REPORT No: P WMA 19/000/00/0507

Volume 3 of 7

Appendix B

DEPARTMENT OF WATER AFFAIRS AND FORESTRY

Directorate: National Water Resource Planning

WESTERN CAPE WATER SUPPLY SYSTEM: RECONCILIATION STRATEGY STUDY

Scenario Planning for Reconciliation of Water Supply and Requirement

Appendix B: Starter document for Selection of Intervention Workshop

FINAL

CITY OF CAPE TOWN | ISIXEKO SASEKAPA | STAD KAAPSTAD

June 2007

Submitted by:
Ninham Shand (Pty) Ltd in Association with
UWP Consulting (Pty) Ltd

NINHAM SHAND CONSULTING SERVICES

UWP CONSULTING

WESTERN CAPE RECONCILIATION STRATEGY STUDY

INITIAL SCREENING OF OPTIONS WORKSHOP
4 August 2005

WORKSHOP STARTER DOCUMENT

Table of Contents

Page No.

CONTEXT

1. WESTERN CAPE WATER SUPPLY SYSTEM (WCWSS) 1
2. OVERVIEW OF THE BERG WMA STUDY AREA 3
3. OVERVIEW OF THE BREEDE WMA STUDY AREA 4
4. THE SCREENING WORKSHOP 8
5. POTENTIAL AUGMENTATION OPTIONS 10

SECTION A 16

A1. AGRICULTURAL WATER DEMAND MANAGEMENT 17

SECTION B 20

B1. WATER TRADING 21

SECTION C 23

C1. REMOVAL OF INVASIVE ALIEN PLANTS 24
C2. REMOVAL OF COMMERCIAL FORESTRY 26

SECTION D 28

INTRODUCTION TO THE USE OF TREATED EFFLUENT OPTIONS 29

D2. USE OF TREATED WASTEWATER FOR COMMERCIAL IRRIGATION; EXCHANGE FOR FRESH WATER ALLOCATIONS 34
D3. USE OF TREATED WASTEWATER FOR POTABLE USE 37
D4. DUAL RETICULATION NETWORK 40

SECTION E 42

INTRODUCTION TO URBAN WATER DEMAND MANAGEMENT OPTIONS 43

E1. LEAKAGE DETECTION AND REPAIR 44
E2. LEAKAGE REPAIR BEYOND THE METER 47
E3. PRESSURE MANAGEMENT 48
E4. USE OF WATER EFFICIENT FITTINGS 50
E5. ELIMINATION OF AUTOMATIC FLUSH URINALS 52
E6. ADJUSTMENT OF WATER TARIFFS, METERING AND CREDIT CONTROL 54
E7. USER EDUCATION 56
E8. PROMOTION OF GREY WATER USAGE 58
E9. RAINWATER TANKS 60
E10. PROMOTION OF PRIVATE BOREHOLES AND WELLPOINTS 62

SECTION F 64

TABLE MOUNTAIN GROUP AQUIFER INTRODUCTION 65

F2. TABLE MOUNTAIN GROUP AQUIFER TSA H8 – STEENBRAS DAM 70
F3. TABLE MOUNTAIN GROUP AQUIFER TSA T4 –THEEWATERSKLOOF 73
F4. CAPE FLATS AQUIFER 76
F5. WEST COAST AQUIFER 80

Table of Contents

Page No.

F6. NEWLANDS AQUIFER....85
F7. CONJUNCTIVE USE OPTIONS....87

SECTION G 90

G1. RAISING LOWER STEENBRAS DAM....91
G2. THE UPPER CAMPANULA DAM....94
G3. THE LOURENS RIVER DIVERSION....97
G4. THE EERSTE RIVER DIVERSION....100
G5. VOËLVLEI AUGMENTATION PHASE I....103
G6. VOËLVLEI AUGMENTATION PHASE II AND III....106
G7. A NEW DAM AT MISVERSTAND....109
G8. TWENTY FOUR RIVERS DAM....112
G9. WATERVALS RIVER DAM....115
G10. THE UPPER MOLENAARS DIVERSION....118
G11. MULDERSVLEI OPTIMISATION SCHEME....122
G12. THE WEMMERSHOEK DAM AND PIPELINE....124
G13. THE MICHELL'S PASS DIVERSION....126
G14. LINKING BRANDVLEI DAM TO THEEWATERSKLOOF DAM FOR TRANSFER....130
G15. RAISING THEEWATERSKLOOF DAM....133
G17. THE UPPER WIT RIVER DAM....138
G18. THE UPPER WIT RIVER DIVERSION....141
G19. THE OLIFANTS RIVER DIVERSION....144

SECTION H 147

H1. DESALINATION....148

SECTION I 152

I.1 WATER TRANSFERS FROM THE CONGO RIVER....153
I2. WATER TRANSFERS FROM THE ORANGE RIVER....156
I3. TOWING OF ICEBERGS....157
I4. OTHER OPTIONS ARISING FROM PUBLIC MEETINGS....158

1. Western Cape Water Supply System (WCWSS)

1.1 INTRODUCTION

The WCWSS supplies the City of Cape Town (CCT) and other water user associations (irrigators) in the catchments of the Berg and Eerste Rivers. The WCWSS also supplies water to irrigators in the Riviersonderend catchment area of the Breede WMA.

1.2 THE MAIN DAMS

The main storage dams are the DWAF dams, *Theewaterskloof* (in the Breede WMA, which also serves irrigators in the Riviersonderend valley) and *Voëlvlei*, the *Wemmershoek*, *Upper Steenbras* and *Lower Steenbras Dams* owned by CCT and the future *Berg River Dam* that will initially be owned by the Trans Caledon Tunnel Authority (TCTA) and later transferred to DWAF.

Located in a winter rainfall area, characterised by wet winters and dry summers, the dams are filled during the wet winter months (April to September) when about 90% of the annual runoff occurs and water demands comprise only about 30% of the annual demand.

During the dry summer months (October to March) inflows to the dams are small and irrigation demands and garden watering demands in the urban areas are large. Approximately half of the storage in the dams is required to store water during the winter in order to meet the high water demands during the summer. The other half of the dams' storage is required to provide long-term carry over storage for droughts.

1.2.1 The Benefits of an Integrated Scheme

The dams are operated in an integrated manner to minimise spillage during the wetter years and thus to maximise the stored water available for essential uses during droughts. The effects of droughts are mitigated by progressively restricting supplies during droughts, with less essential users provided at lower assurance of supply, being more severely restricted. During the winter filling of the dams, the demands are shifted onto those dams that appear more likely to spill. This minimises the occurrence of the situation where one dam spills while there is storage available in another dam.

The CCT has co-operated to help minimise spillage by :

- introducing additional capacity in its water treatment works and bulk water pipelines to enable flexibility in the allocation of the demands on the different dams and to provide interconnectivity between the various sources.
- reducing the demands on their own dams (Wemmershoek and Steenbras), although there might be short-term benefits for them to use water from their own dams preferentially, and only use the other dams as backup during drier periods. However, this would increase spills and reduce the system yield.
- DWAF has also introduced one system tariff for the CCT which also allows the City greater flexibility.

Figure 1 shows the layout of the WCWSS.

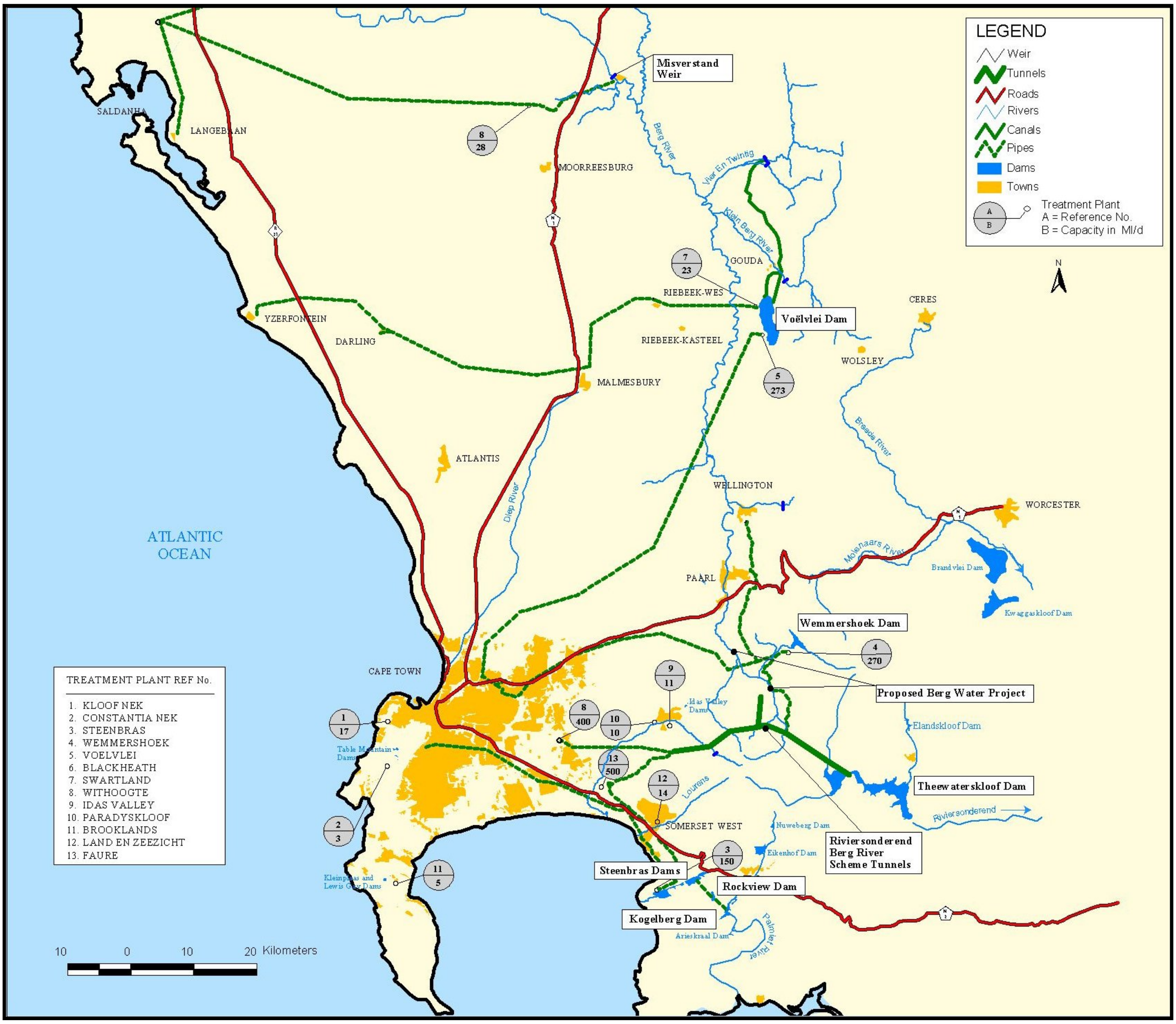
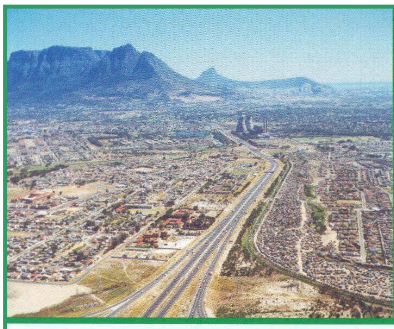


Figure 1 The Integrated Western Cape Water Supply System

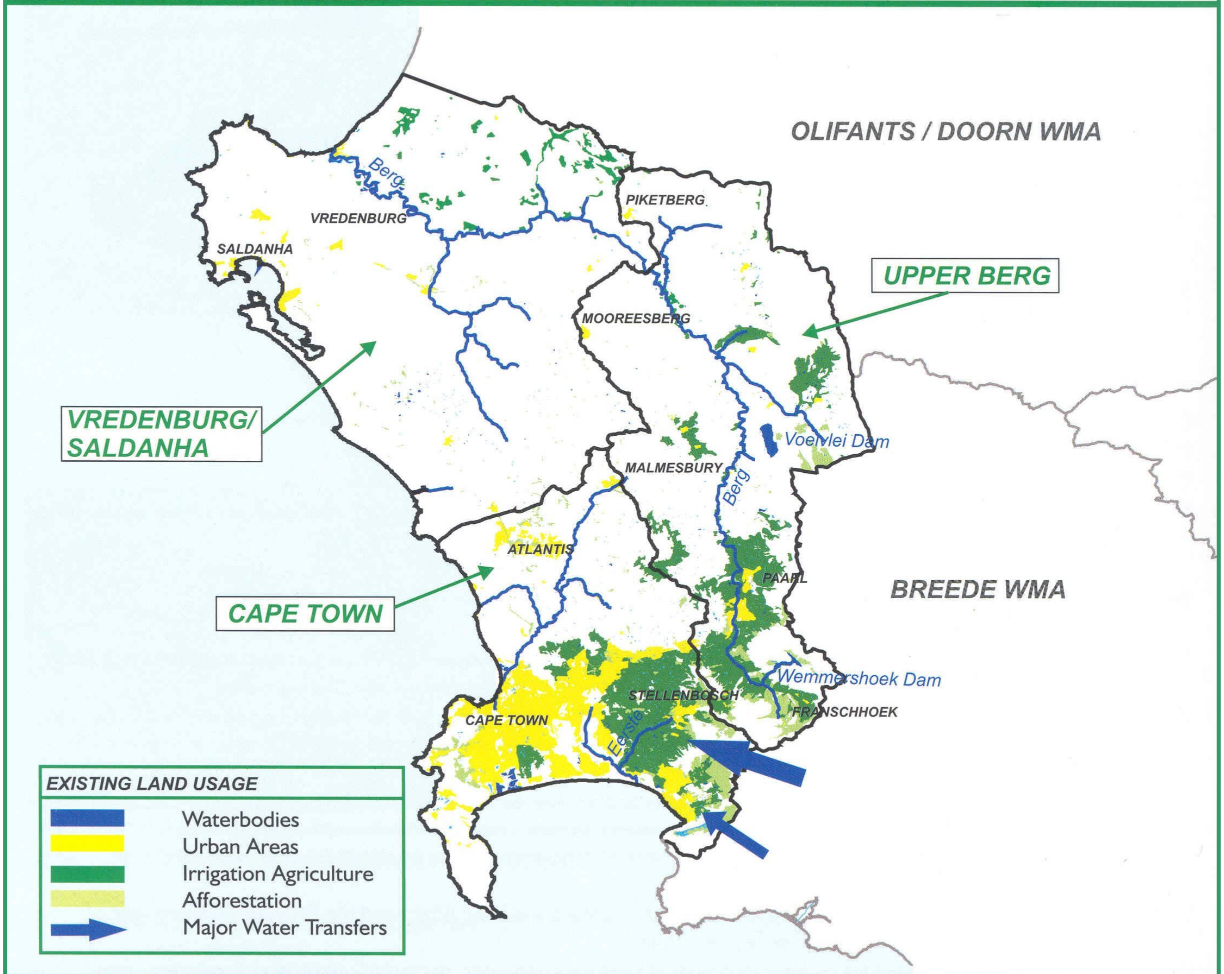
2. Overview of the Berg WMA Study Area

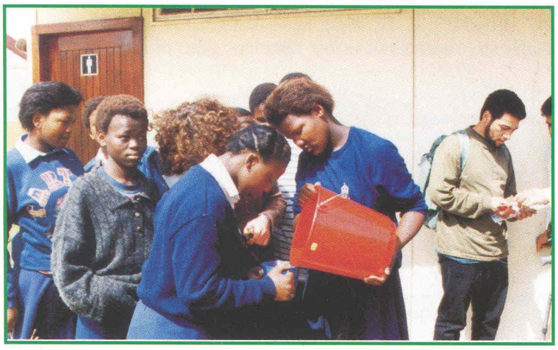


Berg Water Management Area

CHARACTERISTICS OF WMA

Dominant Activities	- Irrigated agriculture, wine and table grapes and deciduous fruit exports - Coastal resort towns
Gross Domestic Product	- Approximately 86% of Provincial GDP
Population	- 3 482 000 people (2001)

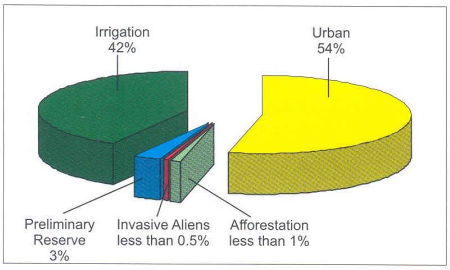




Unlike any of the other WMAs in the Western Cape, urban water use is significant in the Berg WMA

The Berg river estuary is of international conservation importance, especially for bird life

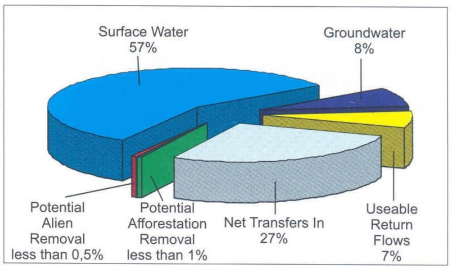
CONSUMPTIVE WATER USE
(745 million m³ per annum)



Current shortfall:
36 million m³ per annum

Natural Mean Annual Runoff:
1 429 million m³ per annum

WATER SUPPLY
(709 million m³ per annum)



- Urban and agricultural water usage comprise 54 % and 42 % of consumptive usage respectively, with 27 % being imported from the Breede WMA
- The Berg Water Project (Berg River Dam and Supplement Scheme) is currently being built to alleviate the current water stress in the WMA

STRATEGIC PERSPECTIVES IN THE BERG WMA:

- The Western Cape System Model of the major water supply components must be updated regularly
- The Berg River Reserve must be modelled to determine its impact on the availability of water
- Develop water quality management strategies for the middle and lower Berg River
- Licenses for new irrigation expansion in the Berg WMA must be continuously considered with preference given to water trading
- Reuse of treated wastewater remains an important future source for the Cape Metropolitan Area

WATER SUPPLIES : STATUS & DEVELOPMENT POTENTIAL

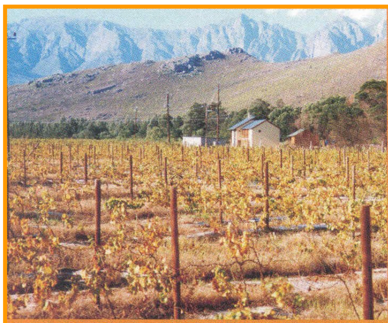
Catchment	Existing Supplies	Development Potential		Potential Future Use
		Surface Water	Ground Water	
Upper Berg	Restricted	Voëlvlei	Limited	Urban / Agriculture
Vredenburg/ Saldanha	Restricted	Limited	Limited	Urban / Industry
Cape Town	Restricted	Moderate & Re-use	Moderate	Urban / Industry

Concerns - Water quality in the lower reaches of the Berg River and the effect of water resources development on the ecological functioning of the estuary.

WATER USAGE

Potable Water -	8% of people substandard (2001)
Water Services Provider/Authority-	City of Cape Town West Coast DM (District Municipality)
Additional Water Services Authorities	6 B-municipalities + Winelands DM
Irrigation Boards -	15
Water User Associations -	1 established to date
Projects for Resource-Poor Farmers	5
Working for Water (2004/2005) -	Budget R5 million

3. Overview of the Breede WMA Study Area



Breede Water Management Area

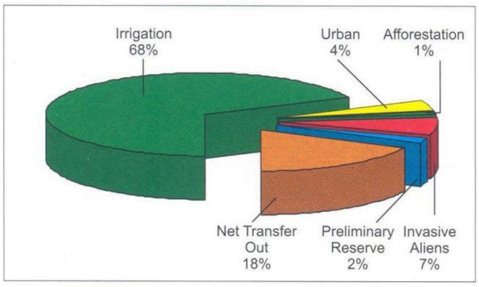
CHARACTERISTICS OF WMA

Dominant Activities	- Irrigated agriculture, wine and table grapes and deciduous fruit exports. - Coastal resort towns and tourism
Gross Domestic Product	- Approximately 6% of Provincial GDP
Population	- 437 000 people (2001)

Conservation of catchments is vital to ensuring sustainable water resources

Irrigation agriculture predominates in the upper reaches of the WMA

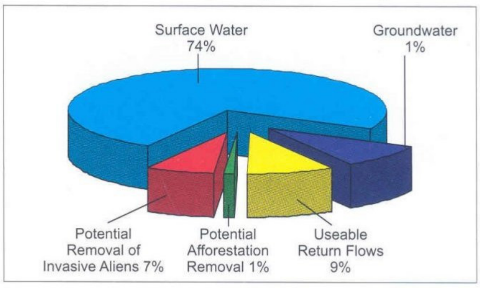
WATER USAGE / PRELIMINARY RESERVE
(1071 million m³ per annum)



Current Surplus:
19 million m³ per annum

Natural Mean Annual Runoff:
2 472 million m³ per annum

WATER SUPPLY
(1090 million m³ per annum)



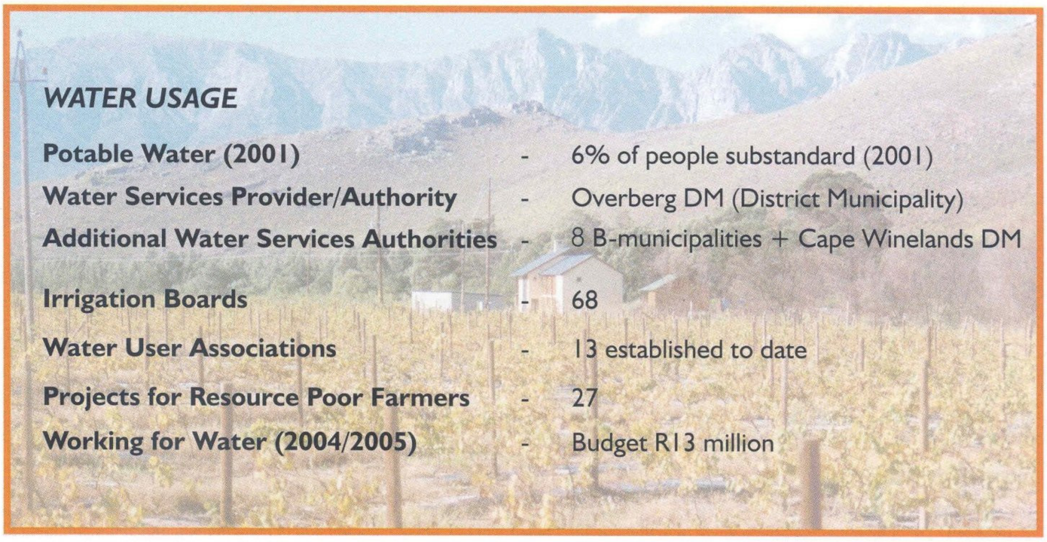
- Irrigation comprises 68% of the total consumptive water use and water exports 18%
- Many coastal resort towns are located in water scarce areas
- Decisions regarding the implementation of the final Reserve, particularly in the Riviersonderend catchment will greatly influence the availability of water to other water use sectors

STRATEGIC PERSPECTIVES IN THE BREEDE WMA:
- The potential transfer of additional water into the Berg WMA must be investigated
- The available surplus of 19 million m³ per annum shall be for meeting increasing urban water requirements
- Off-channel storage and controlled groundwater development shall be the preferred options for irrigation expansion
- Improved salinity management in the middle and lower Breede River remains a high priority
- Applications for water use licenses shall require a component of the use to be by Resource Poor Farmers
- Groundwater shall be the preferred resource for local municipal water supply augmentation

WATER SUPPLIES : STATUS & DEVELOPMENT POTENTIAL

Catchments	Existing Supplies	Development Potential		Potential Future Use
		Surface Water	Ground Water	
Upper Breede	Moderate surplus	Moderate	Moderate	Agriculture/Export
Lower Breede	Moderate surplus	Moderate	Limited	Agriculture
Riviersonderend	Balanced	Moderate / (Lower catchment)	Moderate	Agriculture
Western Overberg	Balanced	Moderate	Moderate	Coastal Towns/Export
Eastern Overberg	Balanced	None	Limited	Coastal Towns

Concerns - Salinity in lower reaches of the Upper Breede limits further agricultural development in this area.



WATER USAGE

Potable Water (2001) - 6% of people substandard (2001)
Water Services Provider/Authority - Overberg DM (District Municipality)
Additional Water Services Authorities - 8 B-municipalities + Cape Winelands DM
Irrigation Boards - 68
Water User Associations - 13 established to date
Projects for Resource Poor Farmers - 27
Working for Water (2004/2005) - Budget R13 million

KEY FINDINGS OF THE BERG WMA INTERNAL STRATEGIC PERSPECTIVE

The Berg WMA Internal Strategic Perspective (ISP) identified the urgent need to conduct this reconciliation study of Western Cape Water Supply System as demands are expected to exceed the supplies, including those from the Berg Water Project, by about 2012, as indicated in Figure 2.

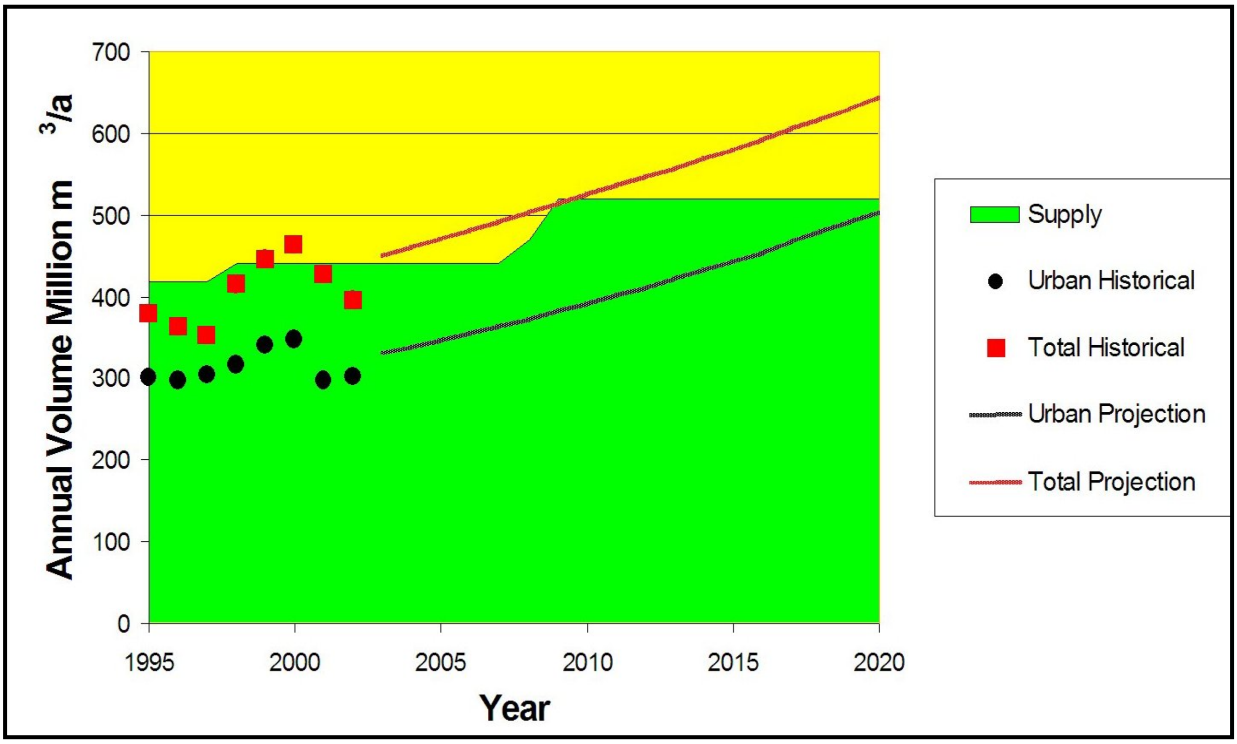


Figure 2 Historical and Projected Water Demands on the Western Cape Water Supply System

Therefore, the ISP identified the need to review all previously identified options and particularly the re-use of effluent as large volumes of wastewater currently flow into the sea. The possible development of the Table Mountain Group Aquifer as a supply is currently being investigated by the City of Cape Town.

As the implementation of a new scheme from identification to completion may take up to five years, it is essential that the most likely future augmentation options and sequence of implementation be determined as soon as possible.

KEY FINDINGS OF THE BREEDE WMA INTERNAL STRATEGIC PERSPECTIVE

Drawing on the recently completed Breede River Basin Study (BRBS, 2003) and the Breede WMA Internal Strategic Perspective (ISP, 2004), the following key findings are presented. These represent a summary of those findings which have a significant bearing on the water resources planning within the Berg WMA.

The Reserve

The Breede River has one of the higher estuary requirements (53% of the natural MAR) of the large rivers in the country. Despite the high preliminary Ecological Water Requirement of 975 million m^3/a, the resulting impact on the present day yield (1 in 50 year) is only 16 million m^3/a. This is due to the fact that:

i The current Ecological Water Requirements for the Lower Breede River (Class "C") and its estuary (Class "B") are almost entirely met through present day flow conditions. Meeting the few seasonal shortfalls accounts for the relatively small impact on the present day yield.

ii The ISP recommends that the Riviersonderend River be retained at a Class "E" (its present ecological status), at least for the interim. Were the river to be rehabilitated to a Class "D" (the scientific recommendation of the BRBS), the resulting impact on yield would be about 85 million m^3/a, with much of that having to be provided through releases out of Theewaterskloof Dam. The yield from the dam is already fully allocated and compulsory licensing would be required to resolve the over-allocation. The CCT and irrigators dependent on water from the dam would then need to curtail use (cutting back on farming and other economic activity) or develop other sources to offset this impact.

A decision on the Reserve implementation in the Riviersonderend River should be supported through the development of Reserve implementation scenarios. A well-informed public participation process will then follow, leading to a decision on the Reserve and Resource Quality Objectives for the river. In the interim, the status quo will be maintained as the management class.

Potential Transfer Schemes

The following potential transfer schemes from the Breede WMA to the Berg WMA were identified in the Breede River Basin Study and the ISP :

Transfer Scheme Name	Potential Yield (Mm^3/a)	Comment
Michell's Pass Diversion	53	Diverts water into Voëlvlei Dam via a canal at Michell's Pass, but additional pumping capacity required at Brandvlei to maintain status quo. **FAVOURABLE** for transfer.
Upper Molenaars Diversion	27	Diverts water to either Berg River Dam or Wemmershoek Dam, but additional pumping capacity required at Brandvlei to maintain status quo. **FAVOURABLE** for transfer.
Augmenting Theewaterskloof Dam out of Brandvlei Dam	33	Transfers would be from Brandvlei Dam to Theewaterskloof Dam, then via the existing RSE tunnel to the Berg WMA. This option limits further irrigation development in the Breede WMA. **NOT FAVOURABLE** for transfer.
Increased transfers from the Palmiet River	25	Transfers would be via the existing Palmiet Pumped Storage Scheme. **FAVOURABLE** for transfer.

As indicated in the above table, the three provisionally preferred transfer schemes are the Michell's Pass Diversion, the Upper Molenaars Diversion and the increased transfers from the Palmiet River.

Potential local schemes

The Breede River Basin Study and the ISP also identified the more favourable schemes for augmenting the existing irrigation supplies. However, the requirements of the Ecological Reserve will probably limit the extent of development of the water resources of the Breede for local usage and transfer to between 90 and 140 million m^3/a. The upper limit would be possible if the recommended river classes were adopted, with the exception of the Riviersonderend River (maintained at status quo). All invasive alien plants would also need to be removed.

4. The Screening Workshop

4.1 INTRODUCTION

The Western Cape Reconciliation Strategy study will produce a long-term strategy for the management of reconciling water supply with demands from the Western Cape Water Supply System (WCWSS) area. The study will *inter-alia* recommend options to reconcile demand with supply. Two screening processes will be undertaken as part of the study. At the Preliminary Screening Workshop, all previously documented water conservation and demand management and other intervention options, along with all documented potential augmentation schemes will be evaluated, along with new/recently identified options. Options identified through the public participation process have been incorporated.

From the Preliminary Screening Workshop a scope of work will be drawn of studies that need to be investigated further at reconnaissance/pre-feasibility level, which will be documented in the Inception Report. Once the required investigations have been done (over approximately a six-month period), the second Screening Workshop will be held, where options will be ranked. Following that, the Reconciliation Strategy will be written.

The study will serve to identify those development options that warrant further study (at feasibility level). In doing so, the future investment made by the Department into undertaking more detailed studies could focus on those options most likely to be socially, economically and environmentally acceptable.

4.2 OBJECTIVES OF THE PRELIMINARY SCREENING PROCESS

The objectives of the initial screening workshop are to:

- Identify schemes that require no further evaluation.
- From existing information, assess the acceptability of the various options identified in previous studies in terms of technical, financial, environmental and social criteria;
- Ascertain which intervention or development options or combinations thereof would warrant further investigations at reconnaissance or pre-feasibility level, and what aspects should be investigated in this study;
- Augment the existing information with specialist inputs from the DWAF and other key stakeholders.

Some issues to consider during the evaluation of options are :

- The importance of additional storage;
- The speed and cost of implementing a large scheme versus a number of smaller schemes;
- The ability of the Western Cape Water Supply System to accommodate the additional yields that could be made available.

4.3 STARTER DOCUMENT

This Starter Document provides information for discussion purposes. The content is based on available documentation, which for the purposes of this workshop provides information that can be used for strategic level decisions. It is anticipated that the workshop participants will provide further information and critically review the information contained in the Starter Document, which has been drawn from disparate sources, is based on different assumptions and is of varying detail, age and confidence.

It is important to note that for each option presented in this document, an attempt has been made to estimate the yields after allowance for the best available estimate of the Reserve. It is however acknowledged that provisional Reserve estimates present a degree of uncertainty. Nevertheless, an attempt is made to at least show a reasonable order of magnitude of its potential impact.

The purpose of this document is to provide adequate background material to facilitate informed discussion at the Screening Workshop in order to confirm the development options that may warrant further investigation.

4.4 ATTENDANCE

It is anticipated that the workshop will be attended by identified DWAF staff, the consultant team and supporting specialists, CCT officials, representatives from National and Provincial Government Departments and representatives from the Berg and Breede WMAs, identified through the Public Participation Process, and Study Steering Committee members.

4.5 ANTICIPATED OUTCOMES OF THE SCREENING WORKSHOP

Following the screening workshop, a draft Screening of Options Report will be prepared based on this starter document and the information derived from the workshop. The draft Screening of Options Report will be distributed to all participants for their review and further inputs. A public meeting will be held, as part of the Public Participation Process, where the findings of the workshop will be presented to the public. Opportunity will also be provided for the public to comment. All comment will then be assimilated into the Study Report.

4.6 SCREENING OF OPTIONS

The screening of the various identified development options would be based on a number of criteria, namely:

- potential scheme yields, inclusive of the impact of the Reserve;
- updated financial cost estimates and unit reference values (URVs);
- socio-economic implications;
- ecological implications.

Non-starter options should be quickly identified, and criteria under which such options would be considered again will be identified. Each criterion will be assigned a colour-coded rating, based on how favourable the option is rated for those particular criteria. A three tier rating system is envisaged as follows :

- Favourable
- Moderately favourable
- Unfavourable

The following diagram illustrates three hypothetical cases :

SCHEME NAME	CRITERIA					
	Non-Starter	Yield	URV	Socio-economic	Environmental	Available Information/ Technology
Scheme 1	Y					No previous implementation
Scheme 2						
Scheme 3						

Those operations which appear to be obvious non-starters will be flagged. Comment will also be required as to the extent of available information and whether the technology has been successfully utilised previously.

4.7 OVERVIEW OF POTENTIAL DEVELOPMENT OPTIONS

In Section 5, an overview of each potential scheme is provided and information on the various criteria is provided for comment and discussion. Figure 3 shows the approximate position of each potential scheme in relation to the existing water resources infrastructure.

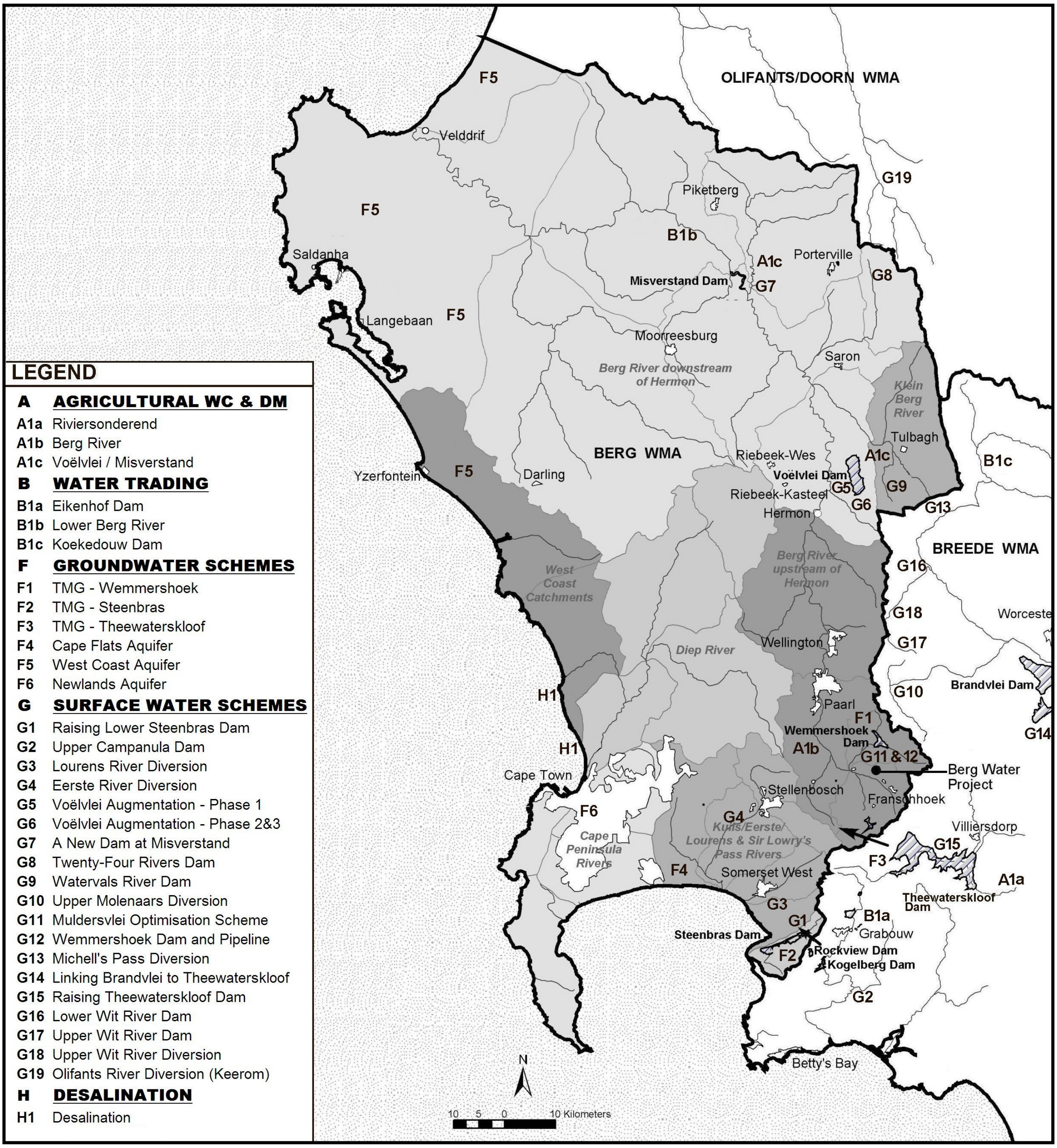


Figure 3 Locality Map

5. Potential Augmentation Options

The following potential augmentation options are presented in this document. The information is drawn from various existing reports. Whilst the base information differs in the extent and reliability of information, it nevertheless represents the latest available sources of information for each option.

Section A: AGRICULTURAL WATER CONSERVATION AND DEMAND MANAGEMENT

Section B: WATER TRADING

Section C: CHANGES IN LANDUSE
- C1: Removal of Invasive Alien Plants
- C2: Removal of Commercial Forestry

Section D: WATER RE-USE
- D1: Use of Treated Wastewater for Local Irrigation and Industrial Use
- D2: Use of Treated Wastewater for Commercial Irrigation, Exchange with Irrigation Schemes Fresh Water Allocation
- D3: Use of Treated Wastewater forPotable Use
- D4: Dual Reticulation Network

Section E: URBAN WATER CONSERVATION AND DEMAND MANAGEMENT
- E1: Introduction to Water Demand Management Options
- E2: Leakage Detection and Repair
- E3: Leakage Repair Beyond the Meter
- E4: Pressure Management
- E5: Use of Water Efficient Fittings
- E6: Elimination of Automatic Flush Urinals
- E7: Adjustment of Water Tariffs, Metering, Credit Control
- E8: User Education
- E9: Promotion of Grey Water Usage
- E10: Rainwater Tanks
- E11: Promotion of private boreholes and wellpoints

Section F: GROUNDWATER SCHEMES
- F1: TMG - Wemmershoek
- F2: TMG - Steenbras
- F3: TMG - Theewaterskloof
- F4: Cape Flats Aquifer
- F5: West Coast Aquifer
- F6: Newlands Aquifer

Section G: **SURFACE WATER SCHEMES**

G1: Raising Lower Steenbras Dam
G2: Upper Campanula Dam
G3: Lourens River Diversion
G4: Eerste River Diversion
G5: Voëlvlei Augmentation - Phase 1
G6: Voëlvlei Augmentation - Phase 2&3
G7: A New Dam at Misverstand
G8: Twenty-Four Rivers Dam
G9: Watervals River Dam
G10: Upper Molenaars Diversion
G11: Muldersvlei Optimisation Scheme
G12: Wemmershoek Dam and Pipeline
G12: Michell's Pass Diversion
G14: Linking Brandvlei to Theewaterskloof
G15: Raising Theewaterskloof Dam
G16: Lower Wit River Dam
G17 Upper Wit River Dam
G18: Upper Wit River Diversion
G19: Olifants River Diversion (Keerom)

Section H: **DESALINATION**

H1: Desalination

Section I: **OTHER SCHEMES**

I1: Water transfers from the Congo River
I2: Water transfers from the Orange River
I3: Towing of icebergs
I4: Other options arising from public meetings

SECTION A

AGRICULTURAL WATER CONSERVATION AND DEMAND MANAGEMENT

A1. Agricultural Water Demand Management

1. INTRODUCTION

The information presented is based on the recently completed:

- Berg WMA Internal Strategic Perspective (ISP)
- Breede WMA ISP; and
- The Breede River Basin Study (BRBS)

The water available to virtually all the existing irrigation water supply schemes in the Berg and Breede WMAs is fully allocated, and agricultural water users must be encouraged to use water more efficiently. In the agricultural sector, conveyance losses and poor efficiency contribute to the overall losses. Irrigation accounts for an estimated 41% of total consumptive water requirements (i.e. excluding the ecological Reserve) in the Berg WMA. In the Breede WMA the agricultural water requirement constitutes 93% of the current total in-catchment water requirement, and this sector therefore offers significant potential savings. For example, a pilot study undertaken in the Robertson area suggests that less than 50% of the water diverted into Greater Brandvlei Dam reaches the farm boundaries.

A number of Water Conservation and Demand Management (WC/DM) options for improving the efficiency of irrigation water use have been identified and are briefly described below. No quantitative assessments and unit reference values of these options have previously been prepared, and none are presented here. However it is likely that some of the options will provide considerable savings at URVs comparable or lower than most additional schemes.

2. RIVER RELEASE MANAGEMENT

In the Berg WMA, releases from Misverstand Dam for irrigation uptake by farmers along lower Berg River take place via a bottom gate outlet, unsuitable for controlled releases. Furthermore, there is no remote sensing facility between Voëlvlei Dam and Misverstand Dam to control releases from Voëlvlei Dam so as reduce the risk of spilling at Misverstand. The installation of telemetry to automatically control releases and reduce spillage from the system, is seen as essential and likely to be highly cost effective.

Freshening releases to improve water quality contributes significantly to water loss in the Breede River catchment. These releases (about 22 million m^3/a) from Greater Brandvlei Dam in the Breede River are required to reduce salinity in the middle and lower reaches of the Breede River. Of the total release, approximately 10 million m^3/a is utilised opportunistically (as and when water quality is suitable) for irrigation in the lower reaches of the Breede River. Salinity management initiatives such as the use of interceptor drains should be considered. This is particularly important in catchments such as the Berg and Breede River catchments where the river channel serves both as a conveyance system and a collector drain for irrigation return flows.

Timing of releases from storage dams, (notably Theewaterskloof, Greater Brandvlei and Voëlvlei Dams, and in future the Berg River Dam) into the river channels and conveyance canals, for uptake by farmers is not as efficient as it could be as these are not based on short-term demand projections.

The manual interpretation by experienced water bailiffs as to the timing of releases ensures best operation under existing circumstances. In future, decision support systems may be required to assist operators who are less experienced.

3. IRRIGATION PRACTICES

Within both the Berg and Breede WMAs, on-farm losses occur between the point of abstraction and the field edge. Actual irrigation technologies are, for the most part, modern and sophisticated and do not leave much room for improvement. It is recognised that many farmers have installed efficient on-farm irrigation methods such as drip and microjet.

4. IRRIGATION CANAL LOSSES

The overall impression is that with the exception of invasive alien plant removal, virtually no WC/DM measures are being applied to the conveyance systems, river channels and canals.

Irrigation canals are extensively used in the Breede River catchment. Whilst little can be done to reduce evaporation losses, proper maintenance and upgrading of ageing water distribution infrastructure serving the Water User Associations (WUAs), can significantly reduce conveyance losses. Within the Breede River catchment, some of the WUA infrastructure is in excess of 100 years old. Concrete lined canals, exposed to “soft water” become rough and eventually undermine the structural strength.

The BRBS has indicated that capital replacement costs of typical irrigation canals could be in the order of R25 000 per scheduled hectare and the operating and loan repayment costs between R5 000 and R10 000 per hectare. From a cost perspective there is therefore huge motivation for maintenance and upgrading of existing infrastructure.

Many of the canals are weakened with the consequence that losses are high and that elevated saline return flows occur. Canal lining refurbishments might not be affordable by irrigators and the possibility of the lining being undertaken by the urban sector could be considered. In return, an exchange for some of the additional water that would become available could be considered as a trading option.

5. FARM DAM LOSSES

The Berg and Breede catchments contain a vast number of private farm dams. In the Berg WMA for example it is estimated that 40% of the total irrigation requirement is met from farmers’ own sources. Over and above evaporation losses, losses from farm dams can be significant. The Robertson pilot study (mentioned previously) indicated that farm dam seepage losses amounted to 6% of the volume released for irrigation purposes. It is likely though that the costs associated with lining of farm dams will be prohibitively expensive.

6. CROP SELECTION

The type of crop selected for a particular area is the most important factor influencing the quantity of water required for irrigation. Whilst on the one hand the selection of alternative crop types could reduce water requirements, the potential income must also be taken into account. Planting low value "thirsty" crops in water scarce areas should be avoided.

7. CROP DEFICIT IRRIGATION

This is a technique aimed at providing controlled water stress by periodically irrigating at less than the full irrigation demand of the crop. It offers the opportunity to take maximum advantage of the available yield. This technique requires meticulous monitoring of soil moisture content, well designed irrigation systems and proper management of pruning and fertilising.

8. METERING

Very limited metering of irrigation usage currently takes place. The metering of all irrigation releases from source to point of abstraction from canals, and to field application is necessary to provide a detailed understanding of utilization and losses. This would assist in defining the benefits to be obtained from the various WC/DM measures, in controlling abstractions and usage by irrigators, and in billing for water actually consumed.

SECTION B

WATER TRADING

B1. Water Trading

1. INTRODUCTION

The information presented for the Trading of Existing Allocations is taken from the City of Cape Town's (CCT's) Bulk Water Supply Study *The Potential for Purchasing Water Rights from Agricultural Users who have Allocations from Voëlvlei and Theewaterskloof Dams* (Ninham Shand Report No 3282/9531, July 2002). The Berg and Breede Internal Strategic Perspectives were also referenced with respect to the potential for trading of water out of Koekedouw Dam in Ceres and Eikenhof Dam near Grabouw.

Not all water allocated to agricultural users is being utilised. Therefore, there is potential for purchasing water rights from those agricultural users who are not fully utilising their allocations.

2. OPPORTUNITIES FOR WATER TRADING

2.1 Theewaterskloof and Upper Berg

In July 2002, an analysis into the potential for purchasing water allocations from agricultural users was undertaken by the CCT. That study indicated that for the periods Nov 1998 - Oct 2000 and Nov 2000 - Oct 2001, the Zonderend and Upper Berg River Irrigation Boards used less than 60% of their allocations from the WCWSS. In volume terms this translated to approximately 57 million m^3/a not being utilised by the agricultural users during the stated periods. There is therefore potential for trading of unexercised allocations from within the WCWSS.

The Agreement for the Berg Water Project between DWAF and the Trans Caledon Tunnel Authority (TCTA) states that farmers supplied from the Western Cape Water Supply System will:

- continue to receive water at a 98% assurance of supply until they take up their full allocations.
- receive water at a 91% assurance once their full allocations are taken up.

A licence application is required for any water trading.

2.2 Eikenhof Dam

The Breede ISP Report indicates that 5% of summer allocations and 20% of winter allocations out of Eikenhof Dam are unused within the Groenland Irrigation Board. Approximately 4,5 million m^3/a of allocated water is currently unutilised, although it is paid for. This water could be released from the dam and transferred into the Western Cape System via the Palmiet Pumped Storage Scheme.

2.3 Koekedouw Dam

The Breede ISP also indicated that there is up to 3 million m^3/a of unexercised allocations out of Koekedouw Dam, which serves irrigators in the Koekedouw Water User Association (WUA), and the town of Ceres. The dam is owned by the WUA. This water could potentially be purchased and transferred into Voëlvlei Dam via the proposed Michell's Pass Diversion Scheme.

3. FINANCIAL COSTS

Acquiring water via trading would need to be assessed on a case-by-case basis. The associated costs for acquiring water via trading will vary from one potential source to another. Factors influencing this include current irrigation development potential, crop types and potential revenue. Koekedouw and Eikenhof Dams are privately owned and negotiation with the dam owners will need to be undertaken.

4. ECOLOGICAL

The identified water trading options are unlikely to have any significant environmental impacts. In the case of Eikenhof Dam, the existing transfer scheme from the Palmiet River to the Upper Steenbras Dam would be used. Water quality considerations have therefore already been accounted for. There would be some increase in flow in the Palmiet River between Eikenhof and Kogelberg Dams. From Theewaterskloof Dam, the water would be fed into the existing system with no environmental impact. From Koekedouw Dam, water could be released into the Upper Breede River and be abstracted at the potential Michell's Pass Diversion scheme for transfer to Voëlvlei Dam. Impacts on the Breede River would depend on the seasonality of the releases, in addition to those of the Michell's Pass Diversion.

5. SOCIO-ECONOMIC

The transfer of water from one water use sector to another can impact on the socio-economics of the areas in question (changes in land-use, job losses, etc.). However, where unused allocations are traded this risk is not relevant. The seller is required to provide an indemnity that no land claim has been lodged against his property in terms of the Restitution of Land Rights Act. The purchaser is required to apply for a water use licence.

6. OTHER ISSUES

Specific strengths and weaknesses include :

- **Strengths**
  - does not necessarily require infrastructure development;
  - unused allocations from the system are by default integrated into the system;
  - environmental and social impacts can be managed;
  - the selling price can be negotiated.

- **Weaknesses**
  - relies on a voluntary offer to sell;
  - cannot be forced without Compulsory Licensing.

SECTION C

CHANGES IN LANDUSE:

- INVASIVE ALIEN PLANTS
- COMMERCIAL FORESTRY

C1. Removal of Invasive Alien Plants

1. THE EXTENT OF INVASIVE ALIEN PLANT INFESTATION

Within the catchment of the Berg River, it is estimated that the condensed area of invasive plant infestation (year 2000 land-use) is approximately 137 000 ha (*Berg Water Resource Situation Assessment*, 2002). Most of this lies within the lower Berg River catchment and is primarily found in the riparian zones.

1.1 Current Removal Strategy

Through the Working for Water programme, the clearing strategy is focussing on the uppermost (high rainfall) areas of the Berg River catchment. In particular, clearing efforts have prioritised a 30 m strip on either side of the river channel. In the high mountain areas, attention is focussed on light infestations to reduce the risk of spreading of seeds.

1.2 The Impact of Invasive Alien Plants on Surface Water Runoff

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 in the Berg River are also reduced by invasive alien vegetation.

It is estimated that in the Berg WMA :

- the average annual reduction in surface water runoff is in the order of 87 million m^3/a. Of this, about 21 million m^3/a occurs in the Upper Berg River and 55 million m^3/a in the Lower Berg River.
- the resulting impact on the 1 in 50 year yield from the Berg WMA, is about 2 million m^3/a (Ref : Berg WMA Internal Strategic Perspective).

The potential clearing of riparian vegetation along a section of the Lower Berg River has recently being investigated in the *Pre-feasibility Study of Potential Water Sources for the Area Served by the West Coast District Municipality*. The draft report concludes that downstream of Voëlvlei Dam (between Zonqwasdrift and Misverstand Weir) there is about 380ha of riparian invasive alien plants. It further suggested that the average annual yield at Misverstand Weir could be increased by as much as 1.4 Mm^3/a if this riparian alien vegetation were to be cleared. The equivalent impact on the yield at a 1 in 50 year assurance would need to be assessed for comparison with the ISP estimate indicated above.

2. COSTS OF CLEARING

Clearing costs vary, depending on the species and density of the infested areas. An order of magnitude for clearing is as follows:

Infestation Density	Pinus	Acacia	Eucalypts
	Clearing Costs (R/ha)		
Light (5 - 25%)	644	1 473	2 823
Moderate (25 - 50%)	1 154	1 587	3 042
Dense (75 - 100%)	3 503	4 204	3 139

(Ref : *Pre-feasibility Study of Potential Water Sources for the Area Served by the West Coast District Municipality*).

3. ECOLOGICAL

The following environmental benefits are associated with clearing of invasive alien plants :

- improved biodiversity;
- control of erosion and reduction in fire hazard.

4. SOCIO-ECONOMIC

The main socio-economic benefit associated with clearing of invasive alien plants is job creation.

5 THE WAY FORWARD

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. The benefit of clearing within the riparian zone, upstream of storage dams appears to be favourable.

C2. Removal of Commercial Forestry

1. THE EXTENT OF COMMERCIAL FORESTRY

The extent of commercial afforestation in the Berg Water Management Area (WMA) and in the Breede River catchment is estimated to be as follows :

- **Berg WMA (11 970 ha) :**
  - 7 710 ha in the Berg River catchment with 7 500 ha lying upstream of Voëlvlei Dam
  - 240 ha in the Diep River catchment
  - 1 120 ha in the Cape Peninsula
  - 2 040 ha in the Kuils/Eerste/Lourens/Sir Lowry's Pass River catchments
  - 860 ha in the Steenbras River catchment

- Breede River Catchment (5 800 ha) :
  - 1 340 ha in the Upper Breede catchment, upstream of Greater Brandvlei Dam
  - 2 220 ha in the Riviersonderend River catchment, most of which lies in the catchment of Theewaterskloof Dam
  - 2 280 ha in the Lower Breede catchment, to the north of Swellendam
  - the remainder spread sporadically throughout the rest of the Breede River Basin.

1.1 Current Strategy

Mountain-to-Ocean (MTO), formerly SAFCOL, together with the Department of Water Affairs and Forestry have determined that commercial afforestation is not economically viable in most forests of the Western Cape. Current plans envisage that this will be phased out by (date ?). It is likely that some of the areas will be reduced to their natural state while others may be utilised for agricultural development by Resource Poor Farmers or commercial agriculture.

1.2 Impact on Runoff

Within the Berg WMA, for example, commercial afforestation is estimated to reduce runoff by about 26 million m^3/a. This has a resulting impact on the 1 in 50 year yield from the WMA of about 6 million m^3/a (Ref : Berg ISP).

Within the Upper Breede and Riviersonderend catchments, the reduction in runoff is estimated to be about 7,5 million m^3/a with a resulting impact on the 1 in 50 year yield of 1 million m^3/a (Ref : Breede ISP).

Although current practice is not to plant trees in the riparian zone, afforestation's greatest impact is on low flows and therefore on the run-of-river yield.

2. COSTS OF REMOVAL

There should be no direct costs associated with the planned removal in commercial forests as this is already being implemented. It is envisaged that follow-up clearing and removal of the invasive alien regrowth will also be undertaken.

3. ENVIRONMENTAL

There will be significant environmental benefits where commercial forests are removed and returned to natural vegetation. There will be no such benefits where these areas are used for agricultural purposes, except perhaps the reduced likelihood of invasive alien trees establishing in the adjacent natural fynbos areas.

4. SOCIO ECONOMIC

The decision to discontinue commercial afforestation will reduce employment opportunities, both in logging and the associated sawmills. However, the phased withdrawal will include placement of staff in alternative employment.

SECTION D

WATER RE-USE

Introduction to the Use of Treated Effluent Options

It is important to note that the information presented on water re-use is based on the City of Cape Town's Integrated Water Resource Planning Study. Within the Berg WMA, the potential for re-use exists within all municipalities. The information presented serves as an indication of the order of magnitude of the potential. It merely utilises the findings of the CCT Study as this represents the most comprehensive re-use study to date, and no bias is intended towards the CCT.

Domestic and industrial wastewaters are discharged into sewer networks, which generally convey the wastewater to a wastewater treatment works, where biological treatment of various forms takes place. The treated wastewater is then either discharged into an adjacent watercourse or the sea, often with some negative environmental impact.

The use of treated effluent therefore entails the interception of the treated effluent and using the reclaimed water beneficially. Possible uses for treated effluent include:

- Urban irrigation of sportsfields and public open spaces;
- Use in certain industrial processes;
- Agricultural irrigation;
- Dual reticulation systems for garden watering and toilet flushing (also see use of 'grey-water' and 'rain tanks' under water demand management);
- Aquifer recharge; and
- Potable re-use.

The various re-use options presented above would have differing water quality requirements with the most economical re-use options generally being those that require the least amount of subsequent treatment. The practicality and costs of using treated effluent from a single waste water treatment works for a number of re-use options therefore requires careful consideration.

A total in excess of 500 Ml/day (182.5 million m^3/a) of wastewater is treated at the various wastewater treatment works in the Cape Town Metropolitan area, of which approximately 10 % is currently being re-used, primarily for summer irrigation purposes.

Treated effluent therefore represents a significant potential water source, whose development has to a large extent been inhibited by people's aversion to the notion of coming into contact with treated effluent. While there are potential health risks associated with the use of treated effluent, the majority can be avoided through good engineering practice and operations management.

Previous studies undertaken have indicated that local irrigation, agriculture and industrial use could potentially utilise about 40 % of the effluent treated during summer, with the irrigation and agricultural usages falling away during winter. It can therefore be seen that the use of treated effluent to potable standards is required in order to maximise the exploitation of this source.

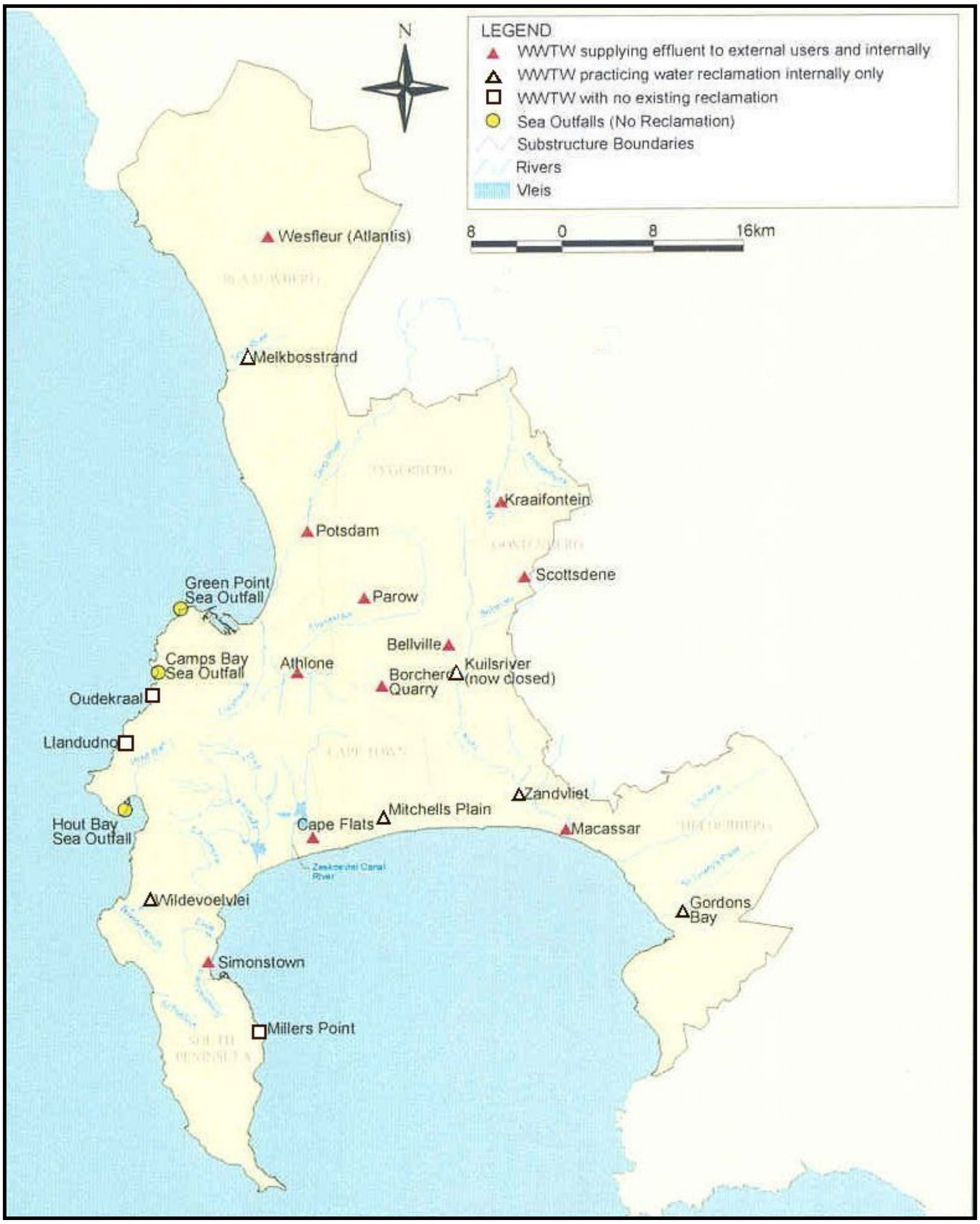
The following criteria would impact on the re-use potential of effluent from a particular works :

- Size of supply;
- Extent of local demand;

- Nature of influent;
- Quality of treated wastewater;
- Impact on downstream environments;
- Intended use of treated effluent.

Various re-use options are presented in this document as individual supply augmentation options. However, the collective use of a number of treated effluent re-use options, which may be appropriate to a particular area or wastewater treatment works, may be more appropriate. Therefore, the various options need to be considered as part of an overall strategy for the use of treated effluent.

The locations of the WWTW within the CCT are shown in the Figure below.



D1. Use of Treated Wastewater for Local Irrigation (and Industrial Use)

1. OPTION LAYOUT

Potential exists for re-use in proximity to all WWTW and surrounds.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT *Investigation into the distribution of treated effluent* series of reports on the various wastewater treatment works (WWTW) within the CMA, dated November 2003 and August 2004.

This option entails the use of treated wastewater, primarily for the irrigation of sportsfields and public open spaces, but also for agricultural and industrial purposes, via a separate treated wastewater distribution network, emanating from existing WWTW within the CCT.

Although the investigation undertaken by the CCT proposed a number of specific schemes, one for each of the thirteen WWTW investigated the information has been collated and considered as a collective option for comparison purposes with other augmentation schemes. Some of the individual schemes proposed are more cost effective than others and some schemes may become less cost effective as they extend further from the WWTW. Each of the complete schemes proposed have been considered in this option.

Apart from further filtration, no further treatment of the wastewater is considered for this option. Greater potential for the use of treated wastewater for industrial processes may exist, provided that further treatment of the wastewater is considered. This may not be practical to implement and has therefore not been considered for this option.

3. "SCHEME"/OPTION YIELD

Based on the investigations undertaken, the potential yield for this option was estimated at 34 million m^3/a, which takes into account the seasonal nature of irrigation use. The CCT's study investigated 13 of the 20 WWTW within the CMA.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	206.0
Annual operating cost (R million)	2.8
NPV Cost (R million)	195.1
Unit Reference Value (R/m^3)	**0.55**(2)

1) Capital and O&M costs are escalated at 7% / a to 2005
2) URV calculated at an 8% /a discount rate

5. ECOLOGICAL

Limited environmental impact is anticipated. A possible impact is the build-up of the salinity levels in the soils with time (or toxins if industrial wastewaters are used). However, as irrigation will only take place during the summer months, it is anticipated that much of the salinity build-up will be leached out during the winter months.

6. SOCIO-ECONOMIC

This option will provide limited temporary work opportunities but does pose some potential health risks, linked to possible exposure to treated effluent, if the disinfection is inadequate. Commercial agriculture may be impacted if the use of treated effluent impacts on the local and international acceptability of the produce.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

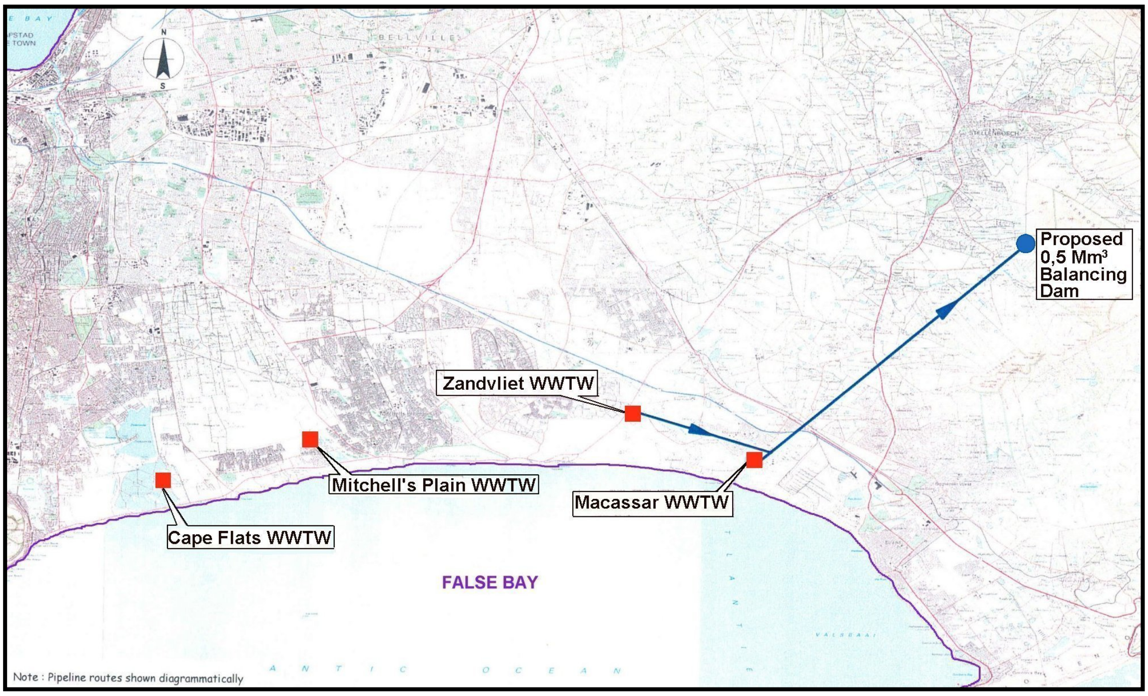
- **Strengths**
  - There is already a demand for treated wastewater, especially in terms of the irrigation of sportsfields and to a lesser extent for agriculture. This demand is however largely driven by tariffs and/or the scarcity of water.
  - This option provides a fairly significant yield potential.

- **Weaknesses**
  - Potential health risks, e.g. if unsterilised effluent is used to irrigate sportsfields where contact sports are played.
  - The potential health risk associated with accidental cross-connection of treated wastewater distribution networks with the potable water network.
  - The potential for the build-up of toxins in the soils, especially if industrial effluent enters the wastewater treatment streams.
  - The current absence of a formal tariff structure and policy for the supply of treated effluent. Unless specific by-laws are passed, this option will largely be demand driven and the tariff structure will determine the attractiveness of this option. There is at present no policy for the basis of providing a treated wastewater supply, e.g. specific return periods or Private Public Partnership type arrangements.

- Increased institutional implications in terms of the operation and maintenance of the WWTW (quality of effluent produced), the management of the dual networks and the monitoring of the previous mentioned requirements.
- The demand has decreased in some areas due to ongoing blockages of sprinkler systems and odours.
- The legality of local authorities to sell treated effluent is not established nor is the associated tariff structure.

D2. Use of Treated Wastewater for Commercial Irrigation; Exchange for Fresh Water Allocations

1. OPTION LAYOUT



2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report 8 of 12 – *Potential for the use of treated wastewater within the CMA.*

This option entails the exchange of treated domestic wastewater effluent with untreated freshwater (currently being supplied to farmers) for commercial irrigation use. The exchanged freshwater will then become available for treatment and subsequent potable use.

The Helderberg and Stellenbosch irrigation schemes, which currently receive some 20 million m^3/a of water from the Riversonderend – Berg River Government Water Scheme, have been identified for the possible large-scale use of treated wastewater.

In order to achieve the above, treated domestic wastewater will need to be pumped from the Zandvliet and Macassar WWTW via a 45 km long pipeline and against a 350 m head, to a small balancing dam (0.5 million m^3 capacity) near the exit of the Stellenbosch Tunnel. From the balancing dam, existing infrastructure will be used for the distribution and irrigation of the wastewater.

Due to the nature of the irrigation demands and the limited area available for storage at the Stellenboschberg Tunnel exit, the proposed scheme is based on the summer usage of treated wastewater only.

This option entails no additional treatment of the wastewater to that currently being provided at the respective WWTW. These WWTW treat predominantly domestic effluent.

3. OPTION YIELD

During previous investigations, it was considered that farmers would only be willing to exchange 25% of their allocations, implying a probable yield of 5 million m^3/a.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	134.0
Annual operating cost (R million)	2.4
NPV Cost (R million)	114.0
Unit Reference Value (R/m^3)	**2.77** (2)

1) Capital and O&M costs escalated at 7% /a to 2005
2) The URV is calculated at an 8% /a discount rate

5. ECOLOGICAL

Limited environmental impact is anticipated. A possible impact is the build-up of the salinity levels in the soils with time. However, as irrigation will only take place during the summer months, it is anticipated that much of the salinity build-up will be leached out during the winter months.

6. SOCIO-ECONOMIC

This option will provide limited temporary work. It does pose some potential health risks, where crops irrigated with wastewater are eaten raw or where workers are in direct contact with the wastewater (e.g. where overhead sprayers are used). Economic impacts due to a resistance from international markets in particular, may be of concern.

7. OTHER ISSUES

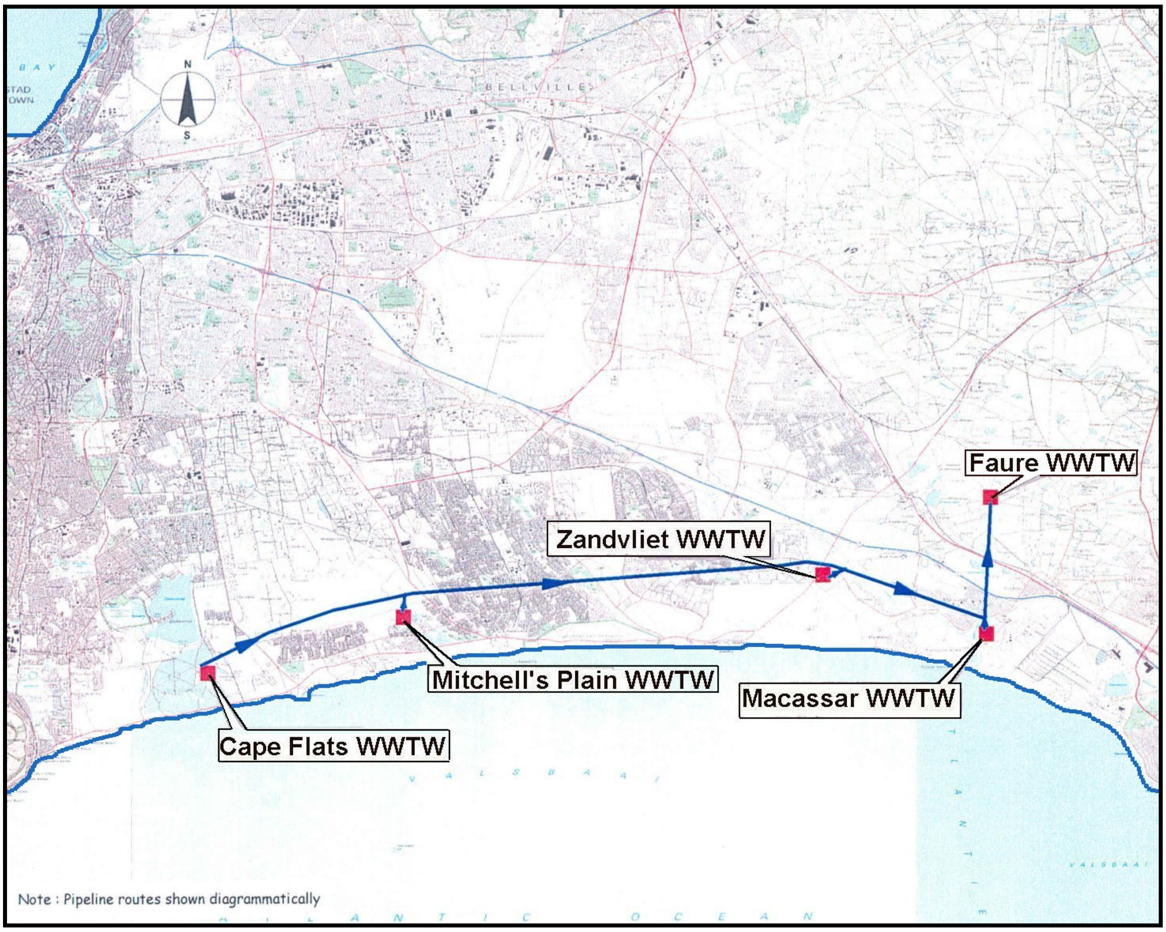
Specific strengths and weaknesses of the option include:

- **Strengths**
  - Potentially a relatively large treated wastewater consumer.

- **Weaknesses**
  - There is a general public aversion to the idea of being exposed to wastewater.
  - The ability to reach agreements with the farmers may be problematic.
  - There are possible negative international perceptions which could reduce the marketability of the produce.
  - The salinity of the treated wastewater and the possible impacts on the soils and the crops.
  - Increased institutional implications due to the need for effective monitoring.
  - Guidelines from the Department of Health which advise against the use of treated wastewater for crops which are eaten raw.
  - Relatively long implementation period.
  - The legality of local authorities to sell treated effluent is not established nor is the associated tariff structure.

D3. Use of Treated Wastewater for Potable Use

1. OPTION LAYOUT



2. OPTION DESCRIPTION

Useless otherwise stated, the information presented is taken from the CCT Integrated Water Resources Planning Study of 2001: Report of 8 of 12 – *Potential for the use of treated wastewater within the CMA.*

This option entails the use of treated wastewater, reclaimed to potable water standards, for domestic use on a continuous basis (i.e. all year round). It is proposed that domestic wastewater, treated via conventional wastewater treatment processes, be treated further and blended with freshwater, before being distributed for domestic consumption.

The scheme proposed to implement this option, entails the pumping of treated effluent from each of the WWTWs along the False Bay coast (Cape Flats, Mitchells Plain, Zandvliet and Macassar) to a reclamation works to be located at the existing Faure Water Treatment Works (WTW), from where the effluent will be treated, blended and then distributed via existing infrastructure.

As the Faure WTW has a current treatment capacity of 500 Mℓ/day and as the Department of Health requires a 1:4 blending ratio, the scheme proposed is based on a design flow of 100 Mℓ/day.

It can be noted that the previous mentioned WWTWs have a collective wastewater supply potential of between 155 Mℓ/day (making provision for the commercial irrigation option) and 223 Mℓ/day. The potential to extend this scheme to the Blackheath WTW, in order to maximise the treated effluent use, does exist. This option and the use of other treatment technologies have however not been investigated in depth to date.

3. OPTION YIELD

The yield of this scheme amounts to 100 Mℓ/day or 37 million m^3/a.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	1 212.4
Annual operating cost (R million)	100.3
NPV Cost (R million)	1 587.6
Unit Reference Value (R/m^3)	**5,51** (2)

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate

5. ECOLOGICAL

A positive impact is envisaged for the Kuils River estuary and near-shore marine environment associated with reduced return flows. The impacts of the pipeline and reclamation plant are not expected to be severe.

6. SOCIO-ECONOMIC

This option will have a slight positive impact by creating temporary work opportunities. It does however have possible negative health impacts and public acceptance impacts, especially by certain religious groupings. This option may also result in the need to increase tariffs.

7. OTHER ISSUES

Specific strengths and weaknesses for this option include:

- **Strengths**
  - Has a relatively high yield potential, although it may not be practical to fully utilise the yield, due to the manner in which the water resources are managed to optimise the system yield.
  - The reclamation process has been used successfully over a number of years, both in Windhoek and in Pretoria (pilot project).

- **Weaknesses**
  - Public aversion to the idea of drinking treated wastewater.
  - Significant institutional implications in terms of the operation and maintenance of the respective WWTWs and the reclamation plant.
  - High capital and operational costs.
  - Possible health implications (hormones, pharmaceutical compounds and disinfection by-products).
  - The legality of local authorities to sell treated effluent is not established nor is the associated tariff structure.

D4. Dual Reticulation Network

1. OPTION

Applicable throughout the study area, particularly where new developments are taking place, offering the opportunity for implementation during construction of new infrastructure.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from CMC's Strategic Evaluation of Bulk Wastewater of June 1999 : Report 25 of 37 - *Water Reclamation: A Strategic Guideline*.

As gardening accounts for approximately 35% of domestic water consumption and toilet flushing a further 30%, the use of lower-grade water for these purposes would result in a significant reduction in potable water use.

This option entails the use of treated effluent, conveyed to domestic users via a separate reticulation network, specifically for gardening and toilet flushing use. This option needs to be considered in conjunction with several of the Water Demand Management Options (i.e. 'use of grey water', 'private boreholes', 'rainwater tanks' and 'user education') and the "local irrigation and industrial treated effluent" use option presented earlier, as the demand management options target the same uses. This option may need to utilise the same reticulation network as the treated effluent option.

3. OPTION YIELD

Previous studies have indicated a potential yield of 28 Mm^3/a (based on 91 050 erven being reticulated).

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	375.4
Annual operating cost (R million)	4.9
NPV Cost (R million)	325.8
Unit Reference Value (R/m^3)	**1.25** (2)

1) The capital and O&M costs have been escalated from 1997 at 7 % /a.
2) URV is calculated at an 8 % /a discount rate.

5. ECOLOGICAL

The use of treated effluent will have a positive impact on the environment, as a result of reduced river abstraction and reduced effluent discharge into the environment. However, there is a potential negative impact, as a result of the medium to long-term build up of pollutants in the soil and possibly in the groundwater.

6. SOCIO-ECONOMIC

This option would have a slight positive impact in terms of employment. There are, however, possible negative health implications linked to the possible exposure to treated effluent (e.g. potable and treated effluent networks being mistakenly interconnected), or inadequately disinfected spray being inhaled.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include :

- **Strengths**
  - Readily implementable for new housing developments, but not for retrofitting existing developments.
  - Could possibly use the ‘local irrigation network’ if only for toilet flushing (if the quality is appropriate).

- **Weaknesses**
  - No quality standards in place as yet within South Africa for gardening and toilet use.
  - Potential health hazard.
  - In terms of gardening purposes, the system will only be used during the summer months.
  - This option will have an institutional implication for municipal staff, both those working at the wastewater treatment works and on the network supervision staff.

SECTION E

URBAN WATER CONSERVATION AND DEMAND MANAGEMENT

Introduction to Urban Water Demand Management Options

The information presented on urban water conservation and demand management is based on the City of Cape Town's Integrated Water Resource Planning Study. Within the Berg WMA, the potential for urban water conservation and demand management exists within all municipalities. The information presented serves as an indication of the order of magnitude of the potential. It merely utilises the findings of the CCT Study as this represents the most comprehensive re-use study to date, and no bias is intended towards the CCT.

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.

Through Water Demand Management (WDM), the objective is to minimise water wastage and to ensure the optimal use of water, which often requires a fundamental shift in the perception of consumers, of the value of water. This can be achieved through a number of initiatives as listed below, and 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;
- Adjustment of water tariffs, metering and credit control;
- User education.

Although not necessarily direct water demand management initiatives, the following supply augmentations have also been considered as part of WDM:

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

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

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

The various WDM options are presented as individual options in this document. However, one or a combination of the above options would be appropriate to achieve an objective in a particular area. Therefore the respective WDM options should not be considered individually, but rather as a part of an overall strategy, to achieve a specific objective.

E1. Leakage Detection and Repair

1. OPTION

Potentially applicable throughout the network of water reticulation systems.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 6 of 12 – *Potential savings through leakage repair of piping.*

Leakage repair to piping entails the reduction of distribution losses in the reticulation network (i.e. between the bulk meter and the consumption meter) by implementing procedures to proactively identify and repair leaks in the network. The focus of this intervention is primarily on the larger leaks, as the smaller leaks are more difficult (expensive) to locate.

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/consumption 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 savings is therefore the difference between actual UAW and the 15% of AADD target (provided the actual UAW is above the 15% level).

Investigations undertaken for the CCT during 2000 indicated the potential saving as tabulated below:

Potential savings to be achieved through leakage repair

Zone/Administration	Total Water Supplied (Mm^3/a)	UAW (%)	Potential Saving (Mm^3/a)
Blaauwberg	27.4	16	1.7
Cape Town	93.1	20	4.7
Helderberg	16.4	20	1.0
Oostenberg	23.7	17	0.5
South Peninsula	42.0	24	3.8
Tygerberg (Central)	20.0	15	0.0
Tygerberg (West)	17.2	27	2.2
Tygerberg (South)	6.6	22	0.9
Tygerberg (Coastal)	20.0	19	0.8
Tygerberg (East)	20.4	13	0.0
Tygerberg (North)	6.9	13	0.0
Total	**293.7**	**-**	**15.6**

4. UNIT REFERENCE VALUE

The URV for an option such as *leakage repair* 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. The estimated costs are tabulated below:

ITEM	Escalated to 2005 (@ 7% /a)
Capital cost (R million)	63.1
Annual operating cost (R million)	0
NPV Cost (R million)	58.6
Unit Reference Value (R/m^3)[1,2]	**0.31**

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate

5. ECOLOGICAL

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

6. SOCIO-ECONOMIC

This option will have slight positive impacts in terms of the following:

- Reduced number of standing water pools and associated health benefits in poorer communities (a high percentage of leakages in these areas);
- This option is labour intensive by nature, and therefore has the ability to generate a large number of semi-skilled and skilled employment opportunities.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

- **Strengths**
  - Short implementation period
  - Positive socio-economic, environmental and financial impacts.
  - On going capital costs are funded through savings after about three years.

- **Weakness**
  - Has a large institutional implications.
  - The sustainability of the benefits over the long-term are unknown.

E2. Leakage Repair Beyond the Meter

(Not available for background reading. Will be provided at the Workshop.)

The repair of leakages beyond the domestic meters (i.e. household leaks such as leaking taps and toilets) is not included in the definition of "*Leakage Repair*", but projects have been initiated in the past to undertake *leakage repairs* within households, especially low income households, with significant impact. It must be noted that even good quality water fittings will start to leak with time, if they are subjected to high pressures. Therefore, retrofitting of water fittings should, where appropriate, be implemented in conjunction with *pressure management*.

E3. Pressure Management

1. OPTION

Potentially applicable throughout the urban areas of the study area.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 5 of 12 – *Potential savings through pressure management.*

Normal reticulation design practice requires that reticulation networks are designed to accommodate peak design flows, whilst maintaining certain minimum and maximum pressures throughout the network. The peak conditions are often related to fire flow conditions i.e. design for worst case scenario, which may happen infrequently. The effect of the above is that networks may experience relatively high pressures during times of low demand, e.g. at night. As leakage rates are dependent on the pressures within a network, by reducing the pressure during low demand periods, it is possible to reduce the volume of water wasted through leakage.

This option therefore entails dividing the reticulation network into defined zones, and installing equipment to reduce the pressures within these zones during periods of low demand.

Pressure management reduces both reticulation/distribution and household losses. It is therefore necessary to distinguish between the savings due to *pressure management* and the savings due to *leakage repair.* Leakage repair generally focuses on larger leaks, whereas pressure management generally focuses on background leaks (leaks that can not readily/economically be addressed through leakage repair).

3. OPTION YIELD

The estimated yield for this option ranges from between 27.8 million m^3/a to 11.1 million m^3/a. An amount of 16.7 million m^3/a has however been deemed to be a realistic figure.

The above yield estimate was based on data from a select area (only area that had adequate data at the time of the investigation) and then projected throughout the CMA area via a benchmarking methodology. The yield represents the potential savings from pressure management, less the potential savings from *leakage repair*, to avoid double counting of savings.

Some have considered the yield estimate to be subjective and conservative.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	77,1
Annual operating cost (R million)	1,2
NPV Cost (R million)	81,7
Unit Reference Value (R/m^3)	**0,40** (2,3)

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate
3) The above figures do not include the potential positive financial benefits ito wastewater infrastructure i.e. the impact of delayed upgrade costs; reduced treatment costs.

5. ECOLOGICAL

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

6. SOCIO-ECONOMIC

The consequence of *pressure management* is not a reduced level of service, but rather an appropriate level of service throughout the day. The option will therefore have a positive socio-economic impact as a result of reduced water “leakage” loss and a longer replacement period of household fittings. This could be significant for low income households.

Pressure management will have no impact on fire fighting ability at night, provided the controllers installed are able to respond to the increased demands.

7. OTHER ISSUES

Specific strengths and weakness of the option include:

- **Strengths**
  - Can be implemented within a relatively short period.
  - Increases the longevity of both water and wastewater infrastructure.
  - Has no negative environmental and socio-economic impact.

- **Weaknesses**
  - Will have increased institutional implications.

E4. Use of Water Efficient Fittings

1. LAYOUT

Potentially applicable throughout the urban areas of the study area.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 7 of 12 – *Water efficient fittings, automatic flush urinals, grey water and private boreholes and wellpoints.*

This option entails the use of water efficient fittings for toilets, showers and hand basin taps/mixers for both domestic and non-domestic users (commercial, municipal and industrial users).

Options for implementation include both new developments and the retrofitting of existing installations.

3. OPTION YIELD

During previous investigations, it was deemed that only 30% of the estimated potential saving would be realistic, implying the following likely savings:

- Residential users = 6.1 million m^3/a
- Non-residential users = 1.8 million m^3/a
- Total = 7.9 million m^3/a

4. UNIT REFERENCE VALUE

The potential financial costs are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	62.0
Annual operating cost (R million)	0
NPV Cost (R million)	51.6
Unit Reference Value (R/m^3)	**0.60** (2)

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate

5. ECOLOGICAL

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

6. SOCIO-ECONOMIC

This option has the potential to create limited skilled and semi-skilled employment opportunities.

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**
  - No by-laws are in place at present to enforce usage of water efficient fittings (new installations or retrofitting of existing installations).
  - Requires ongoing maintenance to remain effective.
  - Should be implemented together with a user education programme.
  - Needs continuous involvement i.e. can't be a once-off initiative for sustainable benefits.
  - Requires consumer buy-in.
  - Some have considered the yield estimate to be subjective and conservative.

E5. Elimination of Automatic Flush Urinals

1. LAYOUT

Potentially applicable throughout the urban areas of the study area.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 7 of 12 – *Water efficient fittings, automatic flush urinals, grey water and private boreholes and wellpoints.*

This option entails the replacement of automatic flush urinals (AFUs) with either user-activated or waterless urinals.

AFUs are water wasters by their very design (operate even when not specifically required to do so). Furthermore, as AFUs are predominantly found in public office buildings, railway stations, schools and privately owned hotels, bars and restaurants, they tend to be poorly maintained. Malfunctioning AFUs use substantially more water than a functioning AFU.

3. OPTION YIELD

Previous studies (based on an estimated 5 000 AFUs within the CMA area) estimate the potential savings for this option at 4.2 million m^3/a.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	14.2
Annual operating cost (R million)	0
NPV Cost (R million)	13.6
Unit Reference Value (R/m^3)	**0.26** (2)

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate

5. ECOLOGICAL

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

6. SOCIO-ECONOMIC

No significant socio-economic impacts (positive or negative) are foreseen.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include :

- **Strengths**
  - Can be implemented within a relatively short time period.
  - Has limited impact on users.

- **Weaknesses**
  - Only the former Cape Town Administration had by-laws enforcing the retrofitting of alterations to AFUs (was required with a 2-year period – 2000 base year).
  - Needs to be implemented concurrently with an active public awareness campaign, especially to address those AFUs in private institutions.
  - Local authorities have limited capacity to enforce/police the replacement programme.

E6. Adjustment of Water Tariffs, Metering and Credit Control

1. LAYOUT

Applicable throughout the urban areas of the study area.

2. DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 9 of 12 – *Adjustment of Water Tariffs, Metering, Credit Control, Water Restrictions and User Education.*

The adjustment of tariffs, metering and credit control are separate initiatives, which collectively have the objectives of:

- Reducing water consumption by making people aware of and paying for the water they consume; and
- Ensuring the equitable distribution of the costs of water provision.

Sliding scale tariffs are used to both subsidise a basic water supply and to encourage efficient use of water by charging progressively higher costs, the higher the water consumption (i.e. the user pays). The overall objective of balancing income and expenditure however still remains. Price elasticity is the measure of the % change in consumption divided by the percentage change in tariff (i.e. consumption sensitivity to price). There is however limited information available regarding price elasticity in the study area.

Universal metering is required in order to know the location and volume of water usage, the extent of water losses and to ensure an equitable distribution of the costs of supply *(i.e. to meter accurately is to know).* Although the installation of meters in itself will not directly reduce water consumption, case studies have indicated savings of up to 20 % where individual meters have been installed.

Effective credit control and debt management is fundamental to sound financial management and WDM. By making people pay for the water they consume, the value of the service is reinforced and water is more efficiently used.

Public acceptance of the above measures will however to a large extent be dependent on the effectiveness of an associated user education/public awareness campaign.

3. OPTION YIELD

Based on a 30 % tariff increase and *price elasticity of -0.2* (not tested but perceived to be appropriate, possibly even conservative, over the full range of water consumer categories), a savings of 6 % (20 million m^3/a) should be obtainable.

Although metering and credit control may indirectly result in savings, no potential savings have been determined for these options.

Previous studies have however indicated that 50% of the potential savings would be realistic, implying a resulting yield of 10 million m^3/a.

4. UNIT REFERENCE VALUE

No significant costs are envisaged for the implementation of increased tariffs or stricter credit controls, and as the costs of universal metering and meter replacement should be covered by connection fees and a levy on water tariffs, a URV of R 0.00/m^3 was adopted for this option.

5. ECOLOGICAL

This option should have no significant implications for the environment.

6. SOCIO-ECONOMIC

This option would impact on the higher water consumers (i.e. middle to high income households, commercial, industrial and institutional consumers) with insignificant impact on low consumers (poor). This option will have no impact in terms of employment and health, but its acceptance by the public would be dependent on the effectiveness of an associated public awareness campaign.

7. OTHER ISSUES

The specific strengths and weaknesses of the option include:

- **Strengths**
  - Relatively quick to implement.
  - Is fundamental to sound financial management.
  - Should be accepted if consumers are adequately informed of objectives/developments (i.e. transparency is key).

- **Weaknesses**
  - A culture of non-payment exists in certain areas and sectors.
  - Could be politically sensitive if communities currently not paying for water are required to pay for consumption over and above the basic free water allocation.

E7. User Education

1. OPTION

Applicable throughout the study area

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 9 of 12 – *Adjustment of Water Tariffs, Metering, Credit Control, Water Restrictions and User Education.*

An effective education and public awareness campaign is essential to the successful implementation of water demand management initiatives. This focuses on making consumers aware of their responsibility to use water more efficiently by providing them with tools and guidelines to enable them to reduce their water consumption, without necessarily having a negative impact on the quality of their life; i.e. focus on achieving behavioural changes.

Typical user education initiatives would include:

- Informative billing;
- Distribution of informative information (media marketing);
- Provision of consumer advisory services;
- Creation of forums to interact with specific sectors; and
- Community outreach programmes.

3. OPTION YIELD

Based on previous investigations, it was deemed that only 50% of the estimated potential savings of 20 million m^3/a would be realistic, implying savings of 10 million m^3/a.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	0
Annual operating cost (R million)	7.0
NPV Cost (R million)	92.7
Unit Reference Value (R/m^3)	0.70

1) The annual cost of R 5.0 million escalated from 2000 at 7 % /a.
2) URV calculated using a discount rate of 8 %.

5. ECOLOGICAL

This option will have no significant implications on the environment.

6. SOCIO-ECONOMIC

This option should assist all consumers to manage their water consumption and hence water bills. No health impacts are envisaged, whilst the impact on employment will be dependent on the scope of the programme employed.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

- **Strengths**
  - Relatively quick to implement.
  - Brings the provider/authority in close contact with the consumer (i.e. facilitates an informed environment).

- **Weaknesses**
  - Would have an institutional impact on the authority.

E8. Promotion of Grey Water Usage

1. LAYOUT

Potentially applicable throughout the urban areas of the study area.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 7 of 12 – *Water efficient fittings, automatic flush urinals, grey water and private boreholes and wellpoints.*

This option entails the interception of water from showers, baths and hand basins on site, before it enters the sewer systems, and the use of this grey water for gardening purposes. The use of grey water for toilet flushing has not been considered, as there are currently no commercially viable systems which can treat the grey water to the required standards.

The wastewater from kitchen sinks and washing machines is also not considered due to the high solids content and the possible negative impacts of softeners and other chemicals on the environment.

3. OPTION YIELD

Based on previous investigations, it was deemed that only 30% of the estimated potential savings would be realistic, implying a total savings of 1 million m^3 /a.

4. UNIT REFERENCE VALUE

The URV calculations for these options do not include the potential positive financial impacts on wastewater infrastructure, i.e. the impact of delayed upgrade costs and reduced treatment costs. The potential financial costs are as follows:

Low density households (i.e. larger households/higher income)

ITEM	Escalated to 2005 (@ 7% /a) [(1)]
Capital cost (R/household)	5 610
Annual operating cost (R/household)	-330[(3)]
NPV Cost (R/household)	1 199
Unit Reference Value (R/m^3)	**1.05**

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate
3) This figure is an annual average of maintenance, overhaul and electricity costs and the savings due to reduced water usage, over a specific time period.

Medium density households (i.e. smaller sized households)

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R/household)	5 610
Annual operating cost (R/household)	-145
NPV Cost (R/household)	3 636
Unit Reference Value (R/m³)	**4.88** (2)

1) Capital and O&M costs escalated at 7% /a to 2005
2) URV calculated at an 8% /a discount rate
3) This figure is an annual average of maintenance, overhaul and electricity costs and the savings due to reduced water usage, over a specific time period.

5. ECOLOGICAL

There is a potential negative impact, as a result of medium to long-term build-up of pollutants in the soil and possibly in the groundwater.

6. SOCIO-ECONOMIC

This option could have a slight positive impact in terms of employment but would have a negative health impact if used and maintained inappropriately.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

- **Strengths**
  - Relatively quick to implement.

- **Weaknesses**
  - Owner/user driven initiative (dependent on costs and public acceptance).
  - Potential health hazard.
  - Systems on the market at the time of the study made no provision for treatment i.e. could not be used for toilet flushing.
  - Long term impact of detergents/pollutants on the environment is unknown.
  - No quality standards in place within South Africa at the time of the study for gardening and toilet use.
  - System will only be used during the summer months (reduced saving potential).
  - Systems are more cost effective for higher income households.
  - Some have considered the yield estimate to be subjective and conservative.

E9. Rainwater Tanks

1. OPTION

Potentially applicable throughout the study area

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 7 of 12 – *Water efficient fittings, automatic flush urinals, grey water and private boreholes and wellpoints.*

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 gardening is not deemed feasible for the study area, due to the amount of storage required for use during the drier periods. This option has therefore to a large extent been used as an alternative to *grey water* use for toilet flushing.

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

The potential yield for his option is estimated at 15 m^3/a per household, whereas the water requirement for toilet flushing for high consumption households is estimated at between 50 m^3/a to 70 m^3/a, i.e. a potable water supply is still required.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R/household)	7 013 (3)
Annual operating cost (R/household)	0
NPV Cost (R/household)	7 013
Unit Reference Value (R/m^3)	**35.4 ((2)**

1) Capital and O&M costs escalated at 7% /a to 2005.
2) URV calculated at an 8% /a discount rate.
3) The costs given above are based on the average of a range of options.

5. ECOLOGICAL

No negative environmental impact is anticipated.

6. SOCIO-ECONOMIC

No negative socio-economic impact is anticipated (nominal loss of revenue to the local authority).

7. OTHER ISSUES

Specific strengths and weaknesses of the option include:

- **Strengths**
  - Quick to implement.
  - Recent reductions in the costs of rainwater tanks may make it more affordable.

- **Weaknesses**
  - The use of unsterilised rainwater from rainwater tanks for domestic purposes has been prohibited since 1972.
  - The option would largely be driven by the property owner.
  - Limited potential savings.
  - Expensive to implement but recent price decreases.

E10. Promotion of Private Boreholes and Wellpoints

1. LAYOUT

Potentially applicable throughout the urban areas of the study area.

2. OPTION DESCRIPTION

Unless otherwise stated, the information presented is taken from the CCT Integrated Water Resource Planning Study of 2001: Report No 7 of 12 – *Water efficient fittings, automatic flush urinals, grey water and private boreholes and wellpoints.*

This option, which is a supply augmentation option as opposed to a demand management option, entails the use of groundwater, either via boreholes or wellpoints, for garden watering.

The use of either a borehole (a submerged pump located 10 to 60m below the surface) or a wellpoint (a surface mounted pump which can abstract water from up to 8m below the ground) is dependent on the nature of the ground conditions. Wellpoints, which are cheaper to install than boreholes, have lower yields than boreholes, but are generally adequate for watering small to medium sized gardens.

The quality of the groundwater that can be abstracted from either boreholes or wellpoints will generally be suitable for garden watering. Due to the high costs of a borehole installation to most households, this option has been evaluated based on wellpoint usage.

3. OPTION YIELD

During previous investigations it was deemed that only 40% of the estimated yield was realistic, implying a yield of 3,6 million m^3/a (i.e. some 35 000 additional households install private wellpoints).

4. UNIT REFERENCE VALUE

The potential financial costs are as follows :

ITEM	Escalated to 2005 (@ 7% /a) [1]
Capital cost (R/household)	3 156
Annual operating cost (R/household)	-154[2]
NPV Cost (R/household)	622
Unit Reference Value (R/m^3)	**0.46**

1) Updated URV using a Discount Rate of 8%
2) This figure is an annual average of maintenance, electricity and overhaul costs and the savings due to reduced water usage, over a specific time period.

5. ECOLOGICAL

The influence of the abstraction from the aquifers, via boreholes and wellpoints could impact on springs, seeps and river base flow, especially if relatively large volumes are abstracted from small areas or areas with low recharge.

6. SOCIO-ECONOMIC

No negative health impacts are anticipated, unless wellpoints are located close to waste disposal sites and/or wastewater treatment works.

7. OTHER ISSUES

Specific strengths and weaknesses of the option include :

- **Strengths**
  - Quick to implement.
  - Wellpoints are relatively inexpensive when compared with boreholes.

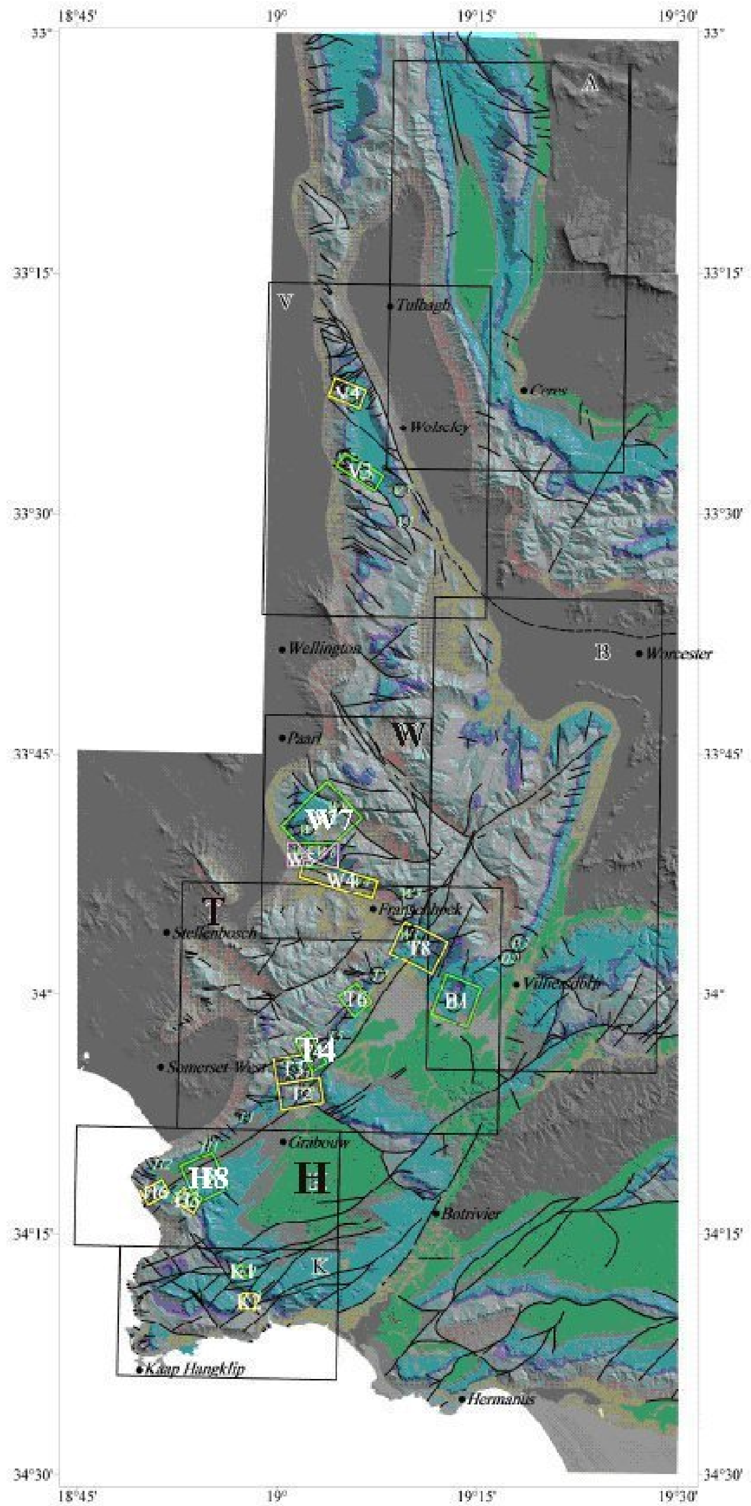
- **Weaknesses**
  - The option is driven by the property owner.
  - The areas suitable for the use of wellpoints (i.e. the Cape Flats) are generally associated with low income households and low gardening use.
  - The effectiveness of this option is dependent on the household consumption and the marginal water tariff.
  - May have an impact on local authority revenues, especially during the summer months.

SECTION F

GROUNDWATER DEVELOPMENT OPTIONS

Table Mountain Group Aquifer Introduction

1. SCHEME LAYOUT



2. AVAILABLE INFORMATION

Most of the information on the TMG Aquifer and the various Target Site Areas (TSAs) was taken from: City of Cape Town, CMC Administration (2004). Report 1 : *Hydrogeology Report*. Prepared by the TMG Aquifer Alliance as part of the Preliminary Phase of the TMG Aquifer Feasibility Study and Pilot Project.

Further information regarding the scheme was taken from the following sources:

- City of Cape Town, CMC Administration (2004). Report 4. *Infrastructure Report*. Prepared by the TMG Aquifer Alliance as part of the Preliminary Phase of the TMG Aquifer Feasibility Study and Pilot Project.
- City of Cape Town, CMC Administration (2004). Report 5. *Environmental and Ecological Report*. Prepared by the TMG Aquifer Alliance as part of the Preliminary Phase of the TMG Aquifer Feasibility Study and Pilot Project.
- Ninham Shand. 2004. TMG Aquifer Feasibility Study and Pilot Project: Draft Scoping Report. Report Number 400396/3715.

The TMG Aquifer Feasibility Study identified a number of TSAs for further investigation. The three most promising sites, ranked with high priority and suggested for further investigation at this stage, are the TSAs T4, H8 and W7. These are described in more detail in the following sections of this document.

The other identified TSAs as well as possible targets outside of the study area of the TMG Aquifer Feasibility Study should be considered for future local groundwater supply and augmentation of bulk water supply to the WCWSS.

These further areas include :

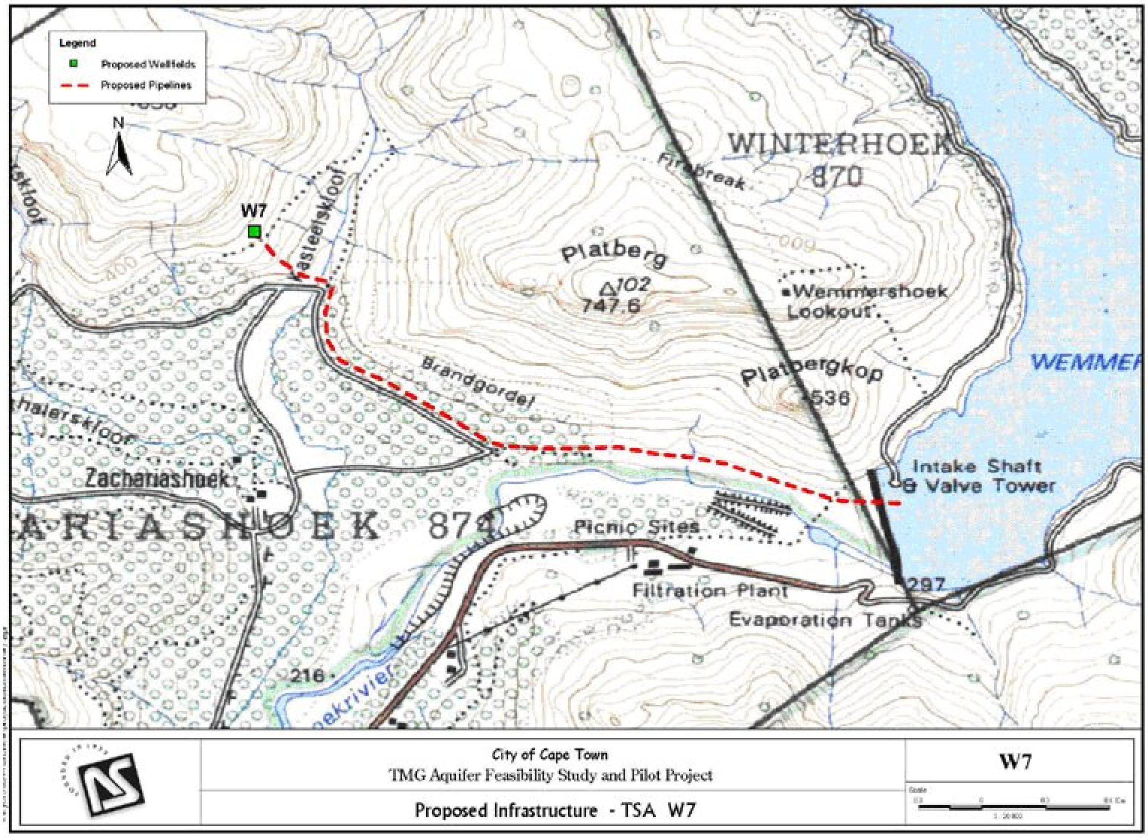
- Agter Witzenberg
- Hexriver Mountains
- Kogelberg
- Hottentots Holland Mountains
- Voëlvlei
- Brandvlei
- Piketberg
- Peninsula

3. SCHEME YIELD

Options outside of the TMG Aquifer Feasibility Study have not been investigated at a feasibility level. Consequently, no scheme yield was determined. However, from other studies a scheme yield of 10 – 20 million m^3/a can be inferred for each of the above schemes. No cost estimates for the different schemes outside of the TMG Aquifer Feasibility Study are currently available.

F1. Table Mountain Group Aquifer TSA W7 - Wemmershoek

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Three main (W)NW/(E)SE fault structures cross Target Zone W. The La Motte Fault coincides roughly with the southern boundary of the Wemmershoek Mountains. Along the western segment of this boundary, the Skurweberg Formation is downthrown to the north by several hundred metres, and juxtaposed against the basement granite and basal strata of the Peninsula Formation. The Klein Drakenstein Fault downthrows the Skurweberg to the south against the same units along the western side of the Wemmershoek reservoir. The zone of faulting between the Du Toitskloof tunnel area and the upper portion of Stettynskloof, has a similar sense of displacement.

The potential scheme would comprise the following :

- Establishment of 13 production and several monitoring boreholes,
- Equipping the boreholes,
- Construction of a pipe network and pipeline to Wemmershoek Dam.

It is assumed that the existing water treatment facilities can accommodate the additional volume and different quality of the abstracted groundwater.

3. SCHEME YIELD

The scheme yield for the pilot phase is estimated to be 5 million m^3/a. The total yield of the wellfield will be defined after completion of the TMG Aquifer Feasibility Study and Pilot Project. However, it is expected that the final yield will be more than 20 million m^3/a.

4. UNIT REFERENCE VALUE

Currently only cost estimates for the pilot wellfield are available, as given below:

ITEM	Costs escalated to 2005 (@ 7% /a) (1)
	To Wemmershoek Dam
Capital cost (R million)	24.8
Annual operating cost (R million) (2)	1.2
NPV Cost (R million)	?
Unit Reference Value (R/m^3)	0.56

1) Updated URV using a Discount Rate of 8%.
2) Includes conveyance costs from wellfield to dam. Excludes water treatment costs.

5. ECOLOGICAL

The TSAs in Target Zone W – except for W1 and W4 – appear to have no rare species within their boundaries, except on the upper slope of Spitskop in W7.

There is also some concern that large-scale abstraction would affect flows in the Berg River. Some of these effects (in the Berg River) could be off-set through ecological flow releases from Wemmershoek Dam or the Berg River Dam.

The TMG Aquifer Alliance has developed a Monitoring Protocol as part of the TMG Feasibility Study to improve the understanding of potential impacts.

6. SOCIO-ECONOMIC

There are concerns from the public, conservation organisations and existing groundwater and surface water users regarding potential impacts.

7. OTHER ISSUES

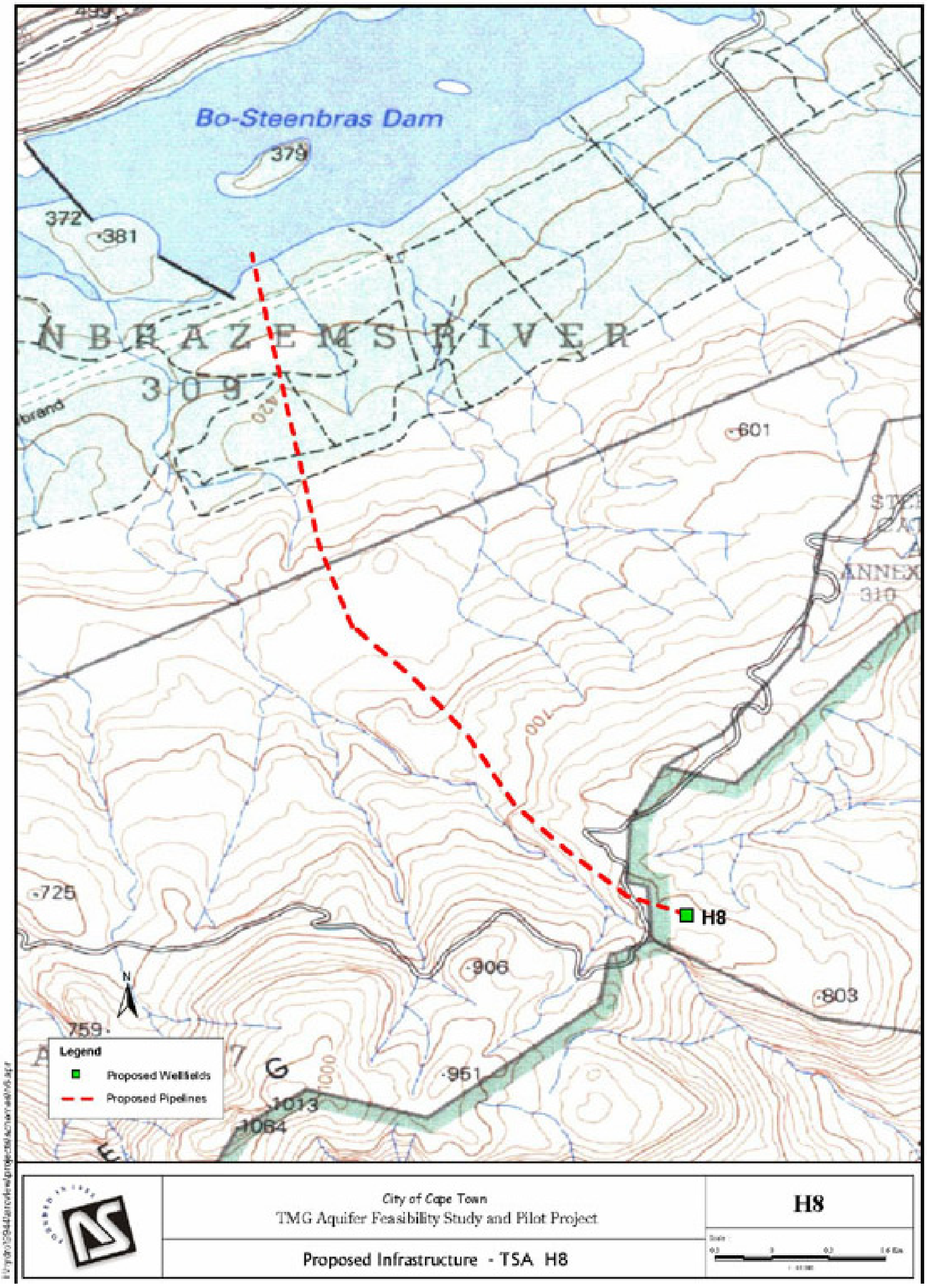
Specific strengths and weaknesses of the potential scheme include :

- **Strengths**
    - Evaporation-free storage within TMG Aquifer
    - High recharge percentage in TMG outcrops
    - High groundwater potential
    - Direct transfer of abstracted water into Wemmershoek Dam
    - Possibility for conjunctive use and optimisation of storage

- **Weaknesses**
    - Feasibility currently unknown.
    - There is a lack of knowledge regarding cost of development and operation, water quality and sustainable yield.
    - Ecological impacts largely unknown. There are concerns regarding possible short and/or long term impacts on seeps and river base flows.
    - Uncertainty regarding the requirement for additional water treatment facilities at Wemmershoek Dam.

F2. Table Mountain Group Aquifer TSA H8 – Steenbras Dam

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The potential targets in TSA-H8 are both the Skurweberg Aquifer (shallow unconfined) and the Peninsula Aquifer (deep confined) within a moderate to steep, NNW-dipping limb of the Steenbras Syncline, possibly faulted along the main Steenbras-Brandvlei Megafault.

A NW/SE-striking fault, which controls the drainage lines, is one potential hydrotect within the unconfined to semi-confined Skurweberg Aquifer. Most of the exposed trace of the fault in the south-eastern part of H6 falls within an area of Skurweberg recharge, where the aquifer is effectively unconfined. The north-western end of the fault trace displaces the Skurweberg-Rietvlei contact, which is a probable aquitard above the more confined portion of the Skurweberg Aquifer within the main Steenbras Syncline.

The potential scheme would comprise the following :

- Establishment of 13 production and several monitoring boreholes,
- Equipping the boreholes,
- Construction of a pipe network and pipeline to the Upper Steenbras Dam.

It is assumed that the existing water treatment facilities can be extended to accommodate the additional volume and different quality of the abstracted groundwater.

3. SCHEME YIELD

The scheme yield for the pilot phase is estimated to be 5 million m^3/a. The total yield of the wellfield will be defined after completion of the TMG Aquifer Feasibility Study and Pilot Project. However, it is expected that the final yield will be more than 20 million m^3/a.

4. UNIT REFERENCE VALUE

Currently only cost estimates for the pilot wellfield are available, as given below :

ITEM	Costs escalated to 2005 (@ 7% /a) (1)
	To Steenbras Dam
Capital cost (R million)	25.9
Annual operating cost (R million) (2)	1.3
NPV Cost (R million)	?
Unit Reference Value (R/m^3)	0.59

1) Updated URV using a Discount Rate of 6%
2) Includes conveyance costs from wellfield to dam. Excludes water treatment costs.

5. ECOLOGICAL

The eastern shore of the Steenbras Dam is part of the core zone of the Kogelberg Biosphere Reserve, while the western shore is situated in the buffer zone. The ridge top that defines the Steenbras watershed (running roughly NE-SW to end at Kogelberg Peak and partly in TSA H3 and H8) has at least six well-known high altitude rare species, many of which are associated with peaty areas on the upper slopes.

6. SOCIO-ECONOMIC

There are concerns from the public, conservation organisations and existing groundwater and surface water users regarding potential impacts.

7. OTHER ISSUES

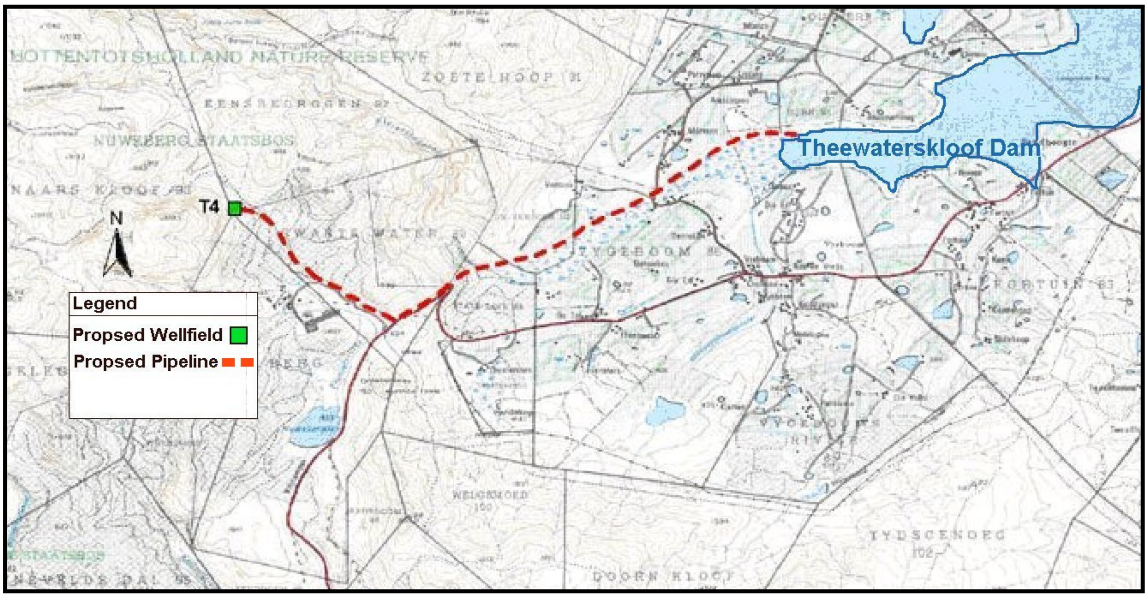
Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - Evaporation free storage within the TMG Aquifer
  - High recharge percentage in TMG outcrops
  - High groundwater potential
  - Direct transfer of abstracted water into Steenbras Dam
  - Possibility for conjunctive use and optimisation of storage

- **Weaknesses**
  - Feasibility currently unknown
  - Environmental impacts unknown
  - Potentially a high level of public opposition due to the location in the buffer zone of the Kogelberg Biosphere Reserve.
  - The cost of water treatment is likely to be higher than from most surface water sources.

F3. Table Mountain Group Aquifer TSA T4 –Theewaterskloof

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

This area contains a convenient transect across the Steenbras-Brandvlei Megafault (SBM), where it crosses the upper Palmiet River close to the Palmiet-Riviersonderend catchment divide. The main target feature is the deep Peninsula Aquifer in the western footwall of the SBM. Production wells and/or aquifer monitoring opportunities also exist in the eastern SBM hanging wall, and in the exposed Peninsula of the northern recharge zone.

Successful groundwater development in the T4 area could naturally extend over time into the adjacent T3 target area. It is also relevant to note that the location of T4 close to the Palmiet-Riviersonderend catchment divide, provides flexibility to the future direction of infrastructure development. Depending upon the success of groundwater exploration results during the present project, the potential for a hydrogeologically motivated tunnel or wide-diameter horizontal directional drilling, along parts of the SBM between T4 and T2 and/or between T4 and T5, is not beyond speculation.

The scheme would comprise the following :

- Establishment of 13 production and several monitoring boreholes,
- Equipping the boreholes,
- Construction of a pipe network and pipeline to Theewaterskloof Dam.

It is assumed that the existing water treatment facilities can accommodate the additional volume and different quality of the abstracted groundwater.

3. SCHEME YIELD

The scheme yield for the pilot phase is estimated to be 5 million m^3/a. The total yield of the wellfield will be defined after completion of the TMG Aquifer Feasibility Study and Pilot Project. However, it is expected that the final yield will be more than 20 million m^3/a.

4. UNIT REFERENCE VALUE

Currently only cost estimations for the pilot wellfield are available, as given below :

ITEM	Costs escalated to 2005 (@ 7% /a) (1)
	To Theewaterskloof Dam
Capital cost (R million)	34.7
Annual operating cost (R million) (2)	1.3
NPV Cost (R million)	?
Unit Reference Value (R/m^3)	0.71

1) Updated URV using a Discount Rate of 8%
2) Includes conveyance costs from wellfield to dam. Excludes water treatment costs.

5. ECOLOGICAL

It can be expected that a number of rare species, associated with wetlands and shale layers, could be found in the TSA.

Most of the potential drill sites are situated on the border between the Hottentots Holland Nature Reserve and agricultural land and forestry. In the existing forestry areas possible drilling effects can easily be mitigated. Existing forest roads and tracks can be used for access. If the borehole sites are required to be located in the nature reserves, impacts due to access and drilling platform preparation can be expected.

Most production and/or monitoring boreholes in the T4 area can be sited on or close to existing forestry road access.

There is some concern that, if large-scale abstraction were to take place, the baseflow in the Palmiet River would be affected. However, these effects could be off-set by the fact that the Palmiet River is already heavily managed and impacted by abstraction, and there are several dams on the system, which can be used to regulate flow, and in particular meet the Ecological Reserve in the lower Palmiet River, where the river is in the best ecological condition.

6. SOCIO-ECONOMIC

There are concerns from the public, conservation organisations and existing groundwater and surface water users regarding potential impacts.

7. OTHER ISSUES

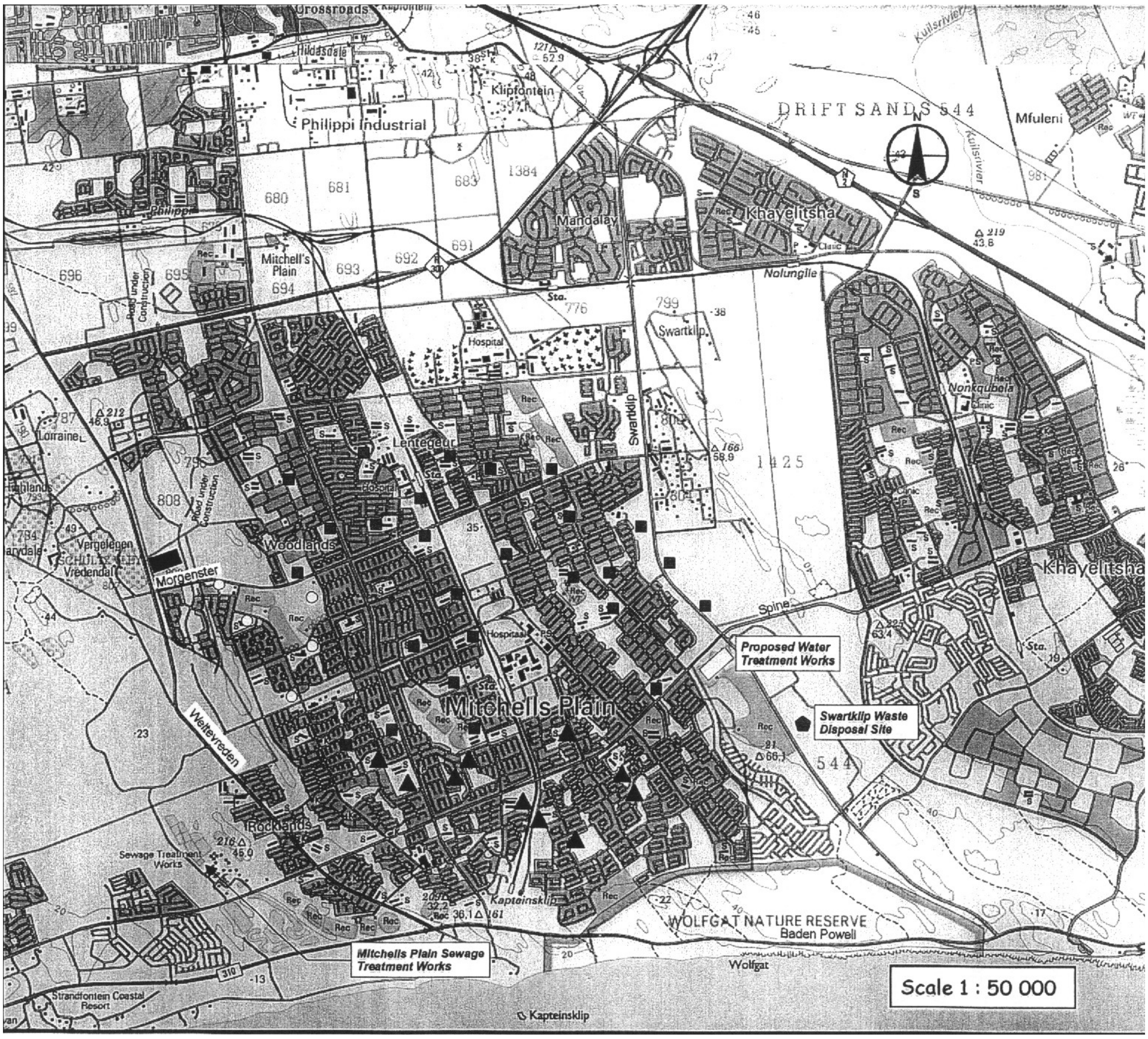
Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - Evaporation-free storage within TMG Aquifer
  - High recharge percentage in TMG outcrops
  - High groundwater potential
  - Direct transfer of abstracted water into Theewaterskloof Dam
  - Possibility for conjunctive use and optimisation of storage

- **Weaknesses**
  - Feasibility currently unknown
  - Environmental impacts unknown
  - The cost of water treatment is likely to be higher than from most surface water sources.
  - Potentially a high level of public opposition due to the location in or adjacent to the Hottenhots Holland Nature Reserve.

F4. Cape Flats Aquifer

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Most of the information was taken from Fraser, L, Hay, R, Kleynhans, S H, Luger, M, Weaver, J. (October 2001). *Integrated Water Resource Planning Study – Cape Flats Aquifer,* Ninham Shand. Further information regarding the scheme was taken from the following sources :

- Fraser, L and Weaver, J. (2000). *Cape Flats Aquifer: bulk water for Cape Town now*, Council for Scientific and Industrial Research (CSIR).
- Fraser, L and Weaver, J. (2000). *Groundwater impact scoping for the Cape Flats Aquifer*, Council for Scientific and Industrial Research (CSIR).
- Vandoolaeghe, M A C. (1990). *The Cape Flats Aquifer*.

The Cape Flats Aquifer (CFA) Scheme would comprise the following :

- Establishment of production and monitoring boreholes,
- Equipping the boreholes,

- Construction of a buried pipe network,
- Construction of a 50 Mℓ/d on-site lime softening plant,
- Construction of a 25 Mℓ buffer reservoir, and
- The construction of a pump station to pump water from the buffer reservoir into the distribution network.

Two possible layouts of the scheme could be implemented. However, only one is described in this document due to the other's proximity to the Swartklip Waste Site and Mitchell's Plain Waste Water Treatment Works. In the option described, all production boreholes are sited within public open spaces, parks and school grounds. The boreholes in the eastern zone would be in the north-eastern corner of the high yielding zone. These boreholes would lie upstream of the existing Swartklip Waste Site and also to the east of Swartklip Products. Boreholes in the western zone would be located east, west and north of the Mitchell's Plain WWTW.

The boreholes also need to be at least 500m from the Philippi agricultural area to reduce the impact of pumping.

Typical groundwater from the CFA is high in alkalinity, hardness, salts and iron and is over-saturated in calcium carbonate. Typical treatment required would be :

- Reduction of turbidity,
- Iron removal,
- Oxidation of ammonia,
- Disinfection,
- Reduction in hardness,
- Fluoridation.

Both schemes mentioned above comprise the construction of either an on-site or tertiary 50 Mℓ/d water treatment works.

3. SCHEME YIELD

The scheme yield is estimated to be 18 million m^3/a.

4. UNIT REFERENCE VALUE

Based on a yield of 18 million m^3/a, the URV of the scheme is as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	52,9
Annual operating cost (R million) (2)	6,2
NPV Cost (R million)	127,5
Unit Reference Value (R/m^3)	0.58

1) URV as given in original cost estimation (2001)
2) Excludes water treatment costs.

5. ECOLOGICAL

River systems
Rivers in the vicinity of the proposed scheme include the Kuils River, Lotus River and Salt River. The Kuils River is the most significant and contributes approximately 0.5 million m^3/a of recharge to the aquifer. The river is upstream of the proposed scheme, which is unlikely to impact on the river.

Seasonal vleis
Several seasonal vleis are found in the Swartklip area. The extent of the cone of depression due to pumping is not expected to extend to more than 1 000 m from the wellfield. There are no seasonal vleis identified of notable ecological importance except for those in the Swartklip area.

Permanent vleis
Zeekoevlei and Rondevlei are important and are situated some 7 km to the west of the proposed scheme. These permanent vleis are located outside the cone of depression and thus are unlikely to be impacted by abstraction.

Marine Ecosystem
The *Anaulis australis* occurring in the surf zone of False Bay are reliant on dissolved silica. The silica is derived from groundwater that is discharged into False Bay. The populations of these diatoms are unnaturally high due to the WWTW in the area. A slight decrease in groundwater discharge will have a small effect on their numbers.

Terrestrial Systems
Most of the Cape Flats is covered with alien vegetation. Patches of Sandplain Fynbos, Strandveld and Renosterveld vegetation are found but are not likely to be reliant on groundwater.

6. SOCIO-ECONOMIC

Philippi/Weltevreden Agricultural areas
The farming community is solely dependent on groundwater for irrigation. Abstraction from the wellfield could result in a lowering of the water table in the agricultural area. This could negatively impact on the availability of groundwater. Studies done in the agricultural area indicate that farmers are already over-exploiting the aquifer, which has led to a decrease in yield, with boreholes having to be drilled ever deeper. Abstraction from the proposed wellfield could create the perception that it is affecting the water supply in the Philippi/Weltevreden area.

Human Health
Groundwater abstracted from the CFA will be treated to the same standards as current domestic supply. Possible pollution from solid waste disposal sites and WWTW needs to be monitored. Over-abstraction can lead to seawater intrusion. Proper monitoring and management would reduce the impacts to a negligible risk.

Public acceptability of scheme
The community's acceptability of using groundwater for domestic supply could be significant.

Private Domestic/Garden irrigation
A lowering of the water table will affect local water users, especially wellpoint users. There is a need to conduct a hydrocensus to establish the current extent for domestic/garden irrigation of local groundwater use.

Land subsidence
The lowering of groundwater levels may lead to the compaction of dry sand and the dewatering of clay. This might cause land subsidence, resulting in the possible cracking of foundations to existing buildings. However, this usually happens in deep aquifers and with a lowering of the water table of tens of meters. Land subsidence is not expected to occur and there was no evidence of subsidence during the pilot scheme.

Visual impacts
Infrastructure that may have a visual impact include boreholes, pipelines and the water treatment works. Pipelines will be buried underground and the boreholes will be covered with lockable manholes. The design of the water treatment works needs to consider the visual impact thereof.

Employment opportunities
Approximately 30-40 temporary jobs will be created during the two-year construction phase with only 2-3 long-term jobs for management and maintenance of the wellfield.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - 18 million m^3/a yield
  - Minimum environmental problems expected
  - Additional treatment plant would increase CCT treatment capacity
  - Low distribution costs
  - It is possible to abstract the 18 million m^3/a during summer only

- **Weaknesses**
  - Possible pollution
  - Public acceptability
  - No calibrated flow model available

F5. West Coast Aquifer

1. SCHEME LAYOUT

2. SCHEME DESCRIPTION

Several aquifers have been identified in the northern part of the Berg River Catchment between Atlantis and Yzerfontein. These aquifers include the following :

- Adamboerskraal Aquifer
- Langebaan Road Aquifer
- Elandsfontyn Aquifer
- Grootwater Aquifer
- Atlantis: Witsand and Silwerstroom Aquifers

Some of these aquifers, particularly the Langebaan Road and the Elandsfontyn aquifers, have been included in the Saldanha Underground Government Water Control Area. The areas were declared with the intention to preserve these resources for the anticipated industrialisation of the area and expected resultant increased water demand. The Groundwater Report of DWAF West Coast Study provides the most recent information on the West Coast aquifers.

Adamboerskraal Aquifer
This aquifer is situated on the northern bank of the Berg River, approximately 30 km to the north-east of Vredenburg. The short-term and long-term exploitation potentials are estimated at 2,4 million m^3/a and 16 million m^3/a, respectively. The quality of the water is reported to be good. The aquifer was not included in the proclaimed Saldanha Underground Government Water Scheme. It lies adjacent to the ecologically sensitive Berg River estuary at Velddrif.

Langebaan Road Aquifer
The Langebaan Road Aquifer occurs in the Cenozoic deposits situated in the area between the Berg River, Langebaan Lagoon, Darling and Hopefield. Recent studies indicate that the aquifer has a maximum yield of 2,8 million m^3/a with a safe yield of 1,8 million m^3/a. The aquifer was developed in 1999 to partially meet the future water demands of the Berg River - Saldanha System, with an annual allocation of 1,4 million m^3/a. Infrastructure for possible increased future abstraction was installed.

Elandsfontein Aquifer
The Elandsfontyn Primary Aquifer Unit is situated south of the Langebaan Road Primary Aquifer Unit and is connected to it through a low flow boundary stretching from Langebaan to Hopefield. The short-term and long-term exploitation potential of the aquifer have been determined to be 4,80 million m^3/a and 3,20 million m^3/a, respectively. The aquifer is situated adjacent to the ecologically sensitive Langebaan Lagoon, where subterranean outflows from the aquifer occur. This source is potentially extremely environmentally sensitive.

Grootwater Aquifer
The Grootwater Primary Aquifer Unit occurs in the unconsolidated coastal sediments between Yzerfontein in the north and the Modder River to the south. It was proclaimed as a Subterranean Government Water Control Area in 1990. The allocation to properties within the Subterranean Water Control Area totals almost 3 million m^3/a. The exploitation potential of the Grootwater Aquifer was estimated between 2,6 and 3,8 million m^3/a.

Atlantis Aquifer
The Atlantis Aquifer supplies the towns of Atlantis and Mamre and is situated within the Blaauwberg Municipality. Water abstraction from the Atlantis Aquifer system is concentrated from two wellfields, namely, Witzand and Silwerstroom (Fleisher, 1990) and is augmented by artificial recharge using urban storm water (Fleisher and Eskes, 1992). The primary aquifer

comprises essentially consolidated sand deposits, overlying greywackes and shales of the Malmesbury Group (Parsons *et al,* 1999). The general groundwater flow is towards the sea and some discharge occurs through springs.

The potential schemes for the West Coast aquifers would involve :

- local abstraction and use for local communities (i.e. domestic and agricultural use).
- artificially recharging the aquifers with treated storm water and/or surplus surface water (i.e. winter floods).

3. SCHEME YIELD

The long-term additional yields of the different aquifers are estimated to be :

- Adamboerskraal Aquifer – 2,4 million m^3/a
- Langebaan Road Aquifer – 2,8 million m^3/a
- Elandsfontyn Aquifer – 4,8 million m^3/a
- Grootwater Aquifer – 3,8 million m^3/a
- Atlantis: Witsand and Silwerstroom Aquifers – fully exploited

4. UNIT REFERENCE VALUE

The cost estimate is based on the complete scheme, including the above-mentioned aquifers (excluding Atlantis). The URV is based on a 1994 cost estimate, escalated at 7% per annum to date.

ITEM	Costs escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	703.02
Annual operating cost (R million) (2)	22.94
NPV Cost (R million)	
Unit Reference Value (R/m^3)	0.6

1) URV as stated in original cost estimation (1994)
2) Excludes water treatment costs.

The URV needs to be re-determined as the potential yields presented above are significantly less than the yields used in the 1994 cost estimate.

5. ECOLOGICAL

The development and utilisation of the Atlantis Aquifer provides an indication of the ecological impacts that can arise from the development of similar primary aquifers.

Atlantis Aquifer

Groundwater levels in the vicinity of the Witsands and Silwerstroom areas have dropped 5-7 m over a period of 20 years, indications are that this has stabilised (Parsons *et al,* 1999). This gradual lowering of the water level has not, however, resulted in any apparent negative ecological impacts.

No visible signs of any impact caused by groundwater abstraction are currently visible. Silwerstroom spring is still flowing in spite of continual groundwater abstraction from the wellfield for the past 22 years (Parsons *et al,* 1999). Prolonged pumping in the Silwerstroom wellfield has, however, affected the natural flow regime of the aquifer and has caused an increase in salinity in the pumped water.

Interference with the natural regime of the Atlantis aquifer occurs on the basis of :

1. artificial recharge of the aquifer through urban storm water, particularly at the Witsand area
2. diversion of inferior quality water into the coastal region of the aquifer, and
3. the percolation of water from the maturation ponds situated at the Atlantis waste water treatment works into the aquifer.

The maturation ponds located at the Atlantis WWTW extends over an area of 50 000 - 70 000 m^2 (Fleisher and Hon, 1991). Although lined, unknown quantities of water percolate out of the ponds and can be seen in seepages below the ponds and flooding of low-lying land nearby. Chemical quality of the percolated water has, however, been found to be better than the water from the aquifer (Fleisher and Hon, 1991).

Brackish water occurs in the area of the Silwerstroom wellfield (north and north east), the southern regions of the Atlantis aquifer and downstream of the coastal recharge areas. Salinity levels do not yet exceed the 4 000 mg/ℓ Cl established level.

The thin thickness of the aquifers along with the fine grain lithology of the aquifer indicates that unfavourable conditions for water abstraction exist for large sections of the aquifer (Fleisher and Hon, 1991). Boreholes situated within these areas are relatively low yielding. Special care will be required in borehole design and gravel packing.

Other West Coast Aquifers

The CSIR has investigated the impacts that exploitation of the Langebaan Road Aquifer will have on groundwater seepage which may support plant communities next to the Berg River. Similar environmental concerns have been raised about the exploitation of the other West Coast aquifers.

6. SOCIO-ECONOMIC

Associated costs

The thin thickness of the aquifers along with the fine grain lithology of the aquifer indicates that unfavourable conditions for water abstraction exist for large sections of the aquifer (Fleisher and Hon, 1991). Boreholes situated within these areas are relatively low yielding. Special care will be required in borehole design and gravel packing.

Health impacts

No health hazards will be involved in the utilisation of groundwater by pumping it at a distance beyond 70 m from the maturation ponds (Fleisher and Hon, 1991). However, the quality of some of the aquifer formation contains water of high salinity or high chloride levels not suitable for potable use.

Political and institutional considerations

Future abstraction will have to be distributed correctly to include factors such as the thin thickness of the aquifer, the decline of the groundwater level at the Witsand aquifer and the further development of the wellfields. If not, the local depression in Witsand will deepen, resulting in decreasing yields in the individual production boreholes.

7. STRATEGIC ISSUES

Specific strengths and weaknesses include :

- **Strengths**
    - Potential to extend the wellfields to exploit the full potential of groundwater abstraction, particularly for the Witsand area;
    - Conjunctive use of groundwater and surface water;
    - Artificial recharge with surface water surplus (winter floods) to enhance groundwater potential;
    - Wellfield model can serve as a tool for optimising and subsequent management of the wellfields.

- **Weaknesses**
    - Decline of water levels in the semi-confined aquifer will have an impact on the yields of individual boreholes;
    - A natural constraint exists within the thin thickness of the aquifer;
    - Outdated URV estimates.

F6. Newlands Aquifer

1. SCHEME LAYOUT

Refer to locality maps in Introduction to this document.

2. SCHEME DESCRIPTION

Most of the information was taken from :

- City of Cape Town (1992). Western Cape System Analysis: *Utilisation of Less Conventional Water Sources*. Ninham Shand.
- Western Cape System Analysis. Evaluation of the Options Conference, 28 to 30 April 1996. Information Pack for Delegates.
- City of Cape Town (1994). Western Cape System Analysis: *Options for the Supply of Water in the Western Cape*. Ninham Shand.
- *Water Resources and Water Resource Planning*: City of Cape Town. 2001.

Several springs exist in the Newlands area. Most of these springs are privately used. One spring is currently used by the City of Cape Town (1.5 million m^3/a). It is proposed to use the aquifer by means of boreholes and abstract up to 10 million m^3/a of groundwater.

The scheme would comprise the following :

- Establishment of production and monitoring boreholes,
- Equipping the boreholes,
- Construction of a buried pipe network.

3. SCHEME YIELD

The potential scheme yield is estimated to be 10 million m^3/a, while the safe yield was previously set at 7 million m^3/a.

4. UNIT REFERENCE VALUE

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	5.51
Annual operating cost (R million) (2)	0.551
NPV Cost (R million)	?
Unit Reference Value (R/m^3)	0.53

1) URV as given in 1996 for 7 million m^3/a
2) Excludes water treatment costs.

5. ECOLOGICAL

Baseflow to the Liesbeeck River could be reduced with accompanying impacts on aquatic ecosystems. The lowering of the water table could impact on the natural environment.

6. SOCIO-ECONOMIC

Lowering of the water table will affect local water users, especially wellpoint users. There is a need to conduct a hydrocensus to establish the extent of local groundwater use in this area.

7. OTHER ISSUES

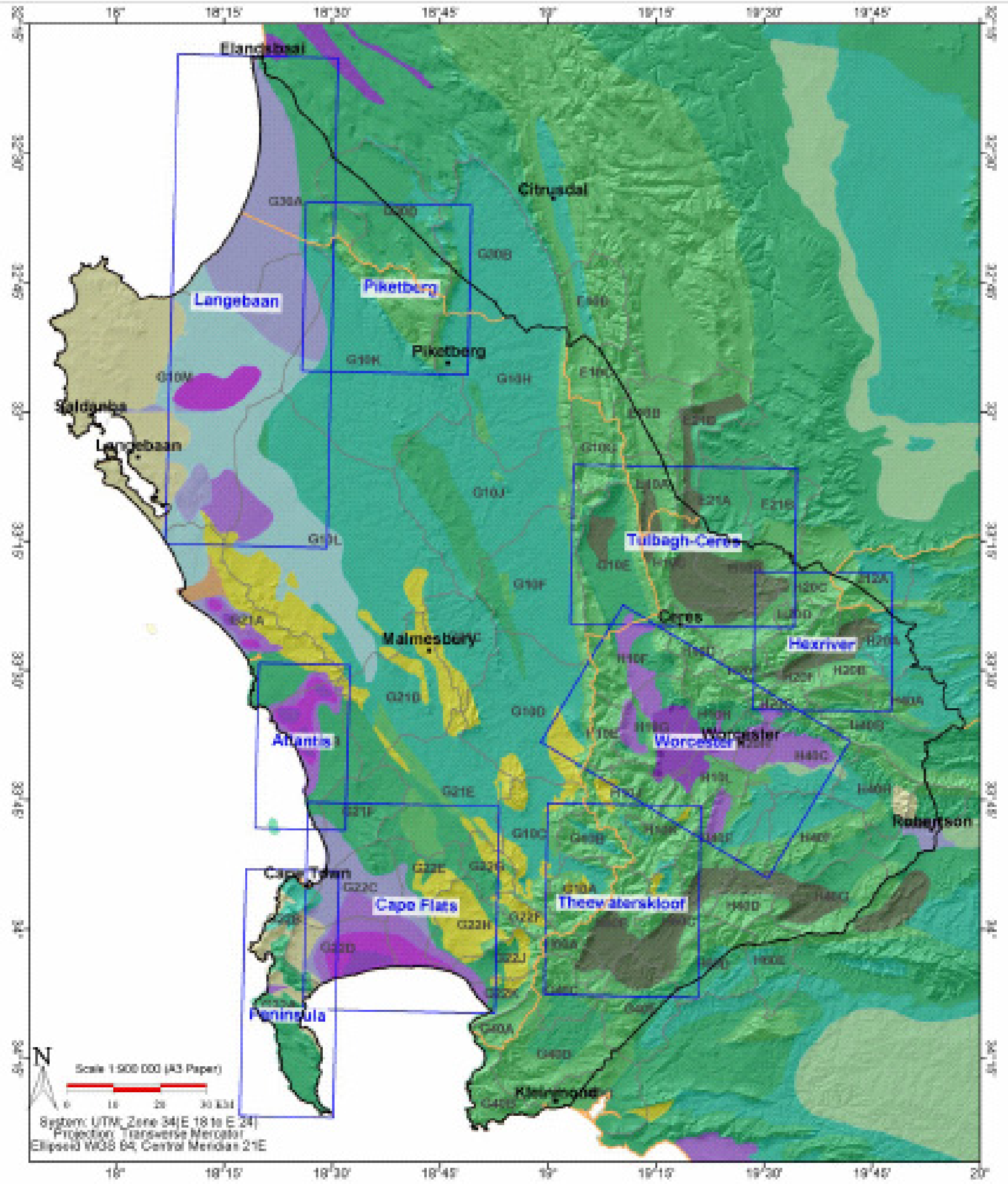
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Financially attractive
  - Located within users location will save on distribution costs

- **Weaknesses**
  - Small yield
  - Possible operational difficulties

F7. Conjunctive use options

1. SCHEME LAYOUT



2. SCHEME DESCRIPTIONS

Conjunctive use can be grouped into two main options :

- Injection of surplus surface water into aquifers for evaporation free storage and later use (called Aquifer Storage and Recovery [ASR] scheme); and
- Pumping of groundwater into surface water storage facilities in times of drought, or to supplement the surface water during periods of shortfall.

The following table summarises the possible conjunctive use options for the various aquifers in the study area.

Aquifer	Aquifer interaction	SW - GW interaction	Potential / Scenarios
Coastal Aquifers			
Cape Flats	Partly fed by TMG Aquifer, via Newlands Aquifer	Baseflow, vleis	Flood management; Blending with surface water
Atlantis	Underlying bedrock	Baseflow	Artificial recharge, ASR; Supply
Darling	Underlying bedrock	Baseflow	Artificial recharge, ASR; Supply
Langebaan	Underlying bedrock and TMG	Baseflow, wetlands	Artificial recharge, ASR; Supply
TMG Aquifers			
Theewaterskloof	Local alluvium	Springs and gaining streams (via alluvium)	Augmentation; Conjunctive use with Theewaterskloof Dam or Wemmershoek Dam
Tulbagh – Ceres	Local alluvium	Springs and gaining streams (via alluvium)	Current use; Conjunctive use with transfer scheme
Hexriver Mtn	Local alluvium	Springs and gaining streams (via alluvium)	Current use; Conjunctive use with farm dams
Worcester	Underlying TMG	Baseflow of Upper Breede River	Augmentation; Conjunctive use with Brandvlei Dam
Peninsula	Local alluvium and outflow to Newlands springs	Springs	Augmentation; Conjunctive use with dams on Table Mountain and Simon's Town
Piketberg	Connection to Langebaan / Die Vlei Aquifer	Springs	Conjunctive use with farm dams; Augmentation to Aurora

3. SCHEME YIELD

These schemes are not investigated further and therefore, no scheme yield was established.

4. UNIT REFERENCE VALUE

No cost estimation for the schemes is currently available.

5. ECOLOGICAL

Not investigated.

6. SOCIO-ECONOMIC

Not determined.

7. OTHER ISSUES

Specific strengths and weaknesses include :

- **Strengths**
  - Conjunctive use of surface water and groundwater to optimise water demand and supply
  - Evaporation free storage within the subsurface

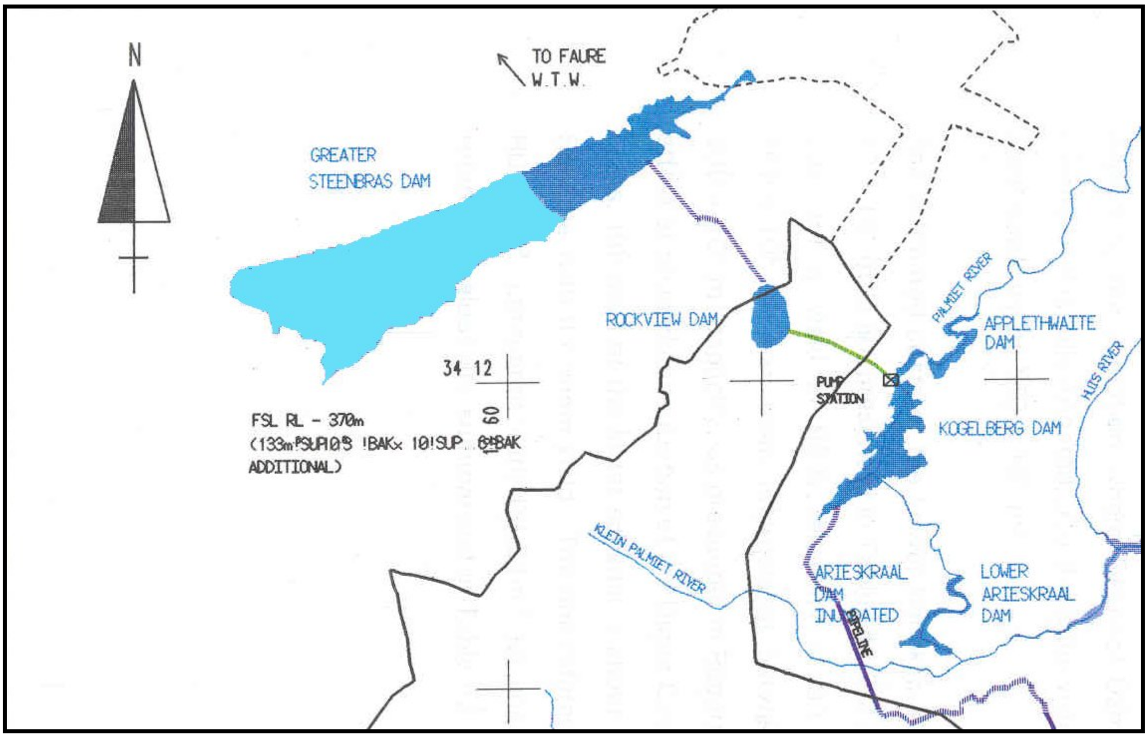
- **Weaknesses**
  - Currently not investigated

SECTION G

SURFACE WATER DEVELOPMENT OPTIONS

G1.Raising Lower Steenbras Dam

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information presented here is taken from the *Assessment of the Instream Flow Requirements for the Palmiet River and the Freshwater Requirements for the Palmiet Estuary,* 2000*.* Cost estimates were based on the 1994 Western Cape System Analysis Report.

This scheme entails the raising of the existing Lower Steenbras Dam by 24 m to the same Full Supply Level as that of the Upper Steenbras Dam (370 masl), effectively creating one Greater Steenbras Dam. The scheme would rely on the existing transfers from the Palmiet Pumped Storage Scheme as well as runoff into the dam from within its own catchment area.

3. SCHEME YIELD

Based on the 2000 Environmental Water Requirement (EWR) study, it was identified that depending on the EWR scenario, an increased yield of between 41 and 49 million m^3/a could be achieved through the raising of Lower Steenbras Dam.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows and are based on escalating the equivalent cost estimates from the 1994 WCSA report:

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	258
Annual operating cost (R million) (2)	0
NPV Cost (R million)	258
Unit Reference Value (R/m^3)	**0,89**

1) Using a Discount Rate of 8%
2) Includes raising Steenbras Dam and excludes water treatment costs.

Note: The URV is based on an escalated cost estimate dating back to 1994 (WCSA), when the capital cost for the civil works was estimated to be R107 m. The resulting present day capital cost estimate and URV is considered to be too.

5. ECOLOGICAL

The Desktop Method for determining the EWR for the Steenbras River for a Class A/B yields an EWR of some 44% of the MAR or for a Class B river yields an EWR of 35%.

The raising of the Lower Steenbras Dam would result in some 600 ha of commercial forest plantation being inundated. This impact is deemed to be of low significance. The scheme would operate using the existing conveyance infrastructure.

6. SOCIO-ECONOMIC

Various recreational facilities surrounding the Lower Steenbras Dam would be inundated. The inundation of these recreational areas is likely to have an impact on the public's enjoyment of the amenity and the income generated through entry fees. The significance of this impact is considered to be low.

The inundation of the commercial forest plantation may have an impact on forestry industry and employment in the area. This impact is considered to be of low significance.

7. OTHER ISSUES

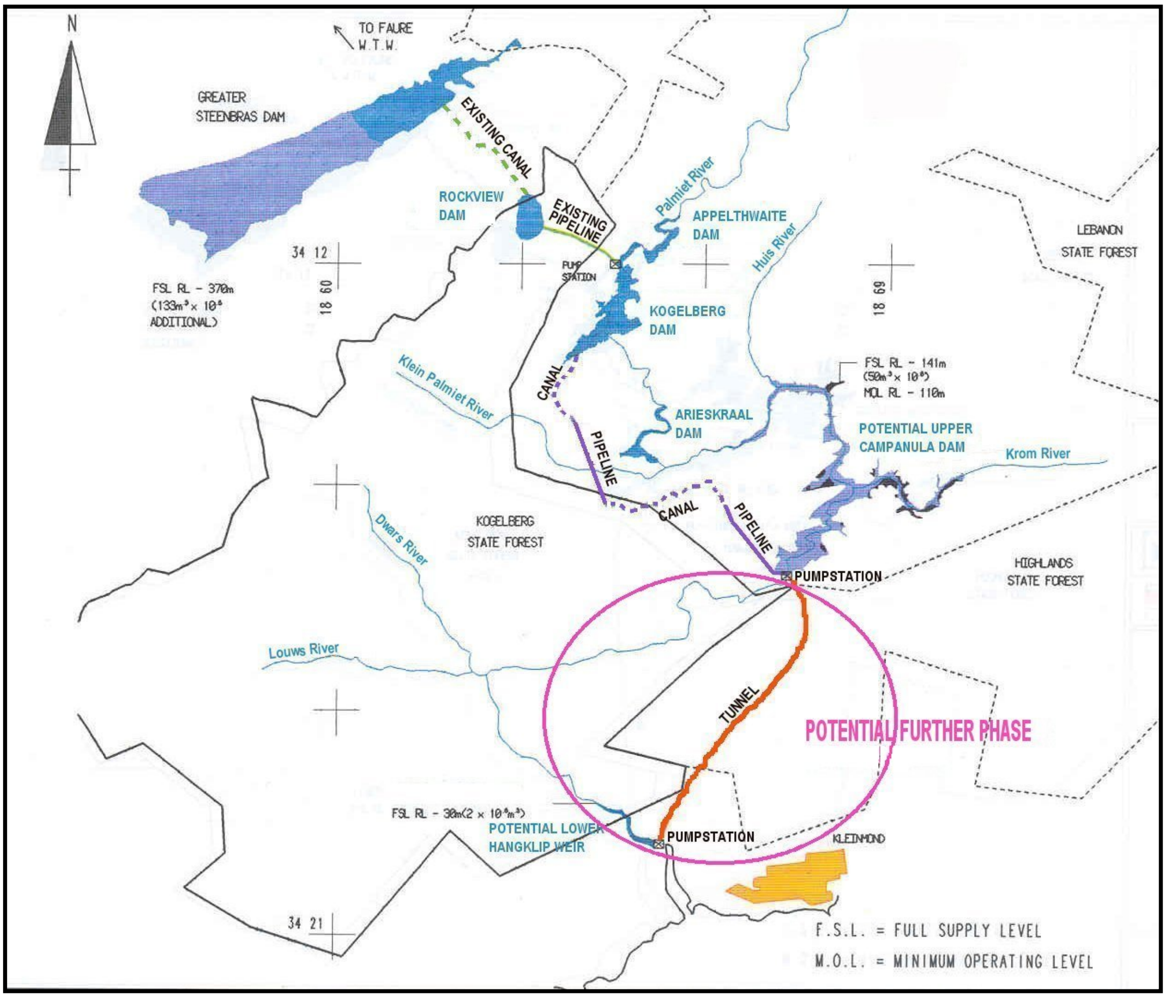
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Can be integrated into the existing WCWSS;
  - Components of delivery infrastructure are already in place;
  - No encroachment on established irrigated land;
  - Environmental impact of raising Lower Steenbras Dam is considered to be low.

- **Weaknesses**
  - Present day cost estimate seems low.

G2.The Upper Campanula Dam

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information for his scheme is taken from the Western Cape System Analysis (1990s) and the *Assessment of the Instream Flow Requirements for the Palmiet River and the Freshwater Requirements for the Palmiet Estuary, 2000.*

Alternative 1

The scheme involves the construction of a small dam (50 million m^3 capacity) on the Lower Palmiet River at the Upper Campanula site, close to the northern boundary of the Kogelberg Biosphere Reserve. This would inundate some existing orchards. To reduce the extent of environmental impact, the main storage component of the scheme would be a raised Lower Steenbras Dam (see Option G1).

Water from Upper Campanula Dam would be conveyed via a pipeline, syphon and two lengths of canal into the existing Kogelberg Dam. Most of this route would be outside of irrigable land. From Kogelberg Dam, the water would be transferred into a raised Lower Steenbras Dam (additional storage capacity of 133 million m^3/a) via the existing Palmiet Pumped Storage Scheme.

Alternative 2

A further potential phase includes an abstraction weir just upstream of the Palmiet River estuary. This takes advantage of the flow in the tributaries downstream of the Upper Campanula Dam site. Abstracted water would be pumped into Campanula Dam, via a tunnel. The yield of the alternative scheme is based on the WCSA EWR of a minimum regulated flow of 20 million m^3/a into the estuary.

3. SCHEME YIELD

Alternative 1

The EWR assessment suggests a potential yield of 76 million m^3/a from this scheme. This includes raising Lower Steenbras Dam and the existing transfers from the Palmiet River via the Palmiet Pumped Storage Scheme. This is based on the following assumptions :

- The impact of the raised Eikenhof Dam has been taken into account;
- The yield is sensitive to changes in EWR scenarios;
- All suitable privately owned land is assumed to be fully irrigated.

Alternative 2

The yield determined in the WCSA for the overall scheme is 93 million m^3/a.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows and are based on escalating the equivalent 1992 base costs used in the WCSA.

ITEM	Alternative 1 Escalated to 2005 (@ 7% /a) (1)	Alternative 2 Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	569	882
Annual operating cost (R million) (2)	5,0	11,3
NPV Cost (R million)	457,0	741,8
Unit Reference Value (R/m^3)	**0,78**	**1,03**

1) Using a Discount Rate of 8%
2) **Alternative 1** includes Campanula Dam, land access, pump stations, canals, pipelines, raising Steenbras Dam. Water treatment costs are excluded. **Alternative 2** further includes Hangklip Weir, tunnel to Upper Campanula Dam and pumping costs between them.

Note: For both options, the URV is based on escalated cost estimates at an annual escalation of 7% per annum, dating back to 1992 base prices (WCSA). The resulting present day capital cost estimates and URVs are considered to be too low.

5. ECOLOGICAL

In terms of the construction impacts on the Kogelberg Biosphere, a dam at Campanula would inundate existing orchards. The pipeline from Campanula to Kogelberg would pass through areas of least environmental sensitivity. Access could be managed to reduce potential impacts by remaining outside of the more environmentally sensitive areas.

In implementing the Reserve, the potential impacts associated with the reduced flow in the Palmiet River, as a result of the dam, can be mitigated.

A potential weir (near the estuary) and a tunnel (from weir to Campanula) would cause significant disruption to the core areas of the biosphere (Alternative 2). The core areas are the most environmentally sensitive. Tunnelling activities such as portal development, removal of spoil material, access and blasting would impact on the core area of the biosphere.

6. SOCIO-ECONOMIC

There would be some loss of existing irrigated land due to inundation. This would have an impact on the farming operation of the affected farms.

7. OTHER ISSUES

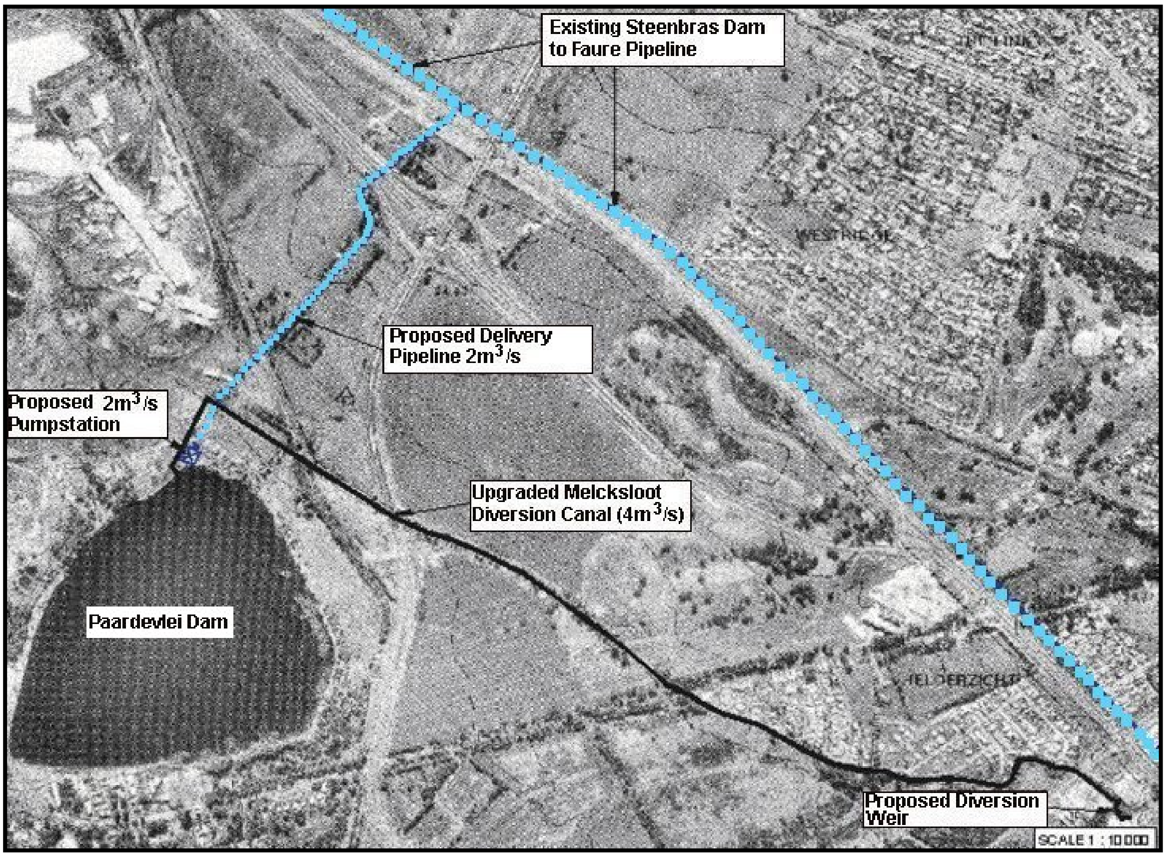
Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - Can be integrated into the existing WCWSS;
  - Large components of infrastructure are already in place;
  - Limited encroachment on established irrigated land;
  - Environmental impact of raising Lower Steenbras Dam is considered to be low.

- **Weaknesses**
  - Environmental and social impacts associated with inundation upstream of the Upper Campanula Dam;
  - Disturbance to the biosphere, particularly if Alternative 2 were adopted;
  - Possible public resistance to the scheme;
  - Low confidence URV calculation.

G3. The Lourens River Diversion

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Unless otherwise stated, the information presented for this scheme is taken from the CCT Integrated Water Resource Planning Study of 2002: Report No 3 of 12 – *Lourens River Diversion*.

The Lourens River Diversion Scheme would divert surplus winter water out of the Lourens River via a 1 m high concrete weir of 1000 m^3 storage capacity. The weir would be located at the existing Melcksloot diversion off-take, just downstream of the N2 road. Water would gravitate via an upgraded Melcksloot canal into a raised Paardevlei balancing dam. From the dam, the water would be pumped through a 1,35 km long, 1,2 m dia steel pipeline (of 2 m^3/s delivery capacity) into the existing Steenbras-to-Faure pipeline, and thence to the Faure WTW. The scheme would take 5-6 years to implement and the primary beneficiary would be the CCT.

Following the recent discussions between the CCT and developers of the property surrounding Paardevlei, the CCT has accepted that Paardevlei will not be utilised as part of the Lourens River Diversion Scheme. It is now envisaged that the scheme will comprise a slightly larger weir on the Lourens River immediately downstream of the N2, and a pump station with variable speed drive pumps to deliver a portion of the flow directly to the Faure Water Treatment Works via the existing Steenbras-Faure pipeline. It is envisaged that the cost of this scheme will be similar to that described above, and on which the URV, described below, is based.

3. SCHEME YIELD

The optimum scheme would yield about 19,4 million m^3/a, after allowing for Ecological Water Requirements (EWRs), for a Class "C" river. Without allowance for EWRs, the yield would increase only slightly to about 20,9 million m^3/a.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows :

ITEM	Escalated to 2005 (@ 7% /a) [(1)]
Capital cost (R million)	45,6
Annual operating cost (R million) [(2)]	2,3
NPV Cost (R million)	70,5
Unit Reference Value (R/m^3)	0,32

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.

5. ECOLOGICAL

The overall impact of this scheme is likely to be minimal, given the already severely degraded state of the Lourens River. The construction of a 1 m high weir at the existing Melcksloot diversion will interfere with sediment transport through capturing of floods which move fine sediments through the system. The weir structure is likely to interfere with the migration of indigenous fish to the lower reaches of the river and estuary. Furthermore, the pond-like conditions upstream of the weir could encourage the further spread of alien fish such as carp.

Raising of the Paardevlei Dam would result in the inundation of land surrounding the dam, including habitat for a number of resident and migratory bird species, including a breeding heronry in the willow trees in the south-eastern corner of the dam. This impact is considered to be of low significance, and will not arise if Paardevlei and the diversion canal are omitted from the scheme.

Diverting further water from the Lourens River will result in decreased flows in the lower reaches of the river and the estuary. Since the diversion would only take place during the high flow winter months, this significance of this impact is deemed to be low. Furthermore, run-off from the hardened surfaces of Somerset West will possibly mitigate the winter water high flow abstractions.

6. SOCIO-ECONOMIC

The Lourens River is located within a Protected Natural Environment, and sections of the banks of the river have been designated public open space (POS). The construction of the weir and upgrading of the canal will impact on some portions of the POS and private land, which could affect land value. This impact is considered to be of low significance.

AECI, who owns the Paardevlei Dam and surrounding land, are developing the area surrounding the dam for commercial, office and residential purposes. Raising the dam is likely to have a negative impact on AECI's proposed development. This impact is considered to be of medium significance. Furthermore, the raising of the dam is likely to result in an increase in the level of the water table and flooding of low-lying areas, which could cause damage to a complex of historical buildings to the south-east of the Paardevlei Dam. This is likely to have an impact on land-use and values in the area. This impact is considered to be of low significance, as it is manageable. These impacts will not arise if Paardevlei and the diversion canal are omitted from the scheme.

7. OTHER ISSUES

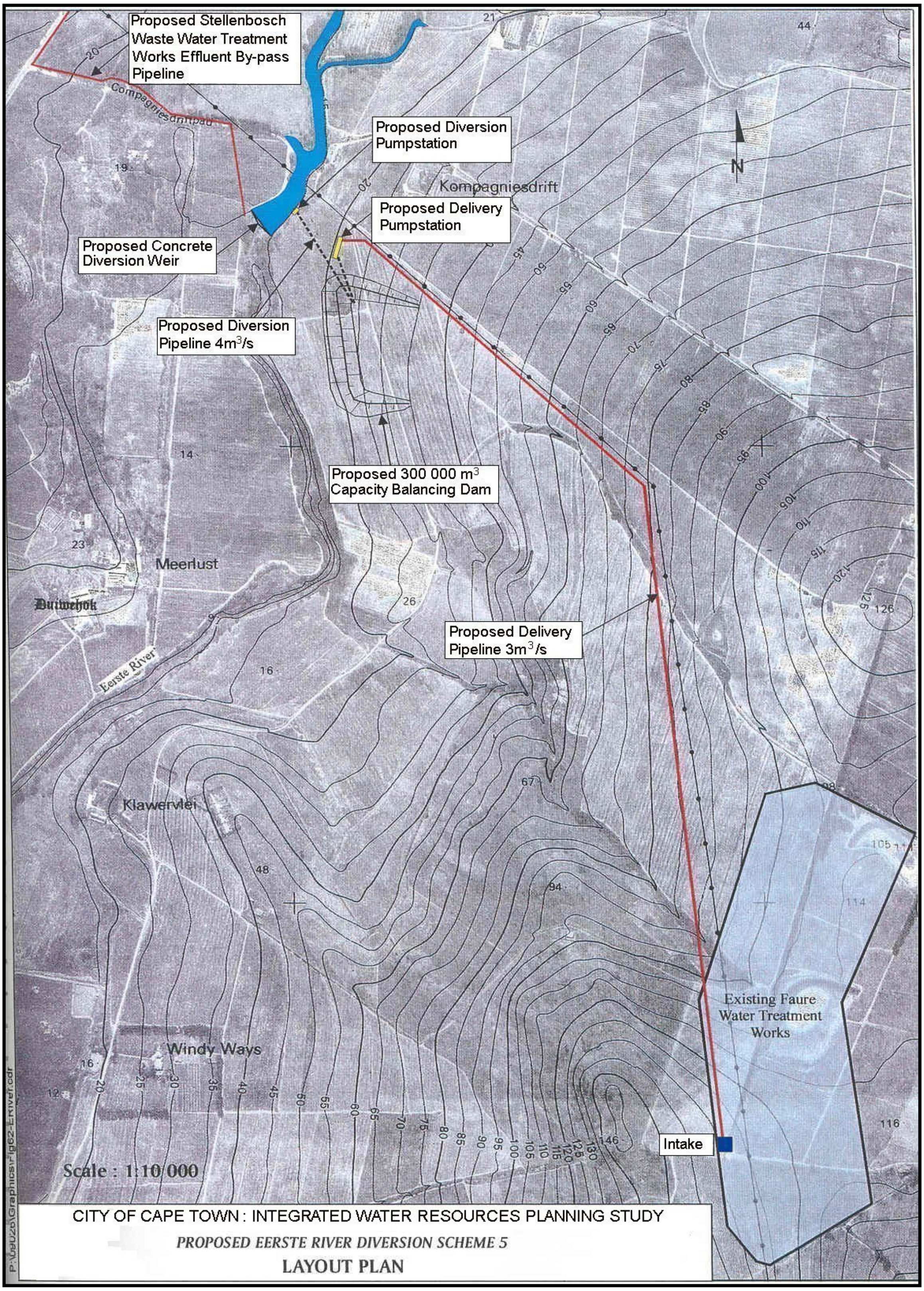
Specific strengths and weaknesses of the scheme include:

- **Strengths**
  - Close proximity to Faure WTW, existing balancing dam, and existing reticulation infrastructure;
  - Easily integrated into the Western Cape Water Supply System (WCWSS);
  - Offers improved carry over storage (winter into summer) in City's bulk storage dams;
  - Short implementation period of 5-6 years.

- **Weaknesses**
  - Potential increased localised flooding due to raising of water table at Paardevlei Dam;
  - Lourens River is susceptible to urban pollution upstream of the diversion weir with resulting water quality concerns;
  - If scheme is also integrated with Eerste River Diversion and/or Cape Flats Aquifer Schemes, available yield may exceed demand at Faure WTW.
  - The ecological impact of the scheme and on the Lourens River Protected Natural Environment.

G4. The Eerste River Diversion

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Unless otherwise stated, the information presented for this scheme is taken from the City of Cape Town's (CCT's) Integrated Water Resource Planning Study of 2002: Report No 2 of 12 – *Eerste River Diversion*.

The scheme would augment the water supply to the CCT. Surplus winter water would be pumped from a concrete diversion weir (4 m high and of 35 000 m^3 capacity) on the Eerste River into an adjacent off-channel balancing dam, at a rate of 4 m^3/s. From the balancing dam, the water would be pumped to the Faure WTW, via about 2,2 km of rising main, where it would be treated. Other infrastructure requirements include a bypass from the Stellenbosch WWTW, which is situated upstream, to ensure that at least this component of poorer water quality, bypasses the point of diversion.

Specific concerns are primarily water quality related and include the impacts of dense settlements upstream, industrial waste discharge, and effluent water quality discharged at Stellenbosch WWTW.

3. SCHEME YIELD

The optimum scheme would yield about 8,3 million m^3/a, after allowing for Ecological Water Requirements (EWRs), for a Class "D" river.

4. UNIT REFERENCE VALUE

The potential financial costs are as follows :

ITEM	Escalated to 2005 (@ 7% /a) [(1)]
Capital cost (R million)	101,5
Annual operating cost (R million)	1,9
NPV Cost (R million)	94,9
Unit Reference Value (R/m^3)	1,28 [(2)]

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.

5. ECOLOGICAL

The reservoir behind the weir would inundate some 1 200 m of the Eerste River and into the Kompagniesdrift tributary. This would result in the loss of riverine and riparian habitat of moderate environmental importance. The off-channel dam and associated pipeline to the Faure WTW would not have any significant impact on the terrestrial flora or fauna.

The reduction in flow downstream would have a small impact on the lower reaches of the Eerste River, and on the floodplain/pan/wetland system south of the N2. The scheme would not have any significant negative impact on the Eerste River estuary, as the system receives elevated flows throughout the year due to the discharge of large volumes of treated sewage effluent into the Kuils River system, as well as stormwater runoff. The proposed scheme would not have any significant effect on flood peaks, but would reduce the freshets/ within year high flows.

Due to the nature of the scheme (small weir pumping to an off-channel dam in winter), it should be possible to satisfy all components of the Reserve. There may be some water quality concerns associated with the weir and balancing dam, due to the relatively high nutrient loading in the Eerste River.

6. SOCIO-ECONOMIC

The inundation associated with the proposed weir and balancing dam would affect some 3 ha of valuable agricultural land. As the pipeline would be aligned adjacent to existing vehicular tracks, the impact on agricultural land would not be significant. The weir may impinge or inundate the historic ford and access across the Eerste River for the landowner. The infrastructure would not be incompatible with the sense of place of the area and would be unlikely to affect the historical/cultural value of the surrounding farms.

The abstraction of winter water is unlikely to affect the water supply to the Lower Eerste River Irrigation Board, which abstracts from the river downstream.

The proposed sewage effluent bypass pipeline would have to be carefully routed so as to minimise impacts on landowners and users.

7. OTHER ISSUES

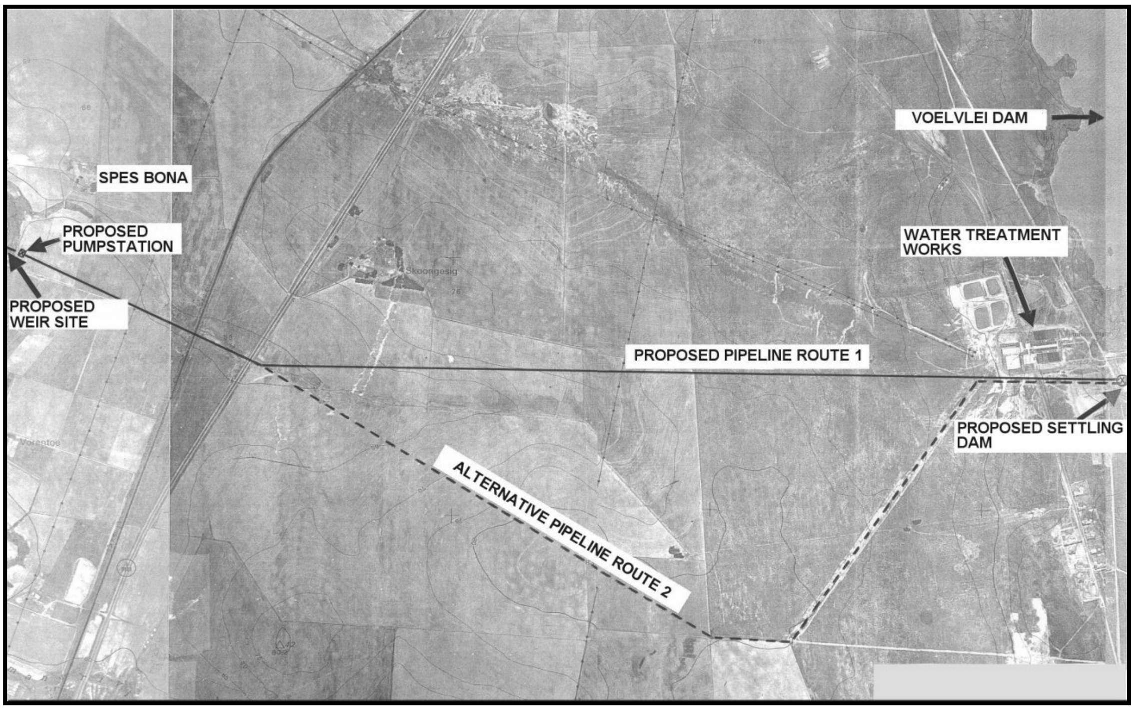
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Close proximity to Faure WTW and existing reticulation infrastructure;
  - Easily integrated into the Western Cape Water Supply System (WCWSS);
  - Offers improved carry over storage (winter into summer) in City's bulk storage dams;
  - Short implementation period of 4-5 years.

- **Weaknesses**
  - Requires addressing of water quality related issues in the Eerste River;
  - If also integrated with Lourens River and/or Cape Flats Aquifer Schemes, available yield may exceed demand at Faure WTW.

G5. Voëlvlei Augmentation Phase I

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information presented is taken from the *CCT, CMA Bulk Water Supply Study - Voëlvlei Augmentation Scheme - Phase I*, Report No. 3245/9531 of 2002.

The scheme entails the abstraction of surplus winter water from the Berg River at Spes Bona. The water would be pumped to the Voëlvlei WTW where it would be treated, either for :

- storage in the existing Voëlvlei Dam, or
- direct delivery to CCT.

The infrastructure requirements for direct treatment and supply to the CCT would be :

- a weir and intake at Spes Bona;
- 3,16 m^3/s pump station
- 1 500 mm dia steel delivery pipeline of up to 5 km long to the existing WTW;
- a desilting facility;
- a pipeline from the desilting facility to the existing Voëlvlei Dam intake;
- alterations to the existing chemical feed arrangements at the WTW.

For storage in Voëlvlei Dam, the last two items above would be replaced by pre-treatment and discharge into Voëlvlei Dam.

The key characteristics of the scheme are :

i) Only surplus winter water would be abstracted;
ii) 20 million m^3/a would be available to take up the spare capacity in the existing Voëlvlei WTW and pipeline to CCT.
iii) Surplus yield (over and above ii) could be used to improve the assurance of supply to other users currently reliant on Voëlvlei Dam (current shortfall of about 30 million m^3/a).
iv) When river flows are too low to permit abstraction, water will be drawn directly from Voëlvlei Dam.

3. SCHEME YIELD

Current estimates suggest that between 35 and 45 million m^3/a could be achieved. The ecological water requirement as determined in 2002 has been allowed for in this estimate. However, the ecological flow requirements of the estuary have not yet been determined. A conservative yield of 35 million m^3/a has therefore been assumed.

4. UNIT REFERENCE VALUE

The URV has been estimated to allow for escalation of 7% p.a. from 2002 to date. The potential financial costs for the scheme are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	87,0
Annual operating cost (R million) (2)	9,7
NPV Cost (R million)	165,1
Unit Reference Value (R/m)	0,50 (3)

1) URV based on a discount Rate of 8%.
2) Excludes water treatment costs and related WTW upgrade.

The URV would increase to about R0,60/m^3 for the option of pre-treatment and storage in the existing Voëlvlei Dam.

5. ECOLOGICAL

The lower Berg River is in a poor ecological state, however the Berg River estuary is of considerable ecological value and of major importance to birdlife at regional and national levels. Maintenance of the estuary requires that the wetlands are flooded during winter floods.

The requisite weir, some 5 km of large diameter pipeline and a desiliting facility would be constructed to the east of the Berg River, between the river and the Voëlvlei Dam. The proposed weir, with a maximum height of 1 m would have a slight affect on water levels for a distance of 1 km upstream of the weir. This impact is of a low significance. The area between the proposed weir site and Voëlvlei Dam is located partly within a Provincial Nature Reserve and the Voëlvlei Conservancy. The Reserve contains substantial areas of Renosterveld vegetation, a veld type that has become rare due to the extensive agricultural activities in the area. Furthermore, the Geometric Tortoise, which is endangered, is also found in the Reserve. The impacts associated with the construction of the weir, pipeline and desilting facility in this sensitive environment are considered to be of medium significance, but could be mitigated by optimising the pipeline layout and affording special protection to the tortoises and their eggs during the construction process. Provided that the EFR is met, and since water would be abstracted during the winter, seasonal flow patterns and the ecological functioning of the estuary are unlikely to be affected.

6. SOCIO-ECONOMIC

The construction of a weir on the Berg River is likely to have an impact on the agricultural community and canoeists, the scale of which would be dependent on the size of the weir. This impact is, however, deemed to be of low significance.

With increasing demands being placed on Voëlvlei Dam, the water level in the dam may vary more greatly than in the past, causing an inconvenience to members of the Voëlvlei Yacht Club and other users.

7. OTHER ISSUES

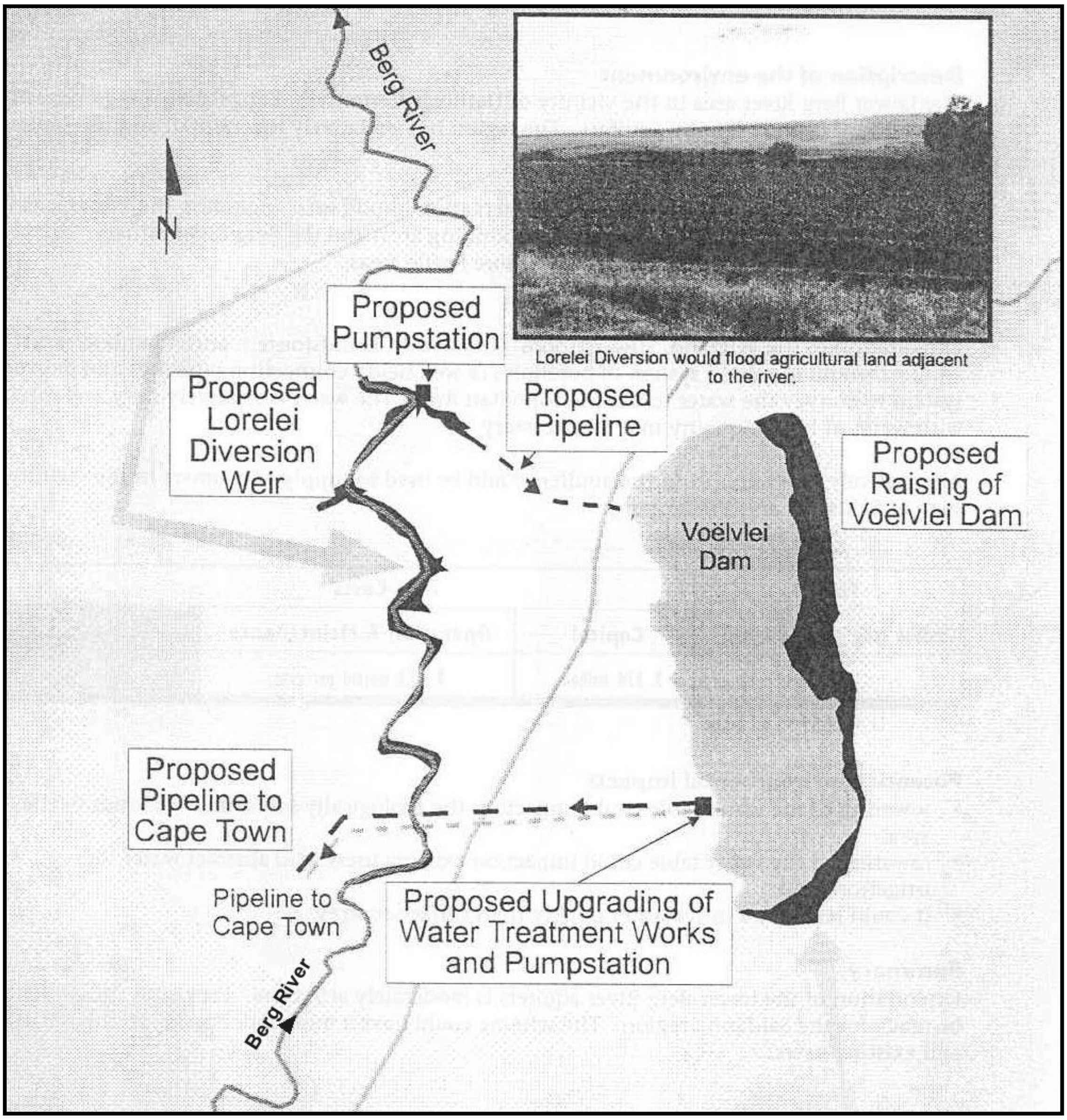
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Scheme allows for spare capacity in existing CCT infrastructure to be utilised;
  - Offers opportunity to reduce current shortfall on Voëlvlei Dam.

- **Weaknesses**
  - Water quality differences between the Berg River water and water in Voëlvlei Dam necessitates additional water treatment;
  - Scheme yields remain provisional until the Reserve requirements for the Lower Berg River and the estuary are set.

G6. Voëlvlei Augmentation Phase II and III

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information presented for this option is taken from the Western Cape System Analysis (1990s). It should be noted that Phases II and III have not been studied further since then. The extent of abstraction from the Berg River was considered to be of high environmental impact on the river and estuary. Phase II and III are nevertheless briefly described as follows :

In addition to the abstractions under Phase I, Phase II involves a 9 m raising of Voëlvlei Dam. Phase III would follow immediately after Phase II with a 7,5 m high weir (4 million m^3 capacity) on the Berg River, inundating about 190 ha. The diversion capacity of $3m^3/s$ (Phase I) would be increased to 20 m^3/s.

Increased pumping and pipeline conveyance capacity to Voëlvlei Dam would be required. Abstraction would be restricted to winter months when EWR has been met. The existing infrastructure would not be sufficient and the WTW would need to be expanded, as well as the pumping capacity of the pump station on the delivery line to Cape Town. A second pipeline to Cape Town would also be required.

3. SCHEME YIELD

Based on the 1990's assessment, Phase II and III would increase the existing Voëlvlei scheme yield (95 million m^3/a) by an additional 110 million m^3/a. Revised Reserve determinations have not yet been taken into account and the ecological flow requirements of the estuary have yet to be determined. These are likely to reduce the yield to some extent through the need to release sufficient flood flows to maintain the estuary.

4. UNIT REFERENCE VALUE

The costs associated with Phase II and III are as follows. These costs are updated from the WCSA, escalated to 2005, at a rate of 7% per annum.

ITEM	ESCALATED TO 2005 @ 7%/A (1)
Capital cost (R million)	1 096
Annual operating cost (R million) (2)	18,7
NPV cost (R million)	1 325
Unit reference value (R/m^3)	0,98

1. Updated URV using a discount rate of 8%
2. Excludes second pipeline to Cape Town and water treatment costs.

An approximate estimate has been made of the costs associated with a new 78 km steel pipeline (1,5 m ID) to Cape Town, pump stations and new 500 Mℓ/d water treatment works at Voëlvlei Dam. This would be required if the yield of 110 million m^3/a were to be realised. The financial implication is that the URV shown above could be expected to approximately double (± R2,1/m^3).

5. ECOLOGICAL

The raising of Voëlvlei Dam would result in the inundation of approximately 130 ha of vegetation, including rare renosterveld and habitat of the rare and endangered geometric tortoise. In Phase III of the project, the construction of a 7.5 m high weir on the Berg River would result in the inundation of up to 190 ha of irrigated farm land, comprising mostly vineyards. These impacts are considered to be of medium significance.

The condition of the lower reaches of the Berg River is poor. Increased abstraction from the river may, however, have a detrimental effect on the floodplain and estuary. While the weir will cause attenuation of some of the annual floods, the EWR study for Skuifraam Dam indicated that there was excess water available for utilisation in the lower reaches of the Berg River, provided that sufficient flood flows were released to maintain the estuary. The significance of this impact is therefore considered to be low, provided that the EWR is met.

6. SOCIO-ECONOMIC

The raising of the Voëlvlei Dam may inconvenience the yacht and angling clubs, which are based on the dam. Some facilities may be inundated if the full supply level of the dam is raised. This impact is considered to be of low significance.

The construction and subsequent raising of a weir on the Berg River is likely to have an impact on the agricultural community and canoeists, the scale of which would be dependent on the size of the weir and the area inundated. This impact is deemed to be of medium significance.

7. OTHER ISSUES

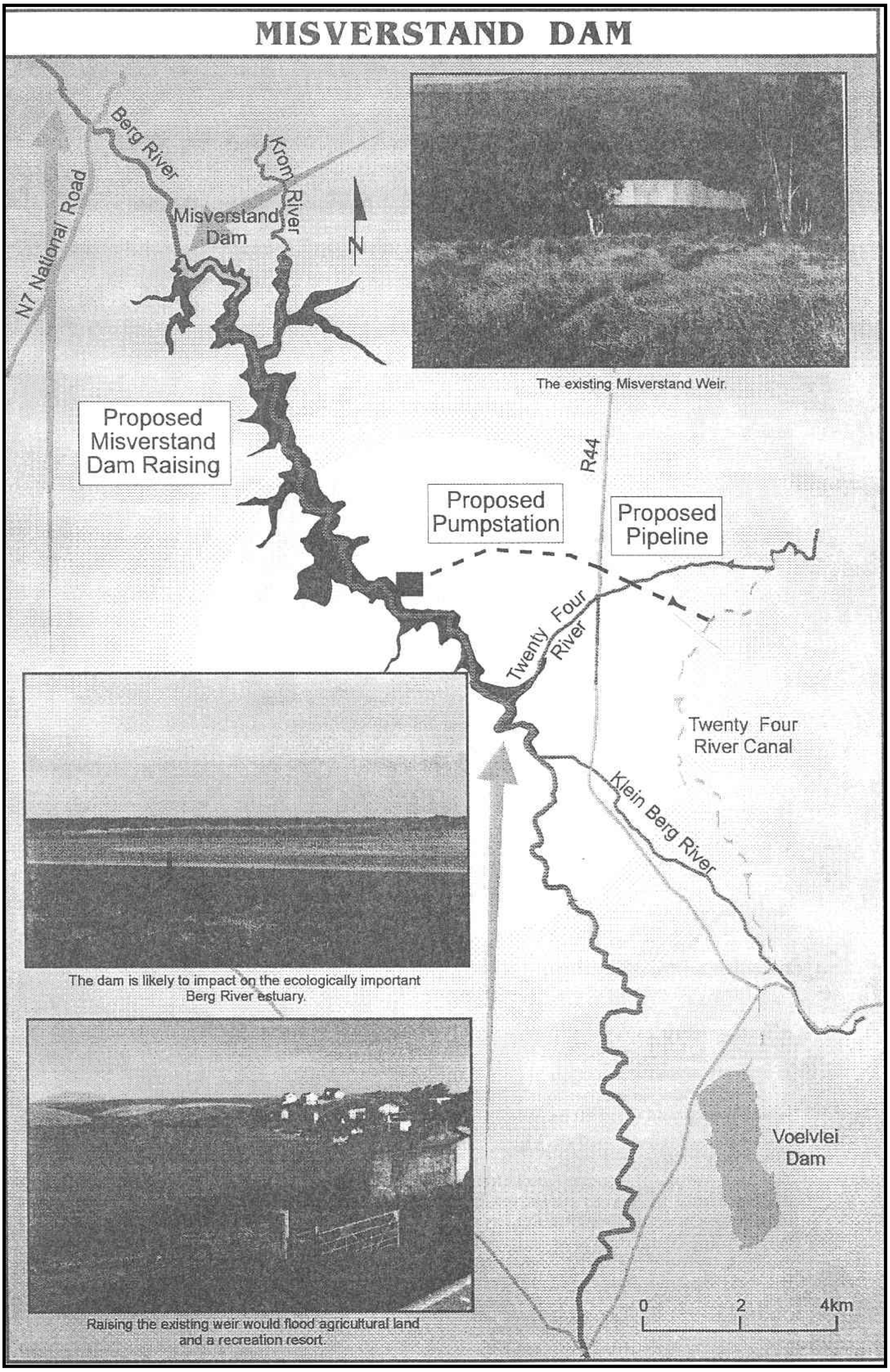
The strengths and weaknesses of the scheme are :

- **Strengths**
  - Offers significant increase in yield.

- **Weaknesses**
  - Significant potential inundation of established agricultural land, 50 ha of nature reserve and important natural heritage sites;
  - Significant potential impact on riverine and estuarine ecology;
  - Scheme was last assessed in 1990s;
  - The estuarine water requirement (not yet determined) is likely to reduce the yield;
  - Additional pipeline to Cape Town required and additional WTW at Voëlvlei Dam;
  - Poor water quality in the Berg River is likely to result in increased eutrophication of Voëlvlei Dam.

G7.A new dam at Misverstand

1. SCHEME LOCATION



2. SCHEME DESCRIPTION

The information presented is drawn from the Western Cape System Analysis (1990s) and the *Pre-Feasibility Study of Potential Water Sources Supplying the West Coast District Municipality,* 2003.

The Misverstand Weir on the Berg River near Piketberg has a storage capacity of 6 million m^3/a. The weir currently provides water to the Vredenburg / Saldanha area via abstractions treated at the Withoogte WTW.

The construction of a new dam in close proximity to the existing weir is an option to meet the growing water demands of the West Coast. Alternatively, the dam could be integrated with Voëlvlei Dam by pumping of water from the potential dam to the Twenty-four Rivers canal, which feeds Voëlvlei Dam. Studies of this scheme undertaken to date have not taken the water quality differences (Berg River vs Voëlvlei Dam) into account.

3. SCHEME YIELD

The Western Cape System Analysis (1990s) indicated that a 27m high dam (280 million m^3 capacity) would yield about 70 million m^3/a, after allowance for EWRs (Ref: WCSA, 1996). Subsequent to that, a further increase in the IFR was included to accommodate the needs (provisional) of the Berg River estuary. This resulted in a further reduction in the yield estimate to 40 million m^3/a.

The yield will need to be re-determined once the Reserve for the Lower Berg River and the estuary has been set. For the purposes of this study, a yield of 40 million m^3/a has been assumed.

4. UNIT REFERENCE VALUE

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	801,6
Annual operating cost (R million) (2)	17,6
NPV cost (R million)	1131,0
Unit reference value (R/m^3)	2,3

1. Update URV using a discount rate of 8%.
2. Excludes water treatment costs.

5. ECOLOGICAL

The lower Berg River is in a poor ecological state, however, the Berg River estuary is of considerable ecological value and of major importance to birdlife at regional and national levels. Maintenance of the estuary requires that the wetlands are flooded during winter floods.

The construction of a 27 m high dam wall in the vicinity of the Misverstand weir would result in an additional 3000 ha of agricultural land (vineyards and wheat fields) being inundated. The construction of a transfer pipeline to the Twenty Four Rivers canal would also result in the temporary destruction of productive agricultural land.

6. SOCIO-ECONOMIC

The construction of the new dam at Misverstand would result in large areas of productive agricultural land, infrastructure and a resort being flooded, which is likely to have an impact on the economy, which is considered to be of medium significance.

Canoeing, and most notably the Berg River Canoe Marathon, is likely to be affected by the reduced flows in the lower Berg River. This impact is considered to be of low significance.

7. OTHER ISSUES

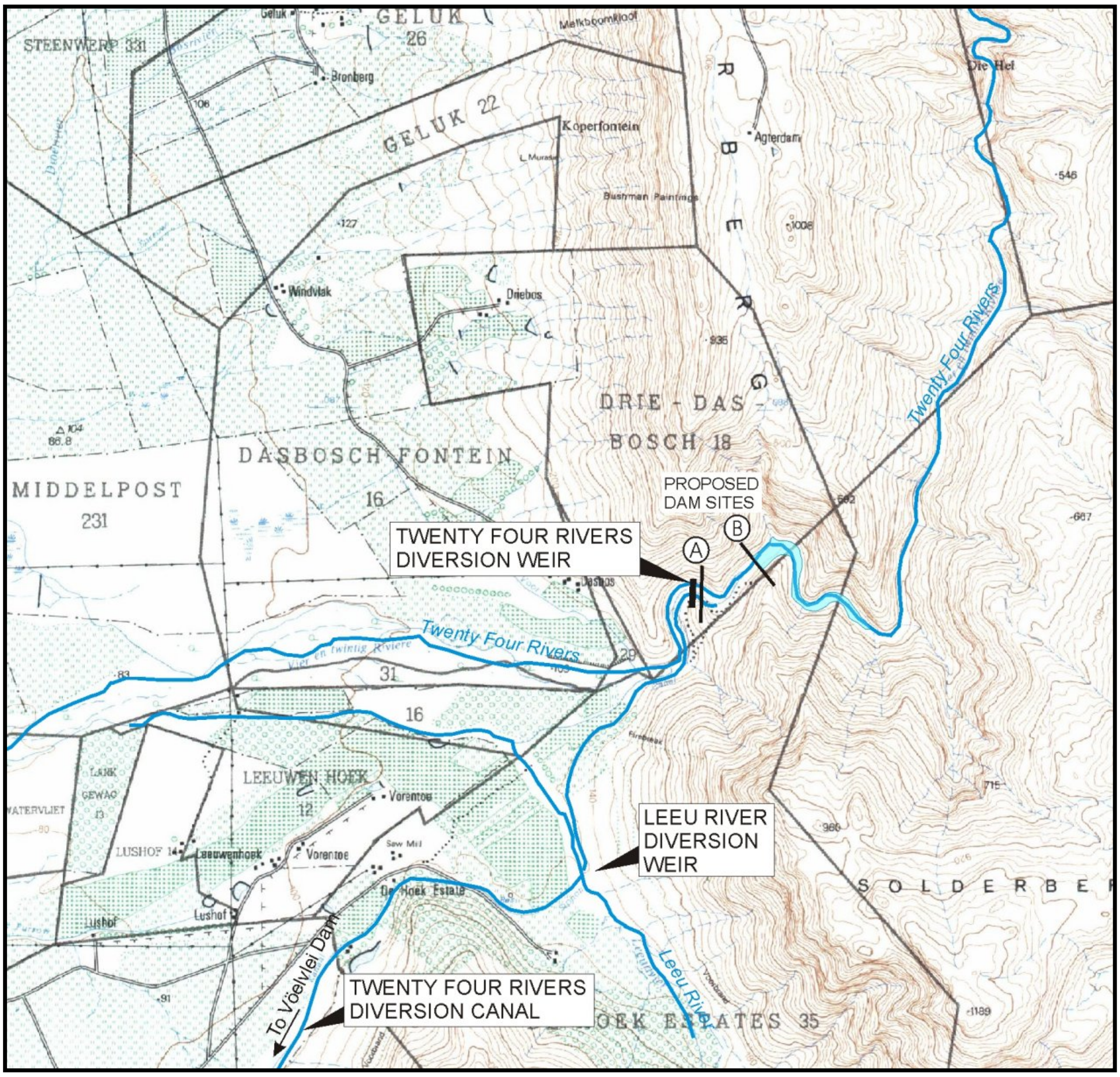
The strengths and weaknesses of the project are :

- **Strengths**
  - The scheme could either be integrated with Voëlvlei Dam or used to supply the West Coast only.

- **Weaknesses**
  - Reducing flow in the Berg River would impact the downstream water quality.
  - There would be inundation of extensive areas of vineyards, wheat fields, homesteads, a resort and recreation facilities.
  - The reduced downstream flows will affect recreational activities such as canoeing.
  - A large dam may have thermal stratification problems.
  - Water in the dam would have slightly elevated salinity levels compared with current abstractions from Misverstand Weir.

G8. Twenty Four Rivers Dam

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Information presented is drawn from the Kwezi V3 (2003) report, *Pre-feasibility Study of the Potential Water Sources for the area served by the West Coast District Municipality - Phase I* and the currently ongoing Phase II of the same study.

The Twenty Four Rivers Dam would function as a balancing reservoir to improve the efficiency of the current diversions into Voëlvlei Dam. Of the options investigated in the West Coast Study, a 21 m high rockfill dam of 1 million m^3 capacity, located at the existing diversion site, appears to be the most favourable option.

3. SCHEME YIELD

Initial estimates suggested that the balancing storage provided by a 1 million m^3 rockfill dam would increase the yield of Voëlvlei Dam by 4,9 million m^3/a. However, this was based on an EWR of 2,4 million m^3/a (57% of MAR). Subsequently, a desktop Reserve estimate for a Class D river was determined. This indicated a higher EWR (winter low flow scenario = 5 million m^3/a) than previously determined and a resulting yield increase of only 1,8 million m^3/a, which has been assumed for the URV calculation.

4. UNIT REFERENCE VALUES

The potential financial costs for the 1 m^3/s rockfill balancing dam are :

ITEM	2004 COSTS (1)
Capital cost (million)	9,9
Annual operating cost (R million) (2)	0,02
NPV cost (R million)	9,0
Unit Reference Value (R/m^3)	0,63

1. Updated URV using a Discount Rate of 8%.
2. Costs exclude the water treatment costs.

5. ECOLOGICAL

The Twenty Four Rivers downstream of the existing weir is in a poor ecological condition, and is considered to be a D or E category river. Its ecological importance and sensitivity is, however, high.

The proposed dam in the vicinity of the existing weir would inundate some 20 ha of relatively undisturbed river and land, which is likely to support diverse riverine and fynbos communities. This impact is considered to be of a medium significance. Water would be transferred to the Voëlvlei Dam via the existing canal system, thereby requiring no additional disturbance.

The dam is likely to act as a barrier to the migration of fish between the main stem of the river and the upper reaches of the Twenty Four Rivers. The significance of this impact is considered to be low.

6. SOCIO-ECONOMIC

The additional water provided through this scheme would be transferred to the Voëlvlei Dam, from where it will be supplied to the City of Cape Town and the West Coast District Municipality. The provision of additional water is deemed to be of high significance.

7. OTHER ISSUES

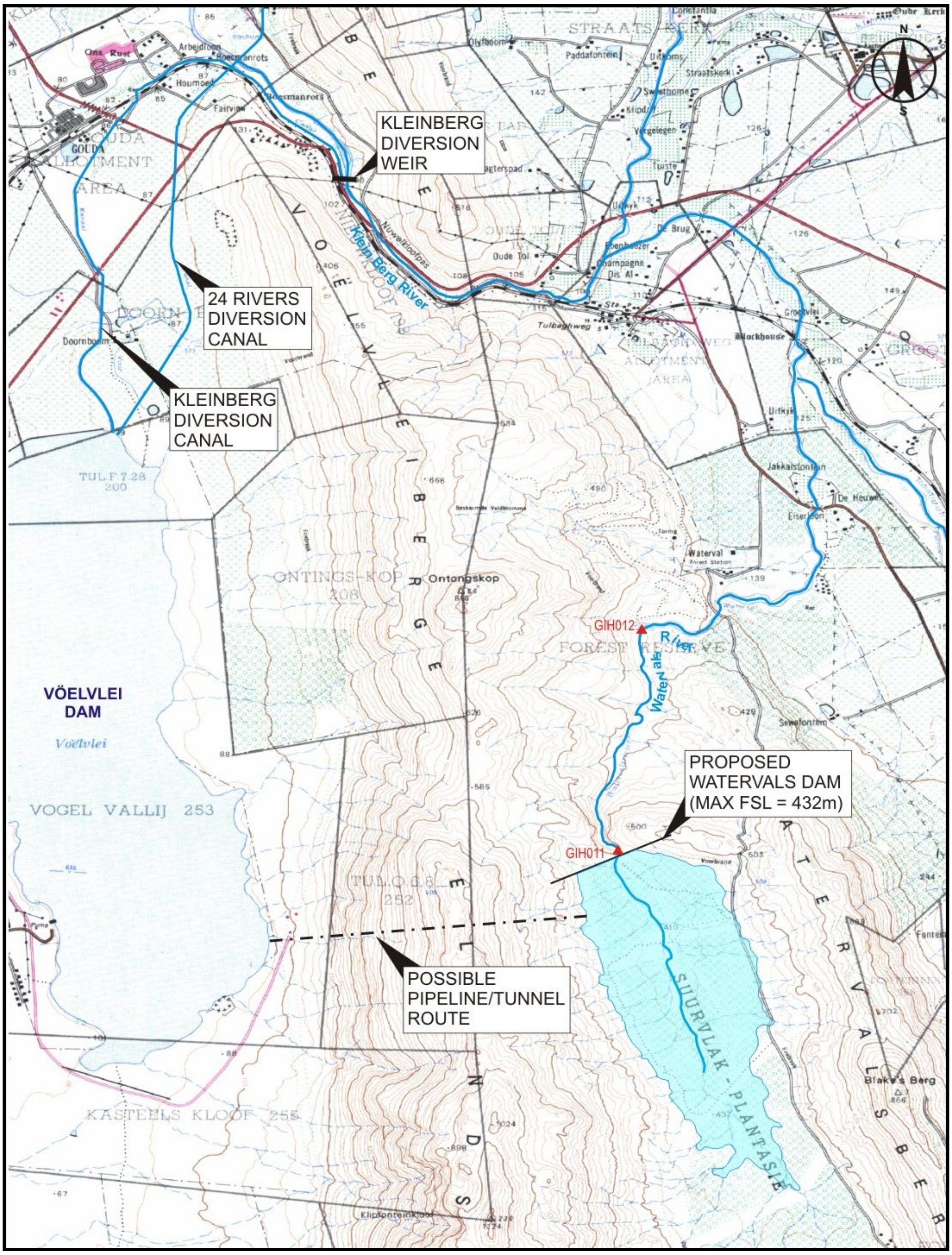
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Offers potential to either augment the West Coast or CCT;
  - Improved assurance of supply from the Twenty Four Rivers to Voëlvlei Dam.

- **Weaknesses**
  - The yield is sensitive to river classification and this has yet to be set.
  - Water is exposed to canal losses in the existing canal system, estimated to be about 15%.
  - Relatively high ecological impacts associated with inundation.

G9.Watervals River Dam

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Information presented here is drawn from the Kwezi V3 report (2003) *Pre-feasibility Study of Potential Water Sources for the Areas served by the West Coast District Municipality*.

The Watervals River Dam Scheme would involve the construction of a 12 million m^3 rockfill dam on the Watervals River, a tributary of the Klein Berg River. The maximum full supply level of the 14 m high dam would be 432 m. The water from the proposed Watervals Dam would gravitate underneath the catchment divide via a tunnel into Voëlvlei Dam. This was identified as the preferred option for conveying water from the potential Watervals Dam to Voëlvlei Dam.

3. SCHEME YIELD

It is estimated that the scheme could provide an increase to the firm yield of Voëlvlei Dam of 3,8 million m^3/a. The relatively low yield is attributed to the fact that the dam will reduce the volume of water currently available for diversion into Voëlvlei Dam at the existing Klein Berg River Diversion. The estimated yield does not account for the EWR, which is likely to be significant as the potential dam site lies upstream of a nature reserve. The required EWR releases are likely to further reduce the yield benefit.

4. UNIT REFERENCE VALUES

ITEM	ESCALATED TO 2005 @ 7%/a (1)
Capital cost (R million)	45,9
Annual operating cost (R million)	0,1
NPV cost (R million)	42,0
Unit reference value (R/m^3)	1,46

1. Update URV using a Discount Rate of 8%.
2. Excludes water treatment costs.

It is likely that much of the yield gain would be to be allocated to meeting the Reserve. Consequently, the URV could be expected to increase significantly once the Reserve is implemented.

5. ECOLOGICAL

The Watervals River is a tributary of the Klein Berg River. The EWR was determined assuming a PES of A/B, as the PES was unknown.

The proposed dam would flood some 160 ha of land, largely comprising the Suurvlak plantation, and some pristine mountain fynbos and high altitude seeps. The requisite transfer tunnel would cross areas of pristine mountain fynbos and renosterbos adjacent to Voëlvlei Dam.

6. SOCIO-ECONOMIC

The impacts on the Suurvlak forestry may result in some socio-economic impacts. However, Mountain-to-Ocean (formerly SAFCOL) proposes to discontinue the Suurvlak Plantation. Therefore, the effects of the proposed dam would be small.

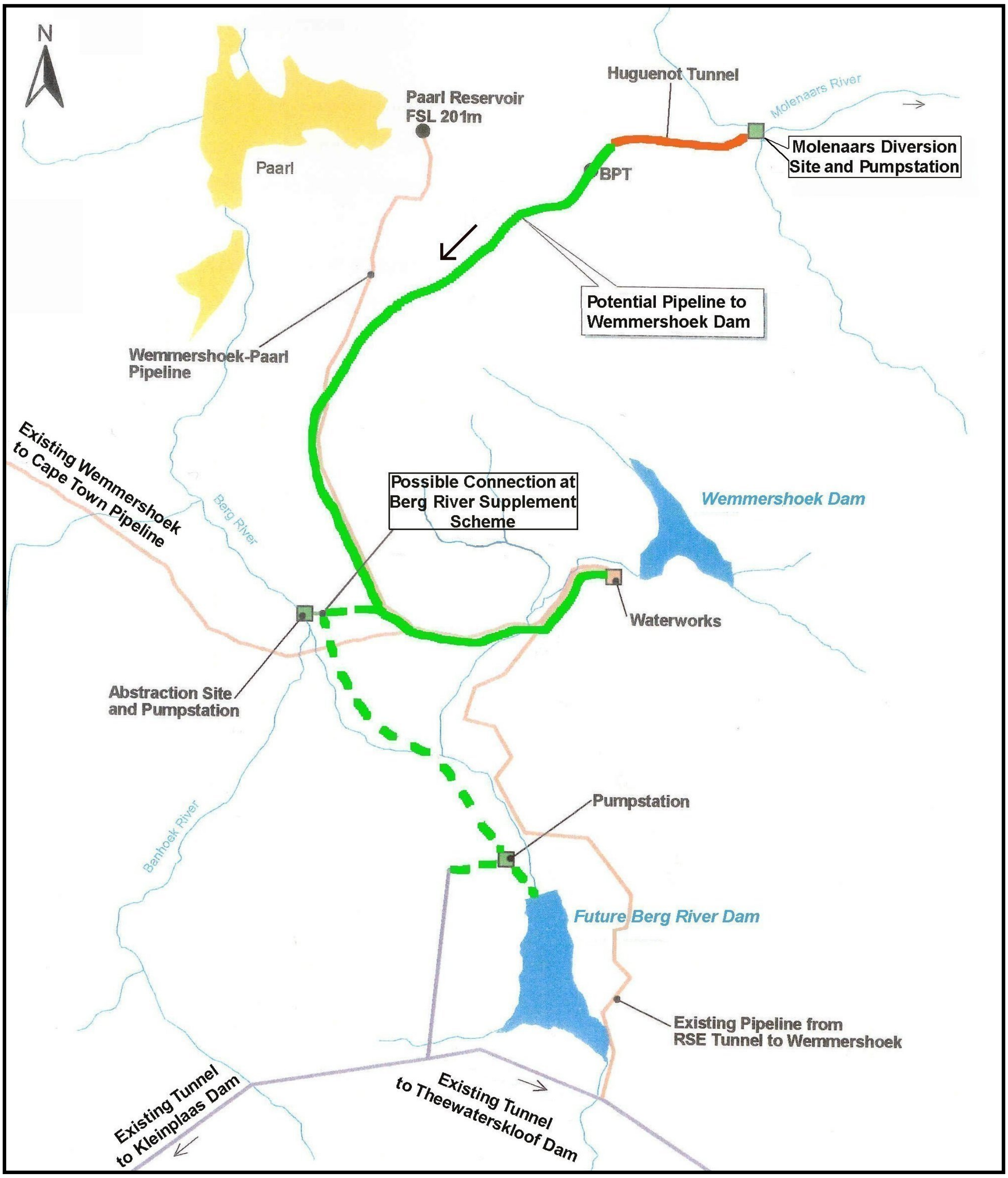
7. OTHER ISSUES

- **Strengths**
  - Scheme can be integrated with Voëlvlei Dam.

- **Weaknesses**
  - Information presented is based on a pre-feasibility study.
  - Further studies beyond this phase may alter the current view of the scheme significantly in terms of yield.
  - Constructing a dam on the Watervals River could significantly impact the downstream water quality.
  - The scheme yield is low and may even reduce after the ERWs are set.
  - From an economic point of view, the Watervals River Dam is expensive, relative to other options for augmenting Voëlvlei Dam.

G10. The Upper Molenaars Diversion

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

Unless otherwise stated, the information presented for this scheme is taken from the DWAF's Breede River Basin Study of 2004: Report No PH 00/00/2702 – *Regional Scheme Development Options and their Environmental Implications;* Report No. 18464USO - *Pre-feasibility Study of Potential Water Sources for the Area Served by the West Coast District Municipality.*

This scheme comprises the construction of a pumping sump in the Molenaars River and adjacent pump station. Winter flows would be pumped to the east portal of the existing Huguenot Tunnel and conveyed under gravity from there through the existing 1,2 m dia. pipeline in the tunnel to the west portal. Thereafter, water would be conveyed under gravity via a new pipeline of approximately 26 km from the west portal to Wemmershoek Dam. The diversion capacity would be 5 m^3/s.

As an alternative, a similar option would be possible for gravitating the water to the Berg River Dam via the Supplement Scheme, either in a new separate pipeline or in a larger supplement scheme pipeline. For the purposes of costing, a separate pipeline has been assumed.

3. SCHEME YIELD

The optimum scheme would yield about 27 million m^3/a, after allowing for Ecological Water Requirements (EWRs), for a Class "B" river at the diversion site.

4. UNIT REFERENCE VALUE

The potential financial costs for the scheme are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)	
	To Wemmershoek	*To Berg R Dam*
Capital cost (R million)	298,8	345,21
Annual operating cost (R million) (2)	2,3	2,3
NPV Cost (R million)	156,1	179,0
Unit Reference Value (R/m^3) (3)	1,12	1,28

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.
3) Does not include the cost of additional pumping capacity required to maintain the yield of Brandvlei Dam.

The URV of the scheme amounts to 1,12 R/m^3. For the alternative conveyance of water to the Berg River Dam, the pipeline length would increase by about 4,5 km, with an estimated URV of about 1,28 R/m^3.

The Molenaars Scheme would have some impact on the existing diversions into Greater Brandvlei Dam and on the potential additional yield of the dam. This impact was not determined during the BRBS or DWAF's study of sources to serve the West Coast District Municipality.

5. ECOLOGICAL

Since the proposed scheme does not require the construction of a dam or weir in the Molenaars River, the impacts on the terrestrial environment due to inundation are likely to be negligible. The requisite pipeline from the Huguenot Tunnel to the Wemmershoek Dam would traverse limited areas of indigenous vegetation, and therefore this impact is likely to be of low significance.

The Molenaars River is rated as Category 1 Ecological Importance and forms part of the 10% core of perennial foothill rivers in the Fynbos Bioregion earmarked for conservation. Furthermore, the Moolenaars River is the only major foothill river in the south-western Cape that is in relatively good condition.

Since the scheme does not result in an in-channel obstruction, the impacts on the Molenaars River should be of a minor significance and mitigatable. The scheme is likely to have a small impact on major floods, and thus on the annual flooding of the Papenkuils Wetlands. This impact is considered to be of low significance. Furthermore, the scheme is unlikely to have any impacts on downstream water quality, due to the small volumes that would be abstracted, provided that the EWR is satisfied.

However, the cumulative impact of the existing and proposed water resource developments on the ecological functioning of the lower reaches of the Breede River and its estuary are of concern.

6. SOCIO-ECONOMIC

The proposed scheme would have no impact on the recreational activities that currently take place on the Molenaars River (trout fishing and white water rafting) since there would be no obstruction to the flow in the river. The sense of place would be slightly affected as the pump sump would comprise a building and pump station but this is close to the road and the Huguenot Tunnel infrastructure.

Due to the operating rules, the proposed abstraction is unlikely to affect current irrigation operations in the Breede River valley. However, the water diversion may foreclose some of the potential further irrigation development in the Breede River Valley. This impact is considered to be of low significance.

The scheme would, however, augment the yield of either the Wemmershoek or the Berg River Dam, which would have a positive impact for the Cape Metropolitan Area and the Berg Water Management Area. This positive impact is considered to be of medium significance.

If the reduced yield in Brandvlei Dam is not reinstated by the provision of additional pumping capacity at the Papenkuils Pump Station then there would have significant adverse impacts on irrigators and their associated communities.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include :

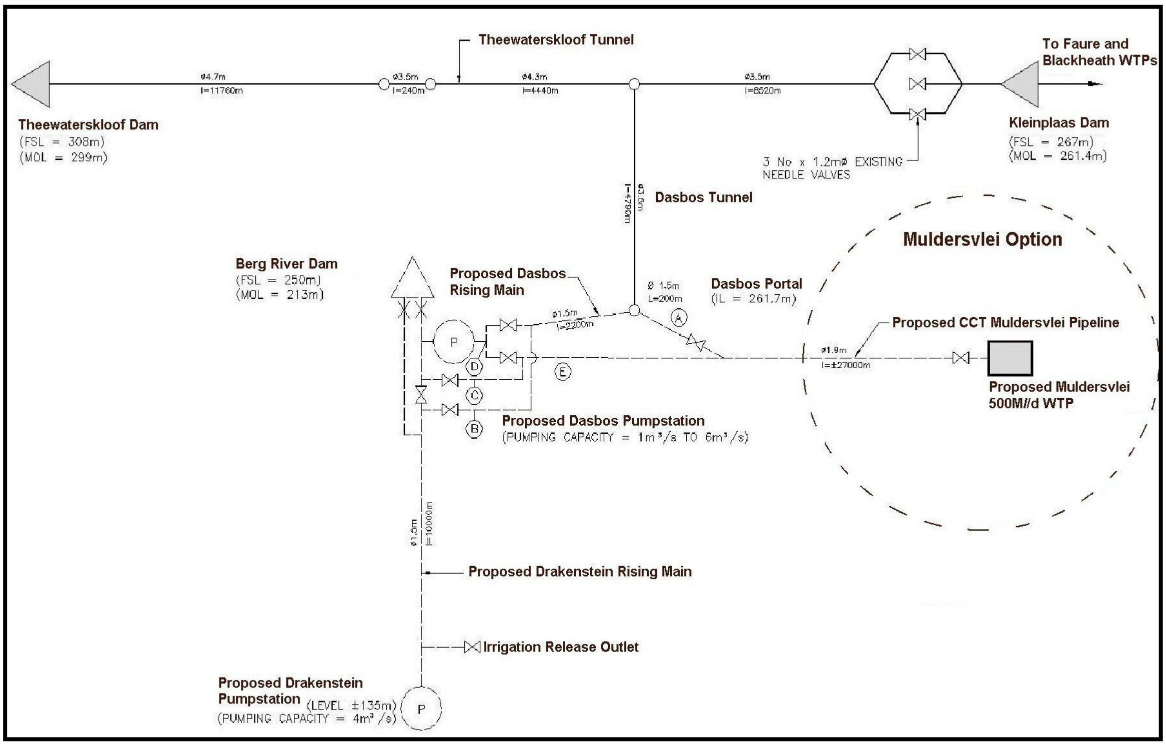
- **Strengths**
  - Pipework through Huguenot Tunnel is already in place;

- Storage in the Wemmershoek or Berg River Dams offers some reduced risk in the event of the RSE tunnel being closed;
- No weir should be required across the Molenaars River.

- **Weaknesses**
  - Some aesthetic impacts in Du Toits Kloof and along the pipeline route;
  - Less water available for existing irrigation from Greater Brandvlei Dam and in the Breede River Valley unless pumping capacity at Papenkuils is increased.

G11. Muldersvlei Optimisation Scheme

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

This option forms part of the potential enhancement of the current Berg Water Project (BWP) and has recently been investigated by the CCT. While it offers no benefit in terms of increasing the BWP yield (81 million m^3/a), it does offer a potential financial saving to the CCT. This would be achieved via the construction of a new 500 Mℓ/day water treatment works at Muldersvlei which would be primarily fed under gravity from the Berg River Dam (BRD). Pumping would only be required when the storage in the BRD drops to about 30% of its Full Supply Capacity. The scheme offers the opportunity to utilise better quality water from the BRD, rather than from Theewaterskloof Dam, with significant savings in water treatment costs.

3. SCHEME YIELD

No additional yield.

4. UNIT REFERENCE VALUE

This has not been determined. It has however been estimated that up to 56 million m^3/a could be supplied from the BRD, with a unit cost water treatment saving of R0,20/m^3. This equates to annual cost saving to the CCT of about R11,0 million/a.

5. ECOLOGICAL

The benefit of this scheme is that it offers the opportunity to avoid having to mix Theewaterskloof water (lower quality) with good quality Upper Berg River water in the BRD. The Theewaterskloof water would be used to supply irrigation by making releases from the tunnel into the Berg River lower downstream. This would however perpetuate the current ecological impacts associated with releasing Theewaterskloof water in summer. The flexibility is however retained in being able to still make irrigation releases from the BRD and to supply the new water treatment works at Muldersvlei, from Theewaterskloof Dam.

The impacts of the pipelines, WTW and storage reservoir are not significant.

6. SOCIO ECONOMIC

Some impacts on landowners and agriculture are anticipated, as well as some visual impacts and impacts on the sense of place in the vicinity of the WTW.

7. OTHER ISSUES

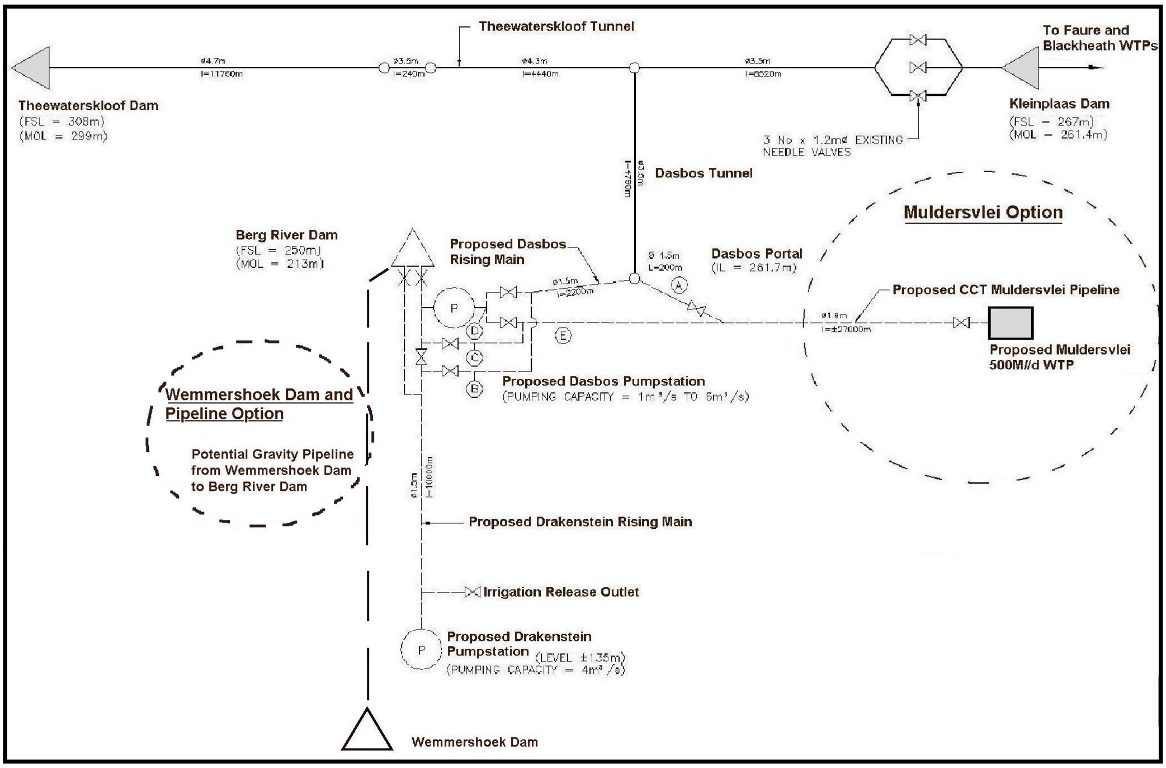
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Easily integrated into the Western Cape Water Supply System;
  - Is financially attractive;
  - Can be simultaneously implemented with the BWP;
  - Offers operational flexibility in terms of releases and reduces reliance on at least part of the RSE tunnel.

- **Weaknesses**
  - Requires a redesign of the Dasbos Adit pipeline to accommodate increased flow velocities;
  - Has no water quality benefit for the Berg River aquatic ecology or abstractors.

G12. The Wemmershoek Dam and Pipeline

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

This option forms another potential enhancement to the Berg Water Project (BWP) and has been investigated recently by the CCT. It has been identified that an additional yield of 5 million m^3/a is available from within the catchment of Wemmershoek Dam. The dam currently supplies water to Cape Town and to Paarl and Wellington, via a gravity pipeline from the Wemmershoek WTW, situated just downstream of the dam. The WTW is also supplied with water out of Theewaterskloof Dam via a pipeline (Wemmershoek Pipeline) leading from the Riviersonderend-Berg-Eerste Tunnel.

The potential exists to interconnect the Wemmershoek Dam and BRD directly so as to transfer surplus water from Wemmershoek Dam into the BRD, under gravity. In so doing the additional yield of 5 million m^3/a could be utilised.

Water from Wemmershoek Dam to the Berg River Dam would either be transferred by reversing the flow in the Wemmershoek pipeline or via a new pipeline about 12 km long. The periods of transfer are estimated to be about one or two months respectively for these options, but would also depend on the respective water levels in the two dams.

3. SCHEME YIELD

The scheme would yield 5 million m^3/a.

4. UNIT REFERENCE VALUE

(Not determined). The URV is expected to be low due the gravitational feed between Wemmershoek Dam and the BRD, with low associated operating costs.

5. ECOLOGICAL

From a water quality perspective, the scheme allows for water of similar quality to be transferred into the BRD from Wemmershoek Dam. The impacts of the additional pipeline are unlikely to be significant.

6. SOCIO ECONOMIC

Not assessed but expected to be insignificant.

7. OTHER ISSUES

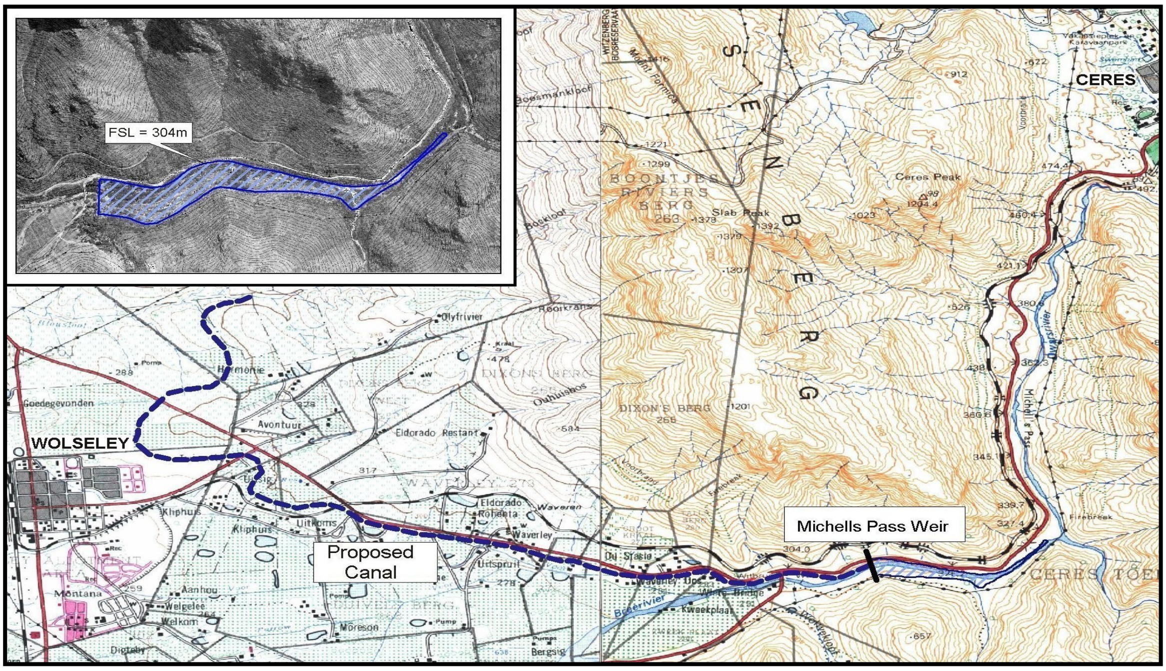
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - The scheme operation (gravity) is cost effective;
  - It can be implemented without impacting on the design of the BRD supplement scheme.

- **Weaknesses**
  - Not determined.

G13. The Michell's Pass Diversion

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information presented for this scheme is taken from two sources, namely :

- DWAF's Breede River Basin Study (BRBS) of 2004: Report No PH 00/00/2702 – *Regional Scheme Development Options and their Environmental Implications*.
- DWAF's *Pre Feasibility Study of Potential Water Sources For the Area Served by the West Coast District Municipality.* Report No 18464USO.

A 10 m high weir on the Dwars River (Upper Breede) would divert winter water via a 9 km canal across the catchment divide, into a tributary of the Klein Berg River. The existing Klein Berg diversion weir and canal would then divert the water into Voëlvlei Dam. The BRBS assessed three diversion capacities at Michell's Pass, namely 4, 8 and 12 m^3/s. The scheme could alternatively also supply the West Coast area through a sharing of the resource.

3. SCHEME YIELD

The BRBS investigated the following scheme yields for the Michell's Pass diversion.

- 4 m^3/s diversion - 36 million m^3/a
- 8 m^3/s diversion - 52 million m^3/a
- 12 m^3/s diversion - 60 million m^3/a

The yields take account of the requirements of existing downstream users, and to at least maintaining present day flows for meeting EWRs. However, the effects on the diversion into Brandvlei Dam would be significant, as discussed below. The potential cost of a second pipeline to Cape Town from Voëlvlei Dam has not been taken into account. It is considered that the yield could be fully utilised (within existing infrastructure) by Cape Town, the growing West Coast regions and the current shortfalls on Voëlvlei Dam.

The West Coast Study investigated a 1m^3/s pumping diversion at Michell's Pass and found the effective increased yield from Voëlvlei Dam (11 million m^3/a) to be adequate to meet the projected West Coast District Municipality's water demands (up to 2022).

For a 1 m^3/s diversion at Michell's Pass, the following impacts on the yield of Greater Brandvlei Dam could be expected.

- A yield reduction of 6 million m^3/a (assuming the existing 5 m^3/s Papenkuils abstraction), which could be recovered by increasing the Papenkuils Diversion capacity from 5 to 6,4 m^3/s.
- A yield reduction of 11 million m^3/a (assuming the potential 20 m^3/s Papenkuils abstraction), which could be recovered by increasing the potential diversion capacity from 20 to 23,7 m^3/s, without providing additional storage.

4. UNIT REFERENCE VALUE

The potential financial costs for the 8 m^3/s Michell's Pass diversion scheme (yield of 52 million m^3/a) are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	77,3
Annual operating cost (R million) (2)	0,2
NPV Cost (R million)	38,2
Unit Reference Value (R/m^3)	0,15 (3)

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.
3) Excludes the cost of additional pumping capacity into Brandvlei.

The URV of the 8 m^3/s diversion scheme amounts to 0,15 R/m^3, assuming present day river classes downstream and excludes water treatment.

5. ECOLOGICAL

The present ecological status of the Breede River in the vicinity of the weir is a Category D/E. However, the river in the vicinity of Michell's Pass is an example of a rare foothill rejuvenation zone. The weir is unlikely to have an effect on the downstream environment, due to its small capacity, but lotic habitat would be created upstream of the weir for some 1.5 km. This may create habitat for the small-mouthed bass, threatening survival of the indigenous fish. This impact is however considered to be of low significance. Furthermore, the scheme is unlikely to have an impact on the Breede River estuary, as the volume of water to be abstracted is very small.

The construction of a 10 m high weir is likely to flood an area of some 15 ha. The area consists of fynbos that is recovering after the removal of alien vegetation. The construction of the transfer canal is likely to disturb some 130 ha of land, which is not considered to be of ecological importance. Therefore the significance of this impact is considered to be low.

The Breede River valley is heavily utilised as a source of water for irrigation and domestic consumption. The lower reaches of the Breede River have poor water quality along its middle and lower reaches due to irrigation return flows during the summer, but water quality is good during the winter months when the diversion would take place. Abstraction at the weir may result in further elevated phosphate and salinity levels. However, provided that the EWR is satisfied, the significance of this impact is likely to be low.

The effects of the scheme may be greater for the receiving environment, since the transfer of water will result in elevated winter flows in the Klein Berg River. Furthermore the scheme may result in the transfer of organisms into the Berg River catchment.

6. SOCIO-ECONOMIC

The construction of the canal would result in crossings of various access tracks and footpaths. The scale of this impact is, however, small and is deemed to be of low significance. The weir is likely to lead to the inundation of an old road into the Tierhoekkloof tributary. The importance of the road is unknown, and the significance of the impact is considered to be low.

The land surrounding the weir site is presently uncultivated, and the canal would lead to the loss of some productive land. However, existing agricultural users would not be impacted by the abstraction of water. The impact to agriculture is expected to be of low significance.

There are currently no recreational activities taking place at the proposed weir site. However, the construction of the weir may result in opportunities for fishing. Furthermore, the proposed scheme would increase the amount of water available in the Berg Water Management Area, and would allow for increased transfers from Voëlvlei Dam to Cape Town or to the West Coast area. This impact is considered to be of a high significance.

If the reduced yield of Brandvlei Dam is not reinstated by the provision of additional pumping capacity at the Papenkuils Pump Station, then this would have significant adverse impacts on irrigators and their associated communities.

7. OTHER ISSUES

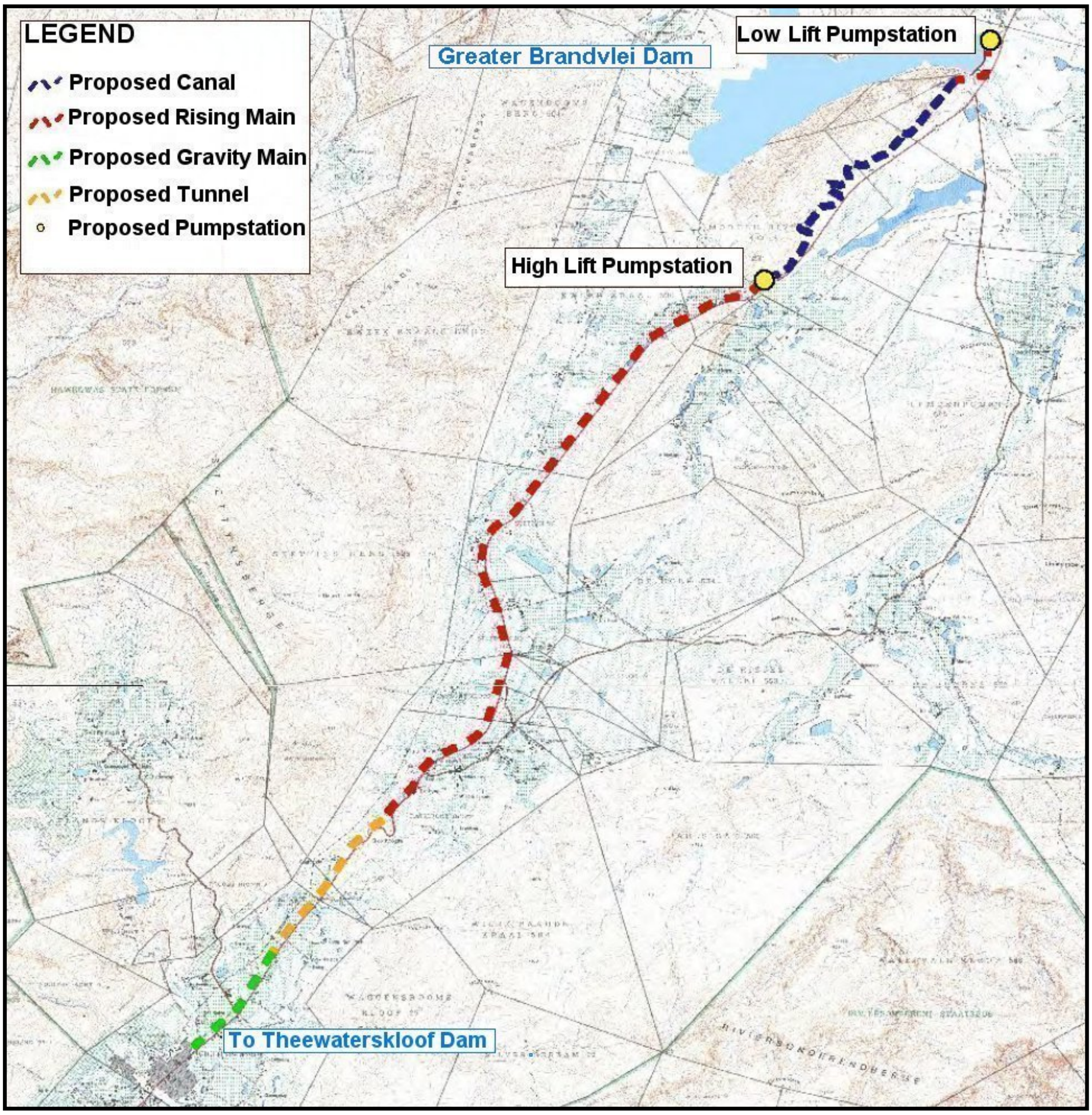
Specific strengths and weaknesses of the scheme include :

- **Strengths**
    - Versatile in terms of augmenting supply to Cape Town, the West Coast or both;
    - Scheme can be integrated into the WCWSS;
    - Water quality is good;
    - Potential to augment stressed local supply schemes at Wolseley and Tulbagh.

- **Weaknesses**
  - May require additional pipeline to Cape Town;
  - Existing diversion infrastructure on Klein Berg River will re-quire upgrading;
  - Impacts of diversions > 1 m^3/s on the yield of Greater Brandvlei Dam are not yet assessed, but would adversely affect existing irrigation unless pumping capacity at Papenkuils is increased;
  - Diversion capacity is limited to prevent inundation of the Witels River, upstream of the diversion weir;
  - Risks to the Berg River system due to the transfer of excessive water and organisms;
  - Severe impact on further irrigation development out of Brandvlei Dam.

G14. Linking Brandvlei Dam to Theewaterskloof Dam for transfer

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information presented for this scheme is taken from DWAF's Breede River Basin Study (BRBS) of 2004: Report No PH 00/00/2702 – *Regional Scheme Development Options and their Environmental Implications*.

This scheme is based on the potential transfer of water from Greater Brandvlei Dam (GBD) to Theewaterskloof Dam (TWK), via a combination of pipelines, a canal and a tunnel. The scheme relies on the augmentation of GBD, of which the option to increase abstraction into the dam from the Papenkuils run-of-river abstraction site appears to be the most economical. After supplying the demand of existing GBD users, spare water would be transferred to Theewaterskloof for direct transfer from Theewaterskloof to the CCT.

A delivery rate of 2 m^3/s was adopted in the BRBS.

3. SCHEME YIELD

The incremental yield of this scheme is estimated to be 41 million m^3/a. This takes into account the compensation flows (5 m^3/s) required downstream of the abstraction site, as well as any additional releases from GBD required to meet the EWRs of the closest downstream IFR site (Le Chasseur). The current EWRs for the Lower Breede River (Class "C") and its estuary (Class "B") are almost entirely met through present day flow conditions.

4. UNIT REFERENCE VALUE

The BRBS did not take water treatment costs into account when assessing the URV. The potential financial costs (including the costs associated with the Papenkuils Pump Station) are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	426,8
Annual operating cost (R million) (2)	15,2
NPV Cost (R million)	282,9
Unit Reference Value (R/m^3)	1,40

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.

5. ECOLOGICAL

Raising of the Papenkuils weir would directly affect the Papenkuils wetlands, by exacerbating the impact of abstraction and storage in the Greater Brandvlei Dam (GBD). This may result in a change to plant communities and species phenological responses downstream of the weir. These are considered to be significant impacts. The construction of the pipelines and canals may impact on the rare coastal Renosterveld and Sand Fynbos. These impacts are, however, deemed to be of low significance.

A major concern of the proposed scheme would be the impacts associated with the inter-basin transfer (IBT). Impacts associated with the IBT include, *inter alia,* differences in water quality between the GBD and Theewaterskloof Dam and the risk of transferring fauna and flora to the Theewaterskloof Dam and conceivably into the upper reaches of the Berg River. Plant species of concern include propagules of the exotic Kariba weed. Furthermore, the discharge of up to 2 m^3/s of water into the Elands River is likely to result in erosion of the existing channel, with further impacts on the degraded riverine ecosystem. The impacts for the receiving environment are deemed to be of medium to high significance.

6. SOCIO-ECONOMIC

Additional water sent to Theewaterskloof Dam would be transferred directly to the Western Cape Water Supply System. This positive impact is considered to be of a medium to high significance.

The volume of water to be abstracted is small and water would only be transferred to Theewaterskloof Dam once the demands of existing users of the GBD have been met. Therefore, the impact on existing users is negligible, and this impact is deemed to be of low significance.

Recreational activities on the Brandvlei Dam may be affected by the increased fluctuation of water levels in the dam, due to the proposed scheme.

The implementation of this scheme would preclude further irrigation development out of GBD in the Breede River catchment. The Breede ISP has suggested that this scheme not be considered as a transfer option, but that GBD continue to serve the users in the Breede River catchment.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include :

- **Strengths**
    - Scheme can be integrated into the WCWSS with no additional infrastructure requirements;
    - Scheme utilises the significant storage capacity available in both Brandvlei and Theewaterskloof Dams.

- **Weaknesses**
    - Theewaterskloof water quality will be impacted by higher colloidal bearing water from Greater Brandvlei Dam;
    - More cost effective potential surface water schemes are possible;
    - Scheme has a high operating cost component;
    - Severe impacts on further irrigation development out of Greater Brandvlei Dam;
    - Significant impacts on the Papenkuils wetland;
    - Risks of transferring organisms to the Theewaterskloof Dam, Riviersonderend River and the Berg River systems.

G15. Raising Theewaterskloof Dam

1. SCHEME LAYOUT

2. SCHEME DESCRIPTION

Theewaterskloof Dam on the upper reaches of the Riviersonderend River (Breede WMA) is owned by DWAF. It has a storage capacity of 434 million m^3/a (Ref: Breede River Basin Study) and is the largest storage dam within the Western Cape Water Supply System. The dam forms the heart of the Riviersonderend-Berg-Eerste (RSE) Government Water Supply System. It stores runoff from its own catchment as well as water transferred into the dam from the Upper Berg River catchments (Banhoek and Wolwekloof) and will be operated conjunctively with the Berg Water Project. The RSE scheme has a 1 in 50 year yield of 234 million m^3/a, of which about 161 million m^3/a is transferred into the Berg WMA. The remaining yield supplies irrigators along the Riviersonderend River via releases made from the dam. The Overberg Rural Water Supply Scheme (Overberg Water) is also supplied via releases, abstracted from the Riviersonderend River. There are no environmental releases from the dam.

The dam's capacity is equivalent to 1,7MAR. As such there is little benefit in raising it in terms of its own incremental runoff. From a water resource perspective, a raised Theewaterskloof Dam would add storage to the Western Cape System. However, transfers into the dam from potential schemes (such as the Brandvlei to Theewaterskloof Transfer), could be managed without a raising, by making transfers when there is spare capacity in Theewaterskloof and utilising those transfers immediately. Nevertheless, additional storage in the WCWSS will be required to balance seasonal supply and demand, and for drought carry-over, as many proposed schemes involve diversions with no additional storage by Lourens, Eerste, Molenaars, Michell's Pass, Voëlvlei Phase 1, etc.

It was recommended in the Breede River Basin Study (2003) that the potential raising of the dam should not be investigated in any detail due the significant extent of developed land and expropriation that would be required.

3. SCHEME YIELD

There would be no significant yield increase from the runoff within the catchment of the dam. Any potential yield increase would be dependant on the size of the potential transfer scheme/s delivering water from elsewhere into the WCWSS. Evaporation losses from the increased surface are would be significant.

4. UNIT REFERENCE VALUE

Not assessed.

5. ECOLOGICAL AND SOCIO-ECONOMIC

The raising of Theewaterskloof Dam would have a significant social impact due to the extent of land expropriation and potential water logging of adjacent areas. Specific concerns associated with a raising are:

- loss of wetlands upstream of the dam;
- the impacts on the riparian properties and structures on those properties;
- the social and economic impacts resulting from the loss of high value fruit crops;
- the effect of waterlogging on deciduous fruit trees located on riparian farms;

It was estimated in 1997 that the potential loss of foreign income as a direct result of a 1m raising would be in the order of R9 million per annum. Escalated at 7% per annum this equates to a current estimate of R16 million per annum, without taking fluctuations in foreign currency into account.

6. OTHER ISSUES

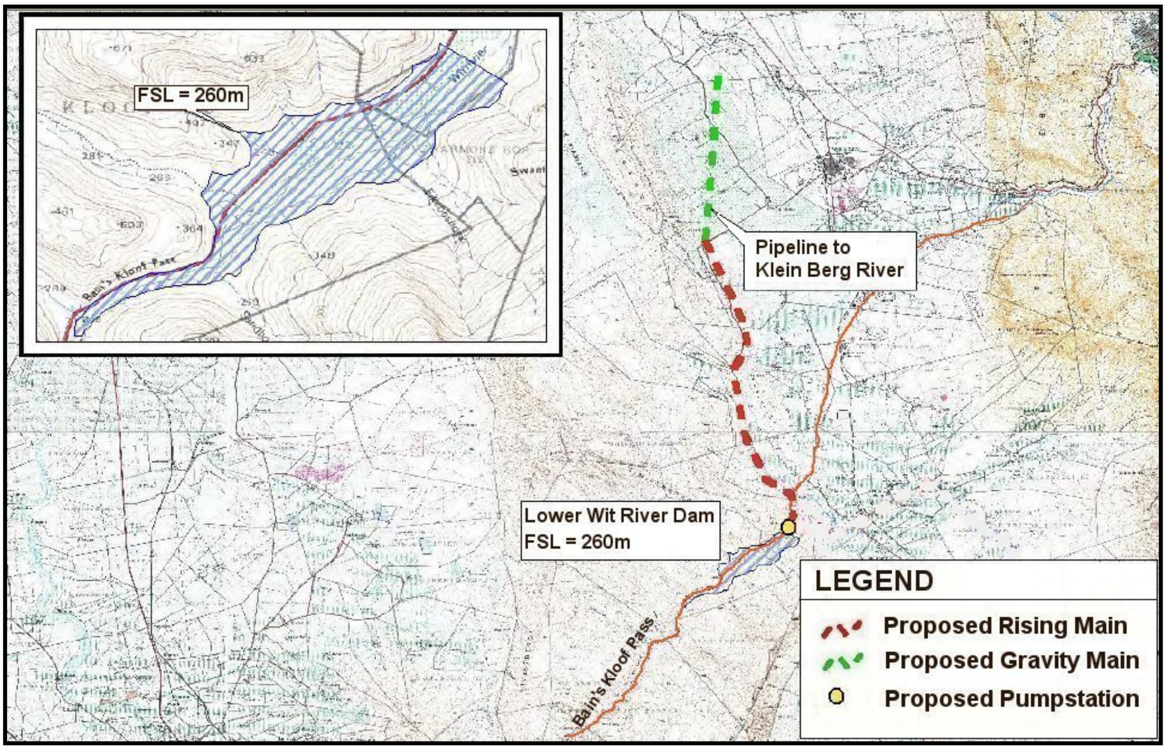
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - The spillway is of short crest length (75 m) and could be easily raised using a spillway gated system;
  - Raising would increase the storage availability within the System;
  - No significant ecological impacts.

- **Weaknesses**
  - Increased evaporation losses;
  - Severe socio-economic impacts (expropriation of high value crops);
  - Potential water logging of surrounding areas.

G16. Lower Wit River Dam

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information presented for this scheme is taken from DWAF's Breede River Basin Study (BRBS) of 2004: Report No PH 00/00/2702 – *Regional Scheme Development Options and their Environmental Implications*.

This scheme entails the construction of a rockfill dam at the bottom of Bain's Kloof on the Lower Wit River. To augment the WCWSS, water would be pumped through a static head of 23 m, at a rate of 1,2 m^3/s, via a rising main of 13 km, across the catchment divide. From the watershed to the point of discharge (the Brakkekloof River tributary of the Klein Berg River), it would be conveyed via a 6,5 km gravity pipeline (700mm dia) with available static head of 100 m. From here the water would flow into the Klein Berg River and be diverted into Voëlvlei Dam. The Lower Wit River Dam would store surplus winter water only, with inflow being released in summer for downstream users.

The BRBS investigate four potential dam capacities, ranging between 12 and 86 million m^3. It concluded that for this scheme, a dam of 24 million m^3 capacity appeared the most favourable option. The dam wall height would be 28 m and have a crest length of 737 m.

Approximately 7 km of the R43 through Bain's Kloof would have to be relocated, with the need for new bridges over both the Wit and Breede Rivers.

3. SCHEME YIELD

The EWRs at the closest downstream IFR site (Le Chasseur) would be maintained in accordance with present day flows for the existing "Class C/D" river at that site. For a 24 million m^3 capacity dam, the yield available via the potential transfer scheme would be about 29,5 million m^3/a.

The impact of the scheme on the pumping requirement at Brandvlei Dam was not assessed during the Breede River Basin Study, but should be taken into account.

4. UNIT REFERENCE VALUE

The BRBS did not take water treatment costs into account when assessing the URV. The potential financial costs are as follows :

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	333,6
Annual operating cost (R million) (2)	3,0
NPV Cost (R million)	176,1
Unit Reference Value (R/m^3) (3)	1,17

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.
3) Does not include the cost of additional pumping capacity to be provided at Papenkuils.

5. ECOLOGICAL

The construction of the proposed dam would inundate some 232 ha of pristine indigenous mountain fynbos, which would permanently displace a suite of mammals, reptiles and birds. The broader area is known to be inhabited by various Red Data species. Furthermore, the requisite pipeline and canal would impact on further areas indigenous vegetation and the canal would form a barrier to the movement of certain animals. These impacts are considered to be of medium significance.

The Wit River hosts three indigenous fish species namely the Burchell's redfin, the Cape Galaxias and the Cape Kurper. Furthermore, the Wit/Breede Rivers form an important migratory route for an eel species. The proposed dam would pose a barrier to the migration of the eel and the witvis, which migrate between marine and freshwater systems during their lifecycles. The impacts on the aquatic ecology are considered to be of high significance.

All of the ecological impacts associated with the transfer of water, described in the Michell's Pass Diversion option will apply.

6. SOCIO-ECONOMIC

The proposed dam is likely to impact on the recreational activities taking place in the Bain's Kloof valley, such as hiking and fishing. A number of tourism establishments would be inundated. This impact is considered to be of medium significance.

The dam would inundate portions of the Bain's Kloof Pass, a National Monument and other sites of cultural and archaeological significance. This impact is considered to be of medium significance.

The dam would inundate some agricultural areas, mainly vineyards. Small areas of agriculture would be lost due to the canal. Furthermore, some homesteads, resorts, farm roads, power lines and telephone lines would have to be relocated due to inundation.

The dam would change the aesthetics and sense of place of the Bain's Kloof Pass and valley. The relocation of the abovementioned infrastructure would further contribute to the visual impact of the scheme. This impact is considered to be of medium significance.

7. OTHER ISSUES

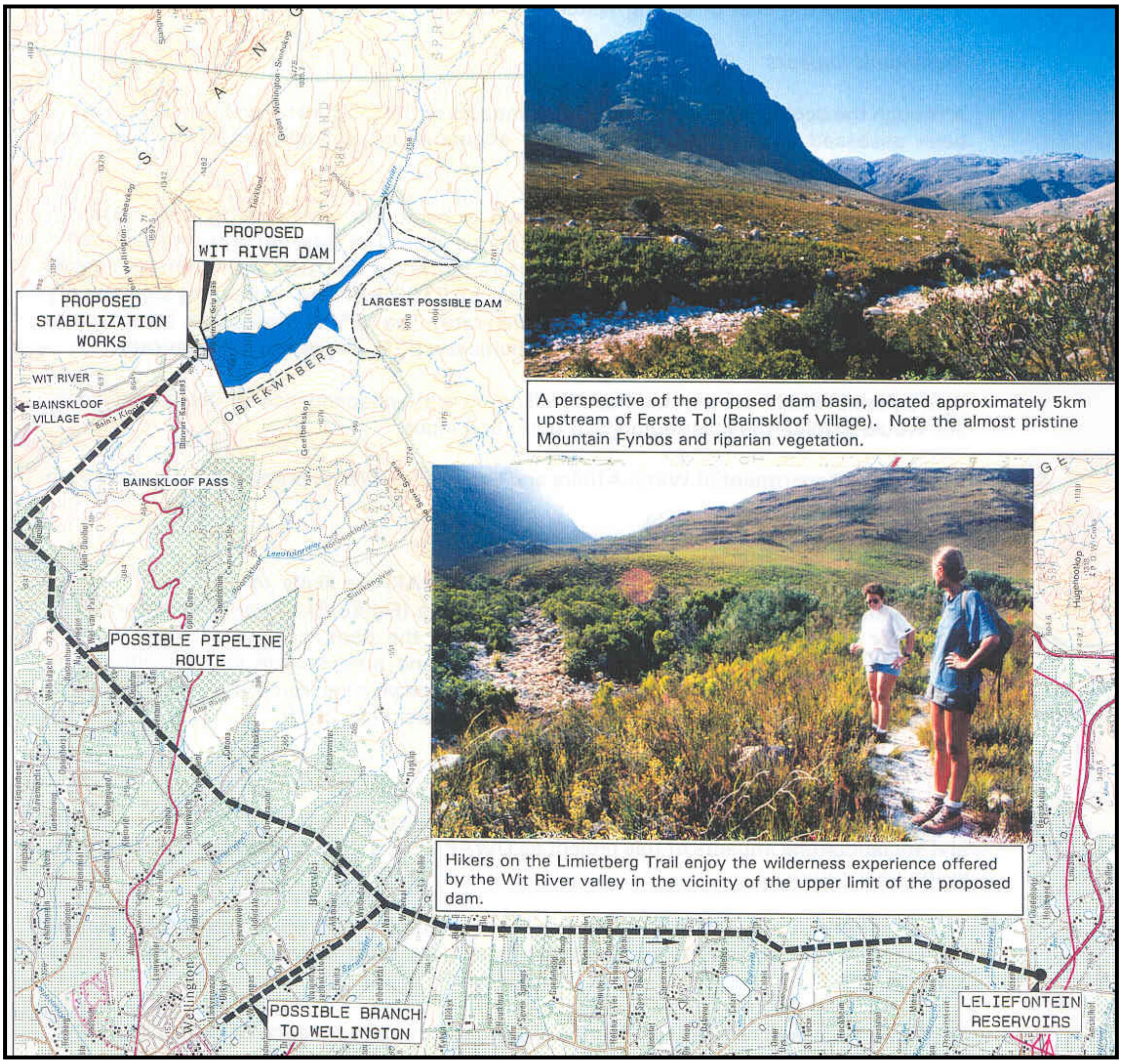
Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Scheme can be integrated into the WCWSS;
  - Water quality of source is high.

- **Weaknesses**
  - Significant relocation of infrastructure and new bridge construction;
  - High ecological impacts;
  - High socio-economic impacts;
  - Impacts on recreational activities and National Monument.

G17. The Upper Wit River Dam

1. SCHEME LAYOUT



A perspective of the proposed dam basin, located approximately 5km upstream of Eerste Tol (Bainskloof Village). Note the almost pristine Mountain Fynbos and riparian vegetation.

Hikers on the Limietberg Trail enjoy the wilderness experience offered by the Wit River valley in the vicinity of the upper limit of the proposed dam.

2. SCHEME DESCRIPTION

The information presented for this scheme is taken from the 1995 report by Ninham Shand entitled *The Upper Berg River Valley Water Supply*, (Report No: 2243/5794) and the Western cape System Analysis of 1994.

This local supply scheme could augment the supply to Paarl and Wellington, as well as irrigators in the Wellington area and along the Berg River. The scheme would relieve the pressure for additional water for Paarl and Wellington from the CCT's Wemmershoek Dam. The potential Upper Wit River Dam site is located 5 km upstream of Bainskloof Village (Eerste Tol). A 32 m high rockfill dam would have a crest length of 650 m, and would inundate 72 ha. This dam size was determined as being adequate to meet the projected water demands of Paarl and Wellington. The dam would store surplus winter that would be stabilised at the site, and then conveyed via a 500 mm dia, 17,5 km steel pipeline to Paarl's existing Leliefontein reservoirs. A 3 km long, 200 mm dia branch pipeline, would deliver water to Wellington.

The existing diversion weir at the dam site diverts about 5 million m^3/a during summer into the Berg WMA for irrigators near Wellington ("Gawie-se-Water scheme"). Compensation releases from the potential dam would be necessary to supply those farmers with established water allocations.

3. SCHEME YIELD

A 32 m high dam of 9 million m^3 capacity would yield about 12 million m^3/a. Whilst the scheme is based on the storage of surplus winter water, the extent of the surplus would need to be reassessed, taking the winter Reserve components into account. Summer flows in the river are currently reduced by diversions at the "Gawie-se-Water" abstraction site.

4. UNIT REFERENCE VALUE

The dam and pipeline are included in the URV calculation. The URV has been re-estimated to allow for escalation at 7% per annum.

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	100,3
Annual operating cost (R million) (2)	0,8
NPV Cost (R million)	110,0
Unit Reference Value (R/m^3)	0,75

1) Updated URV using a Discount Rate of 8%
2) Excludes water treatment costs.

5. ECOLOGICAL

The dam would inundate 72 ha of pristine indigenous fynbos and would permanently displace the associated animals, reptiles and invertebrates. The dam would also act as a barrier to the habitat of the indigenous fish species, namely *Burchell's redfin*, the *Cape bolaxas* and the *Cape Kurper* and could result in the introduction of black bass with adverse consequences. The barrier effect would also prevent the migration of eels and the witvis.

6. SOCIO-ECONOMIC

The dam basin would inundate the existing hiking tail and would have a significant impact on the sense of place of this pristine area.

The dam would inundate areas owned by Wellington Municipality and the Mountain Club.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - The scheme offers an alternative source of supply to Paarl and Wellington;
  - Water quality of the source is high, with only stabilisation required in terms of treatment.
  - For a larger dam, surplus water (over and above Paarl and Wellington's requirements) could be delivered into Wemmershoek Dam, via reversing the direction of pumping in the existing Wemmershoek to Paarl pipeline.
  - The scheme is likely to attract considerable public opposition.

- **Weaknesses**
  - The dam site is located in a pristine mountain fynbos area and the Wit River is of high conservation status.
  - Inundation upstream of the dam wall would result in the loss wilderness areas, cultural heritage sites and will impact on angling and hiking in the area.

G18. The Upper Wit River Diversion

1. SCHEME LAYOUT

2. SCHEME DESCRIPTION

This scheme serves as an alternative option to a dam on the upper Wit River Dam. The scheme would comprise a low weir on the Wit River and one of the following alternatives :

- Enlargement of the Gawie se Water diversion channel which was originally constructed in about 1900 and diverts water across the divide into the Kromme River tributary of the Berg River;
- A new diversion channel constructed adjacent to the original channel if it is decided that the existing channel should be preserved as a heritage site;
- Construction of a tunnel through the mountain to divert flow in excess of the Reserve from the Wit River into the Kromme River. This alternative has been costed. The diverted water would be stored in a dam to be constructed on the Kromme River at a site on the farm Doolhof. The water would be treated and pumped to Wellington and back to Paarl, reversing the flow in the existing pipeline as outlined for the Upper Wit River Dam Scheme. Water could also be reversed into the pipeline from Wemmershoek Dam to the city.

3. SCHEME YIELD

The yield of the scheme would be approximately 10 million m^3/a.

4. UNIT REFERENCE VALUE

The weir, tunnel, dam, pipeline and land acquisition are included in the URV calculation. The cost of pumping is also included.

ITEM	Escalated to 2005 (@ 7% /a) (1)
Capital cost (R million)	40
Annual operating cost (R million) (2)	2
NPV Cost (R million)	64,8
Unit Reference Value (R/m^3)	0,54

1) Discount rate of 8% used for the URV calculation.
2) Excludes the costs of water treatment.

5. ECOLOGICAL

The proposed weir on the Wit River would be similar to the existing gauging weir and therefore would not be a major obstacle to the migration of fish up the river.

The Reserve requirements of the Wit River would be met with little or no impact on floods. The flow in the Kromme River would be increased but in accordance with the normal seasonality. The dam on the Kromme River would act as a barrier and releases would be required to meet the Reserve.

Most of the area inundated by the Doolhof Dam is current cultivated land and therefore the environmental effect would not be significant.

6. SOCIO ECONOMIC

The socio-economic effect on the hiking trail next to the Wit River would be small, although the construction of the tunnel and the disposal of soil could prove unsightly.

The dam at Doolhof would inundate most of the existing farm, including the homestead and outbuildings. Therefore people would be displaced and the farm workers are likely to lose their source of employment. Therefore this impact is rated as significant.

7. OTHER ISSUES

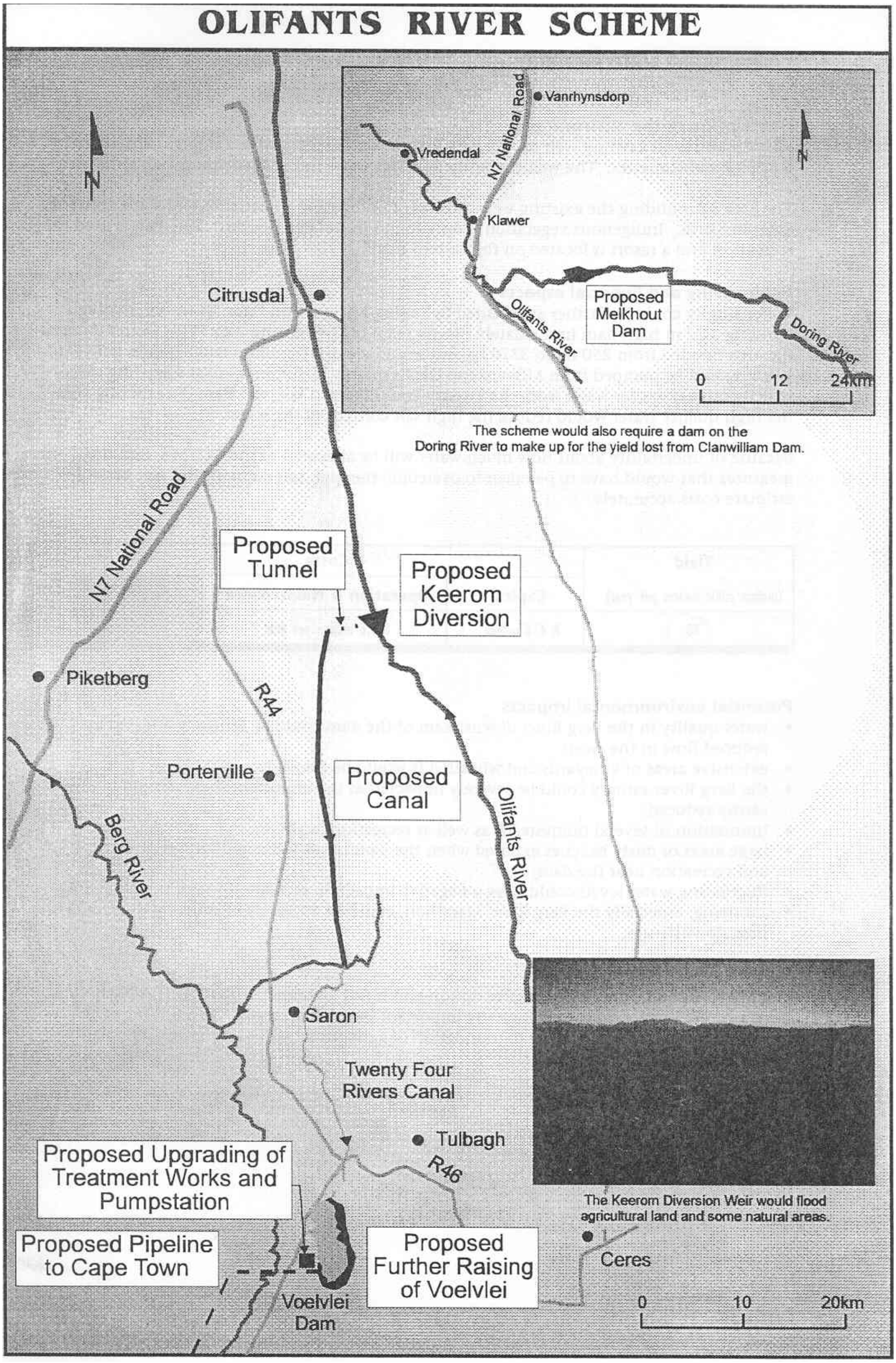
Specific strengths and weaknesses of the scheme included :

- **Strengths**
  - The scheme would require no storage on the Wit River;
  - The diversion would not compromise the Reserve and affect the flood plains.
  - The scheme would inundate very little indigenous natural fynbos.

- **Weaknesses**
  - The dam on the Kromme River would inundate the farm buildings and attenuated lands.
  - The displaced farmer and farm workers would lose their homes and their source of employment.
  - The yield of Brandvlei Dam would be reduced unless the pumping capacity at Papenkuils is augmented.

G19. The Olifants River Diversion

1. SCHEME LAYOUT



2. SCHEME DESCRIPTION

The information for this option is taken from the Western Cape System Analysis (1990s). The diversion would entail a 5 m high weir (1 million m^3 capacity) at the Keerom site on the Upper Olifants River. A tunnel of 34 m^3/s capacity would transfer winter water (120 million m^3/a) into the Berg WMA, where it would be conveyed via a new canal linking into the existing Twenty Four Rivers Canal, feeding into Voëlvlei Dam. Voëlvlei Dam would need to be raised if full advantage of the potential scheme yield were to be taken. A second pipeline from Voëlvlei Dam to Cape Town would also be required, as well as an additional water treatment works.

Furthermore, to recover the impact on the yield of Clanwilliam Dam, new sources of supply would be required from within the environmentally sensitive Doring River catchment. This would be necessary to ensure existing levels of supply to those irrigators downstream of the Olifants/Doring River confluence, currently supplied out of Clanwilliam Dam.

DWAF are currently investigating the feasibility of Raising Clanwilliam Dam. This appears a favourable option for augmenting the supply of water to irrigators in the Lower Olifants River catchment. If the Clanwilliam Dam-raising were to go ahead, the diversion of water out of the Upper Olifants River for transfer into the Berg WMA will become even less favourable.

3. SCHEME YIELD

The Olifants Diversion Scheme could yield about 90 million m^3/a after allowance for the EWRs (as estimated in the early 1990s). The yield would need to be revised once the Reserve for the Olifants River and estuary has been set.

4. UNIT REFERENCE VALUE

The WCSA determined a URV of R1,03/m^3 (1996) for a scheme yielding 90 million m^3/a. However, that cost estimate did not take the following into account:

- a potential new dam on the Doring River to offset the impact on the yield of Clanwilliam Dam;
- the raising of Voëlvlei Dam;
- the additional WTW infrastructure required at Voëlvlei Dam;
- water treatment costs;
- the cost of a second pipeline to Cape Town;

From the outset, this scheme does not appear favourable and as such no attempt has been made to update the URV, which would be significant.

5. ECOLOGICAL

The Olifants River Basin contains unique natural features that are important for conservation, such as the eight endemic fish species supported by the river system. The Ecological Importance and Sensitivity is rated as high, in the upper reaches of the Olifants River, in the vicinity of the proposed weir. Abstraction of winter water from the Olifants River would have a negative effect on the riverine ecosystem, which is already stressed.

The weir would flood some 50 ha of natural vegetation, including partial inundation of the Olifants River gorge, an important feature because of its geological and biological links to Gondwanaland. The significance of this impact is considered high. Furthermore the weir is likely to obstruct the movement of endemic fish to the upper reaches of the Olifants River. The construction of the canals would also result in a loss of some agricultural land. The significance of this impact is considered to be low.

The Doorn River is currently free of impoundments and is therefore important for conservation. The proposed scheme would require a dam to built on the Doorn River to supply water to irrigators in the lower reaches of the Doring River, which is likely to affect some 300 ha of natural vegetation, the migration of endemic fish and the conservation status of the river. This impact is considered to be of medium to high significance.

The impacts associated with raising Voëlvlei Dam are described in Voëlvlei Augmentation Phase II and III (Option G6).

6. SOCIO-ECONOMIC

The Olifants River gorge is deemed to be of great importance due to its geological and biological links to Gondwanaland, and inundation of the gorge was deemed to be unacceptable in previous studies. Consequently, the significance of this impact is considered high.

The construction of the canal would impact on farmers through loss of land and by reducing access to parts of farms. This impact is deemed to be of low significance.

7. OTHER ISSUES

Specific strengths and weaknesses of the scheme include :

- **Strengths**
  - Potential to supply significant additional yield.

- **Weaknesses**
  - Significant ecological impacts;
  - Likely to attract very significant public opposition;
  - High financial costs.

SECTION H

DESALINATION

H1. Desalination

1. SCHEME LAYOUT

The information presented is taken from the *City of Cape Town's CMA Bulk Water Supply Study* of April 2002. Two specific sites were investigated, at reconnaissance level, both of which are located on the West Coast. One site is at Melkbos and the other at Koeberg Nuclear Power Station. The two potential sites are shown in the figure below.

2. SCHEME DESCRIPTION

The two potential sites, although located in reasonably close proximity to one another, differ in their energy requirements. The Melkbos Site would utilise cold water whereas the Koeberg Site would utilise heated water. There is a benefit in utilising heated water (lower viscosity than cold water) in that it reduces the energy costs associated with the reverse osmosis process. Furthermore, water of constant temperature ensures a more efficient desalination plant than one in which the water temperature varies.

The CCT is awaiting the results of a study into the optimum site for a 0,5 Mℓ/d pilot plant. This plant will be utilised for up to 10 years and will serve as the first initiative towards further development of desalination as an option to augment the Western Cape Water Supply System.

Factors influencing site location include :

- locating the intake works at a favourable position on the coast and prefiltration requirements
- available inlet structure
- available energy supply
- potential to use heated water from Koeberg Nuclear Plant
- the availability of existing water conveyance infrastructure
- the location of water demand centres in relation to the desalination site
- the extent of post treatment to balance pH and increase alkalinity
- the return of brine to the sea.

The Blaauwberg area is one of the most rapidly expanding urban areas in the Western Cape and could benefit from the pilot desalination scheme, whilst reducing the current over-allocation on Voëlvlei Dam. The disposal of the resulting brine would be direct to the sea.

3. SCHEME YIELD

For the purposes of this assessment, a treated water output of 60 Mℓ/d (21,9 million m^3/a) was considered for both the Koeberg and Melkbos sites.

4. UNIT REFERENCE VALUE

The URVs for the two options were based on the 2002 cost estimates from the CCT's study. The URV calculation is based on a discount rate of 8%.

ITEM	Koeberg Site	Melkbos Site
Total capital cost (R million)	850	1 130
Annual operating cost (R million)	130	140
NPV Cost (R million)	1 855	2 188
Unit Reference Value (R/m^3)	9,8	11,6

Comment on URV calculations:

1) The URV <u>excludes</u> escalation. The costs of desalination processes have reduced in recent years.
2) The URV includes the following :
   - the capital costs for the intake, pumping mains, desalination process and storage reservoirs.
   - the operating costs, including conveyance.

3) 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. An equivalent saving is therefore applicable to the desalination URVs as no water treatment process is applicable. This results in the Koeberg URV reducing to about R7/m^3 and the Melkbos URV to about R9/m^3.

4) These desalination URVs are likely to further reduce primarily as a result of the strengthening Rand in recent years.

Desalination costs quoted by equipment suppliers often exclude the civil and mechanical capital costs associated with :

- intake infrastructure
- conveyance and pumping infrastructure, and operating costs
- reservoir storage costs

However, technologies are improving and becoming less expensive. Consequently, desalination is likely to be a favourable option as the surface water resource becomes ever more limited.

5. ECOLOGICAL

The desalination process produces highly saline residual brine which is disposed of to sea. Most of the treatment processes use anti-fouling chemicals to some extent and these can have an impact on the marine environment.

As the Koeberg site does not require any inlet works to be constructed, and is located in a disturbed area, the direct ecological impacts are minimal. The Melkbos site has more significant marine and terrestrial footprint impacts. Both options use considerable amounts of electricity and this has secondary environmental impacts associated with coal or nuclear power stations.

6. SOCIO-ECONOMIC

There would be potential visual impacts associated with any intake structure and pump station at the Melkbos site. This can be mitigated to some extent by making use of a pump station below natural ground level.

7. OTHER ISSUES

The strengths and weaknesses of the desalination scheme are :

- **Strengths**
  - Unlimited source of raw water.
  - Process costs can be reduced through integration with a nuclear power plant.
  - Direct environmental impacts can be minimal.
  - Plants can be easily upgraded to increased capacities.
  - Desalination processes are becoming less expensive.

- **Weaknesses**
  - Very few existing desalination plants of equivalent size, therefore no available information on actual annual operating costs.

- Relatively more expensive option than surface water.
- Energy requirements result in secondary environmental impacts.
- Possible public opposition associated with the perception of nuclear related health risks at Koeberg
- URV estimates require updating to take into account the reduction in process costs in recent years.

SECTION I

OTHER SCHEMES

I.1 Water transfers from the Congo River

1. INTRODUCTION

Information presented here is drawn from the Western Cape System Analysis, engineering publications and other sources, including the public process. Three potential means of utilising water from the Congo River (west coast of Central Africa) have been identified, namely :

- Importation by tanker
- Towing of inflatable bladders
- Undersea pipelines

Conventional overland conveyance infrastructure such as pipelines and canals have not been considered due to :

- the risks associated with potential sabotage
- the challenges of multi-national agreements in relation to the overland route
- the anticipated high capital and maintenance costs
- the challenges associated with maintenance.

2. IMPORTATION BY SEA FARING TANKERS

This option involves transporting freshwater taken aboard at the mouth of Congo River on the west coast of central Africa. A fleet of 9 super tankers, each capable of delivering 280 000 m^3 (one round trip) every 17 days could be considered.

Based on 1992 cost estimates, escalated at 7% per annum, one super tanker chartered on a three year contract would cost about R240 000 per day. Fuel costs would be about R50 000 per day. On this basis, the Unit Reference Value of the water would be R17/m^3. Of the options investigated in this study, this represents the most uneconomical of all options.

To achieve a yield of about 50 million m^3/a, a fleet of 9 tankers would be required. Table Bay harbour would not be able to accommodate tankers in excess of 90 000 m^3. Consequently, facilities would be required from an offshore loading point to convey water to a water treatment works such as Faure. These additional costs, as well as payment to the Democratic Republic of Congo, would significantly further increase the URV.

2.1 Other Factors

Other factors to be taken into account include: :

- slight risk of marine pollution
- impact of off-shore conveyance infrastructure
- visual impact of tankers in Table Bay
- political uncertainties could make this an unreliable source.
- High financial costs

3. TOWING INFLATABLE BLADDERS

This option has neither been investigated by DWAF nor the CCT. The information presented is based on an article in the Water 21 Journal of October 2004.

A company operating from the Greek mainland has developed a successful operation in which some Greek Islands in the Mediterranean Sea are supplied with water. Bladders of between 750 m^3 and 2 000 m^3 are towed from the mainland. A similar operation from the Turkish mainland to supply the Turkish region of northern Cyprus has failed. In this case, bladders of 30 000 m^3 units experienced towing problems, eventually causing the contract to be abandoned. Similar attempts to apply this technology along the west coast of the USA have been equally unsuccessful, despite years of research and development.

Challenges in considering such options for South Africa include :

- sea conditions along the towing route
- loading and unloading operations
- the economics of long distance transport.

Sea conditions off both coasts of South Africa are likely to render this type of operation unsuccessful.

4. UNDERSEA PIPELINE

A proposal dating back to 1995 suggested the option of pumping fresh water from the Congo River down the west coast of Africa via a submerged pipeline. The rationale of the option is that a large diameter (12 m) plastic conduit be positioned about 2 m above the sea bed level. The lower density fresh water in the conduit (also of lower density than water) would result in a buoyancy uplift force at a certain depth, sufficient to enable the conduit to be secure, using nylon netting and anchoring ropes. Massive balloon-type containers would be permanently anchored in the sea opposite off-take points, functioning as buffer storage. The proposal was not supported with technical calculations but indicated that for a yield of 700 million m^3/a, the average cost to supply the coast of South Africa would be about R2/m^3.

As part of this study, references to other similar schemes were investigated. It was found that :

- Taiwan officials had conducted a feasibility study to import water from mainland China via a 25 km undersea pipeline. The results for that study indicated that this could potentially supply water at a third of the cost of desalination.
- In Turkey, a feasibility study investigated pumping 75 million m^3 of water per year to Cyprus via a 78 km submerged pipeline. The study was carried out in 1998 with the intention to implement in 1999. The use of HDPE pipe (1,6 m dia, density 960 kg/m^3) was proposed with the same anchoring method (inverse hanging) as described above.
- The option of pumping water from Alaska to California (2 200 km) has not been studied at feasibility level, but some cursory engineering and feasibility work has been undertaken.

Challenges in considering such an option in Southern Africa include :

- pipeline subject to marine hazards.
- passage of the routing would be through the coastal waters of a number of countries.
- environmental concerns.
- high costs and unproven technology.

I2. Water transfers from the Orange River

Neither surface nor undersea conveyance options have been investigated as water from the Orange River is close to being fully allocated. Refer to DWAF's Orange River Development Replanning Study. In addition, the pipeline route to Cape Town would be approximately 600 km long and would either follow the restricted coastal area or the route of the N7. A number of booster pump stations would be required. Therefore, even if surplus water was available for transfer, the cost is likely to be very high. For reasons of availability and cost, this option is not considered feasible and has not been investigated.

I3. Towing of icebergs

1. SCHEME DESCRIPTION

The use of icebergs as a source of fresh water would involve capturing and towing them from the Antarctic and extracting the water in the deep ocean before the continental shelf is too shallow to prevent towage. A processing plant heat exchange plant, smaller vessels, tankers or an undersea pipeline to convey the water to shore would be required. Costs have not been estimated but are likely to be high.

The challenges associated with this option involve untried technology, including :

- selection, wrapping and towing the iceberg;
- how to prevent the iceberg melting before it reaches its required destination;
- how to physically harvest the ice from the iceberg in a manageable way;
- what environmental impacts would be associated with the waters of the Antarctic.

2. OTHER ISSUES

Specific strengths and weaknesses of the scheme are:

- **Strengths**
  - Untapped source.
- **Weaknesses**
  - The difficulties that could be encountered during towing, the process of melting the ice, cutting the icebergs into fragments, and collecting the water and conveying it to a point where any necessary treatment could be carried out.
  - Negative environmental impact in the vicinity of mooring and converting sites.
  - High costs and unproven technology.

I4. Other options arising from public meetings

1 CLOUD SEEDING

Cloud seeding has not been considered as an option as it is not suited to the type of cloud cover experienced in the Western Cape but rather to areas in which Cumulo-Nimbus cloud cover is typical.

2 A DAM ON THE KUILS RIVER

This is not an option as there are no suitable dam sites on the Kuils River. Much of the flow in the Kuils River is attributed to return flows from waste water treatment works which discharge into it. The effluent portion could be treated for re-use and this would not require a dam on the river.

3 DREDGING OF EXISTING DAMS RATHER THAN RAISING OF DAMS

The dams in the Western Cape System do not experience significant silt loading. Dredging may be an option in decades to come but within the next 50 years would not be viable. Deepening of dam basins (other than silt removal) would be expensive, both due the nature of excavation and the need to modify existing outlet structures to be able to take advantage of the additional storage.

4 RAISING NUWEBERG DAM ON THE PALMIET RIVER

Eikenhof Dam on the Palmiet River lies downstream of Nuweberg Dam. Eikenhof was raised in 1999 as this proved to be the most effective means of increasing the yield from that system. Raising Nuweberg Dam would offer little benefit as the dam basin is small and would require significant relocation of the existing road.