note that the URV calculations exclude escalation, cost of land & servitudes and water treatment chemicals

The URV includes the following :

- Capital costs for all infrastructure from river abstraction to Loerie Dam
- Operating costs of all conveyance to Loerie Dam and thereafter to Summit reservoir.

For the surface and groundwater options, water treatment costs have been excluded in the URV calculation. This resulted in a reduced URV of between 15% and 25% for those options. Similarly, no treatment costs were added to this Intervention.

5. ECOLOGICAL

The proposed pump station is located within an aquatic environment that is rated by the Eastern Cape Biodiversity Plan (ECBP) (Berliner and Desmet, 2007; Berliner, Desmet and Hayes, 2007) as an Aquatic Biodiversity Land Management Class (ABLMC) 2b. This means that the river is in a near natural state and environmental authorities may decide to support ecosystem integrity when making decisions with regard to the ecological Reserve. Furthermore, it is also noted by the ECBP that the river is important for fish migration. In the lower branch of the Gamtoos River, towards the coast, the ABLMC class changes to 2a, indicating an important sub-catchment. Therefore, the water quality of the Gamtoos River is very important to prevent degradation of A1 rivers (irreplaceable sub-catchment rivers containing endemic fish) and requires moderate protection. Due to the agricultural/irrigation activities upstream along the Gamtoos River, water pumped into the Loerie Dam is likely to be enriched with nutrients and other elements from the irrigated land, unless treated beforehand. The introduction of this water into the Loerie Dam could have an impact of the water quality of the dam through eutrophication, and the water released from the dam could have an impact on the downstream environment,

With regard to the terrestrial environment, the Gamtoos River and proposed pumping main to Loerie Dam would be located within an ecological corridor despite large areas of land transformed by agriculture, and has a Biodiversity Land Management Class rating of 2 (near-natural state and ecosystem integrity should be maintained). Furthermore, a large area surrounding the Loerie Dam and patches of land along the Gamtoos River are protected and managed in accordance with conservation agreements with landowners. The ECBP strongly recommends that no transformation of natural area should be allowed. According to Mucina and Rutherford (2006) the vegetation surrounding the Gamtoos River consists of Albany Alluvial Vegetation (AZa6), Cape Estuarine Salt Marshes (AZe2) and Cape Seashore Vegetation (AZd3) of which only Albany Alluvial Vegetation is endangered. The pipeline would cut through Albany Alluvial Vegetation, as well as Gamtoos Thicket (AT4) and Loerie Conglomerate Fynbos (FFt2).

6. SOCIO-ECONOMIC

The impact on ecosystems and biodiversity in the aquatic and terrestrial environments of the Gamtoos and Loerie Rivers due to poor water quality would in the long-term have a negative impact on local agricultural activities and production levels, for example low crop yields. This would not only impact on the wellbeing of farmers, but also on local communities depending on jobs provided by and spending power of farmers.

The quality of water from the Loerie WTW would be lower and more viable but would comply with DWAE and SANS Potable Water Standards.

7. OTHER ISSUES

The strengths and weaknesses of the return flow desalination scheme are:

- **Strengths**
  - A reliable water source (return irrigation flow)
  - Implementation can be achieved over relative short time period
  - Source with a very favourable URV (maximises existing under utilised water infra-structure at Loerie WTW and in transfer pipelines to NMBM consumers.

- **Weaknesses**
  - Minimal water quality information is available.
  - Variability in river flow and actual volumes to be abstracted, not accurately measured – this could minimise assumptions made on yield.
  - Water quality, ecosystem integrity and biodiversity could be negatively impacted by releasing enriched water from the Loerie Dam into the Loerie River in order to meet Ecological Flow Release requirements.
  - Environmental scientists from NMMU do not support this scheme on account of the negative impacts that the withdrawal of freshwater would have on the estuarine sea water interface in the ecologically very important Gamtoos Estuary. Therefore the scheme was not considered further as an intervention option.

G4. Tsitsikamma River diversion to Impofu Dam

1. SCHEME LAYOUT

2. SCHEME DESCRIPTION

Various scheme configurations have been investigated in the past. These have consisted of dams and diversion weirs, with some of the schemes linking into larger coastal river schemes from rivers further to the west.

It has been assumed that the scheme would consist of a low diversion weir at the current gauging weir site K8H005, a pump station to pump water via a 12.4 km rising main to a high point, from where the water would gravitate in a 1.4 km pipeline into a stream which flows into Impofu Dam. The water would be treated at the existing Elandsjagt WTW and distributed through existing infrastructure.

A low weir is proposed by this study on account of the higher and possibly unacceptable environmental impact of a dam.

3. SCHEME YIELD

The Tsitsikamma River catchment has been fairly heavily developed with farm dams, irrigation and afforestation, and the catchment also has a fairly large area infested with invasive alien plants. Consequently, the present day flows at the gauging weir site are only a fraction of naturalised flows. In addition, the EWR requirements are quite high at 30% of MAR and a diversion scheme cannot capture all of the floods that pass due to capacity constraints. All these factors impact on the yield potential of a diversion scheme on the Tsitsikamma River.

The additional yield from the present day Impofu Dam with transfers from the Tsitsikamma River was found to vary from 0.96 Mm^3/a for a transfer capacity of 0.25 m^3/s to 3.44 Mm^3/a for a transfer capacity of 4 m^3/s.

4. UNIT REFERENCE VALUE

The unit reference values for a diversion and transfer capacity of 0.25 m^3/s, the cheapest of the capacities investigated, are presented below for a 25-year time horizon.

Table 1 Tsitsikamma River Diversion URV

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	60.1	60.1	60.1	60.1
Annual operating cost	**(R million/annum)**	1.2	1.2	1.2	1.2
NPV Cost	**(R million)**	87.1	75.7	67.9	
Unit Reference Value	**(R/m^3)**	3.95	5.10	6.48	

5. ECOLOGICAL

The following vegetation types are likely to be affected by the proposed weir and pipeline: Garden Route Shale Fynbos (FFh9), Tsitsikamma Sandstone Fynbos (FFs20), Southern Cape Dune Fynbos (FFd11), Southern Afrotemperate Forest (FOz1), Eastern Coastal Shale Band Vegetation (FFb6) and Humansdorp Shale Renosterveld (FRs19) (Mucina and Rutherford, 2006). Of these, Garden Route Shale Fynbos, Eastern Coastal Shale Band Vegetation and Humansdorp Shale Renosterveld are considered to be endangered and the Tsitsikamma Sandstone Fynbos vegetation type to be vulnerable.

Furthermore, according to the Eastern Cape Biodiversity Conservation Plan (Berliner and Desmet, 2007; Berliner, Desmet and Hayes, 2007), the area potentially impacted is rated as Biodiversity Land Management Class (BLMC) 3 and an Aquatic BLMC (ABLMC) rating 1 (the aquatic environment is considered to be in a natural state and a critically important river sub-catchment that should be managed to ensure no biodiversity losses). The lower reaches of the Tsitsikamma River pass through the Huisklip Nature Reserve. With regard to the pipeline, the proposed route would pass through areas with BLMC ratings of 3 (functional landscape), 2 (near-natural landscape) and 1 (natural landscape), with various ecological corridors, wetlands and waterbodies occurring throughout the landscape. Furthermore, the existing weir is located in an area where critically endangered forest patches occur.

No aquatic information is available for the stream that would be used for the discharge into the Impofu Dam. However, the surrounding terrestrial environment is divided into numerous natural (BLMC 1) and functional (BLMC 3) zones.

In terms of construction impacts, the weir would inundate a slightly larger section of river than the current gauging weir. The pump station and pipeline would be located on farm land as well as natural areas. Access could be managed to reduce potential impacts by remaining outside of the more environmentally sensitive areas ("no-go"-areas).

The diversion scheme would allow for ecological Reserve flow releases for the river and estuary before any abstractions would take place. However, the proposed higher weir wall could impact on important ecological processes such as fish migration routes, as well as the Huisklip Nature Reserve. Furthermore, the receiving stream flowing into the Impofu Dam would experience unnatural increased water levels, which could result in changing habitat structures and composition, disruption of ecosystem services and activities and even possibly result in bed and bank erosion. Bed erosion could be mitigated through erosion control structures, however environmental impacts would be difficult to mitigate.

6. SOCIO-ECONOMIC

From a socio-economic perspective, tourism at the Huisklip Nature Reserve could be negatively impacted should environmental degradation occur as a result of lower water levels. Care should also be taken not to impact existing water users, i.e. lower water levels during dry months preventing abstraction by existing users. Furthermore, it would be necessary to either provide a camp onsite for construction workers or transport them to and from the nearest town on a daily basis. The construction work would provide short-term jobs to local people, however job seekers from surrounding areas may also be attracted, impacting on social structures of local communities, including farm workers, and increasing pressure on local municipal services.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - Can be integrated into the existing Impofu Dam supply system to NMBM;
  - Limited inundation and impact on the Tsitsikamma River gorge;
  - Will allow full release of EWRs to maintain a category C river downstream.

- **Weaknesses**
  - Impacts on the aquatic environment, especially the Tsitsikamma River ABLMC 1, during the construction and operational phases;
  - Location of critically endangered forest patches;
  - Possible resistance to the scheme by environmental lobby groups and the public;
  - The low confidence yield calculation is based on only 11 years of observed flow data, but spans a significant drought;
  - Costly.

G5. Guernakop Dam

1. SCHEME LAYOUT

The information for his scheme is taken from the Algoa Water Resources Stochastic Analysis (1996) Report (Report No. PM 000/00/0395) entitled *Possible Future Augmentation Schemes* and the Algoa Prefeasibility Study (2002) Report (Report Number PM000/00/1902) entitled *Hydrology and System Analysis of the Kouga System*.

Currently, the ratio of the Full Supply Capacity of Kouga Dam to the Mean Annual Runoff (MAR) of the Kouga River catchment is smaller than the optimum ratio (approximately 200%) for runoff utilisation for the area. There is also an estimated available capacity of approximately 30 million m^3/a in the conveyance infrastructure to the urban areas of Port Elizabeth, which is not currently being used. To make use of the extra available runoff and available conveyance capacity, the ideal option would be the raising of Kouga Dam. However, owing to (a) the high tensile stresses in the existing dam wall, (b) the alkaline aggregate reaction in the concrete of the dam wall, and (c) the perceived instability of the right abutment; this option becomes undesirable unless a new dam is constructed against or immediately downstream of the existing dam, as described in G6 below.

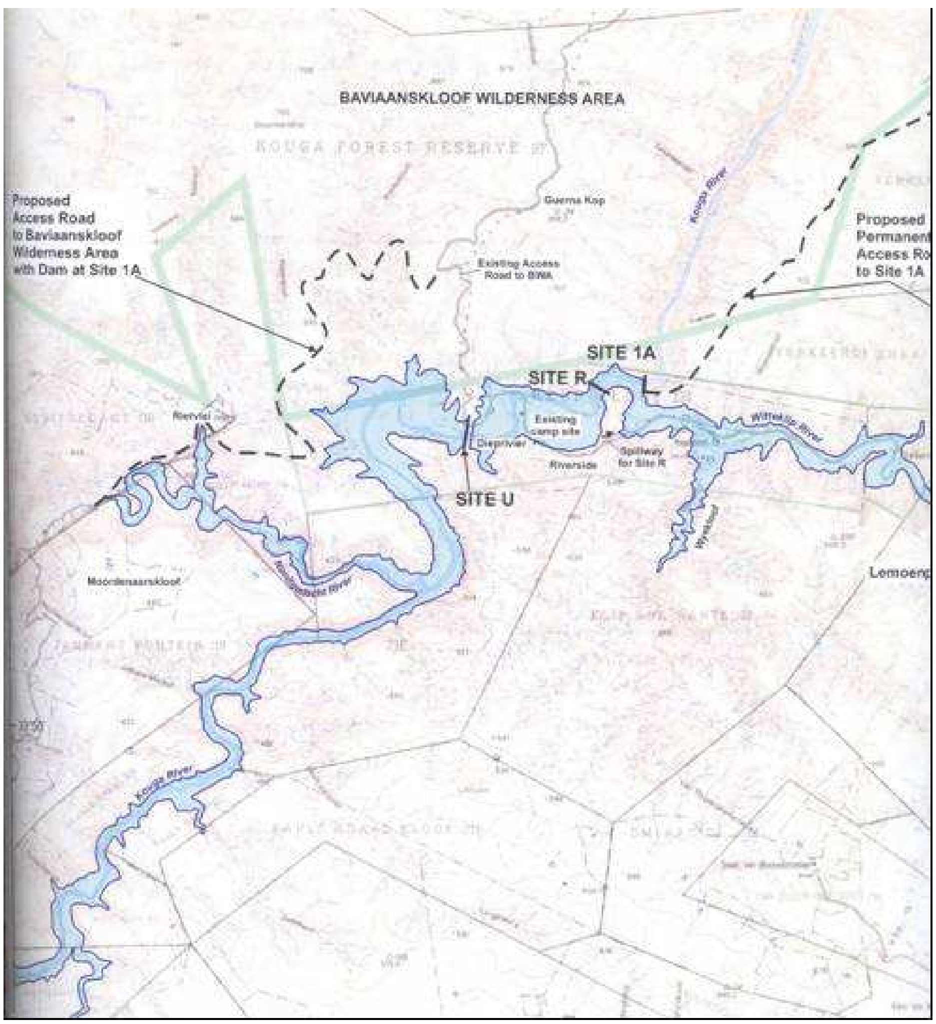


Figure 1 Guernakop Dam and Reservoir

The proposed Guernakop Dam site is approximately 15 km upstream of the upper end of Kouga Dam on the Kouga River. As part of the Algoa Prefeasibility Study (2002), three potential dam sites were investigated. Of the three dam sites considered, the "upper" dam site (Site U) was seen as the most favourable due to its markedly lesser impact on the natural environment. The "intermediate" dam site (Site R) was abandoned due to adverse geological conditions. For the purpose of this Study, therefore, only the "upper" dam site will be considered as the potential site for the proposed Guernakop Dam.

2. SCHEME DESCRIPTION

Although the Algoa Prefeasibility Study considered three dam sizes for Guernakop Dam (100, 150 and 200 million m^3), the system yield results dictated that a dam size of 200 million m^3 was the most favourable due to the larger resulting incremental yield. Therefore, for the purpose of this Study, only a dam of this size will be further considered (refer to the Table below for the dam characteristics).

According to the Algoa Prefeasibility Study, the recommended dam type for the "upper" dam site is a rockfill dam with an ogee spillway. The specific characteristics for this dam are shown in Table 1.

Table 1 Proposed Guernakop Dam Characteristics

Characteristic	Value
Type of dam	Rollcrete
RDD (attenuated)	3850 m^3/s
SED (attenuated)	6900 m^3/s
Spillway length	150 m
Total freeboard	8.5 m
River bed level	213.5 masl
Founding level in river	193.5 masl
Catchment area	2178 km^2
Mean Annual Runoff	± 96 million m^3/a
Sedimentation	2.42 million m^3
Maximum continuous capacity of outlet works	30 m^3/s
Gross Storage	200 million m^3
Full Supply Level	287.5 masl
Non-overspill crest (NOC) level incl. Wave wall	286.0 masl
Maximum wall height	82.5 m
Dam wall crest length	610 m
Surface area at: - FSL - NOC level	 678 ha 825 ha

On account of the increases in the yield as described below, it was also assumed that the capacity of the Loerie Water Treatment Works and the pipeline to the Summit Reservoir would be doubled, and that the Summit to Chelsea main would be boosted.

3. SCHEME YIELD

The yield information for his scheme is taken from the Algoa Prefeasibility Study (2002) Report (Report Number PM000/00/1902) entitled *Hydrology and System Analysis of the Kouga System*.

Table 2 summarises the yield analysis results from the Algoa Prefeasibility Study for two scenarios. Using these results, the incremental yield that can be achieved through the construction of the proposed 200 million m^3 Guernakop Dam can be determined.

Table 2 Algoa Prefeasibility Study Yield Analysis Results

Scenario Name	Description	Historical firm yield (Mm^3/a)	Long-term stochastic yield (M m^3/a)				
			1:10 year	1:20 year	1:50 year	1:100 year	1:200 year
Scenario 1b	Kouga, excl. Loerie	67.16	82	78	67	61	57
Scenario 2b	Kouga and Guernakop, excl. Loerie	90.18	120	115	101	92	83
Incremental yield due to 200 million m^3 Guernakop Dam (million m^3/a)		23	38	37	34	31	26

As evident in Table 2, The Historical Firm Yield (HFY) of the Kouga-Loerie system with just Kouga Dam in place is close to the 1 in 50 year yield, whereas, with Guernakop Dam in place, the reliability of the Historical Firm Yield increases to around the 1 in 100 year yield.

For the purpose of the Algoa Recon Study, the various water augmentation schemes are compared based on the 1:50 year yield, which corresponds to the HFY of the existing major dams in the Algoa Water Supply area. It can therefore be concluded from the results shown in Table 2 that an additional yield of 34 million m^3/a would be provided as a result of the construction of the proposed Guernakop Dam.

4. UNIT REFERENCE VALUE

The unit reference values based on 2009 costs are shown in Table 3.

Table 3 Guernakop Dam Scheme URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Capital cost	**(R million)**	1 452	1 452	1 452	1 452
Annual maintenance cost	**(R million)**	9.7	9.7	9.7	9.7
Annual electricity cost	**(R million)**	17.5	17.5	17.5	17.5
NPV Cost	**(R million)**	1 965	1 735	1 585	1 511
Unit Reference Value	**(R/m^3)**	3.07	4.27	5.90	7.26

5. ECOLOGICAL

The present ecological status class of the catchment is considered to be Class D (largely modified) on account of the large areas infested by alien vegetation. Furthermore, the water quality of the Kouga River has been classified as ideal even though a downstream increase in TDS has been observed. The Guernakop Dam would inundate an area of 678 ha at full supply level which includes near-pristine sections of the Guerna Wilderness Area. Specific areas that would become inundated include sections of the Kouga (± 25 km upstream of the dam wall) and Nooitgedagt Valleys (± 7 km upstream of the Nooitgedagt and Kouga River confluence). Natural vegetation in the area is characterized by Kouga Sandstone Fynbos (FFs27), Kouga Grassy Sandstone Fynbos (FFs28), Groot Thicket (AT3) and Southern Afrotemperate Forest (FOz1). None of these vegetation types are considered to be endangered or vulnerable, however various endemic species do occur in this area.

Potential ecological impacts that were identified during the Algoa Prefeasibility Study (2002) include the dam acting as a barrier to the migration routes of fish and mammal species, trapping of sediment, loss of habitats and habitat diversity, loss of indigenous vegetation (including endemic, rare and endangered species), changes in plant ecology, the creation of anaerobic conditions and the effects to the water quality and hydrological and geomorphologic functioning of the river ecosystem. There are also concerns that further impoundment of the Kouga River with reduced spillway overflows at Kouga Dam could negatively impact the diluting effect of water from this river on the high salinity levels of the Groot River, which joins the Gamtoos River downstream. It would be necessary to conduct a Reserve determination study to determine required flows to improve or maintain the current ecological functioning of the system downstream of the dam.

6. SOCIO-ECONOMIC

The dam would result in the creation of some construction-related employment, which is short-term, in light of the current unemployment rate of 27% in the Eastern Cape. There is however the risk that people may travel to the area seeking employment, potentially resulting in pressure on the existing infrastructure, such as healthcare, education and utilities, disadvantaging the local community. Lastly, the issue of the spread of HIV/AIDS is always a concern, and should be considered in this regard, along with the influx of people into the area.

The establishment of a dam may disrupt the current level of access and recreational opportunities, by inundating the access road to Rietvlei and the river crossing and campsite at Brandekraal. Other issues that were raised during the pre-feasibility study include the visual impact on the surrounding area, changes in the social structure of the local community, the inundation of Khoisan art and other archaeological findings and improving access for poachers into the protected area.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - In the Algoa Prefeasibility Study Report “Environmental Screening in the Kouga River, Guerna Dam”, it was concluded that the negative impact on the environment, caused by the construction of Guernakop Dam at Site U, was acceptable;

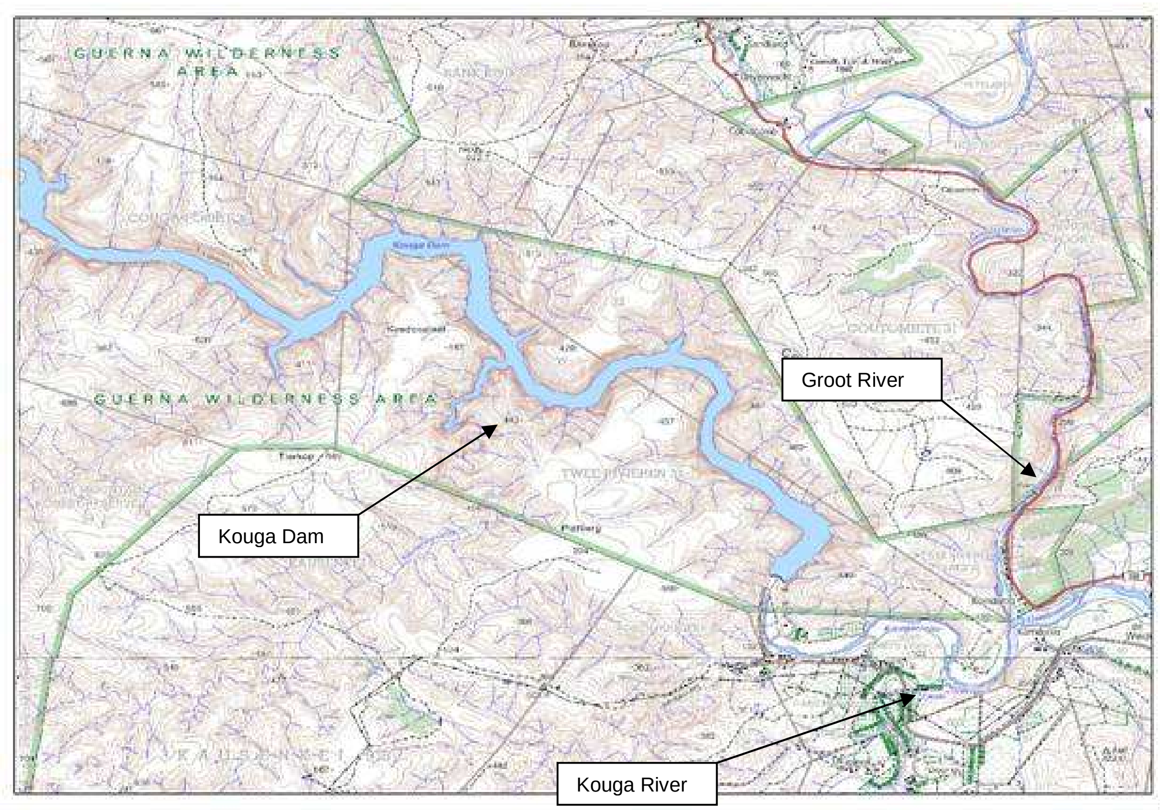
- By supplementing the water in Kouga Dam, this would provide a more reliable water supply to the Algoa area;
- The current situation of over-allocation from Kouga Dam would be rectified;
- The available capacity in the Gamtoos Canal can be utilised;
- Loerie WTW was designed for duplication;
- Summit/Chelsea pipeline can be boosted;
- Geotechnical investigations revealed potential quarry sites upstream of the upper dam site;
- Opportunity to implement the ecological Reserve;
- Opportunity to improve “control” of alien riparian vegetation due to their inundation.

- **Weaknesses**

  - Environmental and social impacts associated with inundation of near pristine nature reserve on either side of the Kouga and Nooitgedagt Rivers;
  - Possible public resistance to the scheme.

G6. Kouga Dam replacement and raising

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Kouga Dam is a concrete arch dam situated on the Kouga River approximately 5 km upstream of the confluence with the Groot River. Kouga Dam has a capacity of about 133 million m^3 and was originally designed to be raised by approximately 17 m, to increase the capacity to about 246 million m^3. The foundations on the right flank of the dam proved to be problematic and therefore the existing dam cannot be raised and may have a higher than normally acceptable safety risk.

It was originally planned that the Kouga and Loerie Dams and the Gamtoos Canal scheme would supply 59.6 million m^3/a to irrigators and 36.5 million m^3/a to NMBM, and an additional 36.5 million m^3/a to NMBM after raising. Development in the catchment area lowered the yield of the dams and this led to the allocation to NMBM being reduced to 23 million m^3/a. However NMBM's Loerie WTW and the downstream pipelines had been constructed with sufficient capacity for the original allocation of 36.5 million m^3/a and with provision for future duplication.

Since the original Kouga Dam cannot be raised it is proposed to construct a mass gravity rollcrete dam immediately downstream of the existing dam with a full supply level of RL 170 m and a capacity of about 313 million m^3, to increase the yield/ allocation to NMBM by about 34 million m^3/a. This would necessitate raising the full supply level by approximately 20 m from the existing RL 150 m to about RL 170 m (i.e. about 3 m higher than originally planned). The area of inundation would increase from about 560 ha to about 1 240 ha.

Although the additional yield would be slightly less than originally envisaged it is proposed that the capacities of the Loerie WTW and the pipelines to NMBM are doubled as originally planned so as to provide additional capacity towards meeting the peak week demand. This would involve duplication of the Loerie WTW and of the Loerie to Summit Rising Main and the installation of booster pumps on the Summit to Chelsea Main.

3. SCHEME YIELD

The determination of the 1 in 50 year yield of 34 million m^3/a is based on the results of the long-term stochastic yield analyses of the Algoa Prefeasibility Study for the proposed 200 million m^3 Guernakop Dam. On the same basis the 1 in 20 year yield would be about 37 million m^3/a. Although the additional capacity of the proposed new Kouga Dam would be about 20 million m^3 less than that of the Guernakop Dam option on which the yield is based (180 million m^3 compared with 200 million m^3) evaporation from the Kouga Dam lake would be smaller as the additional surface area would be considerably less.

4. UNIT REFERENCE VALUE

The unit reference values in terms of anticipated 2009 costs are as follows:

Table 1 Replacement of Kouga Dam Scheme URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Capital cost	**(R million)**	1 782	1 782	1 782	1 782
Annual maintenance cost	**(R million)**	9.7	9.7	9.7	9.7
Annual electricity cost	**(R million)**	17.5	17.5	17.5	17.5
NPV Cost	**(R million)**	2 294	2 055	1 896	1 817
Unit Reference Value	**(R/m^3)**	3.58	5.06	7.06	8.73

However if Kouga Dam must be rebuilt for safety reasons then the marginal additional cost of raising the dam by 20 m would be significantly less than show in Table 1 and the Unit Reference Values would also be significantly lower.

5. ECOLOGICAL

The construction of a second, 90 m higher dam immediately downstream of the existing dam would result in an inundated area more than double the size of the existing Kouga Dam at 1 240 ha. The higher full supply level could extend the length of river inundated from 3 to 4 km downstream of the confluence of the Baviaanskloof and Kouga Rivers to about 2 km upstream of the confluence into both rivers. This additional inundated area would be situated mainly in the Baviaanskloof Wilderness Area and would also extend a short distance into the Guerna Wilderness Area.

The present Ecological Status Class of the quaternary catchment is largely modified (Class D) due to alien vegetation infestations. The vegetation type characteristic of this area is Gamtoos Thicket (AT4), Groot Thicket (AT3), Albany Alluvial (Aza6) and Kouga Grassy Sandstone Fynbos (FFs28). Of these, only Albany Alluvial is considered to be endangered due to the transformation of more than 50% of this vegetation type for cultivation, urban development, road building and plantations. The inundation of this vegetation type could impact the ecological functions of the area downstream of the dam negatively and could result in a loss of endemic, rare and/or endangered species, affecting the functioning of the system.

The new Kouga Dam would not create an additional barrier to flow in the river channel nor to faunal migration routes. It would however result in an overflow (and range of floods) that is less frequent than before. The reduction in frequency of overflows would not affect the existing low and high flows in the relatively unregulated Gamtoos River, since no base flows are currently released from the dam. The frequency of flood flows in the Gamtoos River and estuary would be reduced. There is also concerns that further impoundment of the Kouga River could negatively impact the diluting effect of water from this river on the high salinity levels of the Groot River. The building of a new dam would require the implementation of a Reserve, which would mitigate the aforegoing.

6. SOCIO ECONOMIC

In respect of the inundation of infrastructure, about 2 km of the existing road (R332) into the Baviaanskloof and some hiking trails would be inundated and would need to be relocated. It is also possible that a tourist establishment (camping site at the Berg Plaatz Wilderness Area) may be inundated.

The dam would result in the creation of some construction-related employment, which is short-term, in light of the current unemployment rate of 27% in the Eastern Cape. There is however the risk that people may travel to the area seeking employment, potentially resulting in pressure on the existing infrastructure, such as healthcare, education and utilities, disadvantaging the local community. Lastly, the issue of the spread of HIV/AIDS is always a concern, and should be considered in this regard, along with the influx of people into the area.

7. OTHER ISSUES

Specific strengths and weaknesses of the options:

- **Strengths**
  - Full use would be made of the spare capacity in the existing canal, and the WTW, pump stations and pipelines were planned for duplication;
  - Water is of good quality;
  - The proposed dam would have significantly less impact than the Guernakop Dam, which would also be constructed, on the Kouga River.

- **Weaknesses**
  - It would take 12 to 13 years to implement the scheme;
  - The dam would increase inundation of the Baviaanskloof Wilderness Area;
  - The dam would reduce the frequency of flood flows in the Gamtoos River and into the estuary.

SECTION H

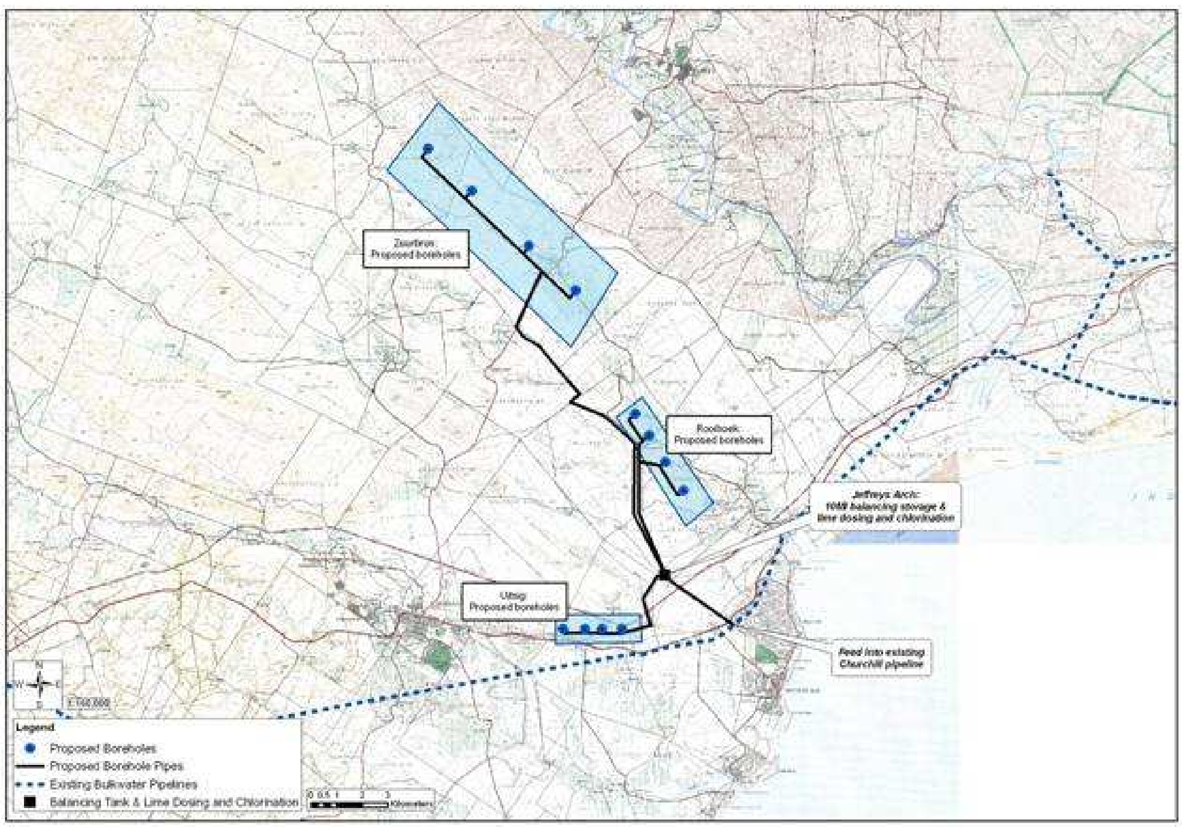
GROUNDWATER

H1. Jeffreys Arch (Jeffreys Arch Hydrogeological Domain)

1. AQUIFER DESCRIPTION

The target groundwater resources are from TMG aquifers in the south-eastern section of the Jefferys Arch. Four wellfield areas has been identified, one of which is already developed, namely the Jeffreys Bay wellfields.

All proposed wellfield areas shown on the map are rough indications of prime drilling target areas. In all cases these identified wellfields would have to be visited in the field. They would need to be reviewed after a process of gathering more borehole data, including studying site-specific reports, undertaking of a hydrocensus, geological mapping and in places, geophysics. The areas delineated below could therefore be changed after they have been studied.



2. SCHEME DESCRIPTION

The average supply from the Jeffreys Bay wellfields is 3 450 m^3/day, and the reported maximum supply is 5 200 m^3/day (Afri-Coast Engineers, 2006, Water Master Plan). Its long-term capacity is unknown. Until this is known, it will be assumed that this area is being fully utilised. This would need to be established, as it may currently be under- or over-utilised, or utilised at its optimum capacity. The remaining three wellfield areas, in order of development preference (i.e. potential for achieving high-yielding boreholes) are listed below.

The potential scheme would comprise the following at each location:

- Drilling about 8 exploration/probe boreholes, 4 production boreholes and 4 far-field monitoring boreholes. Some of the exploration/ probe boreholes would double up as nearby monitoring boreholes;
- Equipping the boreholes to deliver a flow of about 10 ℓ/s each;
- Treating the water to reduce iron precipitation and to neutralise acidity;
- Linking the boreholes to the bulk supply scheme.

Zuurbron area: The north-eastern edge of a major anticline has proven high-yielding boreholes with drilling yields of up to 88 ℓ/s (Goedhart, *et al*, 2004). The aquifer's capacity in this area is unknown.

Rooihoek area: Secondary synclines and anticlines and associated deformation on the NE section of the Jeffreys Arch fold-closure suggest very promising groundwater exploitation areas. The area is as yet unexplored although borehole yields in excess of 5 ℓ/s are found nearby, down gradient of this area, and artesian Peninsula Formation boreholes are found to the west of this site.

Uitsig area: Secondary synclines and anticlines and associated deformation on the SW section of the Jeffreys Arch fold closure suggest very promising groundwater exploitation areas. The area is still unexplored although borehole yields in excess of 5 ℓ/s are found in a similar setting in the Jeffreys Bay well-field.

Water from all three groundwater areas will be pumped to a single treatment and storage site near Jeffreys Bay. The water will be pH corrected (lime dosing) and chlorinated. An 8 Ml balancing storage reservoir and chlorine contact tank will be provided. Water will gravitate under outlet control valve control into the Churchill pipeline or directly to the Jeffreys Bay balancing storage reservoirs.

3. SYSTEM YIELD

The groundwater yields provided in this section are based on the estimated number of high-yielding boreholes (~10 ℓ/s) that can be sited and drilled in each area. The yields take into account suitable drilling targets, 20 hour/day abstraction, borehole spacing and aquifer yields. The latter are based on estimates from Murray, *et al*, 2008.

It is also assumed that land access and other logistical issues do not limit the development of drilling target areas. The production yield estimate of 10 ℓ/s is based on yields from published literature (e.g. Pieterson and Parsons, 2002), consultants reports, the National Groundwater Data base, experience of similar types of geology and hydrogeology and the assumed production yields that are estimated to be in excess of 10 ℓ/s for Table Mountain Group (TMG) production boreholes for Cape Town's water supply (the current TMG Aquifer Feasibility Study and Pilot Project).

The estimated yields of the three main target areas are as follows :

- Zuurbron area: Assume 4 production boreholes can be developed, each with average production yields of about 10 l/s, 720 m^3/day (20-hour day), 0.26 Mm^3/a. Scheme yield is about 2 900 m^3/day or ~ 1 M m^3/a.
- Rooihoek area: Same assumptions as above, i.e. ~ 1 M m^3/a.
- Uitsig area: Same assumptions as above, i.e. ~ 1 M ^{m3}/a.

The total scheme yield of the three areas is estimated to be **3 Mm^3/a (8.2 Ml/day).** However, the Jeffreys Arch has numerous groundwater target areas that are similar to the above three areas, and the potential yield of the greater area could be in the order of **6 Mm^3/a (16.4 Ml/day)**.

Unit Reference Value

The URVs for this option are based on the rough costing performed and on assumed average yields per borehole.

Table 1 Jeffrey's Arch Wellfield URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	109.5	109.5	109.5	109.5
Annual operating cost	**(R million/annum)**	1.52	1.52	1.52	1.52
NPV Cost	**(R million)**	163.4	142.7	129.0	122.3
Unit Reference Value	**(R/m^3)**	2.34	3.04	3.89	4.50

Note that the URV excludes escalation and chemical treatment costs, but includes infrastructure and operating costs.

4. ECOLOGICAL IMPACT

Environmental impacts associated with this type of scheme typically arise during the operational phase, more so than the construction phase. However, construction phase impacts could include disturbance to the natural environment in the form of vegetation destruction and soil compaction, associated with the footprint of the drilling rig and the provision of electricity and pipelines, which could lead to erosion.

Operational phase impacts include impacts on the groundwater table and recharge. Over-utilisation could result in a lowering of the groundwater table that could have various impacts on the current users of the resource. A lowering in the groundwater table could also reduce the amount of water available for the vegetation and areas such as seeps and wetlands as well as streams and rivers that rely on the groundwater base flows.

Vegetation types found in this area are Kouga Grassy Sandstone Fynbos (FFs28), Loerie Conglomerate Fynbos (FFt2), Humansdorp Shale Renosterveld (FR19) and Gamtoos Thicket (AT4) (Mucina and Rutherford, 20062). Of these only Humansdorp Shale Renosterveld is endangered, with only 6% of this vegetation type protected on private land.

[2] Musina, L and Rutherford, M C. (eds). 2006. *The vegetation of South Africa, Lesotho and Swaziland*. *Strelitzia 19.* South African National Biodiversity Institute, Pretoria.

5. SOCIO-ECONOMIC IMPACT

Over-utilisation of groundwater resources could result in the lowering of the groundwater table, impacting on the groundwater users in the area. Many farmers and some communities are dependent on groundwater for irrigation and potable use and these communities could experience water shortages, if abstraction is not carefully monitored and controlled.

6. OTHER ISSUES

- **Strengths**
    - Easy access to all sites;
    - The Zuurbron area has known high-yielding boreholes;
    - The Zuurbron area is within 8 km of a major canal (near Hankey);
    - The Rooihoek area is within 5 km of a major pipeline (near Kabeljousrivier);
    - The Uitsig area is within 3 km of a major pipeline (near Humansdorp);
    - Possibility of conjunctive use and optimisation of sub-surface storage (i.e. large-scale abstraction in summer and artificial recharge in winter).

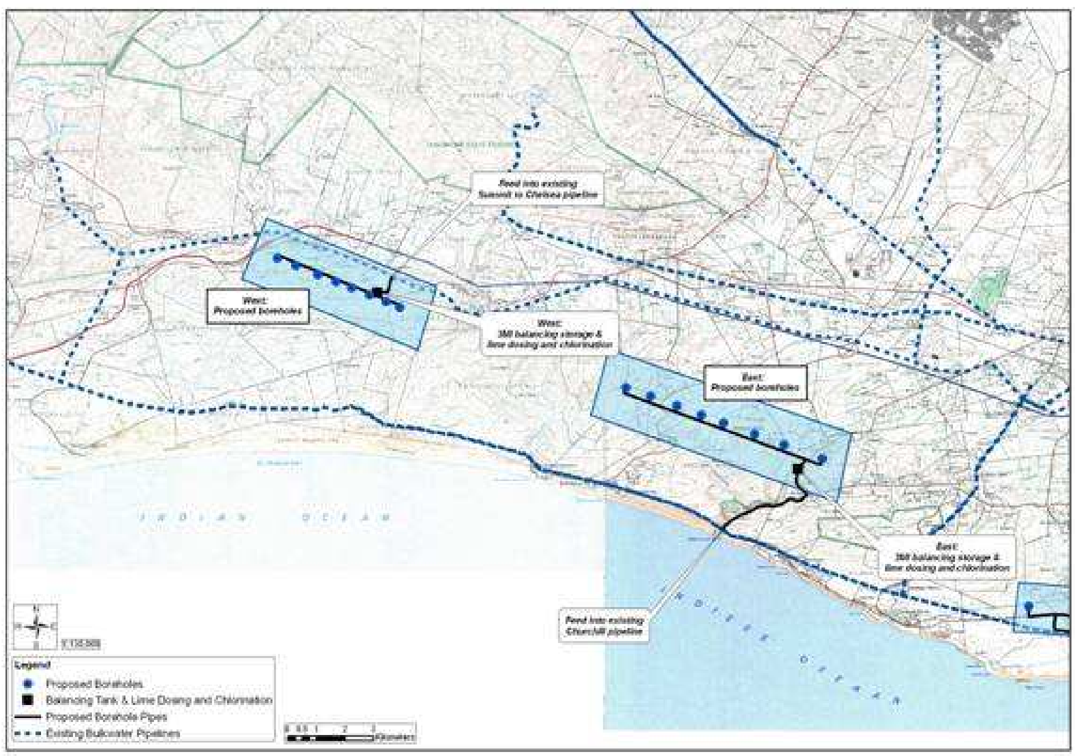
- **Weaknesses**
    - Borehole yields in the Rooihoek and Uitsig areas are not known (i.e. requires full hydrogeological investigation);
    - Ecological impacts are not known (e.g. base flow to streams);
    - Isolated locations of pump controls will require special security and anti-vandal designs.

H2. Van Stadens River Mouth (Pre-Cape Horst hydrogeological domain)

1. AQUIFER DESCRIPTION

The scheme would consist of a number of boreholes located along the southern section of the Elandsberg Fault. It is expected that the phyllites on the southern side of this fault act as a boundary to groundwater flow from the TMG Formations on the northern side, thereby "damming up" the groundwater before it reaches the coast. Several high yielding boreholes were drilled in the Maitland Mines area during mineral research for Anglo American. This data would have to be accessed.

All proposed wellfield areas in the map below are rough indications of prime drilling target areas. In all cases they would have to be visited in the field and reviewed after a process of gathering more borehole data including studying site-specific reports, a hydrocensus, geological mapping and in places, geophysics. The areas delineated below could therefore be changed after they have been studied.



Fig

2. SCHEME DESCRIPTION

The scheme would consist of two sections on either side of the Van Stadens River. One part would consist of developing an 8 km length on the eastern side of the Van Stadens River in the Maitland Mines area, and the other along a 6 km length on the western side of the Van Stadens River.

The potential scheme would comprise the following in each area:

- Drilling about 32 exploration/ probe boreholes, 16 production boreholes and 8 monitoring boreholes;
- Equipping the boreholes to deliver about 10 l/s each;
- Treating the water to reduce iron precipitation and to neutralise acidity;
- Linking the boreholes to the bulk supply scheme.

Water from each groundwater area will be pumped to individual storage balancing sites where the water will first be pH corrected and chlorinated. The Van Stadens West water will be gravity fed into the Summit to Chelsea pipeline and the Van Stadens East water will be gravity fed into the existing Churchill/Elandsjacht pipelines.

3. SYSTEM YIELD

The groundwater yields provided in this section are based on the estimated number of high-yielding boreholes (~10 ℓ/s) that can be sited and drilled in each area. The yields take into account suitable drilling targets, 20 hours/day abstraction, borehole spacing and aquifer yields. The latter are based on estimates from Murray, *et al*, 2008.

It is also assumed that land access and other logistical issues do not limit the development of drilling target areas. The production yield estimate of 10 ℓ/s is based on yields from published literature (e.g. Pieterson & Parsons, 2002), consultants reports, the National Groundwater Data base, experience of similar types of geology and hydrogeology and the assumed production yields that are estimated to be in excess of 10 ℓ/s for Table Mountain Group (TMG) production boreholes for Cape Town's water supply (the current TMG Aquifer Feasibility Study and Pilot Project).

Assuming that 16 production boreholes can be developed, each with average production yields is about 10 ℓ/s, 720 m^3/day (20-hour day), 0.26 Mm^3/a. Scheme yield is ~ 11 000 m^3/day or **~ 4 Mm^3/a**.

4. UNIT REFERENCE VALUE

The URVs for this option are based on the rough costing performed and on assumed average yields per borehole.

Table 1 Van Stadens Wellfield URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	74.67	74.67	74.67	74.67
Annual operating cost	**(R million/annum)**	2.15	2.15	2.15	2.15
NPV Cost	**(R million)**	159.1	129.3	110.5	101.6
Unit Reference Value	**(R/m^3)**	1.70	2.05	2.49	2.82

Note that the URV excludes escalation and chemical treatment costs, but includes infrastructure and operating costs.

5. ECOLOGICAL IMPACT

Environmental impacts associated with this type of scheme typically arise during the operational phase, more so than during the construction phase. However, construction phase impacts could include disturbance to the natural environment in the form of vegetation destruction and soil compaction associated with the footprint of the drilling rig as well as the provision of electricity and pipelines, which could lead to erosion.

As for the scheme above, operational phase impacts relate to changes in the groundwater table and groundwater recharge, due to potential over-utilisation of the resource, which could have an impact on sensitive vegetation, as well as seeps, wetlands and rivers, by reducing the base flows provided by groundwater.

Vegetation types found in the area are Albany Coastal Belt (AT9), Southern Coastal Forest (FOz6), Cape Seashore Vegetation (AZd3), Algoa Dune Strandveld (AZs1) and Algoa Sandstone Fynbos (FFs29) (Mucina and Rutherford, 2006[3]). Algoa Sandstone Fynbos is considered to be endangered, with more than 50% of this vegetation type being transformed and only 2% conserved, in the Van Stadens Wild Flower Reserve, the Island Nature Reserve and a few other private nature reserves.

6. SOCIO-ECONOMIC IMPACT

As mentioned above, over-utilising groundwater resources would result in the lowering of the groundwater level, which could impact existing groundwater users in the area. As noted above, the utilisation of groundwater would require monitoring and evaluation to ensure that existing users aren’t unacceptably impacted upon.

7. OTHER ISSUES

- **Strengths**
    - o The geological setting suggests high potential for very high-yielding boreholes along the main fault zone.
    - o Known high-yielding boreholes in the Maitland Mines area.
    - o Thick limestone beds within the pre-Cape rocks may also provide useful aquifers.
    - o All boreholes are expected to be within 4 km of an existing bulk supply pipeline.
    - o If successful, the scheme could possibly be duplicated in the pre-Cape rocks north of Hankey and Patensie.
    - o Possibility of conjunctive use and optimisation of sub-surface storage (i.e. large-scale abstraction in summer and artificial recharge in winter).

- **Weaknesses**
    - o Trace of Elandsberg fault is not well mapped. To reduce this uncertainty requires detailed geological mapping, geophysical surveys and exploration drilling.
    - o Access is limited due to rugged terrain, and thick sand cover near the coast.
    - o Ecological impacts are not known.

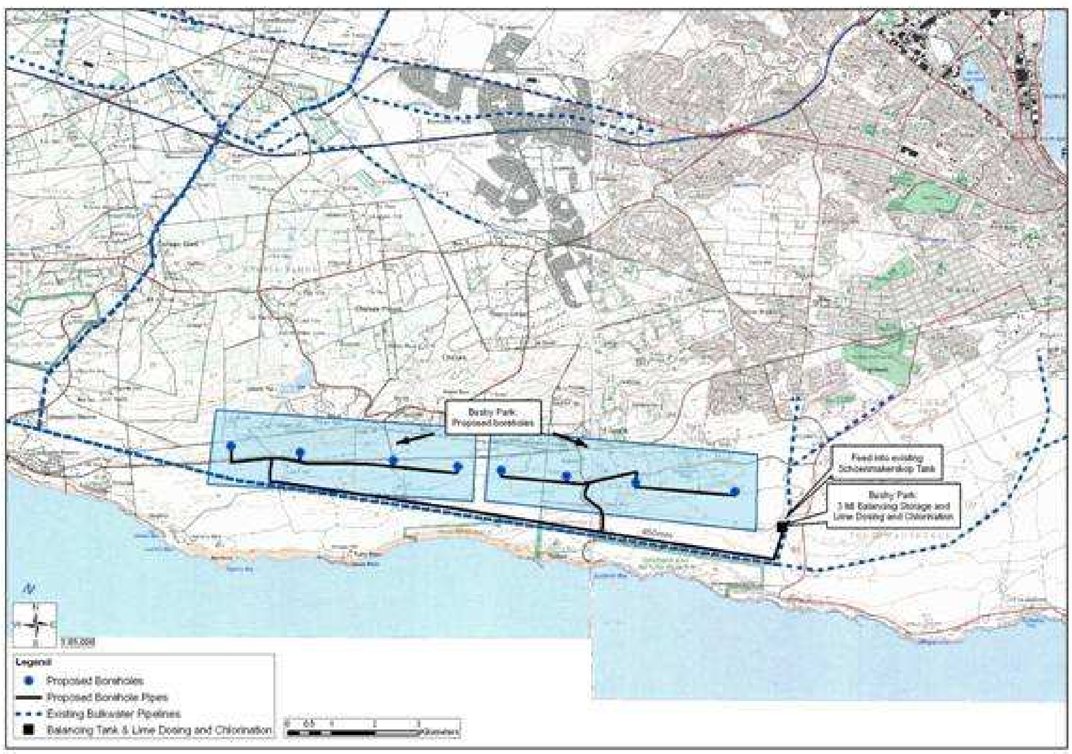
Isolated locations of pump controls will require special security and anti-vandal designs.

[3] Mucina, L. and Rutherford, M.C. (eds) 2006. The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19. South African National Biodiversity Institute, Pretoria.

H3. Bushy Park (Elands-Winterhoek Arch hydrogeological domain)

1. AQUIFER DESCRIPTION

The groundwater resources of the Elands-Winterhoek Arch include a large area encompassing the greater Port Elizabeth area and large parts of the Uitenhage Subterranean Government Water Control Area (USGWCA). The USGWCA and in particular, the area around the Coega Fault is currently being studied by SRK Consulting. This study should indicate whether groundwater in the USGWCA is under- or over-utilised. For this reason attention has only been given to the Port Elizabeth area of this large hydrogeological domain. The target groundwater resources in theses areas are associated with faulting and folding of Table Mountain Group Formations.



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There are three potential target areas: The coastal stretch west of Port Elizabeth, called the Bushy Park area in this report, and the Chelsea and Moregrove faults. High borehole yields are known in the Bushy Park area, but the reason for the high yields is not fully understood. The Chelsea and Moregrove faults appear to have very high groundwater potential (wide, exposed breccia zones in the Moregrove Fault). However, there is little published data on their water-bearing potential and will therefore be excluded, at this stage, as interventions. These faults can be considered as either extensions or alternatives to the Bushy Park area. Of the two faults, the Morgrove Fault is more obvious (e.g. at Shark Rock Peir), whereas the Chelsea Fault in the Noordhoek area is a wide zone of steep bedding-parallel faults. Information on this need to be revised in terms of their extent and permeability since some old faults are known to be sealed (mylonized or have vein quartz fillings).

2. SCHEME DESCRIPTION

The Bushy Park area extends over a 15 km long stretch of TMG rocks that have, in places, been faulted and folded. A prime area includes faulted terrain in an overturned anticline at the edge of the Soekor magnetic ridge. The scheme layout shown in the figure above would consist of a number of boreholes roughly inland and parallel to the coastline between Sea View to Skoenmakerskop. Five Atomic Energy Corporation small diameter exploration boreholes drilled in this area gave an average drilling yield of 10 ℓ/s, and numerous other boreholes have reported yields of between 8 and 42 ℓ/s (Goedhart, et al, 2004). In order to identify prime drilling targets it would be necessary to undertake a hydrocensus in this area, do geological mapping, conduct geophysical surveys and follow up with exploration boreholes.

The potential scheme would comprise the following in each area:

- Drilling about 16 exploration/ probe boreholes, 8 production boreholes and 6 monitoring boreholes
- Equipping the boreholes to deliver about 10 ℓ/s each
- Treating the water to reduce iron precipitation and to neutralize acidity
- Linking the boreholes to the bulk supply scheme.

Water will be pumped along a joint rising main to the present Schoenmakerskop Pump Station site, pH corrected (by dosing with lime) and disinfected. After contact time, the water will be discharged under gravity into the Schoenmakerskop Pump Station Sump/Tank to be blended with Churchill/Elandsjacht water.

3. SYSTEM YIELD

The groundwater yields provided in this section are based on the estimated number of high-yielding boreholes (~10 ℓ/s) that can be sited and drilled in each area. The yields take into account suitable drilling targets, 20 hour/day abstraction, borehole spacing and aquifer yields. The latter are based on estimates from Murray, et al, 2008.

It is also assumed that land access and other logistical issues do not limit the development of drilling target areas. The production yield estimate of 10 ℓ/s is based on yields from published literature (e.g. Pieterson & Parsons, 2002), consultants reports, the National Groundwater Data base, experience of similar types of geology and hydrogeology and the assumed production yields that are estimated to be in excess of 10 ℓ/s for Table Mountain Group (TMG) production boreholes for Cape Town's water supply (the current TMG Aquifer Feasibility Study and Pilot Project).

Assume 8 production boreholes can be developed, each with average production yields of about 10 ℓ/s, 720 m^3/day (20-hour day), 0.26 Mm^3/a. Scheme yield is ~ 5 800 m^3/day or **~ 2 M m^3/a**.

Extensions to the scheme to include the Moregrove and Chelsea faults could potentially increase the yield to **3 - 4 Mm^3/a**.

4. UNIT REFERENCE VALUE

The Unit Reference Values (URVs) for this option are based on the rough costing performed and on assumed average yields per borehole.

Table 1 Bushy Park Wellfield URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	66.07	66.07	66.07	66.07
Annual operating cost	**(R million/annum)**	0.84	0.84	0.84	0.84
NPV Cost	**(R million)**	96.4	84.1	76.5	72.9
Unit Reference Value	**(R/m^3)**	2.1	2.7	3.5	4.1

Note that the URV excludes escalation and chemical treatment costs, but includes infrastructure and operating costs.

5. ECOLOGICAL IMPACT

Environmental impacts associated with this type of scheme typically arise during the operational phase, more so than during the construction phase. However, construction phase impacts could include disturbance to the natural environment in the form of vegetation destruction and soil and soil compaction associated with the footprint of the drilling rig as well as the provision of electricity and pipelines which could lead to erosion.

Operational-related impacts include impacts on the groundwater table and recharge, which could result in a lowering of the groundwater table, having an impact on the fauna and flora of the area. Freshwater seeps and small localised wetlands/ marshes occur along the southern Port Elizabeth coastline and are fed from the coastal granular aquifer and possibly leakage from the underlying fractured TMG aquifer. A lowering in the groundwater table could prevent access to water for vegetation and water-sensitive areas such as the seeps and wetlands mentioned. Furthermore, streams and rivers could also be experience lower levels due to reduced base flows.

Algoa Dune Strandveld (AZs1) is the dominant vegetation type in this area and consists of tall, dense thickets on dunes (Mucina and Rutherford, 20064). Other vegetation types include Cape Seashore Vegetation (AZd3) and Algoa Sandstone Fynbos (FFs29) (Mucina and Rutherford, 2006). None of these vegetation types are considered to be specifically endangered or vulnerable.

6. SOCIO-ECONOMIC IMPACT

Over-utilising of groundwater resources would result in the lowering of the groundwater level, which could negatively impact existing groundwater users in the area. Groundwater use would require monitoring and evaluation to ensure that existing users are not unacceptably impacted upon.

[4] Mucina, L. and Rutherford, M.C. (eds) 2006. *The vegetation of South Africa, Lesotho and Swaziland. Strelitzia 19*. South African National Biodiversity Institute, Pretoria.

7. OTHER ISSUES

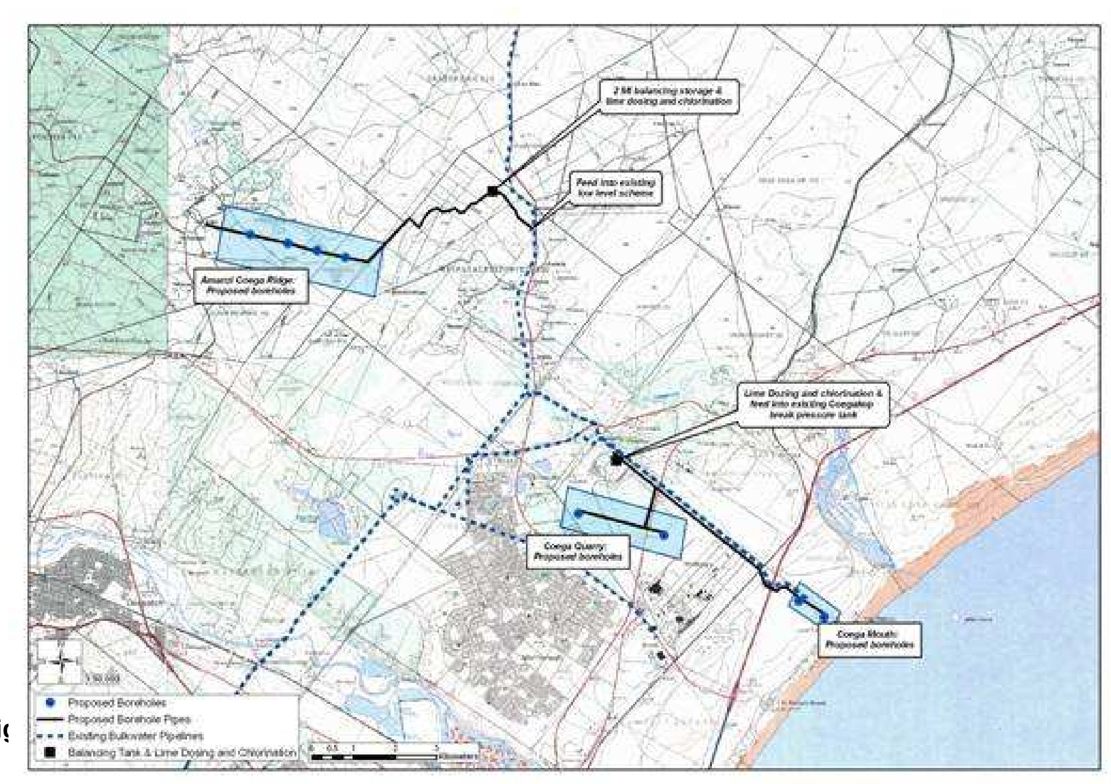
- **Strengths**
  - Easy access;
  - Known high yielding boreholes;
  - All boreholes are expected to be within 2-3 km of an existing bulk supply pipeline;
  - Possible expansion to the Moregrove and Chelsea fault areas;
  - Possibility of conjunctive use and optimisation of sub-surface storage (ie large-scale abstraction in summer and artificial recharge in winter).

- **Weaknesses**
  - Poor quality groundwater in places (electrical conductivity of ~200 mS/m), although this may be the result of mixing potable TMG groundwater with shallow, saline water in coastal granular aquifers;
  - Inland trace and character (ie permeability) of Moregrove and Chelsea faults are not clear;
  - Thick sand cover over Bushy Park area (problematic for groundwater exploration/ borehole siting);
  - Substantial geophysical exploration would be required to identify drilling targets;
  - Ecological impacts are not known;
  - Isolated locations of pump controls will require special security and anti-vandal designs.

H4. South-eastern Coega Fault (Algoa Basin hydrogeological domain)

1. AQUIFER DESCRIPTION

SRK Consulting are currently evaluating the groundwater resources of the USGWCA. Until the results are available from that study, only areas that are considered to be discharge zones of the USGWCA will be considered as current water supply options. The most promising of these areas are three locations on the Coega Fault and associated splays, namely at Amanzi Ridge, Coega Quarry and where the Coega Fault meets the coastline. All areas have high groundwater potential, however, until there is a better understanding of groundwater flow in the USGWCA, relatively low yield estimates will be given. Abstraction from these would have to ensure that the Uitenhage springs are not adversely affected, and that there is minimal interference between these areas, as they all are reliant on the permeability along a common fault zone.



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2. SCHEME DESCRIPTION

The scheme would consist if the three components as indicated below.

2.1 Coega Mouth

This area consists of the narrow belt between the N2 and the coast (around the Coega harbour). Extensive geophysics would be needed to establish the depth of the TMG, which could be as much as 200 m below the surface. Assuming this is correct, a 400 m deep borehole would be needed to give 200 m penetration of TMG aquifer material.

The potential scheme would comprise the following:

- Geophysical exploration;
- Drilling 4 exploration boreholes, 2 production boreholes and 2 monitoring boreholes. Borehole depths would be in the order of 400 m;
- Equipping the boreholes to deliver 20 l/s each;
- Treating the water to reduce iron precipitation and to neutralize acidity;
- Linking the boreholes to the bulk supply scheme.

Note that drilling to greater depths (~400 m as opposed to ~200 m) does not necessarily mean greater yields will be obtained, however, if there is permeability at depth, the pressures and resulting yields will be relatively high. In addition to this, the cost of drilling 400 m production boreholes is high and probably not worthwhile if they cannot sustain production yields of ~20 l/s.

Water abstracted from this groundwater area, will be pumped to Coega Kop reservoir site, pH corrected, disinfected and blended into the Break Pressure Tank.

2.2 Coega Quarry

This also consists of a fairly limited area, and thus the number of production boreholes will be limited to where both the Coega Fault and TMG rocks can be intercepted at depth below the thick clay layer which could be 200 m deep. It is assumed that 400m deep production boreholes will be needed for the same reasons as at Coega Mouth.

The potential scheme would comprise the following:

- Geophysical exploration;
- Drilling 4 exploration boreholes, 2 production boreholes and 4 monitoring boreholes. Borehole depths would be in the order of 400 m;
- Equipping the boreholes to deliver 20 l/s each;
- Treating the water to reduce iron precipitation and to neutralize acidity;
- Linking the boreholes to the bulk supply scheme.

Water abstracted, will be pumped to Coega Kop reservoir site, pH corrected, disinfected and blended into the Break Pressure Tank.

2.3 Amanzi-Coega Ridge

Drill sites would aim to intercept the TMG and the Coega Fault below the Cretaceous overburden. Borehole depths of about 200 m should be adequate.

The potential scheme would comprise the following:

- Geophysical exploration;
- Drilling 8 exploration boreholes, 4 production boreholes and 4 monitoring boreholes. Borehole depths would be in the order of 200 m;
- Equipping the boreholes to deliver 10 l/s each;
- Treating the water to reduce iron precipitation and to neutralize acidity;
- Linking the boreholes to the bulk supply scheme.

Water abstracted, will be pumped to a high lying site, pH corrected and disinfected. A 2Ml storage and chlorine contact tank will be used to gravity feed treated water into the proposed Olifantskop to Motherwell pipeline.

3. SYSTEM YIELD

The groundwater yields provided in this section are based on the estimated number of high-yielding boreholes (~10 ℓ/s) that can be sited and drilled in each area. The yields take into account suitable drilling targets, 20 hours/day abstraction, borehole spacing and aquifer yields. The latter are based on estimates from Murray, *et al*, 2008.

It is also assumed that land access and other logistical issues will not limit the development of drilling target areas. The production yield estimate of 10 ℓ/s is based on yields from published literature (e.g. Pieterson & Parsons, 2002), consultants reports, the National Groundwater Data base, experience of similar types of geology and hydrogeology and the assumed production yields that are estimated to be in excess of 10 ℓ/s for Table Mountain Group (TMG) production boreholes for Cape Town's water supply (the current TMG Aquifer Feasibility Study and Pilot Project).

Coega Mouth: Assume 2 deep production boreholes can be developed, each with average production yields of about 20 ℓ/s, 1440 m^3/day (20-hour day), 0.53 million m^3/a. Scheme yield is ~ 2 900 m^3/day or **~ 1 M m^3/a**.

Coega Quarry: Assume 2 deep production boreholes can be developed, each with average production yields of about 20 ℓ/s, 1440 m^3/day (20-hour day), 0.53 million m^3/a. Scheme yield is ~ 2 900 m^3/day or **~ 1 M m^3/a**.

Amanzi-Coega Ridge: Assume 4 production boreholes can be developed, each with average production yields of about 10 ℓ/s, 720 m^3/day (20-hour day), 0.26 million m^3/a. Scheme yield is ~ 2 900 m^3/day or **~ 1 M m^3/a**.

The total scheme yield of the three areas is estimated to be **3 Mm^3/a**. This may be a very conservative estimate of the groundwater discharge from the TMG aquifer to the sea. The current SRK study into the USGWCA should provide estimates of this discharge, but whatever the findings of that study are, the development of wellfields to intercept this water would have to be developed incrementally whilst monitoring the environmental effects of abstraction.

4. UNIT REFERENCE VALUE

The Unit Reference Values (URVs) for this option are based on the rough costing performed and on assumed average yields per borehole.

Table 1 South-eastern Couga Fault Wellfield URVs

ITEM		Discount Rate 0%	Discount Rate 3%	Discount Rate 6%	Discount Rate 8%
Total capital cost	**(R million)**	53.7	53.7	53.7	53.7
Annual operating cost	**(R million/annum)**	1.41	1.41	1.41	1.41
NPV Cost	**(R million)**	108.0	88.8	76.6	70.8
Unit Reference Value	**(R/m^3)**	1.51	1.85	2.25	2.56

Note that the URV excludes escalation and chemical treatment costs, but includes infrastructure and operating costs.

5. ECOLOGICAL IMPACT

Environmental impacts associated with this type of scheme typically arise during the operational phase, more so than during the construction phase. However, construction phase impacts could include disturbance to the natural environment in the form of vegetation destruction and soil and soil compaction associated with the footprint of the drilling rig as well as the provision of electricity and pipelines which could lead to erosion.

Operational related impacts include impacts on the groundwater table and recharge. Over-utilisation results in a lowering of the groundwater table that could have various cumulative impacts on human, animal and plant life. A lowering in the groundwater table could prevent access to water for vegetation and water sensitive areas such as springs, seeps and wetlands that could dry up completely. Streams and rivers could also experience lower levels due to reduced bas flows.

Vegetation types found in the area are Kouga Grassy Sandstone Fynbos (FFs28), Sundays Thicket (AT6), Coega Bonteveld (AT7), Cape Lowland Freshwater Wetlands (AZf1), Albany Alluvial Vegetation (AZa6), Arid Estuarine Salt Marshes (AZe1) and Cape Estuarine Salt Marshes (AZe2). Of these vegetation types, only Albany Alluvial Vegetation is considered to be vulnerable. More than half of this vegetation type has been transformed and only 6% are statutorily conserved.

6. SOCIO-ECONOMIC IMPACT

Over-utilising of groundwater resources would result in the lowering of the groundwater level, which could negatively impact existing groundwater users in the area. Groundwater use would require monitoring and evaluation to ensure that existing users are not unacceptably impacted upon.

7. OTHER ISSUES

- **Strengths**
  - Easy access;
  - Close to Coega IDZ;
  - Possible expansion along the Coega Fault;
  - Possibility of conjunctive use and optimisation of sub-surface storage (ie large-scale abstraction in summer and artificial recharge in winter).

- **Weaknesses**
  - Substantial geophysical exploration would be required to identify drilling targets;
  - Costly deep boreholes may be needed in places;
  - Ecological impacts are not known;
  - Isolated locations of pump controls will require special security and anti-vandal designs.

Appendix A

Urban water demand forecast for Algoa water supply system

20 October 2009

Contents

1 Introduction

Purpose and scope

The purpose of this report is to develop a set of scenarios for long term urban water demand for the Algoa Water Supply System. The scope of the work is on future urban and industry demands and the report does not cover agricultural demands.

Approach and methodology

Good forecasts are scenario based, and seek to understand the key drivers of demand, and the factors that will affect changes in these drivers over time.

Within an urban context, the most important base drivers of demand of two-fold:

- Population growth
- Economic activity

These two factors are interlinked to some extent, as high levels of growth in economic activity will increase the levels of immigration into the area, whereas depressed economic activity may result in migration away from the area to other centres with higher economic activity and growth.

Other factors which will affect demand include:

- Water use efficiency and technology change
- Climate change
- Pricing
- Management effectiveness

It is therefore useful to have some understanding of the dynamics affecting each of these, and on the basis on this understanding, to develop a set of scenarios of future water demand.

With regards to economic activity, the pace and which the Coega IDZ grows, and the nature of the economic activities within the Coega IDZ will have a very significant effect of furture water demand.

The "dark art" of forecasting

History is not linear and it is usually a mistake to extrapolate into the future based on an analysis of the past. Nevertheless, it is important to also to understand how water demand has grown in the past and what factors have contributed to this growth.

The importance is in the learning

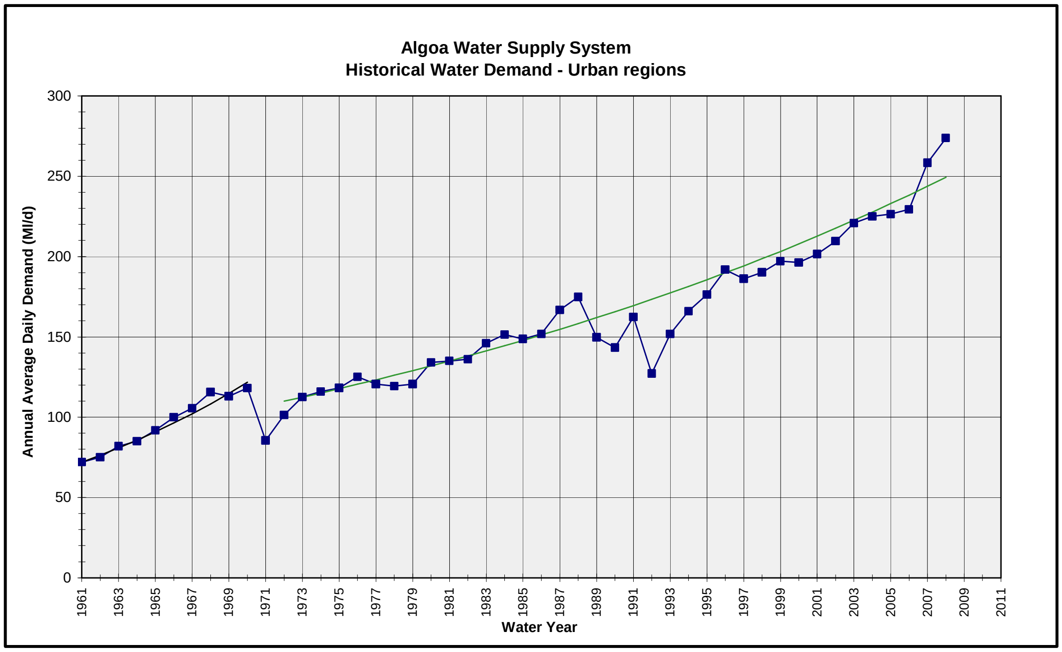
What is learnt in the process of understanding water demand is more important than the scenario forecasts themselves. These need to be subject to ongoing revision as events unfold.

2 Understanding past patterns

Water supplied by water treatment works

We are fortunate to have a long record of monthly and annual volumes of water supplied from the water treatment works which are part of the Algoa Water Supply System (AWSS). This water is supplied mainly to the Nelson Mandela Metropolitan area, with a small component supplied to the coastal towns. Although there are other sources of water supplied to the area, namely from some springs outside Uitenhage, and from ground water supplied to the coastal towns (Jeffrey's Bay, St Francis Bay etc.), these supplies are very small relative to the main supply, and also relatively constant. Therefore, in order to understand the trajectory in urban water demand for the AWSS, it is sufficient to examine the records of supply from the treatment works.

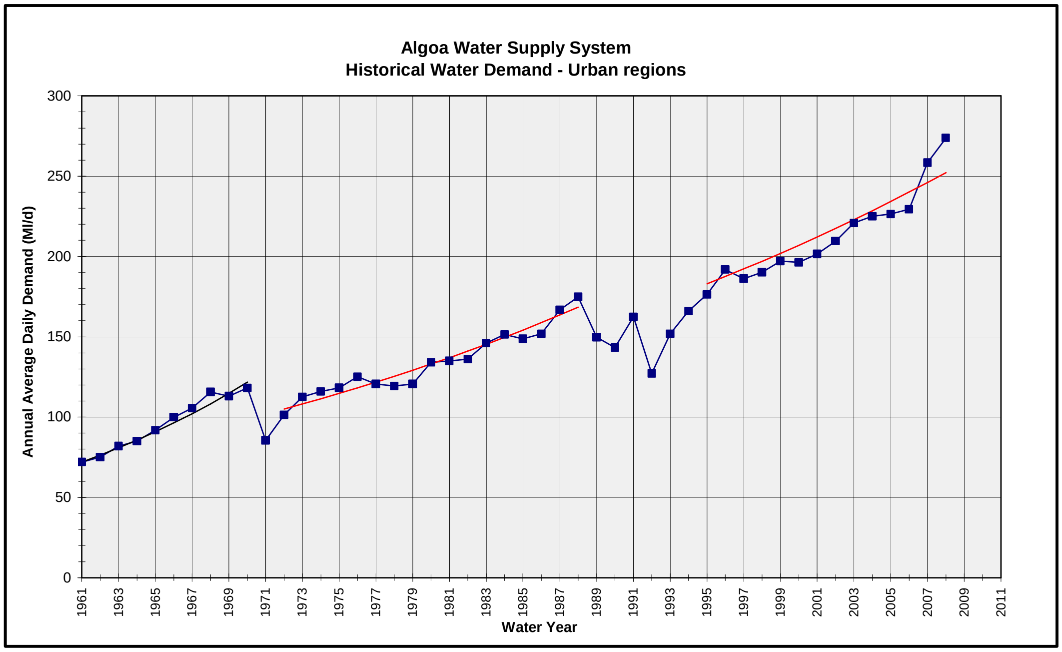
This data is shown below.



3 Figure 1: Historical water demand - Nelson Mandela Metro – perspective 1

Water demand grew rapidly in the 1960s (at about 6% per annum), then water use was curtailed in the 1971 due to the introduction of water metering. Water use recovered quickly, but not to the same level. The growth trajectory appears to have slowed, with overall growth the period 1973 to 2006 at about 2.4% per annum (as shown in the smoothed line), but with an initial increase related to dry weather in 1987 and 1988, and then restrictions were applied in 1989 and 1990, lifted in 1991 and reapplied more strictly in 1992. Thereafter there was a strong recovery in demand in the four years to 1996. Demand grew steadily in the period 1997 to 2006, and a very high increase (for reasons yet to be determined) in 2007 and 2008.

It is possible to view this historical water demand through difference lenses, depending on the years chosen. An alternative view is presented below.



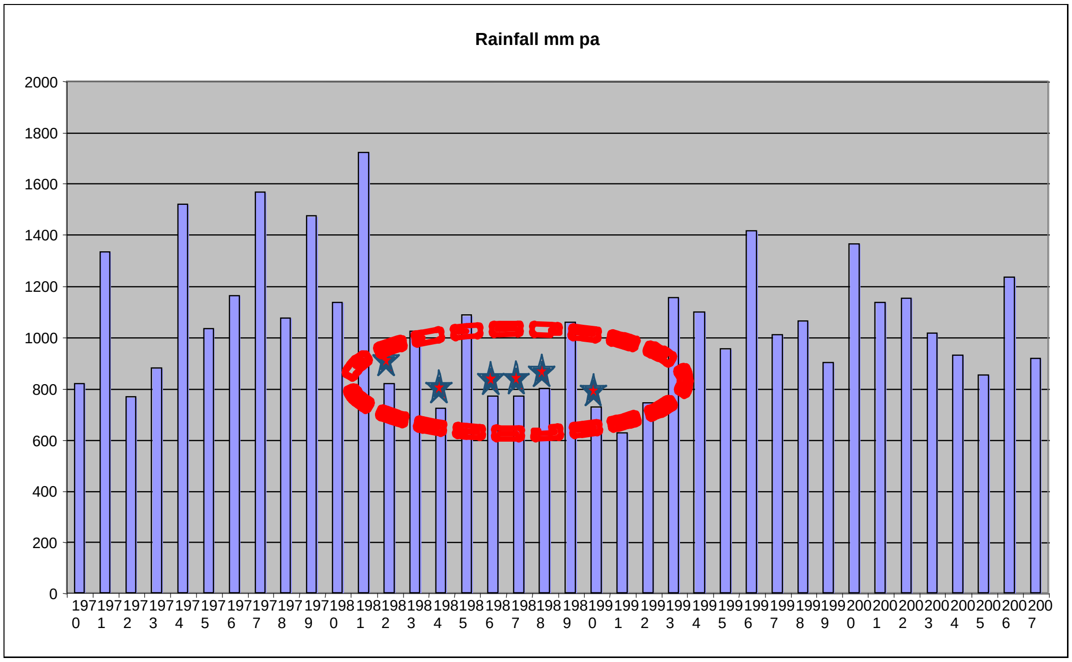
4 ***Figure 2: Historical water demand - Nelson Mandela Metro – perspective 2***

In this view, water growth at 3% per annum is shown as a smoothed line for 1972 to 1988 and of 2.5% per annum for the period 1995 to 2008, with the two trends punctuated by the drought and restrictions in the period 1989 to 1994, and an anomalous (as yet to be explained) rapid increase in the last two years (2007 and 2008).

It can be seen from the above that ones understanding of rate of water demand growth depends on what lens one chooses to view the date, in particular what starting and end points are used in the analysis. There is no correct view, only different ways of viewing the data, highlighting different aspects of the data.

Rainfall

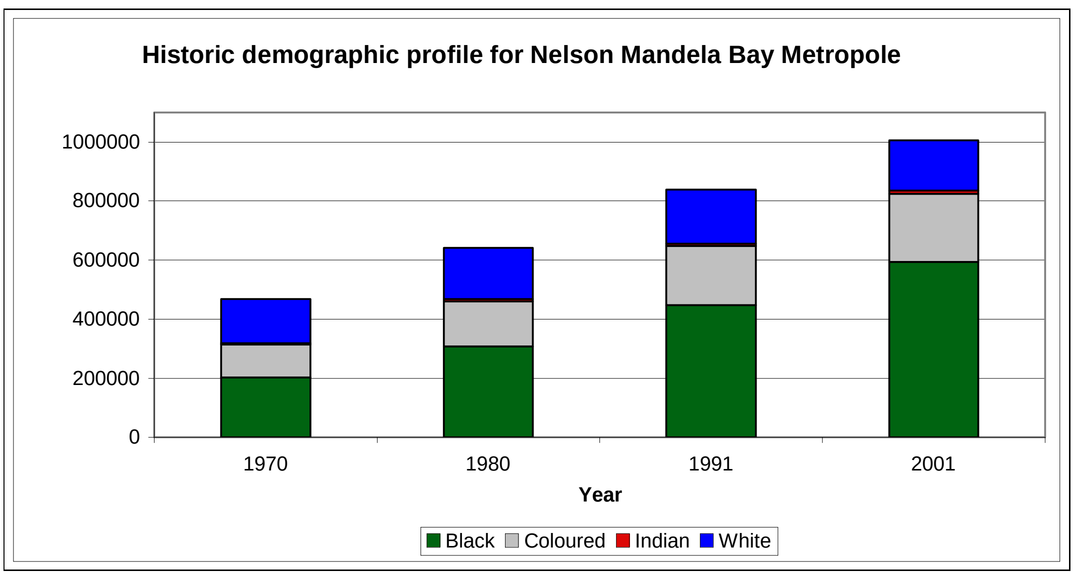
Water demand is also influenced by rainfall. The figure below shows the variable nature of rainfall in the area, with a dry decade evident in the period 1981 to 1992.



5 ***Figure 3: Rainfall variability in Nelson Mandela area***

Population growth

The population more than doubled in the period 1970 to 2001, but the rate of population growth is declining as a result of reduced fertility levels, the impact of HIV-Aids and, surprisingly, low net in-migration.



6 ***Figure 4: Census population***

The demographic analysis undertaken by Charles Simkins, and a study to test Simkin's seemingly counter-intuitive findings[5], confirmed the following:

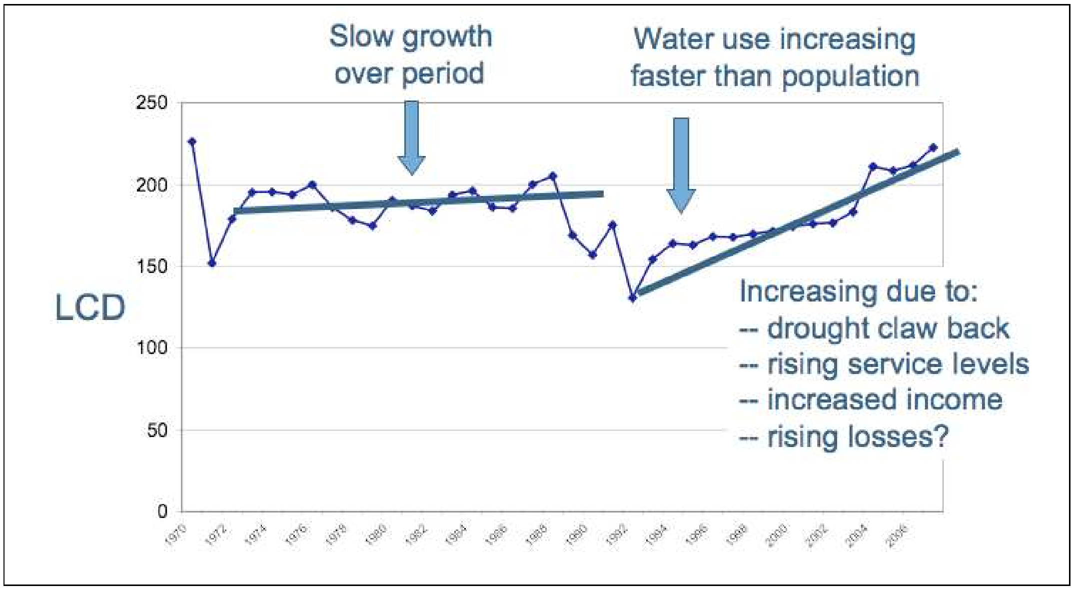
- the proliferation of new dwellings on the urban edge is less a result of urbanization than the movement of people within the Metropolitan area;
- The fertility rate is declining;

[5] NELSON MANDELA BAY MUNICIPALITY - DEMOGRAPHIC UPDATE AND SOCIO-ECONOMIC ANALYSIS / QUALITY OF LIFE IN 26 'CHANGE AREAS' - 2006/7.

- population growth from migration is less that expected because the area is not perceived as a major job-creation area
- HIV prevalence rates for the population as a whole are expected to rise from 1.2% in 1995 to 10.0% in 2010 to 12.6% in 2020 (slowing due to ARV roll-out).

Per capita demand

Per capita demand appears to fit into two trend lines, the first a mildly increasing trend in the period 1972 to 1988, and then a downward adjustment through the drought followed by a strong increase in per capita demand, as show below.

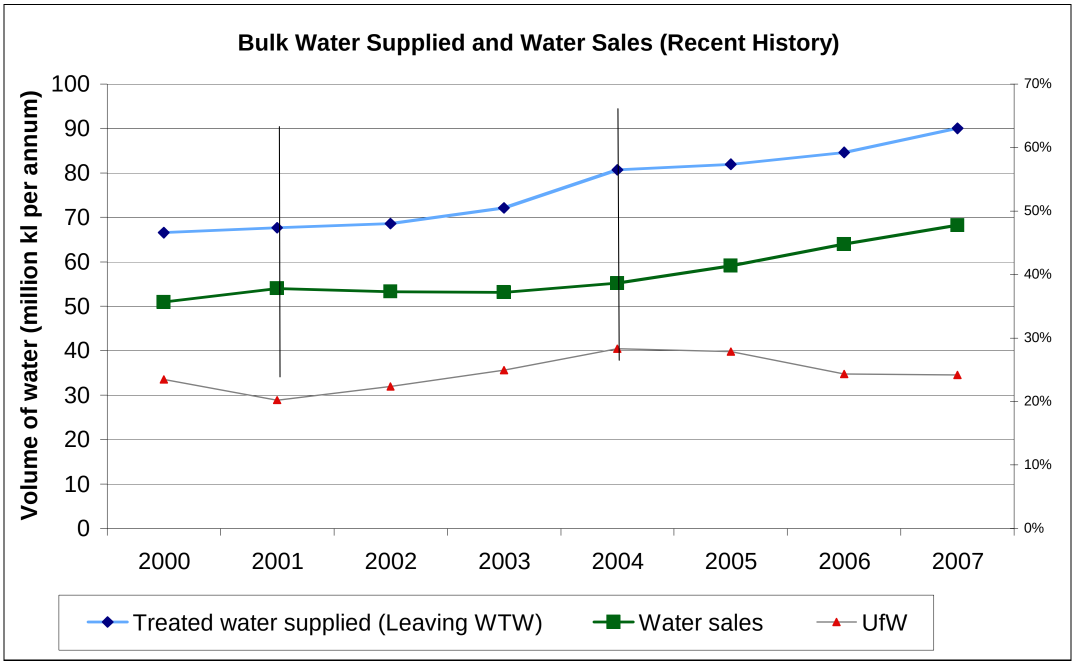


7 Figure 5: Per capital demand

The reason for the strong increase in per capita demand is likely to be as a result of a combination of factors: a post-drought re-adjustment, increasing service levels (post 1994 RDP and related service delivery programmes), increased income levels and higher levels of unaccounted-for water. Without very detailed study it is not possible to determine the relative attribution of these factors.

Management is important

To illustrate the fact that the management of the network is important, a more detailed analysis of billing data versus the volume of water supplied was undertaken for recent years, and shown below.

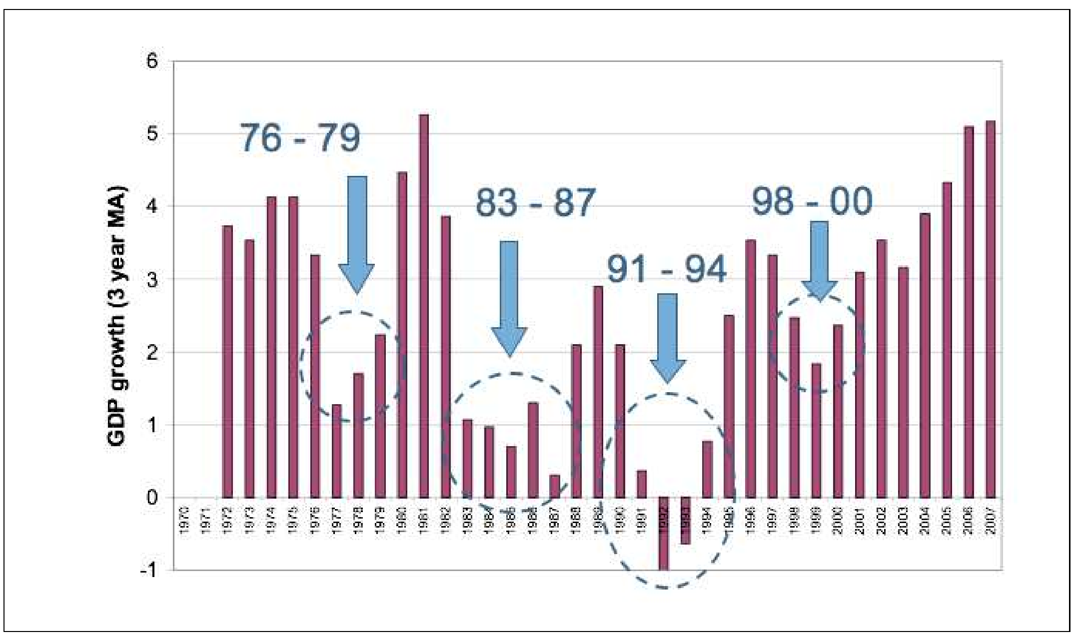


8 Figure 6: Water supplied versus billing data

This data is coarse, and the absolute level of unaccounted-for water should not be considered to be correct. Nevertheless, the trends shown are relevant, showing a period of rising supply of water accompanied by constant billing, followed by a period of flatter supply growth and increasing billing, consequently reversing the trend in unaccounted-for water.

Economic growth

Long term data on economic growth is not available for the local urban area. Nevertheless, national data is a reasonable proxy when looking at high level trends.



9 Figure 7: Economic growth (national)

This data shows four periods of relatively low economic growth and there is a correspondence between water demand growth and economic growth that is evident in the graphic below.

10 ***Figure 8: Correpondence between water demand and economic growth***

11 Future scenarios

Understanding the drivers

Future water use will depend on population growth, economic growth (including both the nature of this growth and how it is distributed), and the price of water.

Key drivers for population growth are the nature of **migration** patterns (which is linked to the relative performance of the regional, local and competing economic centres – particularly Gauteng and the Western Cape), and the trajectory of **HIV/Aids** (linked to the efficacy of the ARV roll-out and other factors).

The performance of the **local economy** is tied, in many ways, to the performance of both the national and international economies, as illustrated during the recent global financial and economic turmoil and downturn. Most importantly, future economic growth is likely to be strongly linked to the performance of the Coega IDZ. As yet, there is no significant confirmed anchor industrial client, though the PetroSA petroleum refinery is looking likely at this stage. Unfortunately, the era of abundant and cheap electricity is over, and the Coega industrial strategy will not be able to depend on energy intensive industries (such as aluminium smelting) establishing themselves there.

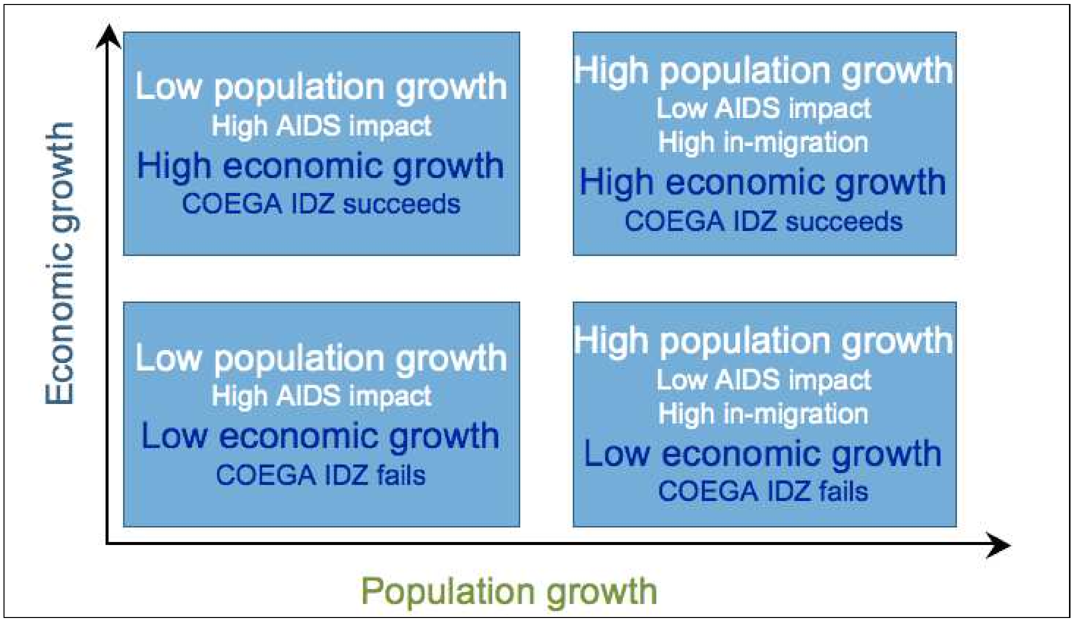
The cost (and hence **price**) of water will also increase significantly in future when the switch to reuse and desalinated water occurs (this is a matter of "when" not "if). This will also have implications for water use efficiency and technology choices.

Scenarios

It is sensible to construct four scenarios based on two axes:

- Low and high economic growth
- Low and high population growth

as shown in the graphic below.



12 Figure 9: Water demand scenarios

These can, for the sake of simplicity, and given the high levels of uncertainty pertaining to future economic growth, be reduced to two scenarios:

- A lower bound water demand line
- An upper bound water demand line

Lower bound planning scenario

The lower bound line is informed by:

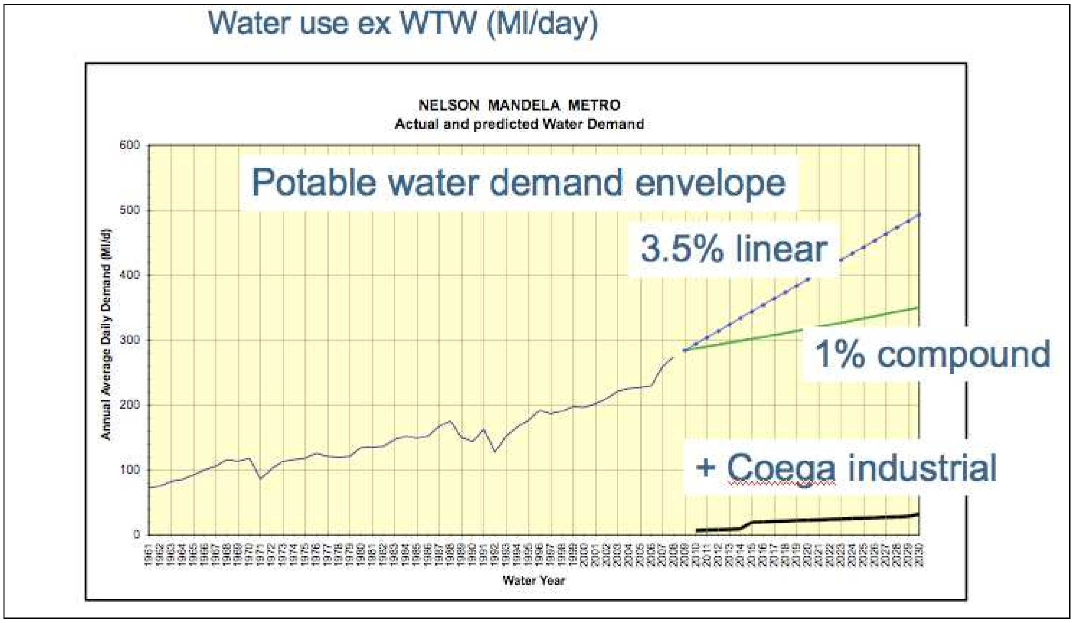
- Population growth at 0.5% per annum
- Low economic growth of 1% per annum

It is hard to imagine water demand growth for the region at less than 1% per annum, and hence a 1% compound growth is used as the lower limit.

Upper bound planning scenario

Within the context of an expectation of lower population growth in the future (compared to the historical record) as a result of lower fertility levels and the impact of HIV-Aids, as well as the fact that future water for industrial use within the Coega IDZ (industrial water demand) is forecast separately, and looking at the historical record for the growth in urban water supply in the region, as well as given the fact that the cost of water to the region is likely to increase significantly as low cost supply options are exhausted; and considering the unfavourable electricity supply and cost situation as well as the possible longer term impacts of the global recession; it is hard to conceive of the growth in potable demand exceeding 3.5% per annum (linear growth) over the medium term.

Therefore, for the purposes of planning, an upper bound of 3.5% linear growth is proposed, subject to ongoing review and revision as events unfold.



13 *Figure 10: Planning scenarios - lower and upper bounds*

Baseline for projection

Water supply in the last 2 to 3 years has shown a rapid increase. The exact reasons for this are not known. However, it is suspected that these could be the result of significant increases in bulk water losses (in failing bulk water pipelines).

In the absence of confirmation of the exact reasons for the increases, it is prudent to accept the actual water supplied in 2008/9 (up to June 2009) as the baseline from which to project future water demand.

This baseline should be revised as necessary and as appropriate in the light of a better understanding of what has contributed to the recent and significant increases in water demand.

Industrial water demand

Most, if not all, new industrial water demand will arise within the Coega IDZ. There is a great deal of uncertainty as to the likely rate of update of industrial water within the Coega Industrial Development Zone. The very recent cancellation of the Aluminium Smelter power contract with Eskom appears to be the final death blow of an energy intensive industrial development strategy for the region based on available and cheap electricity.

> Global aluminium giant Rio Tinto Alcan and South Africa's power utility Eskom confirmed on Thursday that plans for the proposed $2,7-billion Coega smelter project, which was destined for South Africa's Eastern Cape province, had been terminated, owing to Eskom's capacity constraints. In a joint statement, Rio Tinto, Eskom and the South African government revealed that the 'Electricity Supply Agreement', signed in November 2006, had been terminated. Business Day, 16 October 2009.

The Coega IDZ water masterplan has sized the local reticulation design based on an upper bound scenario. While this may be prudent in the case of reticulation infrastructure (avoiding future "double" investment is local reticulation needs to be resized), it is not prudent to use this upper bound forecast for the water demand projection.

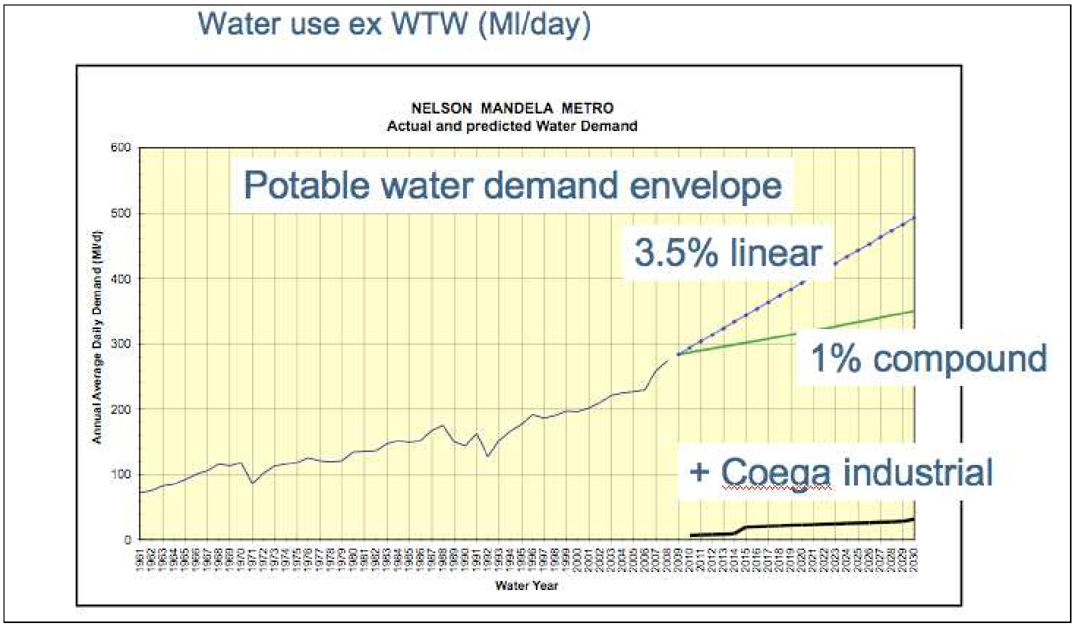
Consequently, the detailed projected maximum water demands within the Coega Water Masterplan were interrogated and a revised industrial water demand project developed. This projection assumes that the major industrial investment within the Coega IDZ will be the oil refinery, with the earliest start date 2015. The latest demand requirements for this refinery were obtained, noting that these are also subject to ongoing revision. What is striking in these revised projections is the low demand for industrial quality water relative to the demand for potable-quality water.

Noting the uncertainty, and the need for ongoing revision and updating as new information becomes available, the Coega <u>industrial</u> demands, for planning purposes are estimated to be as follows: about 5 Ml/day initially (2010), growing to 10 Ml/day y 2014 with a step up to 20 Ml/day in 2015, assuming the PetroSA refinery comes on line in 2015, with demand growing to 30 Ml/day by 2030.

Potable water demand in Coega IDZ is expected to grow from 6 Ml/day to about 10 Ml/day in 2014 with a large step up in 2015 to 40 Ml/day, assuming the PetroSA refinery comes on line then, growing to 55 Ml/day in 2030.

Summary of planning projections

Putting the above scenarios together gives the following:



14 Figure 11: Water demand planning projections

These demand scenarios <u>exclude</u> water demand management, excluded from this report at the request of the client.

15 Conclusions

Measurement of use and management of infrastructure

Careful monitoring of demand is necessary on an ongoing basis

There is a need to understand recent rapid growth in demand by undertaking the necessary investigations.

There is a need to measure and report accurately on IDZ uptake, through appropriate network configuration and installation of meters.

There is an urgent need to put an IDZ service level agreement in place between the municipality and Coega Development Corporation.

Future supply options and infrastructure investment

The insights gained from this work will inform the scenario development exercise. These insights suggest that the scenario development exercise should take the following into account:

The need for a flexible strategy, with regular review.

A preference to avoid expensive lumpy investments in this context of uncertainty.

The need to do feasibility studies for a suite of feasible options which are modular and can be put in place rapidly.

The need to work closely with industries and business on possible partnership options. In the first instance, with PetroSA who are investigating their own desalination options.

The need to consider the priority and order of wastewater reuse. For example, it may be preferable and more economical to do Lower Sundays River desalination first, with wastewater reuse later.

APPENDIX B

CURRENT AND POTENTIAL FUTURE CAPACITIES OF WATER TREATMENT WORKS AND PIPELINES OF THE AWSS

October 2008

CURRENT AND POTENTIAL FUTURE CAPACITIES OF WATER TREATMENT WORKS AND PIPELINES OF THE AWSS

1. PIPELINE AND TREATMENT WORKS CAPACITIES

The existing peak week capacities and possible future peak week capacities have been evaluated for the various components of the AWSS, as portrayed in **Table B1**, for a peak week factor of 1.3. Capacity limitations and potential improvements to infrastructure to increase future capacity are discussed in the Table.

Table B1 Pipeline and treatment works capacities

Conveyance Infrastructure Components	Existing peak week capacity		Possible future peak week capacity		Limitations and possible improvements to infrastructure to increase future capacities and other comments
	Ml/d	Mm^3/a	Ml/d	Mm^3/a	
OLD DAMS					
Sand and Bulk Pipelines					Booster pumps would provide limited capacity increase.
Van Staadens Pipelines					Booster pumps would provide limited capacity increase.
Total Old Dam Pipelines	***16***	***6***	***16***	***6***	***Booster pumps would provide limited capacity increase.***
Linton WTW	20	7	20	7	Max Month Average Annual Daily Demand (AADD) over period 1999-2007 was 11.5 Ml/d in Jan 2002, and max AADD was 8.85 Ml/d for 2003.
GROENDAL/UITENHAGE					
Groendal Pipeline	18	7	18	7	Booster pumps commissioned in 1985. Peak capacity shown is for dam at 70% full and with pipeline boosted but not cleaned for some 5 years.
Uitenhage Springs	6	2	6	2	Capacity of springs limits peak supply. Yield increased to steady 6Ml/d after DWAF capped boreholes in 1992/93.
Groendal Pipeline, WTW and Uitenhage Springs	***24***	***9***	***24***	***9***	***Booster pumps would provide limited increase in capacity.***
CHURCHILL/IMPOFU					
Churchill WTW	105	38	105	38	No augmentation is considered viable and existing supply limited to 100 Ml/d for satisfactory quality water. A 12m-lift booster has been built at Elandsjagt WTW to lift Churchill water into the Elandsjagt final water reservoir during peak flow conditions, i.e. as first capacity upgrade to pipeline system. Prior to this intervention, the outlet from Elandsjagt WTW was operated by throttled valve to balance the hydraulics.
Churchill to Elandsjagt Pipeline and Pumps	143	52	143	52	No augmentation is considered viable. The low lift pump station to be completed but problems have been experienced and it is not operational at present.
Elandsjagt WTW	105	38	160	58	The WTW was designed to be upgraded and was recently upgraded with additions to the sedimentation tanks, etc to provide quality water at 105 Ml/day. A check should be undertaken to determine whether the site can accommodate further extensions.
Elandsjagt to Coastal Towns and to Gamtoos (Coastal Towns) (Gamtoos)	154 (16) (138)	56 (6) (50)	210 (36) (174)	77 (13) (64)	At present a maximum flow of 138 Ml/d can be delivered to Gamtoos, until the bottlenecks presently being addressed have been removed and the additional Gamtoos Pump Station (to Summit Reservoir) is commissioned in 2010 (26 Ml/d). In addition, some 16 Ml/d can be delivered to the coastal towns. The age of pipelines may be the determining factor on whether the pipelines could be boosted beyond 180 Ml/day. A total delivery of 210 Ml/d should, however, be possible with the new Gamtoos pumps installed (the present Maintenance project) and with the draw-offs to Jeffreys Bay and other coastal towns drawing (in 2016) a peak week demand of some 36 Ml/d. The potential for boosting the pipeline from Elandsjagt to Gamtoos may limit the potential increase in supply capacity.

Conveyance Infrastructure Components	Existing peak week capacity		Possible future peak week capacity		Limitations and possible improvements to infrastructure to increase future capacities and other comments
	Ml/d	Mm^3/a	Ml/d	Mm^3/a	
Coastal towns	***16***	***6***	***36***	***13***	***The existing pipeline can supply to the coastal towns their current peak week demand of about 16 Ml/day and in future should be able to provide a peak week demand of about 36 Ml/day.***
Gamtoos to Greenbushes/Chelsea Pipeline and Pumps	***138***	***50***	***145***	***53***	***This pipeline is already boosted, however this additional peak week capacity will only be available once the Gamtoos Pumps have been replaced (upgraded).***
Gamtoos to Summit Pumps and Pipeline	***0***	***0***	***26***	***9***	***These pumps are currently being designed for completion in 2010.***
LOERIE					
Loerie WTW	***100***	***37***	***100***	***37***	***No increase in the existing capacity of the Loerie WTW is indicated, as this would not be effective unless the supply from Kouga Dam to NMBM is augmented. The Loerie WTW was however planned for doubling, i.e. based on the 1963 plans for future raising of Kouga Dam wall. The provision of additional clarifiers may necessitate relocating the sludge dams but an additional filter gallery could be added quite easily.***
Loerie to Summit Pumps and Pipeline	***100***	***37***	***100***	***37***	***A surge analysis will be required to check the pipeline integrity if flows are increased to more than the existing capacity of 100 Ml/day. Increasing the pumping capacity may however not be economical, due to the large increase in head and the expected electricity tariffs. An additional pipeline might be preferable and might only be required if the supply from Kouga Dam is augmented.***
Summit to Chelsea	140	51	140	51	The maximum discharge was 136 Ml/d, however the KwaNobuhle off-take a short distance from Chelsea Reservoir has enabled the peak flow to be increased to about 140 Ml/d. The inlet to Chelsea Reservoir must still be improved to enable the maximum flow to the reservoir for high water levels, without overflowing the inlet building.
Total Pipeline Capacity Gamtoos to Greenbushes+ Summit to City	278	101	278	101	This capacity is only applicable for a peak week factor of 1.3 or higher.
NOOITGEDACHT ALLOCATION					
Scheepersvlakte to Nooitgedacht Pipeline	280	102	280	102	This pipeline was sized to deliver an average flow of 200 Ml/d and a peak flow of 280 Ml/day. Scheepersvlakte Dam has a balancing capacity of 800 Ml which may be drawn down during dry periods and reduce the pipeline capacity.
Nooitgedacht WTW	***73***	***27***	***105***	***38***	***The WTW is currently being upgraded to match the capacity of the pumps. Additional filters will be required to increase the capacity to 105 Ml/day.***
Nooitgedacht to Grassridge Pipeline	93	34	105	38	Either the pumping capacity should be upgraded or the 4th standby pump must be used to deliver 105 Ml/day.
Grassridge to Motherwell Pipeline	135	49	135	49	Upgrading is not required.
Existing Total Capacity and Possible Future Capacity		***135***		***165***	

Notes: 1. Limiting future conveyance infrastructure capacities are shown in ***bold italics***.

2. It has been assumed that transfers can take place within the Metropolitan area and that the possible improvements to the existing infrastructure required to meet the possible future increase in peak week capacities will be provided as indicated in the table.

2. ASSESSMENT OF ADDITIONAL 1 IN 20 YEAR AND 1 IN 50 YEAR YIELDS THAT COULD BE SUPPLIED BY EXISTING PIPELINES

The estimated 1 in 50 year and 1 in 20 year yields of the various sources of supply available to NMBM (after provision for the original ecological allocations but not the recently determined increased ecological reserve releases) are compared in **Tables B2** and **B3** with the present day and future conveyance capacities respectively shown in **Table B1**. These Tables show the following:

- Table B2 shows that the existing conveyance infrastructure supplying NMBM would only be able to supply a peak week demand equivalent to 135 million m^3/a (370 Ml/d) which corresponds to a peak week demand factors of 1.3 and 1.2 for the present day 1 in 50 year and 1 in 20 year yields respectively.
- Table B3 shows that if the existing pipeline infrastructure is upgraded by boosting then the overall peak week capacity of the pipeline system could be boosted to 165 million m^3/a (452 Ml/d) corresponding to peak week demand factors of 1.6 and 1.5 for the present day 1 in 50 year and 1 in 20 year yields respectively. Therefore for a peak week demand factor of 1.3, the boosted infrastructure would be capable of supporting an augmented yield of 127 million m^3/a (165/1.3) which corresponds to augmentation of the present day 1 in 50 year by 26 million m^3/a (127-101) and of the 1 in 20 year yield by 17 million m^3/a (127-110).

Table B2 Assessment of additional 1 in 20 year and 1 in 50 year yields that could be supplied by existing pipelines for a peak week factor of 1.3

Sources of Supply	Possible Future Conveyance Infrastructure Peak Week Capacity (Mm^3/a)	1 in 50 Year Yield or Existing Allocation		1 in 20 Year Yield or Existing Allocation	
		Yield or Allocation (Mm^3/a)	Peak Factor	Yield or Allocation (Mm^3/a)	Peak Factor
Old Dams	6	3	2.0	4	1.5
Groendal/Uitenhage springs	9	6	1.5	6	1.5
Churchill/Impofu	56 (6+50)	44	1.3	51	1.1
Kouga/Loerie	37	22	1.6	23	1.6
Nooitgedacht	27	26	1.0	26	1.0
Combined Total Yield	**135**	**101**	**1.3**	**110**	**1.2**

Notes: 1. Peak Factor based on (Present Conveyance Infrastructure Capacity) / (1 in 20 year or 1 in 50 year yields)
2. Yields based on the 1996 Stochastic Analysis

1

Table B3 Assessment of additional 1 in 20 year and 1 in 50 year yields that could be supplied by boosting existing pipelines for a peak week factor of 1.3

Sources of Supply	Possible Future Conveyance Infrastructure Peak Week Capacity (Mm^3/a)	1 in 50 Year Yield or Existing Allocation		1 in 20 Year Yield or Existing Allocation	
		Yield or Allocation (Mm3/a)	Peak Factor	Yield or Allocation (Mm^3/a)	Peak Factor
Old Dams	6	3	2.7	4	2.0
Groendal/Uitenhage springs	9	6	1.5	6	1.5
Churchill/Impofu	75 (13+53+9)	44	1.7	51	1.5
Kouga/Loerie	37	22	1.6	23	1.6
Nooitgedacht	38	26	1.5	26	1.5
Combined Total Yield	**165**	**101**	**1.6**	**110**	**1.5**

Notes: 1. Peak Factor based on (Future Conveyance Infrastructure Capacity) / (1in 20 year or 1 in 50 year yields)
2. Yields based on the 1996 Stochastic Analysis