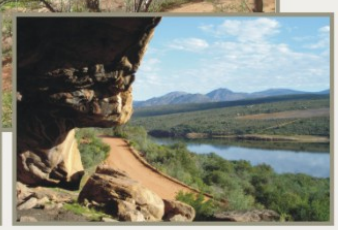
DWAF Report No. P WMA 17/E10/00/0405

DEPARTMENT OF
WATER AFFAIRS
AND FORESTRY

Feasibility Study for the Raising of Clanwilliam Dam

Screening of Options



Final

February 2009

NINHAM SHAND CONSULTING SERVICES

ASCH

JAKOET & ASSOCIATES

DEPARTMENT OF WATER AFFAIRS AND FORESTRY
DIRECTORATE OPTIONS ANALYSIS

FEASIBILITY STUDY FOR THE RAISING OF THE CLANWILLIAM DAM

SCREENING OF OPTIONS

Final

February 2009

Prepared by: Ninham Shand Consulting
P O Box 1347
Cape Town
South Africa
8000

Tel: 021 – 481 2400
Fax: 021 – 424 5588
e-mail: hydro@shands.co.za

In association with: ASCH Professional Services (Pty) Ltd
Jakoet & Associates cc

Prepared for: Director: Options Analyses
Department of Water Affairs and Forestry
Private Bag X313
Pretoria
South Africa

Tel: 012 – 336 8321
Fax: 012 – 338 8295
e-mail: icb@dwaf.gov.za

This report is to be referred to in bibliographies as:

Department of Water Affairs and Forestry, South Africa. 2005. *Screening of Options*. Prepared by A West and M Luger of Ninham Shand (Pty) Ltd, in association with ASCH Consulting Engineers and Jakoet & Associates, as part of the Feasibility Study for the Raising of Clanwilliam Dam. DWAF Report No. P WMA 17/E10/00/0405.

Department of Water Affairs and Forestry
Directorate Options Analysis

FEASIBILITY STUDY FOR THE RAISING OF THE CLANWILLIAM DAM

APPROVAL

Title	:	Screening of Options
DWAF Report no.	:	P WMA 17/E10/00/0405
NS Report No.	:	4415/400415
Authors	:	A West, M Luger
Status of Report	:	Final
Date	:	February 2009

STUDY TEAM **:** **Approved for the Clanwilliam Dam Raising Association by:**

…………………………………..
E. VAN DER BERG
Study Leader

…………………………………..
M J SHAND
Study Director)

DEPARTMENT OF WATER AFFAIRS AND FORESTRY
Directorate Options Analysis
Approved for Department of Water Affairs and Forestry by:

…………………………………..
A D BROWN
Study Manager

…………………………………..
L S MABUDA
Manager: OA

EXECUTIVE SUMMARY

Need for the Screening Process

A number of surface water and groundwater resource studies have been undertaken within the water management area (WMA). Various development schemes were investigated and re-investigated in these studies.

To gain acceptance for the study of the raising of Clanwilliam Dam as a specific development option, a review and comparison of all the potential development schemes (surface and groundwater) in the Water Management Area (WMA) was required to determine how the raising of Clanwilliam Dam would influence the viability of other development options, and *vice versa*. The objective of the screening process was :

- to clarify the policy of the Department of Water Affairs and Forestry (DWAF) and its co-operative partners regarding the need for development in the Olifants/Doorn WMA;
- to review the acceptability of the various potential options identified in previous studies in terms of technical, financial, environmental and social criteria;
- to augment existing information with limited specialist inputs where required; and
- to ascertain whether or not the raising of Clanwilliam Dam is a preferable and defendable development option, for further study with a view to implementation.

This process therefore entailed the comparison of the potential raising of Clanwilliam Dam with other potential water infrastructure development opportunities in the WMA. As part of the screening process, a "Screening of Options" Specialist Workshop was held on 23 November 2004. It was attended by selected DWAF staff, study team members, selected identified stakeholders and specialists in order to workshop the acceptability of the various surface water development options as compared to the raising of Clanwilliam Dam. The potential development of groundwater supply schemes and conjunctive use of groundwater in the region were also addressed.

Summary of Development Options

There are a number of potential surface water schemes that could be developed to increase the availability of water within the Olifants and Doring river catchments. **Figure E1** shows where these potential schemes are located.

Specialist Screening of Options Workshop

A Specialist Screening Workshop was held to discuss and critically evaluate the suite of development options in the Olifants and Doring River catchments and compare these to the potential raising of Clanwilliam Dam, so as to ascertain whether or not the raising of Clanwilliam Dam is a preferable and defendable development option. This key stakeholder workshop was held on 10 February 2005, targeting the WMA Reference Group, where the draft Screening of Options report was presented, so as to solicit further comments and inputs.

A four-point scale was used to evaluate all development options in terms of the following variables :

- capital to yield ratio;
- environmental impacts (barrier/sediment, inundation and downstream effects); and
- beneficiaries (cost, agricultural impact, benefits to users and resource-poor farmer opportunities).

Figure E1 Potential surface water and groundwater schemes in the Olifants and Doring River catchments

It is important to note that the yields of individual wellfields cannot be compared directly to surface water schemes, as there is a lack of data with respect to groundwater yields. Further data collection is required to enable groundwater schemes to be modelled in order to determine comparative costs of groundwater scheme development for comparison with surface water development options.

Summary of Screening Process

The results of the screening process are shown in **Table E1** and **Table E2**.

Table E1 Summary of surface water development options

Colour Rating Index	Low Impact 1 Low Cost	Medium Impact 2 Medium Cost	High Impact 3 High Cost	Very High Impact 4 Very High Cost

Potential Source	Yield (No Reserve) (Mm^3/a)	Capital to Yield Ratio	Environmental Impacts			Beneficiaries			
			Barrier and Sediment	Inundation	Down-stream	Area Supplied	Infrastructure cost	Agric. impacts (Environ-mental)	Benefit to users
OLIFANTS RIVER CATCHMENT									
Raise Clanwilliam	66	2	1	1	3	Not rated	1	1	1
Rosendaal	14	3	2	3	3	Not rated	1	2	1
Visgat	Not Determined	4	3	4	3	Not rated	1	2	1
Grootfontein	90	3	3	4	3	Not rated	1	2	1
Keerom	100	3	3	3	3	Not rated	1	2	1
Additional Farm Dams	10	2	1	1	1	Not rated	1 to 2	1	1
DORING RIVER CATCHMENT									
Leeu River	Not Determined	3	3	Not rated	3	Not rated	3	2	3
Groot River	64	Not rated	4	4	4	Not rated	4	4	4
Aspoort	76	Not rated	4	4	4	Not rated	4	4	4
Reenen		Not rated	Not rated	Not rated	Not rated	Not rated	Not rated	Not rated	Not rated
Melkbosrug	116		4	4	3	Not rated	2	2	2
Melkboom	121	Not rated	4	4	3	Not rated	2	2	2
Brandewyn	50	Not rated	3	3	3	Not rated	2	2	2
Additional Farm Dams	5	Not rated	1	1	1	Not rated	1 to 2	1	1

Table E2 Summary of groundwater development options

Colour Rating Index		Low Impact 1 Low Cost	Medium Impact 2 Medium Cost	High Impact 3 High Cost	Very High Impact 4 Very High Cost

Name	Yield (Mm³/a)	Unit Reference Value (1) (R/m³)	Capital to Yield Ratio (2) (R/m³)	Scheme	Environmental Impacts
DORING RIVER CATCHMENT					
T1a Wellfield (conventional)	5	0.25	2.4	1	2
T1b Wellfield (conventional)	5	0.23	2.1	1	2
OLIFANTS RIVER CATCHMENT					
T2 Wellfield (Conventional)	3.2	0.35	3.5	1	1
T3 Wellfield (Conventional)	2.5	0.49	5.7	1	1
T5 Wellfield (ASR)	20 min but up to 90	0.82	Not determined	1	1
T7 Wellfield (ASR)	121 (Avg)	0.12	1.2	2 to 3	2 to 3
Citrusdal Trough	50 to 100	Not determined	Not determined	1	1
Clanwilliam Trough	Unknown but comparable	Not determined	Not determined	2	1

(1) The URV takes both capital and operating costs into account. The yields are conservative estimates. The URV would reduce for less conservative yield estimates.

(2) The yields are conservative estimates.

Recommendations

The three most favourable and recommended development options for the Olifants/Doorn WMA were :

- the development of off-channel farm dams;
- the development of groundwater schemes;
- the raising of Clanwilliam Dam

or combinations of the above three options.

The raising of Clanwilliam Dam was considered to be a favourable option because it does not introduce a new suite of associated environmental and social impacts, but rather extends existing impacts. Furthermore, the lower Olifants River has already been disturbed by the presence of the Clanwilliam Dam and the Bulshoek Weir. In terms of local and international policy and experience, there is strong support for expanding existing agricultural development rather than creating new dispersed agricultural areas. However, as mentioned above, with the exception of groundwater, the raised Clanwilliam Dam could potentially exclude or diminish other development options in both the Olifants and Doring river catchments.

The raising of Clanwilliam Dam provides flexibility in terms of supplying potential beneficiaries, opportunities and development options for resource-poor farmers (RPFs), the position of new irrigation development and crop variety. Other potential development options on the Olifants and Doring Rivers do not appear to provide the same level of flexibility. Furthermore, Clanwilliam Dam can provide relatively affordable water. This scheme also provides the option of either large-scale RPF development or incremental development over time, depending on the flexibility in terms of funding the scheme.

Based on the feedback received at the Key Stakeholder Workshop, it was evident that there is broad support for the abovementioned most favourable development options, and more specifically for the raising of Clanwilliam Dam.

It was recommended that a study be undertaken to confirm the feasibility of the raising of Clanwilliam Dam for the following reasons :

- The remedial work to be undertaken provides the opportunity to raise Clanwilliam Dam;
- The scheme would have relatively low environmental impacts compared to other development options;
- The scheme would provide flexibility with respect to potential beneficiaries;
- The scheme would provide the possibility to make water available for resource-poor farmers;
- The scheme would provide the opportunity to satisfy the ecological Reserve of the Olifants River and Estuary; and
- The scheme would provide the possibility of expanding existing agricultural development rather than creating new unsupported agricultural areas.

CONTENTS

Section	Description	Page No
1	**INTRODUCTION**	**1**
1.1	Background and need for the study	1
1.2	Need for water resource development in the WMA	1
1.3	Need for the screening process	2
1.4	Stakeholder engagement	2
2	**SUMMARY OF DEVELOPMENT OPTIONS**	**4**
3	**SCREENING METHODOLOGY USED DURING THE SPECIALIST SCREENING OF OPTIONS WORKSHOP**	**6**
4	**SCREENING OF POTENTIAL DEVELOPMENT OPTIONS**	**7**
4.1	Environmental impacts of surface water options	7
4.2	Beneficiaries of surface water options	9
4.3	Environmental impacts of groundwater options	11
4.4	Beneficiaries of groundwater options	11
5	**SUMMARY OF THE BASIS FOR A DECISION**	**12**
5.1	Summary of screening process	12
5.2	WMA scale perspectives	13
5.3	Perspectives on the potential development options	14
6	**RECOMMENDATIONS**	**16**

List of Tables

Table 2.1 List of potential surface water schemes ... 4
Table 2.2 List of potential wellfields ... 4
Table 5.1 Summary of surface water development options ... 12
Table 5.2 Summary of groundwater development options ... 13

List of Figures

Figure 2.1 Potential surface water and groundwater schemes in the Olifants and Doring River catchments ... 5

APPENDICES

APPENDIX A: Clanwilliam Dam Raising Study ~ Updated Specialist Workshop Starter Document (23 November 2004)
APPENDIX B: Summary of Groundwater Screening Inputs
APPENDIX C: Minutes of the Key Stakeholder Workshop (10 February 2005)
APPENDIX D: Summary of issues and concerns submitted by members of the Reference Group in writing

GLOSSARY AND ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
EIA	Environmental Impact Assessment
FSL	full supply level
LORWUA	Lower Orange River Water User Association
RPF	Resource-poor farmers
TMG	Table Mountain Group
WMA	Water Management Area
WUA	Water User Association

1. INTRODUCTION

1.1 Background and need for the study

The Clanwilliam Dam was originally built in 1935, and was raised in the 1970s by adding gates and the use of pre-stressed cables. In order to comply with current dam safety standards applicable for extreme events the Department of Water Affairs and Forestry (DWAF) plans to implement remedial measures in the near future. This presents an opportunity to raise the full supply level (FSL), if the marginal cost of raising, over and above the cost of the strengthening, is economically viable. The necessity of a multi-level outlet also needs to be assessed, in light of the pending recommendations from the Comprehensive Reserve Determination Study, which is currently being undertaken for DWAF.

The required remedial work presents an opportunity to raise the dam by up to 15 m. The Reconnaissance Study (DWAF, 2003), which formed part of the Olifants/Doring River Basin Study Phase II, concluded that raising the dam could cost-effectively result in the provision of increased yield and recommended that it be investigated further at a feasibility level of study.

1.2 Need for water resource development in the WMA

Parts of the Olifants/Doorn Water Management Area (WMA) are extensively developed and often experience shortages in meeting water demands, notably so in the Olifants River catchment downstream of Clanwilliam Dam. There are frequent shortfalls in the supply to the Lower Olifants River Water User Association (LORWUA), despite the fact that no releases are currently being made from Clanwilliam Dam to meet the requirements of the Reserve. Any new development would have to make provision to meet the requirements of the Reserve, which may lead to a further shortfall in supply.

A number of surface water and groundwater resource studies have been undertaken or are underway within the WMA, including *inter alia* the:

- Olifants Doring River Basin Study - Phase 1 (1998);
- Citrusdal Artesian Groundwater Exploration (CAGE) Study (2000);
- Olifants Doring River Basin Study - Phase 2 (2003);
- Olifants-Doorn WMA Water Resources Situation Assessment (2002);
- Olifants-Doorn WMA Overview of Water Resources and Utilisation (2003);
- DANIDA Integrated Water Resource Management (2003);
- Olifants-Doorn Internal Strategic Perspective (2004), and the
- Western Cape Olifants/Doring River Irrigation Study (WODRIS, 2004).

Various development schemes were investigated and re-investigated in the above studies.

1.3 Need for the Screening Process

It was believed that, to gain acceptance for the study of a specific development option, namely the raising of Clanwilliam Dam, a review and comparison of all the potential development schemes (surface and groundwater) in the WMA was required to determine how the raising of Clanwilliam Dam would influence the viability of other development options, and *vice versa*. The objectives of the screening process were:

- to clarify the policy of DWAF and its co-operative partners regarding the need for development in the Olifants/Doorn WMA;
- to review the acceptability of the various potential options identified in previous studies in terms of technical, financial, environmental and social criteria;
- to augment existing information with limited specialist inputs where required; and
- to ascertain whether or not the raising of Clanwilliam Dam is a preferable and defendable development option, for further study with a view to implementation.

This process therefore entailed the comparison of the potential raising of Clanwilliam Dam with other potential water infrastructure development opportunities in the WMA. As part of the screening process, a 'Screening of Options' Specialist Workshop was held on 23 November 2004. It was attended by selected DWAF staff, study team members, selected identified stakeholders and specialists in order to workshop the acceptability of the various surface water development options as compared to the raising of Clanwilliam Dam. The potential development of groundwater supply schemes and conjunctive use of groundwater in the region were also addressed. The Peninsula and Skurweberg aquifers of the Table Mountain Group (TMG) offer significant potential in terms of aquifer storage and recharge.

The purpose of this report is to summarise and document the screening of options that took place during the aforementioned Specialist Workshop with a view to informing a wider range of debate as to the acceptability and desirability of investigating the raising of Clanwilliam Dam.

1.4 Stakeholder Engagement

Stakeholder engagement formed a key component of the screening process. The draft *Screening of Options* Report was distributed to all participants who attended the Specialist Workshop, for their review and further inputs.

Importantly, a Key Stakeholder Workshop was held on 10 February 2005, targeting the WMA Reference Group, where the draft *Screening of Options* report was presented so as to solicit further comments and inputs. Participants were given a further 14 days in which to submit further comments or raise further issues. Notes of the Key Stakeholder Workshop are contained in **Appendix C**, while a summary of the issues raised by key stakeholders is contained in **Appendix D**.

This *Screening of Options* report has been finalised based on outcomes of the Key Stakeholder Workshop and, should the study proceed, will feed into the environmental impact assessment (EIA) process, as part of the contextualisation and consideration of broader alternatives to the raising of Clanwilliam Dam.

2. SUMMARY OF DEVELOPMENT OPTIONS

There are a number of potential surface water schemes that could be developed to increase the availability of water within the Olifants and Doring River catchments. These are summarised in **Table 2.1** yields based on 1MAR dam at each site. **Table 2.2** lists the potential wellfields which could be developed within groundwater schemes. For a detailed description of each site, refer to **Appendix A** for the Updated Specialist Workshop Starter Document.

Table 2.1 List of potential surface water schemes

Olifants River Catchment			Doring River Catchment		
Name of Potential Scheme	**Additional Storage (Mm^3)**	**Additional Yield (Mm^3/a) (1)**	**Name of Potential Scheme**	**Additional Storage (Mm^3)**	**Additional Yield (Mm^3/a) (1)**
Rosendaal Dam	26	14	Leeu River Dam	35	6
Visgat Dam	unknown	unknown	Groot River Dam	159	64
Grootfontein Dam	138	90	Aspoort Dam	395	76
Keerom Dam	153	100	Reenen Dam	250	88
Raise Clanwilliam Dam 5m	63	36	Melkbosrug Dam	400 (4)	116 (3)
Raise Clanwilliam Dam 10m	143	66	Melkboom Dam	400 (4)	121 (3)
Raise Clanwilliam Dam 15m	240	86	Brandewyn Dam	160	± 50 (2)
Farm Dams (Off Channel)	14	10	Farm Dams (Off Channel)	8	5

(1) The yields are gross yields before provision for the Reserve and before any compensation releases other than as indicated in Note (2)
(2) The Yield for Brandewyn Dam has already allowed for IFRs as determined in the WODRIS Study.
(3) Ref: Olifants Doring River Basin Study, 1998
(4) Ref: WODRIS, 2003

Table 2.2 List of potential wellfields

Wellfield Name and Location	**Potential Yield**
T1 - Two wellfields (T1a and T1b) at the confluence of the Doring and Olifants Rivers. Abstraction out of the Peninsula Aquifer.	T1a + T1b, T2, T3: realistic combined yield of 20 Mm^3/a. Maximum combined yield for T1a + T1b and T2 of 60 Mm^3
T2 - Wellfield on the right bank of the Olifants River, above the Bulshoek Weir. Wellfield to abstract groundwater from the Peninsula Aquifer.	
T3 - Wellfield on the left bank of the Sandlaagte valley at Skurfkop Syncline. Abstract groundwater from the Peninsula Aquifer.	
T4 - Brandewyn River valley above confluence with Doring River. Wellfield in river valley to abstract groundwater from both Skurweberg and Peninsula Aquifers.	Capacity not assessed
T5 - Aquifer Storage Recovery Scheme in the unutilised Sandlaagte Valley Aquifer.	Recharge and storage Olifants River water
T6 - Katmakoep area between Vredendal and Strandfontein. Wellfield to abstract groundwater from the Peninsula Aquifer.	Only small-scale abstraction
T7 - Aquifer Storage Recovery Scheme in under-utilised Vanrhynsdorp dolomitic aquifer.	Recharge and storage Olifants River water
Citrusdal Trough - Expansion of the Boschkloof Wellfield at Citrusdal, which presently supplements municipal bulk water supply for Citrusdal. Current abstraction: 1.5 to 2.0 Mm3/a	Not available
Citrusdal Trough - Peninsula Aquifer in E10 catchment.	45 Mm^3/a
Clanwilliam Trough – No wellfield target zones yet identified.	80 – 100 Mm^3/a
Koue Bokkeveld – No wellfield target zones yet identified.	40 – 80 Mm^3/a

It is important to note that the yields of individual wellfields cannot be compared directly to surface water schemes, as there is a lack of data with respect to groundwater yields. Further data collection is required to enable groundwater schemes to be modelled in order to determine comparative costs of groundwater scheme development for comparison with surface water development options.

Figure 2.1 Potential surface water and groundwater schemes in the Olifants and Doring River catchments

3. SCREENING METHODOLOGY USED DURING THE SPECIALIST SCREENING OF OPTIONS WORKSHOP

The purpose of the Specialist Screening Workshop was to discuss and critically evaluate the suite of development options in the Olifants and Doring River catchments and compare these to the potential raising of Clanwilliam Dam, so as to ascertain whether or not the raising of Clanwilliam Dam is a preferable and defendable development option.

A four-point scale was used to evaluate all development options in terms of the following variables:

- capital to yield ratio;
- environmental impacts (barrier/sediment, inundation and downstream effects); and
- beneficiaries (cost, agricultural impact, benefits to users and resource-poor farmer opportunities).

Workshop participants rated each of the above variables using the following scale as follows:

Low Impact **1** Low Cost	Medium Impact **2** Medium Cost	High Impact **3** High Cost	Very High Impact **4** Very High Cost

All the workshop participants rated the raising of Clanwilliam Dam option as a single group before dividing into two groups, one to evaluate the remaining options in the Olifants River Catchment and the other group, the Doring River Catchment. The two groups rated the remaining options in each catchment relative to the raising of Clanwilliam Dam. Participants were divided to make input according to their areas of knowledge or interest, while some specialists moved between the groups.

4. SCREENING OF POTENTIAL DEVELOPMENT OPTIONS

Identified development options that have already been screened out in earlier reports or processes, were not included in this screening process. The more favourable potential surface and groundwater development options were screened in terms of nine technical, ecological and social criteria and were rated in terms of their impacts or cost. The results of this screening process are presented below and are summarised in **Tables 5.1** and **5.2**.

4.1 Environmental Impacts of Surface Water Options

4.1.1 Barrier and Sediment Effects

The raising of Clanwilliam Dam, being an existing dam, is unlikely to have a significant impact on the sediment dynamics of the Olifants River, or further restrict the migration of fish. Given that the raising of the dam would result in an extension of existing impacts rather than the creation of new impacts, this option was awarded a low impact rating.

The potential Rosendaal and Visgat Dams, located on the upper Olifants River above the Visgat gorge, are likely to result in some barrier effect, even though the waterfall forms a natural barrier. Change in sediment dynamics downstream of either dam is unlikely to be of concern. Similarly, the potential Grootfontein and Keerom dams, located downstream of the Visgat Gorge, would also result in some barrier and sediment effects. The Keerom Dam would affect both the Olifants and Ratel Rivers. These options were therefore rated as having a greater impact than the raising of Clanwilliam Dam.

Off-channel farm dams in the upper catchment of the Olifants River are unlikely to have a barrier or sediment effect on the main stem of the river. This option was rated as having a similar impact to the raising of Clanwilliam Dam.

The potential Groot River Dam, located on the Groot River, a major tributary of the Doring River, would create a barrier to the migration of three fish species endemic to the Olifants-Doring River system, preventing migration to spawning areas upstream of the dam, or over-wintering areas in the lower Doring and Olifants rivers. Sediment loads in the Groot River are low, and are likely to be unchanged by the potential dam. This option was rated as having a very high impact due to its potential barrier effect. The potential Leeu River Dam, located on a tributary of the Groot River, would have less of a barrier effect than the Groot River Dam.

The potential Aspoort Dam would have a similar barrier effect to the Groot River Dam, blocking the passage of migratory fish to their spawning areas, in the upstream areas of the river. The Doring River is rich in sediment and the dam would trap large amounts of sediment, having a detrimental impact on the river downstream of the dam. This option was rated as having a very high impact.

The potential Melkbosrug, Melkboom and Brandewyn Dams would each create a barrier to the migration of fish. The effect of the Brandewyn Dam abstraction weir could be mitigated through the installation of a fish ladder. Melkbosrug, Melkboom dams and Brandewyn Dam weir, would also impact on winter river rafting activities. The dams would also act as sediment traps, which would have negative consequences for the downstream river channel and potentially for the estuary. The Melkbosrug and Melkboom dams were considered to have a very high impact, while the Brandewyn Dam located on the Brandewyn tributary were considered to have a high impact.

Off-channel farm dams in the upper catchment of the Doring River and the Koue Bokkeveld are unlikely to have a barrier or sediment effect on the main stem of the river. This option was considered to be similar to the raising of Clanwilliam Dam, and was rated to have a low impact.

4.1.2 Inundation Effects

The increased full supply level associated with the raising of Clanwilliam Dam would inundate some irrigated areas, indigenous vegetation, infrastructure, and cultural heritage sites. The raising of Clanwilliam Dam will result in an extension of existing impacts and was therefore rated as having a low impact, with respect to the inundation effects.

The area of inundation of the potential Rosendaal Dam is already disturbed, comprising largely cultivated land. There are however small areas of fynbos that are relatively undisturbed. The Visgat Dam basin supports rare riverine and mountain fynbos. Consequently the inundation impacts of Rosendaal Dam were rated as high, while the inundation impacts of the Visgat Dam were rated as very high.

The potential Grootfontein Dam would result in the inundation of part of the Visgat Gorge. Previous studies deemed this to be environmentally and socially unacceptable due to the geological and biological importance of the gorge. Consequently the inundation effects of this option were rated as very high. The Keerom Dam site would have a similar effect on the Visgat Gorge, although the extent of area flooded would be less.

The inundation effects associated with the Groot River, Aspoort, Melkbosrug and Melkboom dams were all rated as very high. At each site indigenous terrestrial and riparian vegetation would be inundated. Furthermore, there are unique cultural heritage sites present within the catchments of each of these dams. Inundation of the Brandewyn Dam site is likely to result in the loss of rare and endangered plants. The inundation effects of the Brandewyn Dam were rated as high.

4.1.3 Downstream Effects

A raised Clanwilliam Dam would further absorb small floods, which is likely to further impact on the yellowfish population downstream of the dam, unless specific releases are made as part of the Reserve requirements. Flood attenuation will also have an impact on the estuary. The critical factor for the functioning of the estuary is the size of the saline water ‘wedge’ and its upstream penetration, which is likely to be affected by a decrease in floods. Flood attenuation is however an effect associated with all large dams, and not specific to the raising of Clanwilliam Dam. The downstream effects as a result of the raised dam were rated as high.

The cumulative impacts of many farm dams in the upper catchments of the Olifants and Doring rivers could be significant. Releases made for the Reserve from farm dams are also difficult to manage and control, which could have a significant downstream effect.

Release of irrigation water from Rosendaal or Visgat dams would increase the summer base flows in the Olifants River, potentially threatening indigenous fish species. Furthermore, the introduction of alien fish into the dams could affect the survival of indigenous fish species. The potential Grootfontein or Keerom dams would result in similar downstream effects to the Rosendaal and Visgat dams. These dams would also likely result in the significant absorption and attenuation of floods. The downstream effects of these four dams were considered to be greater than that of Clanwilliam Dam and were rated as high impact.

If Clanwilliam Dam is raised, consideration could be given to concurrently increase off-channel storage in the Olifants River catchment upstream of the dam, for increased irrigation and/or to enable summer Reserve release requirements to be met. This would depend on the feasibility of further irrigation development in the catchment upstream of the dam.

The Groot River provides almost half of the mean annual run-off to the Doring River and much of the base flow. A dam on the Groot River would result in delayed or completely attenuated winter floods, with consequences for the geomorphology and salinity of the middle Doring River. The downstream effects of a dam on the Groot River were therefore rated as being of very high impact. A dam on the Leeu River would have a similar effect, albeit with a smaller magnitude. The downstream effects of the Leeu River Dam were rated as high impact.

The Aspoort Dam is likely to have high evaporation due to the characteristics of the dam basin, leading to an increase in salinity of the dam water, with consequences for flora and fauna downstream. A reduction of freshwater and floodwater flows is also likely to have a negative impact on the Doring River downstream of the dam as well as on the Olifants River Estuary. Consequently, the downstream effects of the Aspoort Dam were rated as very high.

The downstream effects of the Melkbosrug or Melkboom dams would include the loss of winter flushing floods, resulting in increased salinity levels of the lower Olifants River. These downstream effects were rated as high impact. The Brandewyn Dam abstraction weir would affect low flow and small floods in the Doring River, and would facilitate the invasion of alien fish species. The downstream effects of the Brandewyn Dam and weir were rated as high.

4.2 Beneficiaries of surface water options

4.2.1 Areas of Supply, Infrastructure Requirements and Resource-poor Farmer Opportunities

Beneficiaries of increased water availability from the raising of Clanwilliam Dam were mainly considered to be the Clanwilliam Water User Association (WUA), the Lower Olifants River Water User Association (LORWUA), and the Citrusdal Water User Association, with the focus on the provision of water for resource-poor farmers. Upgrading of canals may be required for distribution, however water could also be released down the river for abstraction further downstream. Increased canal usage (up to 168 hrs/week) during peak periods is also an option. New off-channel dams could be provided and filled from the canals in winter, when demands on the existing canal system are lower. A raised dam could potentially also provide an increased assurance of supply to the existing farmers or the opportunity for irrigation expansion. Where high value crops are being farmed, joint ventures between resource-poor farmers (RPFs) and commercial farmers may be most likely to be successful, although this needs to be confirmed. However, other farming models could also be applied successfully. The raising of Clanwilliam Dam was rated as a low cost option.

Being located in the upper Olifants River, the Rosendaal, Visgat, Grootfontein or Keerom dams could supply water to the Citrusdal WUA, or enhance the yield of Clanwilliam Dam, thereby potentially supplying users downstream of Clanwilliam Dam. Existing infrastructure could be utilised by the Citrusdal WUA. However similar infrastructure would need to be provided for new users. Once again there are opportunities for joint venture farming and RPFs downstream of Clanwilliam Dam could also benefit.

Farm dams in the upper catchment of the Olifants River would serve the relevant local farms. Due to the high-tech nature of farming of high-value crops in the area, RPFs are likely to be best supported by and be most successful in joint ventures. However other farming models have also been shown to be viable. This option was also rated as having a low to medium cost.

In 1998 the Northern Cape Government stated its intention to establish a RPF development in the vicinity of Aspoort. This could be supplied either from the Aspoort Dam or the Groot River Dam. The Aspoort, Groot River and Leeu River Dams would be located in remote areas, where there is little or no existing development, no RPFs and a poor road and other infrastructure. A weir downstream of Elandsvlei and pumping mains would be required to supply the irrigation areas in the Northern Cape. These options were rated as having a very high cost.

Dams at either Melkbosrug, Melkboom or the Brandewyn sites could supply a vast area in the lower Olifants River, including Klawer and the proposed Coastal Scheme, or irrigation areas in the immediate vicinity of the dams. RPF developments are already established in these areas, and there is potential to expand these further. However, financial support would have to be provided to the RPFs, due to the high cost of the water supplied from these dams. Infrastructure such as canals, pipelines and pump stations would be required and therefore these development options were rated as being high cost.

Additional farm dams in the upper Doring River would supply water to farms in the area and create potential opportunities for RPFs. This option was rated as having a low to medium cost.

4.2.2 Benefit to Users

The raising of Clanwilliam Dam could provide water to resource-poor farmers, provide improved assurance of supply to existing farmers, provide water for expansion of agricultural activities, or ensure the availability of water for Reserve releases. Additional water from the Rosendaal or Visgat dams would allow for expansion of the areas under irrigation by approximately 750 ha. The Grootfontein and Keerom dams would allow for the supply of an additional 4200 ha and 4700 ha of irrigated land respectively. The Aspoort Scheme, supplied by either the Aspoort Dam or Groot River Dam, does not appear favourable due to the remoteness of the area, poor soils and a small and diminishing window of opportunity to meet the market requirements, making this scheme less favourable than schemes on the Olifants River.

In the areas supplied by the Melkbosrug, Melkboom and Brandewyn dams, the impacts of water quality would need to be further investigated. Economies-of-scale are currently a problem for commercial farmers who need to expand their irrigation areas in order to remain competitive, but are unable to do so without additional water.

4.2.3 Agricultural Impacts

The expansion of agricultural areas associated with the raising of the Clanwilliam Dam would result in the clearing of some natural vegetation. Water supplied from other potential dams on the Olifants River would result in an increase in summer base flows, due to irrigation releases. These options were rated as being of a medium impact.

Agricultural development around the Leeu River Dam would have a medium environmental impact, because large tracts of land have already been cleared. Irrigation return flows may also have an effect on the water quality of the Leeu River Dam. The environmental impacts of supplying water from the Groot River and Aspoort dams for irrigation at the potential Aspoort Scheme include increasing summer base flows by using the river for conveyance, and the impact of the return flows on water quality. These schemes were rated as having a very high impact.

Similarly, for the Melkbosrug, Melkboom and Brandewyn dams, increasing the summer flows would be ecologically undesirable. However, the main issue for these schemes is the impact on water quality from return flows and the resultant increase in salinity. These options were rated as having a medium impact.

4.3 Environmental Impacts of Groundwater Options

Groundwater provides for storage of water without the effects of evaporation impacting on the resource. Impacts during construction associated with the siting of exploration and production boreholes are generally localised and are considered to be low. A possible impact associated with the abstraction of groundwater is its impact on springs in the area, as may be the case with the T2 wellfield. Consequently, most schemes were rated as having a low environmental impact. However, the T7 wellfield was rated as having a medium to high impact, due to uncertainty regarding the water quality from the limestone aquifer. The T1 wellfield was considered to have a medium impact due to an absence of data, making a prediction of the impact on baseflows via springs and subsurface flow difficult.

4.4 Beneficiaries of groundwater options

The supplies from groundwater schemes could be integrated into the system in a similar way to the surface water schemes. However, the cost of groundwater schemes could be further reduced if these are developed to serve nearby areas thus reducing the need for and cost of conveyance infrastructure.

5. SUMMARY OF THE BASIS FOR A DECISION

5.1 Summary of screening process

The results of the screening process are shown in **Table 5.1** and **Table 5.2** below.

Table 5.1 Summary of surface water development options

Colour Rating Index			Low Impact 1 Low Cost	Medium Impact 2 Medium Cost	High Impact 3 High Cost	Very High Impact 4 Very High Cost			
Potential Source	Yield (No Reserve)	Capital to Yield Ratio	Environmental Impacts			Beneficiaries			
	(Mm^3/a)		Barrier and Sediment	Inundation	Down-stream	Area Supplied	Infrastructure cost	Agric. impacts (Environ-mental)	Benefit to users
OLIFANTS RIVER CATCHMENT									
Raise Clanwilliam	66	2	1	1	3	Not rated	1	1	1
Rosendaal	14	3	2	3	3	Not rated	1	2	1
Visgat	Not Determined	4	3	4	3	Not rated	1	2	1
Grootfontein	90	3	3	4	3	Not rated	1	2	1
Keerom	100	3	3	3	3	Not rated	1	2	1
Additional Farm Dams	10	2	1	1	1	Not rated	1 to 2	1	1
DORING RIVER CATCHMENT									
Leeu River	Not Determined	3	3	Not rated	3	Not rated	3	2	3
Groot River	64	Not rated	4	4	4	Not rated	4	4	4
Aspoort	76	Not rated	4	4	4	Not rated	4	4	4
Reenen		Not rated	Not rated	Not rated	Not rated	Not rated	Not rated	Not rated	Not rated
Melkbosrug	116		4	4	3	Not rated	2	2	2
Melkboom	121	Not rated	4	4	3	Not rated	2	2	2
Brandewyn	50	Not rated	3	3	3	Not rated	2	2	2
Additional Farm Dams	5	Not rated	1	1	1	Not rated	1 to 2	1	1

Table 5.2 Summary of groundwater development options

Colour Rating Index	Low Impact 1 Low Cost	Medium Impact 2 Medium Cost	High Impact 3 High Cost	Very High Impact 4 Very High Cost	
Name	Yield (Mm³/a)	Unit Reference Value [(1)] (R/m³)	Capital to Yield Ratio [(2)] (R/m³)	Scheme	Environmental Impacts
DORING RIVER CATCHMENT					
T1a Wellfield (conventional)	5	0.25	2.4	1	2
T1b Wellfield (conventional)	5	0.23	2.1	1	2
OLIFANTS RIVER CATCHMENT					
T2 Wellfield (Conventional)	3.2	0.35	3.5	1	1
T3 Wellfield (Conventional)	2.5	0.49	5.7	1	1
T5 Wellfield (ASR)	20 min but up to 90	0.82	Not determined	1	1
T7 Wellfield (ASR)	121 (Avg)	0.12	1.2	2 to 3	2 to 3
Citrusdal Trough	50 to 100	Not determined	Not determined	1	1
Clanwilliam Trough	Unknown but comparable	Not determined	Not determined	2	1

(1) The URV takes both capital and operating costs into account. The yields are conservative estimates. The URV would reduce for less conservative yield estimates.

(2) The yields are conservative estimates.

5.2 WMA scale perspectives

Developments on the Olifants River would only provide benefit for new or current farmers in the Western Cape Province, with little or no benefit to farmers in the Northern Cape Province.

Significant factors that will have major impacts on the feasibility of the development options situated within the WMA are the requirements of the ecological Reserve for the rivers in the WMA and especially for the estuary. The requirements of the Reserve may preclude further development of some of the rivers, however the study to establish the comprehensive Reserve is still underway and study recommendations are only expected towards the end of 2005.

5.3 Perspectives on the potential development options

The construction of the Keerom or Grootfontein Dam would result in the inundation of the Visgat Gorge with significant environmental and social impacts and therefore these options are not considered further.

The development of farm dams, in the upper catchments of both the Olifants and Doring rivers, appears to have the lowest environmental impact with the greatest benefit to potential beneficiaries. A large proportion of the suitable off-channel dam sites along the Olifants and Doring rivers have already been developed, leaving poorer sites, which are relatively more expensive to develop. The cost of such development could potentially be more feasible for an existing farmer who is expanding, for whom this would only be an incremental cost, whereas this is likely to be a barrier for new or emerging farmers.

Groundwater schemes also appear to have the lowest environmental impacts with the greatest benefit to potential beneficiaries. However, wellfield T7 is considered to have poor water quality and is therefore deemed undesirable, and wellfield T1 requires additional investigation to determine its effect on baseflows and springs. Groundwater or aquifer development schemes comprise more than the development of a single wellfield. The potential development of the six defined groundwater schemes within the study area has not been sufficiently researched. To date, limited information is available to assess potential impacts of groundwater development, and the associated financial costs. Consequently, the information presented in **Table 5.2** is for individual wellfields only and cannot be compared directly to the equivalent cost of the surface water development options.

The raising of Clanwilliam Dam with a potential additional yield of 86 million m^3/a has been rated as the next most favourable option. As the raising of the dam is an expansion of existing activities, this option is favourable from a barrier and sediment effect, an inundation effect, cost of infrastructure, agricultural impact and benefits to users perspective. This dam also provides a realistic opportunity to benefit new RPFs. The required dam safety remedial work provides a window of opportunity to simultaneously raise the dam wall. It is possible that a raised Clanwilliam Dam could affect the incremental yield of other potential surface water development options in both the Olifants and Doring River catchments, especially if the Reserve has to be met. The extent of this impact would depend on the amount by which the Clanwilliam Dam is raised, as well as the specific Reserve requirements.

The Rosendaal and Visgat Dams were rated as having a medium to high impacts with respect to barrier and sediment effects, inundation effects, downstream effects and agricultural impacts. These were however considered to be favourable options, due to existing distribution infrastructure. The impact on the downstream Reserve requirements, particularly in summer when elevated flows in the Visgat Gorge would be undesirable, would however have to be evaluated.

The Doring River is the only major river in the region that is not impounded. It is mostly seasonal, however the perennial Groot River, a major tributary of the Doring River provides a degree of perennially to the Doring River between the Groot River confluence and the Olifants-Doring confluence. A key issue is that water quality is naturally highly variable. Water quality in the Groot River is good but any flow from the upper Doring and the lower Doring tributaries in the

Tankwa Karoo tends to be highly saline. The riverine biota and the riparian vegetation reflect this situation. The building of dams on the Doring River will disturb the present ecological situation but the extent thereof is poorly understood. These factors are critical in determining the acceptability of any development within this river's catchment.

The Groot River Dam is considered unfavourable from an environmental and beneficiaries perspective, due to the reduction of flow to the Doring River, with its associated consequences, and the required new infrastructure to distribute the water. The Leeu River Dam is considered to be unfavourable for the same reasons but to a lesser extent. These options were rated as having high to very high impacts, from an environmental and cost perspective.

Aspoort Dam was rated as having a very high impact, in comparison to the raising of Clanwilliam Dam, and is therefore considered unfavourable. The dam would have an impact on migratory fish populations, unique rock paintings, and the water quality downstream of the dam. Furthermore, new infrastructure involving pumping would be required to establish farming in the area. Evaporation losses would be high and represent the loss of a valuable resource.

The Melkbosrug Dam and Melkboom Dam were considered to have a very high environmental impact, due to the loss of rare and endangered fauna, creating a barrier for various endemic fish species, and impacting on sediment dynamics, unique cultural heritage sites and recreational opportunities. The Brandewyn Dam and weir would have a lower impact but this is still considered high. The cost to beneficiaries was rated as being medium, as there are existing commercial farmers who could assist resource-poor farmers. However, additional conveyance infrastructure would be required.

6. RECOMMENDATIONS

It is clear from **Tables 5.1** and **5.2** above that the three most favourable development options for the Olifants/Doorn WMA are:

- the development of off-channel farm dams;
- the development of groundwater schemes;
- the raising of Clanwilliam Dam;

or combinations of the above three options.

The raising of Clanwilliam Dam was considered to be a favourable option because it does not introduce a new suite of associated environmental and social impacts, but rather extends existing impacts. Furthermore, the lower Olifants River has already been disturbed by the presence of the Clanwilliam Dam and the Bulshoek Weir. In terms of local and international policy and experience, there is strong support for expanding existing agricultural development rather than creating new dispersed agricultural areas. However, as mentioned above, with the exception of groundwater, the raised Clanwilliam Dam could potentially exclude or diminish other development options in both the Olifants and Doring River catchments.

The raising of Clanwilliam Dam provides flexibility in terms of supplying potential beneficiaries, opportunities and development options for RPFs, the position of new irrigation development and crop variety. Other potential development options on the Olifants and Doring rivers do not appear to provide the same level of flexibility. Furthermore, Clanwilliam Dam can provide relatively affordable water. This scheme also provides the option of either large-scale RPF development or incremental development over time, depending on the flexibility in terms of funding the scheme.

Based on the feedback received at the Key Stakeholder Workshop, it was evident that there is broad support for the abovementioned most favourable development options, and more specifically for the raising of Clanwilliam Dam.

It is recommended that a study be undertaken to confirm the feasibility of the Raising of Clanwilliam Dam for the following reasons:

- The remedial work to be undertaken provides the opportunity to raise Clanwilliam Dam a
- The scheme would have relatively low environmental impacts compared to other development options;
- The scheme would provide flexibility with respect to potential beneficiaries;
- The scheme would provide the possibility to make water available for resource-poor farmers;
- The scheme would provide the opportunity to satisfy the ecological Reserve of the Olifants River and Estuary; and
- The scheme would provide the possibility of expanding existing agricultural development rather than creating new unsupported agricultural areas.

APPENDIX A

Clanwilliam Dam Raising Study :
Updated Specialist Workshop Starter Document
(23 November 2004)

CLANWILLIAM DAM RAISING STUDY

SPECIALIST SCREENING WORKSHOP

23 NOVEMBER 2004

Workshop Starter Document

CLANWILLIAM DAM RAISING STUDY

SPECIALIST SCREENING WORKSHOP

23 November 2004
Workshop Starter Document

The purpose of this Starter Document is to serve as a basis for the Specialist Screening Workshop scheduled for 23 November 2004.

The workshop will bring together selected DWAF staff, study team members and other identified key stakeholders within the area of interest. They will discuss options for the future development of water resources in the WMA, with particular focus on the catchments of the Olifants and Doring Rivers and on resource poor farmers.

The document consists of the following sections :

- Background and introduction to the Olifants Doorn WMA
- Description of the proposed schemes in the Olifants River sub catchment
- Description of possible schemes in the Doring River sub catchment

Annexure A contains further information on groundwater resources.

A summary table of templates for comparing the various schemes will be supplied at the workshop.

TABLE OF CONTENTS

Page No.

1. INTRODUCTION 1

1.1 BACKGROUND TO THE SCREENING WORKSHOP 1
1.2 OBJECTIVES OF THE SCREENING PROCESS 1
1.3 THIS WORKSHOP STARTER DOCUMENT 2
1.4 ANTICIPATED OUTCOMES OF THE WORKSHOP 2
1.5 BACKGROUND TO THE WATER MANAGEMENT AREA 3

1.5.1 Groundwater 3
1.5.2 Previous studies 6
1.5.3 The need for water resource development 7

1.6 ENVIRONMENTAL OVERVIEW OF THE DORING AND OLIFANTS RIVERS 8

2. SCHEMES TO BE CONSIDERED FOR IMPLEMENTATION IN THE OLIFANTS RIVER AND DORING RIVER CATCHMENTS 10

2.1 WATER DEMAND MANAGEMENT 10
2.2 INTRODUCTION TO POTENTIAL SCHEMES 10

3. SURFACE WATER AND GROUNDWATER SCHEME OPTIONS : OLIFANTS RIVER CATCHMENT 16

3.1 ROSENDAAL DAM SITE 18

3.1.1 Location 18
3.1.2 Engineering and Financial 18
3.1.3 Environmental Overview 18
3.1.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts 19
3.1.5 Resource Poor Farmers 19

3.2 VISGAT DAM SITE 21

3.2.1 Location 21
3.2.2 Engineering and Financial 21
3.2.3 Environmental Overview 21
3.2.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts 21
3.2.5 Resource Poor Farmers 21

3.3 GROOTFONTEIN DAM SITE 23

3.3.1 Location 23
3.3.2 Engineering and Financial 23
3.3.3 Environmental Overview 23
3.3.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts 24
3.3.5 Resource Poor Farmers 24

3.4 KEEROM DAM SITE 26

3.4.1 Location 26
3.4.2 Engineering and Financial 26
3.4.3 Environmental Overview 26
3.4.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts 27
3.4.5 Resource Poor Farmers 27

3.5 RAISING CLANWILLIAM DAM 29

3.5.1 Location 29
3.5.2 Engineering and Financial 29

3.5.3 Using Catchment Storage Draft Curves – Clanwilliam Example....30
3.5.4 Environmental Overview....32
3.5.5 Beneficiaries, Infrastructure Requirements and Environmental Impacts....32
3.5.6 Resource Poor Farmers....34

3.6 ADDITIONAL FARM DAMS IN THE OLIFANTS RIVER CATCHMENT....35

3.6.1 Beneficiaries, Infrastructure Requirements and Environmental Impacts....35
3.6.2 Resource Poor Farmers....35

3.7 GROUNDWATER SCHEMES....37

3.7.1 Project T2 Conventional Wellfield....37
3.7.2 Project T3 Conventional Wellfield....37
3.7.3 Project T5 Aquifer Storage Recovery....38
3.7.4 Project T7 Aquifer Storage Recovery....39
3.7.5 Conjunctive Use....40
3.7.6 Citrusdal-Boschkloof Wellfield in confined Peninsula Aquifer....41

4. SURFACE WATER AND GROUNDWATER SCHEME OPTIONS : DORING RIVER CATCHMENT....42

4.1 LEEURIVER DAM SITE....44

4.1.1 Location....44
4.1.2 Engineering and Financial....44
4.1.3 Environmental Overview....44
4.1.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts....44
4.1.5 Resource Poor Farmers....44

4.2 GROOTRIVIER DAM SITE....46

4.2.1 Location....46
4.2.2 Engineering and Financial....46
4.2.3 Environmental Overview....46
4.2.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts....47
4.2.5 Resource Poor Farmers....47

4.3 ASPOORT DAM SITE....49

4.3.1 Location....49
4.3.2 Engineering and Financial....49
4.3.3 Environmental Overview....49
4.3.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts....50
4.3.5 Resource Poor Farmers....51

4.4 REENEN DAM SITE....53

4.4.1 Location....53
4.4.2 Engineering and Financial....53

4.5 MELKBOSRUG DAM SITE....55

4.5.1 Location....55
4.5.2 Engineering and Financial....55
4.5.3 Environmental Overview....56
4.5.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts....56
4.5.5 Resource Poor Farmers....57

4.6 MELKBOOM DAM SITE....59

4.6.1 Location....59
4.6.2 Engineering and Financial....59

4.6.3 Environmental Overview 60
4.6.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts 60
4.6.5 Resource Poor Farmers 60

4.7 BRANDEWYN DAM SITE 62

4.7.1 Location 62
4.7.2 Engineering and Financial 62
4.7.3 Environmental Overview 63
4.7.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts 64
4.7.5 Resource Poor Farmers 64

4.8 ADDITIONAL FARM DAMS IN THE KOUEBOKKEVELD 65

4.8.1 Beneficiaries, Infrastructure Requirements and Environmental Impacts 65
4.8.2 Resource Poor Farmers 65

4.9 GROUNDWATER SCHEMES 67

4.9.1 Project T1 Conventional Wellfield 67

1. INTRODUCTION

1.1 BACKGROUND TO THE SCREENING WORKSHOP

The Clanwilliam Dam Raising Association, comprising Ninham Shand, Asch Consulting Engineers and Jakoet & Associates was appointed by the Department of Water Affairs and Forestry (DWAF) to undertake a Feasibility Study for the possible raising of the Clanwilliam Dam. An Inception Phase fieldtrip and workshop was undertaken on 23 and 24 June 2004. Following the workshop, DWAF agreed that the Association should revisit the need for a process that addressed the screening of possible future development options.

It was the view that to gain acceptance of a specific development option (in this case the raising of Clanwilliam Dam), a strategic but holistic options assessment should precede the selection of a possible development option for further study at feasibility level, as part of a widely accepted process. Furthermore, the raising of Clanwilliam Dam would be subject to environmental authorisation through an Environmental Impact Assessment (EIA) process. The consideration of alternatives is a key principle in the EIA process. The outputs of this screening process will therefore feed into the EIA process, in terms of the consideration of broad alternatives, allowing the Feasibility Study and in particular the EIA process[1] to focus on the implications of raising Clanwilliam Dam by 5, 10 or 15m.

1.2 OBJECTIVES OF THE SCREENING PROCESS

The objectives of the screening process are to:

- Clarify the policy of DWAF and its co-operative governance partners regarding the need for development in the Olifants-Doorn WMA;
- Clarify development needs, objectives and intended beneficiaries, particularly resource poor farmers, at a strategic level;
- From existing information, assess the acceptability of the various options identified in previous studies in terms of technical, financial, environmental and social criteria[2];
- Augment the existing information with specialist inputs from DWAF and other key stakeholders;
- Ascertain whether or not the raising of Clanwilliam Dam is a preferable and defendable development option.

This screening process entails three main tasks. Firstly the compilation of this Starter Document, secondly the Specialist Screening Workshop, and thirdly obtaining input on the draft Screening Report from members of the WMA Reference Group.

The purpose of the Specialist Screening Workshop is to work with selected DWAF staff, team members and other identified stakeholders to agree on the development needs, objectives and

[1] Presuming that the Screening process concludes that it is desirable to pursue the raising of Clanwilliam Dam.
[2] An additional outcome of this will be the identification of options for which adequate required information is not available.

intended beneficiaries in the WMA, and the Clanwilliam Dam raising option in particular. Following that, screening of the various identified development options would take place based on a number of criteria, including but not limited to:

- financial costs and incremental yields;
- the likely social and ecological implications;
- the prospective beneficiaries and impacts associated with the utilisation of the water; and
- the opportunities for redressing inequity in terms of access to water (by resource poor farmers).

All comparable/mutually exclusive possible surface and groundwater options need to be assessed at this strategic level in order to support or refute the decision to continue with the Feasibility Study on the raising of the Clanwilliam Dam.

1.3 THIS WORKSHOP 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 unless otherwise stated, the yields of the various options described in the report do NOT make allowance for the impact of Ecological Flow Requirements (EFRs). In the case of Clanwilliam Dam, available information has allowed for a rough estimate of the percentage impact that the EFR may have on the yield. Until the EFR and ultimately the Reserve is determined, this however remains a provisional order of magnitude estimate.

The purpose of this document is to facilitate informed discussion at the Specialist Screening Workshop in order to confirm whether or not the raising of Clanwilliam Dam is a favourable, acceptable and defendable development option.

1.4 ANTICIPATED OUTCOMES OF THE WORKSHOP

Following this Specialist Workshop, an internal draft *Screening of Options* report will be prepared based on this Starter Document and the information derived from the Workshop. The internal draft *Screening of Options* report will be distributed to all participants for their review and further inputs.

A Key Stakeholder Workshop will be held in February 2005, targeting the CMA Reference Group members. The purpose of that workshop will be to present the draft Screening of Options report and to solicit further comments and input.

The final *Screening of Options* report would feed into the EIA process, as part of the contextualisation and consideration of broader alternatives.

1.5 BACKGROUND TO THE WATER MANAGEMENT AREA

The demand for additional water in the Olifants/Doorn Water Management Area (WMA) is largely centred around the catchments of the Olifants River and the Doring River (see Figure 2.1). These catchments border on the Cederberg Mountains in the south-west, where the mean annual precipitation in the upper reaches is more than 900 mm per annum. In the northern half of the Olifants/Doorn WMA, there is no potential for any significant surface water resource development, due to the dry nature of that region (mean annual precipitation of between 100 and 200 mm). Consequently, all surface water resource development options presented in this document are located in the southern half of the Olifants/Doorn WMA, notably the Olifants River and Doring River catchments. Local small schemes were considered where these may have a significant cumulative impact.

Groundwater development potential in the northern sector of the WMA is limited to local development for small town and rural or domestic supply. The water quality varies and recharge depends upon the extreme rainfall events. The groundwater development options presented in this document are located in the Olifants River catchment and the lower reaches of the Doring River catchment. The reason is that this area is dominated by the Table Mountain Group (TMG), comprising two of the most important aquifers; the Peninsula and the Skurweberg Aquifers. These are the aquifers having the greatest storage and recharge potential in the TMG and are in closest proximity to existing surface water storage and also having the greatest as yet unused storage of water. The greatest potential and economic incentive for initiating and developing integrated water resource development and management exists in the south.

About 85% of the total river flow volume occurs during the winter months. In contrast, over 60% of the annual urban demand and 90% of the irrigation demand occurs in summer. This pattern necessitates high levels of assurance in water resource development and management. Consequently, considerable storage capacity is required to store the winter surplus for use in summer.

1.5.1 Groundwater

Appendix B contains a preliminary and summary description of possible approaches to the regional development of groundwater in the WMA with an emphasis on Integrated Water Resource Management and conjunctive use with surface water resources.

The aquifers in the study domain have significant storage potential varying between hundreds and thousands of million m^3 depending upon the aquifer management strategy adopted. A groundwater scheme would comprise upwards of at least 20 wellfields within different scheme domains and strategically located to abstract the water from aquifer storage. Such wellfield siting would take existing infrastructure, site of demand and optimal access to source into account.

Thus individual wellfields cannot be considered as options to facilitate a comparison with surface water schemes as they do not indicate the yield of a groundwater scheme. The latter can only be established once scheme domains are defined, aquifer storage is modelled and preliminary wellfield siting is undertaken (i.e. can the water in storage be cost effectively abstracted). To date, this information is only available for the area north of Bulshoek Weir at a pre-feasibility level and for purposes of exploration (not comprehensive scheme design). Regional information on the relevant aquifers is available south of Bulshoek Weir.

Thus, whilst it would be desirable to be able to compare groundwater schemes with surface water schemes such is not realistically possible and it is more important in this report to illustrate how and where such schemes should be conceptualised and to present relative estimates of cost, impact on the environment and on potential beneficiaries.

Wellfields identified in the WODRIS are listed individually for illustrative purposes. Together, these wellfields would comprise part of a groundwater scheme. The amount of groundwater that could sustainably be abstracted from aquifer storage south of Bulshoek Weir is also presented. Cost estimates, possible environmental impacts and potential beneficiaries are based on comparable schemes and current knowledge.

The following briefly contextualises the groundwater component of the water resource.

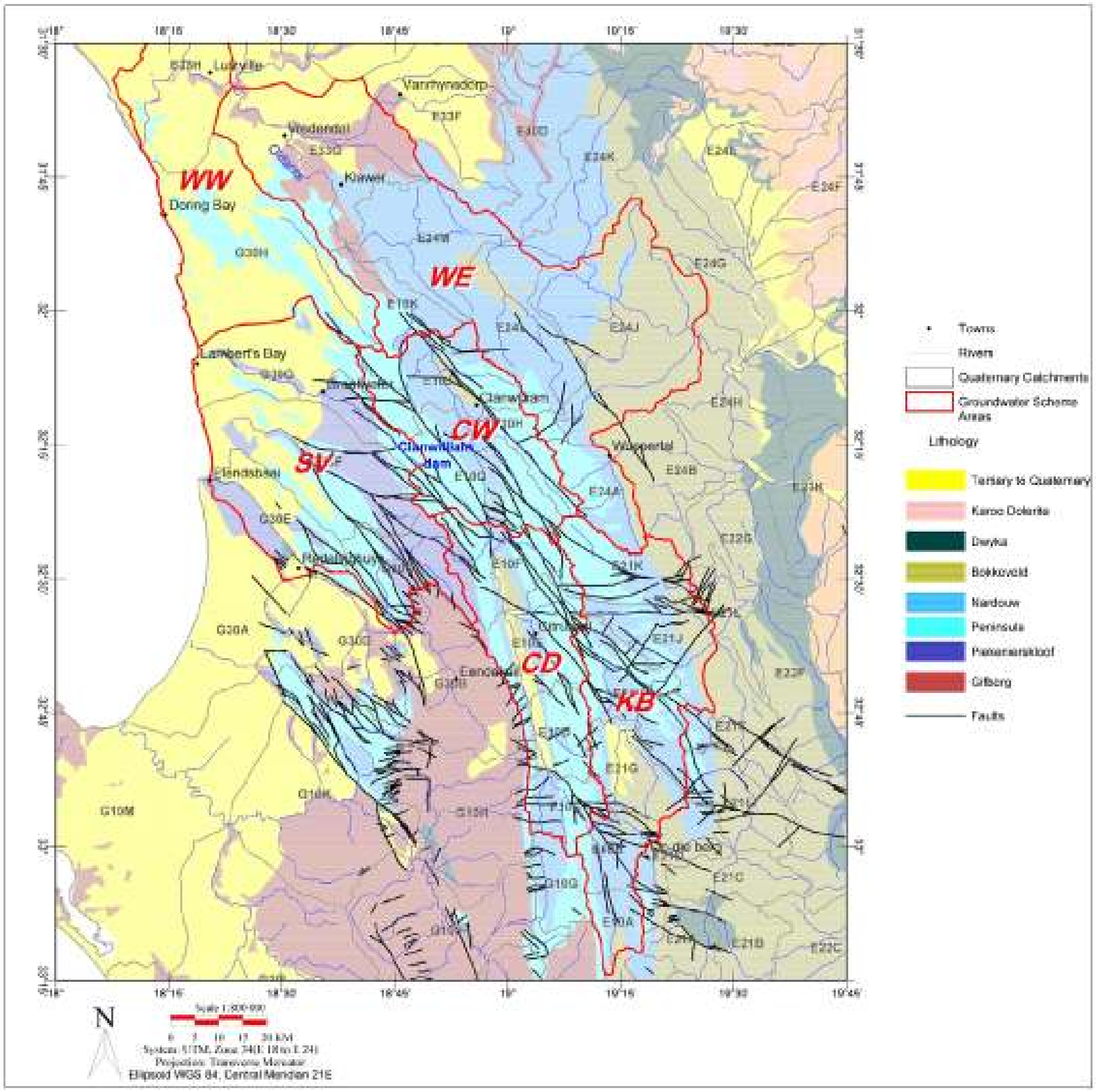
The Peninsula Formation constitutes the middle aquifer in the Table Mountain Group (TMG), and is a topographically dominant unit, building most of the high mountain ranges. It is hydrogeologically most important because of its wide areal extent in the areas of maximum precipitation and recharge potential, as well as the considerable sub-surface volume of permeable fractured rock (storage). Two models that demonstrate the potential benefits of accessing this storage in the Peninsula Aquifer using different aquifer management models are contained in Appendix B.

There are six groundwater scheme domains within the study area. These are shown in Figure 1.1 and summarised in Table 1.1. As stated above, it is only in the WODRIS East and West scheme domains that wellfields and Aquifer Storage and Recovery options have been presented at a conceptual and pre-feasibility level. Preliminary aquifer storage estimates are available for the Peninsula Aquifer in the WODRIS East and West domain and in the Citrusdal Domain. No comparable information is available in the Clanwilliam trough or Kouebokkeveld Domains. The Sandveld Domain is not considered in this study, but ought not be to excluded conceptually.

Both the Peninsula and the Skurweberg Aquifers are currently little exploited although they constitute the largest natural storage facility in the area. The reason for this pattern of little exploitation has been limiting scientific or professional input to the development of groundwater resources by local farmers, who are the primary users.

The Citrusdal Deep Artesian Groundwater Exploration (CAGE) Study estimated that approximately 12 million m^3/a were being abstracted from the Nardouw Aquifers by local farmers. At that time (1998) there was limited abstraction from the Peninsula Aquifer viz. 1,5 – 2,0 million m^3/a from the Boschkloof Wellfield. Abstraction from the primary aquifers along the coast are excluded from further consideration in this Starter Document other than in association with development of the TMG aquifers and surface water in Aquifer Storage Recovery Schemes (ASR).

Two formations viz. the Rietvlei and the Skurweberg are preferred aquifer targets of the farming sector. The reason for this is that these aquifers are close to the homes and developed lands and the water table is relatively high, although the iron content and Total Dissolved Solids (TDS) of the water can be variable, depending upon proximity to the Bokkeveld Shales. The farmers use the groundwater to augment surface water supplies or for use as an emergency supply during summer, largely for the irrigation of citrus in the area upstream and downstream of Clanwilliam Dam, but increasingly groundwater is being developed in order to open new land for development.



WW	*WODRIS West*	*SV*	*Sandveld*
WE	*WODRIS East*	*CD*	*Citrusdal Trough*
CW	*Clanwilliam Trough*	*KB*	*Kouebokkeveld*

Figure 1.1 Groundwater scheme domains

Table 1.1 Groundwater Scheme Domains

Scheme Domain	Area [km]	Quaternary Catchments
WODRIS West	1796	G30H E33H
WODRIS East	3606	E24A E24J E24L E24M E10K E33G
Clanwilliam Trough	1139	E10G E10H E10J
Sandveld	2130	G30E G30F G30G
Citrusdal Trough	1179	E10C E10D E10E E10F
Kouebokkeveld	1653	E10A E10B E21G E21H E21J E21K

In terms of recharge to the Peninsula Aquifer in the Citrusdal Scheme Domain, the CAGE Study indicates a spatially weighted average of 23% in a range of 8 to 52% of MAP. Aquifer recharge to the TMG in these scheme domains is considered adequate to warrant further exploration and planning of groundwater schemes and wellfields.

The current, but not definitive estimates of groundwater sustainably available for abstraction from the Peninsula Aquifer in the Citrusdal Scheme Domain varies between 25 million m^3/a and 45 million m^3/a and up to at least 250 million m^3/a depending upon the storage model, conjunctive use of surface water storage facilities and the aquifer management model taking into account environmental impacts.

1.5.2 Previous Studies

A number of major surface water resource studies have been undertaken within specific areas of the WMA during the past six years. These include :

The Olifants Doring River Basin Study - Phase 1 (1998)
The Olifants Doring River Basin Study - Phase 2 (2003)
The Olifants/Doorn WMA Water Resources Situation Assessment (2002)
The Olifants/Doorn WMA Overview of Water Resources and Utilisation (2003)
The Olifants/Doorn Internal Strategic perspective (2004)
The Western Cape Olifants/Doring River Irrigation Study (WODRIS, 2004)
The Possible Raising of Clanwilliam Dam Feasibility Study (in progress)
DANIDA Integrated Water Resource Management (2003)

The purpose of these studies was not to identify groundwater schemes. There has been no investment for this purpose in the region other than the WODRIS wherein groundwater development options were undertaken at pre-feasibility level as an adjunct to a feasibility study for Melkboom Dam. Refer to Appendix B for details of these studies.

1.5.3 The Need for Water Resource Development

From information extracted from the latest draft (January 2005) of the Olifants/Doorn Internal Strategic Perspective (ISP), the Olifants/Doorn WMA currently experiences significant shortages in meeting current irrigation water requirements. This is particularly severe in the Olifants River catchment downstream of Clanwilliam Dam, where the shortfall is 29 million m^3/a. Table 1.2 shows the reconciliation of water requirements and availability for the Olifants River and Doring River catchments. It should be noted that these shortfalls arise in part on account of the provisions made for the preliminary Reserve (37 million m^3/a), however downstream of Clanwilliam Dam there are currently frequent shortfalls in the supply to the Lower Olifants River WUA although no releases are made for the Reserve.

Table 1.2: Reconciliation of Water Requirements and Availability (Olifants and Doring River Catchments)

Catchment (see Figure 2.1)	Available Yield (million m^3/a)	Water Requirements (million m^3/a)	Balance (million m^3/a)
Olifants u/s of Clanwilliam Dam	197	197	0[3]
Olifants d/s of Clanwilliam Dam	145	174	- 29
Doring River (incl. Kouebokkeveld catchments)	81	81	0
		Total shortfall	- 29

(Ref : Draft Olifants/Doorn ISP, 2005)

The information presented in Table 1.2 is for the NWRS sub-areas within the Olifants River and Doring River catchments. The urban requirement supplied out of the Olifants River catchment is 4 million m^3/a and represents only 1% of the total water requirement out of that catchment. The remaining 99% is utilised for irrigation.

Whilst the growth in the urban water requirement is not expected to be significant, there is a significant interest by farmers to expand their irrigation potential. To do so, interventions such as the following will be required :

- reduction of conveyance losses in canal systems
- improved irrigation efficiency
- improved management of releases
- targeted removal of invasive alien plants
- development of new surface and groundwater schemes
- water trading

[3] If the reserve were to be implemented upstream of Clanwilliam Dam, there would likely be less water available for abstraction by the farmers during the summer months. Farmers would therefore have to store additional winter water in order to meet their summer demands.

The estimated proportions of sectoral water requirements for the whole of the Olifants/Doorn WMA are as follows :

Irrigation	:	95%
Urban	:	2%
Rural	:	2%
Mining and Bulk Industrial	:	1%
Afforestation	:	< 1%

Of the total irrigation water requirement in the WMA (356 million m^3/a), 90% takes place within the catchments of the Olifants and Doring Rivers.

1.6 ENVIRONMENTAL OVERVIEW OF THE DORING AND OLIFANTS RIVERS

The Olifants River, rising in the Agter Witzenberg plateau, is flanked by the Cederberg mountains in the east and the Olifants River mountains and Swartberge in the west. It is a perennial river that drains an area consisting almost entirely of quartzitic sandstone and quartzites of the Table Mountain Group. As a result, the water in the upper reaches of the river, upstream of the confluence with the Doring River, is clear and fresh. Downstream of the Doring River confluence, the concentrations of suspended solids and dissolved salts increases. The Olifants River is important from a conservation perspective because it contains eight endemic fish species.

The Doring River rises on the Northern slopes of the Hex River mountains, and flows in a north westerly direction into the Ceres-Karoo region. It joins with the Olifants River just upstream of the town of Klawer. The Doring River is mostly seasonal, however a section between the Olifants/Doring confluence and the Groot River confluence flows throughout the year, mainly due to the perennial Groot River. Runoff into the Doring River from the northern Cederberg (TMG) area produces good quality water. However, runoff from the Tankwa Karoo is characteristically more saline and turbid due to the presence of shales and mudstones. The Doring River is inhabited by nine indigenous fish species, seven of which are endemic to the river system. Furthermore, the area upstream of the confluence with the Tankwa River is a vital breeding area for the sawfin (*Barbus serra*), the Clanwilliam yellowfish and the Clanwilliam sandfish (*Labeo seeberi*). Lastly, and very importantly, the Doring River is the only major river in the region that is not impounded.

1.6.1 Impacts of Dams on Rivers

The construction of dams on rivers frequently results in a suite of local and remote environmental impacts, which should be taken into account when determining whether or not to construct the dam. Although these impacts are often river specific and difficult to predict, sufficient data exists to enable a general prediction of likely impacts of dams on river systems. The likely impacts include:

Inundation effect – the permanent inundation of wetlands, riparian vegetation and their associated fauna. River and floodplain habitats are some of the most diverse habitats, and the most fertile farming areas. Dams are often built in remote areas, which act as refuges for species that have been displaced from other areas. Furthermore, dams create a new habitat which often favours alien invasive fish species, such as carp and bass. These species out-compete their indigenous counterparts leading to further decline in the indigenous population.

Alteration of downstream flow regime – the construction of a dam leads to the manipulation of the natural flow regime. Consequences of an altered flow regime include:

- Disruption to the hydrological cues for fish spawning;
- Changes in hydraulic and thermal conditions may make the system incompatible for the life-cycle requirements of various organisms;
- Certain species, often seen as pests, may take advantage of the changed environmental conditions or lack of competition and increase in abundance;
- Riparian vegetation may die due to the rapid lowering of the water table or seedlings may not grow due to a lack of bank flooding;
- Lack of floods reduces the scouring of the river bed, with a resultant reduction in habitat diversity; and
- The loss of medium sized floods can cause estuary mouths to close for longer periods or more frequently, with the resultant barrier to nursery areas for certain marine fish species.

Change in sediment loads – dams and reservoirs trap sediment and starve the river downstream of its normal sediment load. The clear water downstream of the dam seeks to recapture its sediment load by eroding the bed and banks of the river. Cobbles and gravel are also eroded, reducing the habitat diversity and exposing the bedrock.

Changes in downstream water quality – dams trap nutrients in the same way as sediments, with the result that blooms of algae and macrophytes are often associated with impoundments. Furthermore, the increased surface area leads to increased evaporation and resultant increase in salinity of the water, which has a negative effect on most aquatic organisms.

Barrier effect – high dam walls form barriers to natural movement of fish and other organisms. Furthermore, dams trap the seeds of riparian plants, affecting recruitment of these species in the river reaches downstream of the dam. Dams and alien fish have been identified as the major contributors to the dramatic decline in the Clanwilliam yellowfish population in the Olifants River.

2. SCHEMES TO BE CONSIDERED FOR IMPLEMENTATION IN THE OLIFANTS RIVER AND DORING RIVER CATCHMENTS

2.1 WATER DEMAND MANAGEMENT

The implementation of urban water demand management will not make any significant impact on the availability of water on a catchment wide scale. However, it is a crucial intervention that must be implemented by all local authorities, so as to prolong the life of existing urban sources of supply. Whilst local authorities are responsible for supplying their consumers, DWAF will not give consideration to the development of any local supply schemes unless water demand management has been conscientiously and rigorously implemented.

In the agricultural sector, there is significant opportunity to save water through water conservation and demand management. It has been estimated that losses in the canal distribution system downstream of Clanwilliam Dam are in the order of 28%. It is considered that a reduction to 15% (Ref : DANIDA Integrated Water Resource Management Study, 2002/2003) could be achieved through maintenance. This alone could substantially reduce the shortfall in the Olifants River catchment downstream of Clanwilliam Dam.

Water demand management, however, will not be sufficient to address the current shortfall in the entire Olifants River catchment. To meet current demands, new sources will have to be developed to firstly address current shortfalls and secondly, for new irrigation development. Alternatively, current demands could be curtailed through the acceptance of lower assurances of supply. Although the Doring River catchment is currently essentially in a state of balance, further irrigation expansion will not be possible without developing additional sources of supply.

2.2 INTRODUCTION TO POTENTIAL SCHEMES

There are a number of potential surface and groundwater schemes that could be developed to increase the availability of water within the Olifants and Doring River catchment. These are summarised in Table 2.1 and Table 2.2. Unless otherwise noted, the yields exclude any allowance for Ecological Water Requirements. This approach has been adopted to allow for an "apples with apples" comparison of potential scheme yields, without having to consider the Reserve. Uncertainties relating to the eventual implementation of the Reserve are numerous. Within the scope of this screening exercise, the development of potential Reserve scenarios for each and every scheme was not possible.

Table 2.1 List of Potential Surface Water Schemes to be Screened

Olifants River Catchment		
Name of Potential Scheme	**Additional Storage (Mm^3)**	**Additional Yield (Mm^3/a) (1)**
Rosendaal Dam	26	14
Visgat Dam	unknown	unknown
Grootfontein Dam	138	90
Keerom Dam	153	100
Raise Clanwilliam Dam by 5m (2)	63	36
Raise Clanwilliam Dam by 10m (2)	143	66
Raise Clanwilliam Dam by 15m (2)	240	86
Farm Dams (Off Channel)	14	10

Doring River Catchment		
Name of Potential Scheme	**Additional Storage (Mm^3)**	**Additional Yield (Mm^3/a) (1)**
Leeu River Dam	35	6
Groot River Dam	159	64
Aspoort Dam	395	76
Reenen Dam	250	88
Melkbosrug Dam (4)	400	116
Melkboom Dam (4)	400	121
Brandewyn Dam	160	± 50 (3)
Farm Dams (Off Channel)	8	5

(1) The yields are gross yields before provision for the Reserve and before any compensation releases other than as indicated in Note (3)

(2) Over and above the existing Clanwilliam Dam storage of 122 million m^3 and yield of 149 million m^3/a.

(3) The Yield for Brandewyn Dam has already allowed for IFRs as determined in the WODRIS.

(4) These yields are based on the ODRB Study of 1998 and are for a 1 MAR dam with no allowance for EWRs or compensation releases. The subsequent WODRIS (2004) reports the following yields for Melbosrug or Melkboom Dams, including an allowance for EWRs :

1 MAR	(400 million m^3)	-	80,6 million m^3/a
1,5 MAR	(600 million m^3)	-	92,3 million m^3/a
2,0 MAR	(800 million m^3)	-	104,2 million m^3/a

The locations of the surface water development options are shown on Figure 2.1.

Figure 2.1 The Olifants/Doring River Basin

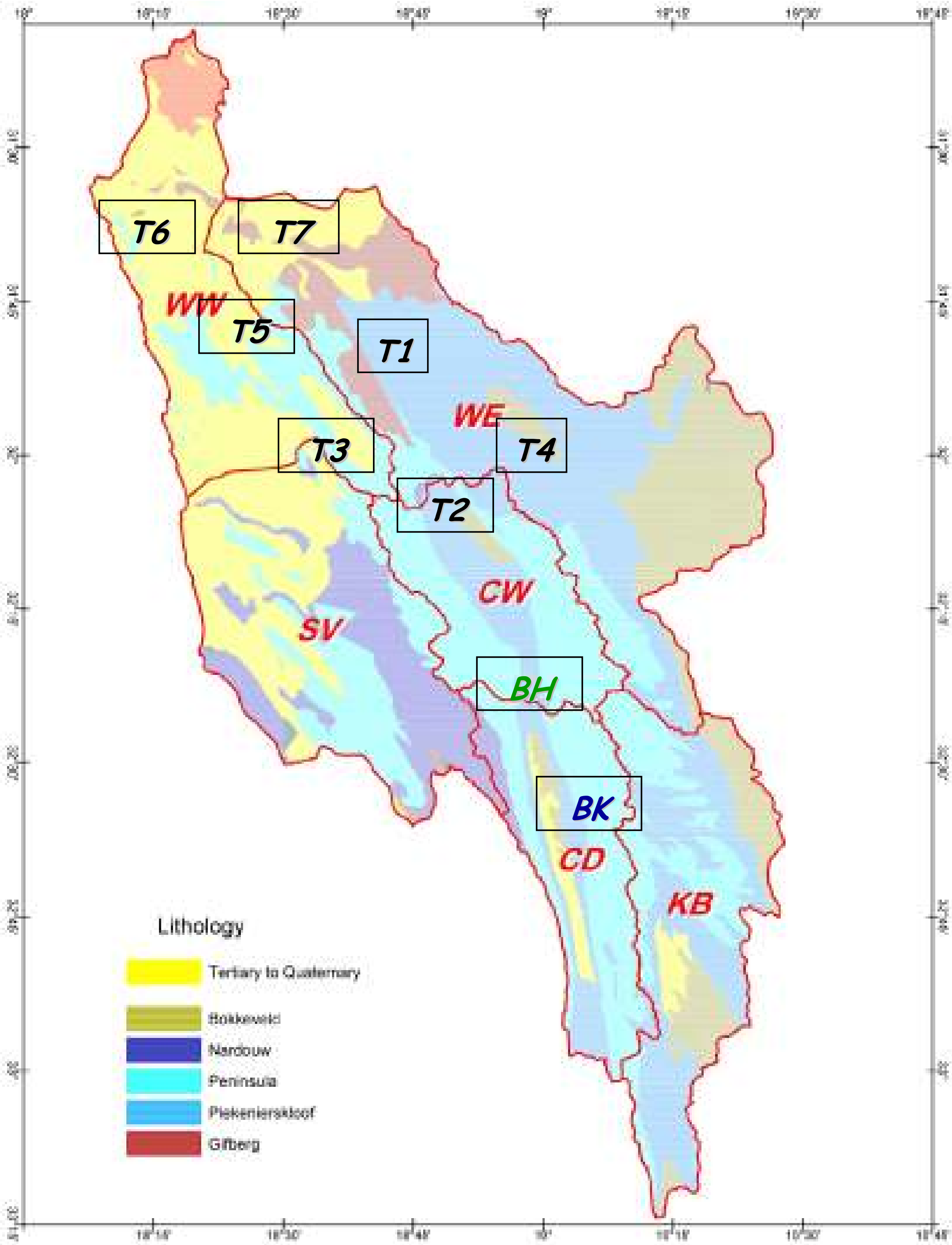
There is only one groundwater scheme that has been developed at conceptual level on the basis of data available at pre-feasibility level. This scheme was developed on the WODRIS and comprises a preliminary list of 5 wellfields in the TMG and 2 Aquifer Storage and Recovery (ASR) Schemes. One wellfield in the Citrsudal Trough Scheme Domain has been developed but between 12 – 20 more such wellfields are possible. The wellfields and estimated sustainable groundwater supply from the different groundwater scheme domains are summarised in Table 2.2. The groundwater target zones in relation to the groundwater scheme domains are shown on Figure 2.2.

Table 2.2 List of Potential Groundwater Schemes to be Screened

Scheme Domain	Wellfield Name and Location	Potential Yield
WODRIS West		
	T3 – Wellfield on the left bank of the Sandlaagte valley at Skurfkop Syncline. To abstract groundwater from the Peninsula Aquifer.	3 – 10 Mm^3/a
	T6 - Katmakoep area between Vredendal and Strandfontein. Wellfield in Katmakoep area to abstract groundwater from Peninsula Aquifer.	Capacity was not assessed
	T5 - Aquifer Storage Recovery Scheme Sandlaagte Valley Aquifer. Storage Recovery Scheme in unutilised Sandlaagte Aquifer.	Pump in and store water from Olifants River
WODRIS East		
	T1 - Two wellfields (T1a and T1b) at the confluence of the Doring and Olifants Rivers. Abstraction out of Peninsula Aquifer.	5 - 20 Mm^3/a, from each
	T2 – Wellfield on the right bank of the Olifants River, above the Bulshoek Weir. Wellfield to abstract groundwater from the Peninsula Aquifer.	3 – 10 Mm^3/a
	T4 – Brandewyn River valley above confluence with Doring River. Wellfield in river valley to abstract groundwater from both Skurweberg and Peninsula Aquifers.	Capacity was not assessed
	T7 - Aquifer Storage Recovery Scheme Aquifer. Storage Recovery Scheme in under-utilised Vanrhynsdorp dolomitic aquifer. Has water quality concerns associated with limestone aquifers.	Pump in and store water from Olifants River
Citrusdal Trough		
	Expansion of the Boschkloof Wellfield at Citrusdal, which presently supplements municipal bulk water supply for Citrusdal.	Not available
	CAGE - Peninsula Aquifer in E10 catchment. The CAGE Study (1998) estimated existing abstraction to be between 1,5 and 2,0 million m^3/a.	45 Mm^3/a
Clanwilliam Trough	No wellfield target zones identified as yet	50 – 100 Mm^3/a
Kouebokkeveld	No wellfield target zones identified as yet	40 – 80 Mm^3/a

The currently identified target zones for groundwater development are shown in Figure 2.2.

WODRIS reports a <u>realistic</u> total combined yield for T1a + T1b + T2 + T3 as 20 million m^3/a (5 million m^3/a each, with not more than 5 million m^3/a from T3). The <u>maximum</u> combined yield for T1a + T1b + T3 was estimated at 60 million m^3/a.



WW	*WODRIS West*	*SV*	*Sandveld*
WE	*WODRIS East*	*CD*	*Citrusdal Trough*
CW	*Clanwilliam Trough*	*KB*	*Kouebokkeveld*

Figure 2.2 Identified groundwater target zones in relation to groundwater scheme domains

In Sections 3.1 to 4.9 each of the schemes listed in Tables 2.1 and 2.2 are described in more detail, and the following information on each is provided.

SCHEME LOCATION
Description of the environment and a map

ENGINEERING AND FINANCIAL

ENVIRONMENTAL OVERVIEW

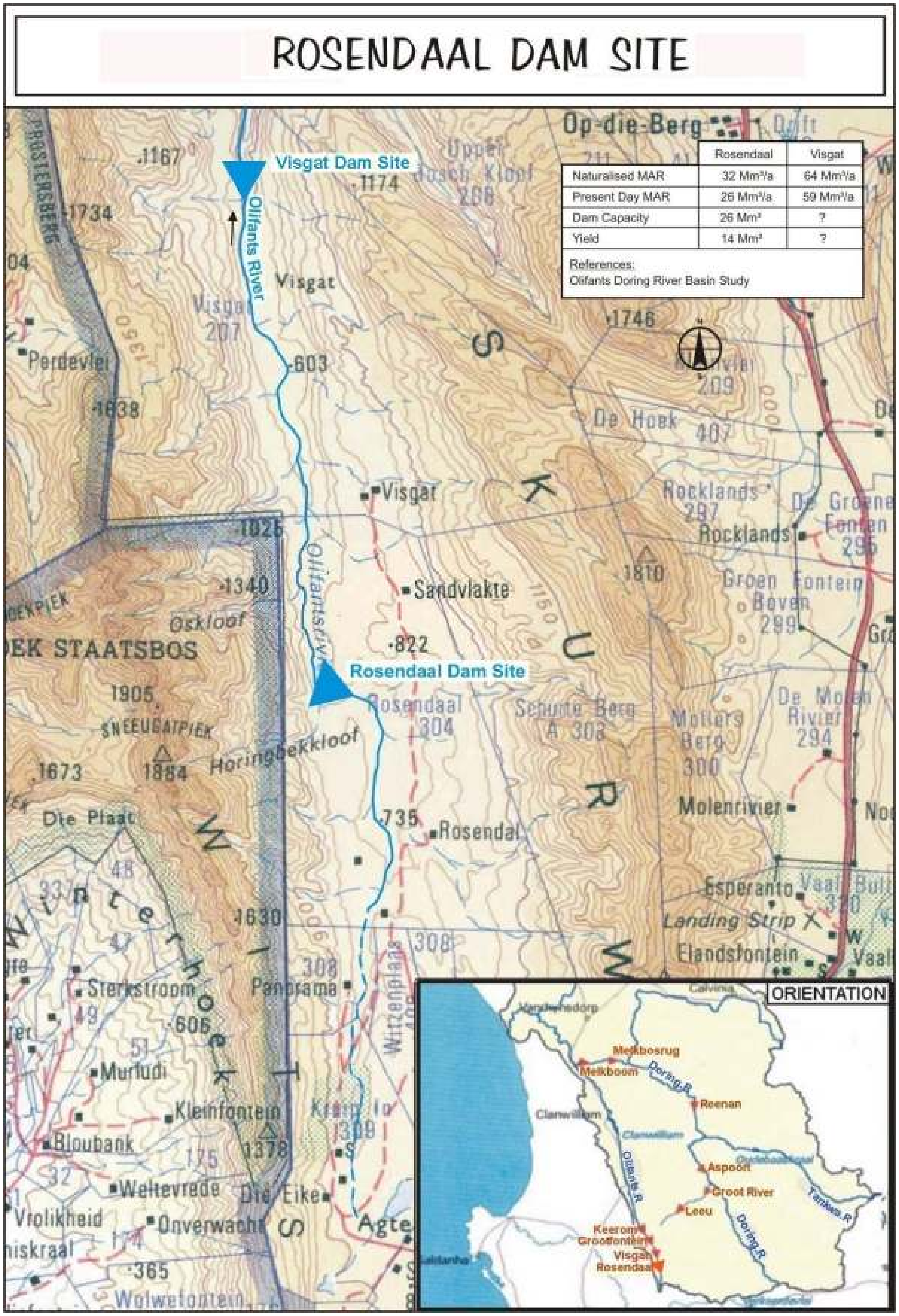
- Barrier and Sedimentation Effects
- Inundation Effects
- Downstream Effects

BENEFICIARIES, INFRASTRUCTURE REQUIREMENTS AND ENVIRONMENTAL IMPACTS

RESOURCE POOR FARMERS

3. SURFACE WATER AND GROUNDWATER SCHEME OPTIONS : OLIFANTS RIVER CATCHMENT

Unless otherwise stated, the yields of the potential surface water schemes presented in Sections 3.1 to 3.6 do not include any allowance for EWRs nor any allowance for downstream compensation releases.



	Rosendaal	Visgat
Naturalised MAR	32 Mm^3/a	64 Mm^3/a
Present Day MAR	26 Mm^3/a	59 Mm^3/a
Dam Capacity	26 Mm^3	?
Yield	14 Mm^3	?

References:
Olifants Doring River Basin Study

Figure 3.1 Rosendaal Dam Site

3.1 ROSENDAAL DAM SITE

3.1.1 Location

The Rosendaal Dam site is the most upstream development option on the Olifants River. The dam site is situated approximately 27 km to the north of Ceres, in the headwaters of the Olifants River.

3.1.2 Engineering and Financial

The Rosendaal Dam was considered as a storage reservoir to supply water to the Citrusdal Water User Association (WUA). The geology on which the proposed earth embankment would be constructed consists primarily of quartzitic sandstone.

The most cost-effective dam has a capacity of 1 MAR. The earth embankment wall would be 42 m high, requiring 1,45 million m^3 of fill material. The dam would have a storage capacity of 26 million m^3 and a yield of 14 million m^3/a (before any compensation releases). The crest length would be 435 m.

The financial costs associated with the construction of the dam are :

Yield Mm^3/a	Construction Cost	Ref Date (Year)	2004 Equivalent Cost (escalation @ 8% p.a.)	Cost:Yield Ratio
14	R65 million	1998	R103 million	7,4

(Ref : Olifants Doring River Basin Study)

The Rosendaal Dam Scheme should be compared with the Additional Farm Dams option (Section 3.6).

3.1.3 Environmental Overview

Environmental issues associated with the proposed Rosendaal Dam include:

Barrier and Sediment Effects
As the dam site is located upstream of the Visgat canyon with its water falls, the dam would not have any barrier effect for the movement of fish and other aquatic organisms. Similarly, due to the low sediment load, the dam would not have a significant impact on the downstream sediment dynamics and associated aquatic habitat.

Inundation Effects
The site is disturbed and comprises mainly of cultivated lands and *Acacia mearnsii*. Fynbos in the remainder of the inundation area is dominated by *Elytropappus rhinocerotis*, *Protea laurifolia*, *P repens* and *Cliffortia ruscifolia* with many geophytes. This vegetation is not often found in the relatively undisturbed state found at this site. The dominant species observed are however widespread.

Downstream Effects

Water for irrigation would be released down the river resulting in an increase in summer base flows that could threaten indigenous fish species, especially in the nursery areas. Furthermore, the introduction and spread of alien fish into the dam could effect the survival of indigenous fish species. The dam site is located immediately upstream of the ecologically important and sensitive Visgat canyon and therefore the water quality and quantity downstream are likely to be of major concern for maintenance of the aquatic ecosystem.

3.1.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

Water would be released down the Olifants River during the summer months for extraction by irrigators served by the Citrusdal WUA. Citrus is the main crop grown by commercial farmers along this reach of river.

If these releases were to replace existing summer abstractions from the river by irrigators then additional water would flow into Clanwilliam Dam during the summer months, enhancing its yield. This additional water could be utilised by irrigators below the dam as discussed in Section 3.5 5 (Raising Clanwilliam Dam).

The existing infrastructure, comprising pumping installations on the river, pipelines and balancing dams, could be utilised by the existing irrigators of the Citrusdal WUA. Similar infrastructure would need to be provided by new irrigators.

The additional water supply would enable the area under irrigation to be extended by about 750ha, the development of which would probably not have any significant impact on existing natural vegetation as much of the area is highly degraded. The main impact would arise from the additional summer releases down the Olifants River, however these releases would also assist to reinstate the natural summer low flows in the river, which have been reduced by the summer irrigation abstractions in the upper reaches of the Olifants River.

3.1.5 Resource Poor Farmers

Resource poor farmers could either benefit from the additional water supply through joint ventures with existing commercial farmers or through the development of their own farms on land provided by Citrusdal Municipality, or on land purchased from commercial farmers. If export citrus farming is to be undertaken then joint venture farming is likely to be more successful on account of the high technology and complicated marketing requirements. The alternative of supplying resource poor farmer beneficiaries below Clanwilliam Dam is discussed in Section 3.5.6 below.

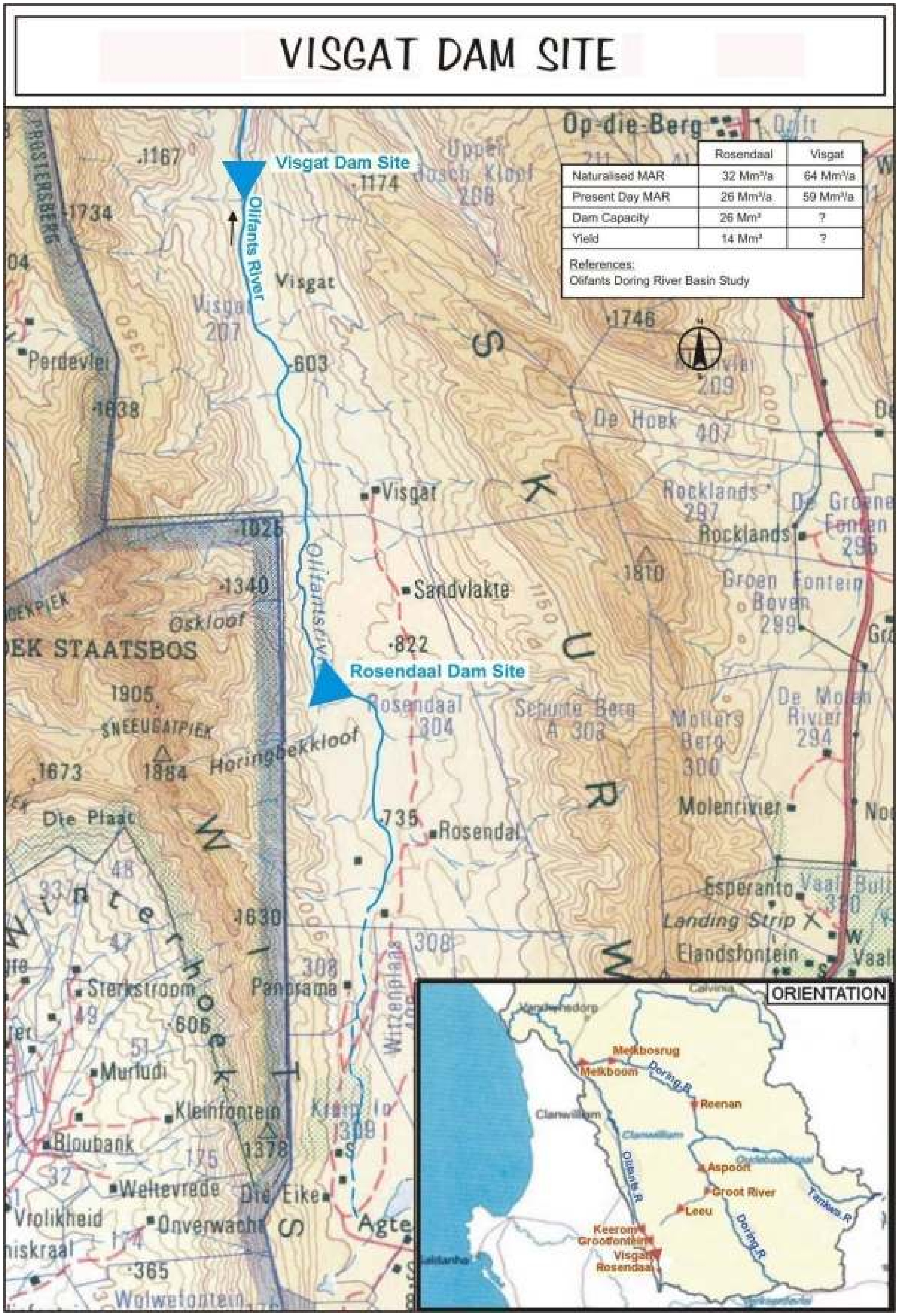


Figure 3.2 Visgat Dam Site

3.2 VISGAT DAM SITE

3.2.1 Location

The Visgat Dam site is located approximately 10 km downstream of the Rosendaal Dam site. Although listed as an option in the 1998 Olifants Doring River Basin Study, no detailed study of the site was undertaken, nor was any dam size evaluated.

3.2.2 Engineering and Financial

This option was not costed in the 1998 Olifants Doring River Basin Study.

3.2.3 Environmental Overview

Environmental issues associated with the proposed Visgat Dam include:

Barrier and Sediment Effects
As per Rosendaal.

Inundation Effects
The riverine and Mountain Fynbos vegetation found at the proposed dam site is in a good state. The two main types of Mountain Fynbos present include *Protea laurifolia* and *Heeria argentea*. The area is rich in rare species due to the diversity of habitats, the high rainfall, which is conducive to the speciation in Mountain Fynbos and its location near to the species rich Winterhoek and Koue Bokkeveld areas. The inundation impacts would be significantly greater than at Rosendaal due to the much larger area of natural vegetation that would be affected as well as the importance of the vegetation present.

Downstream Effects
As per Rosendaal.

3.2.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The ODRB Study reports a present day MAR at the Rosendaal Dam site of 26 million m^3/a and 59 million m^3/a at the Visgat Dam site. Consequently, the yield of Visgat Dam should be significantly higher than that of Rosendaal Dam. The dam would serve the same areas and have the same infrastructure requirements and impacts as those for Rosendaal Dam as described in Section 3.1.4 above.

3.2.5 Resource Poor Farmers

The potential resource poor farmer beneficiaries would be similar to those for the Rosendaal Dam as described in Section 3.1.5 above.

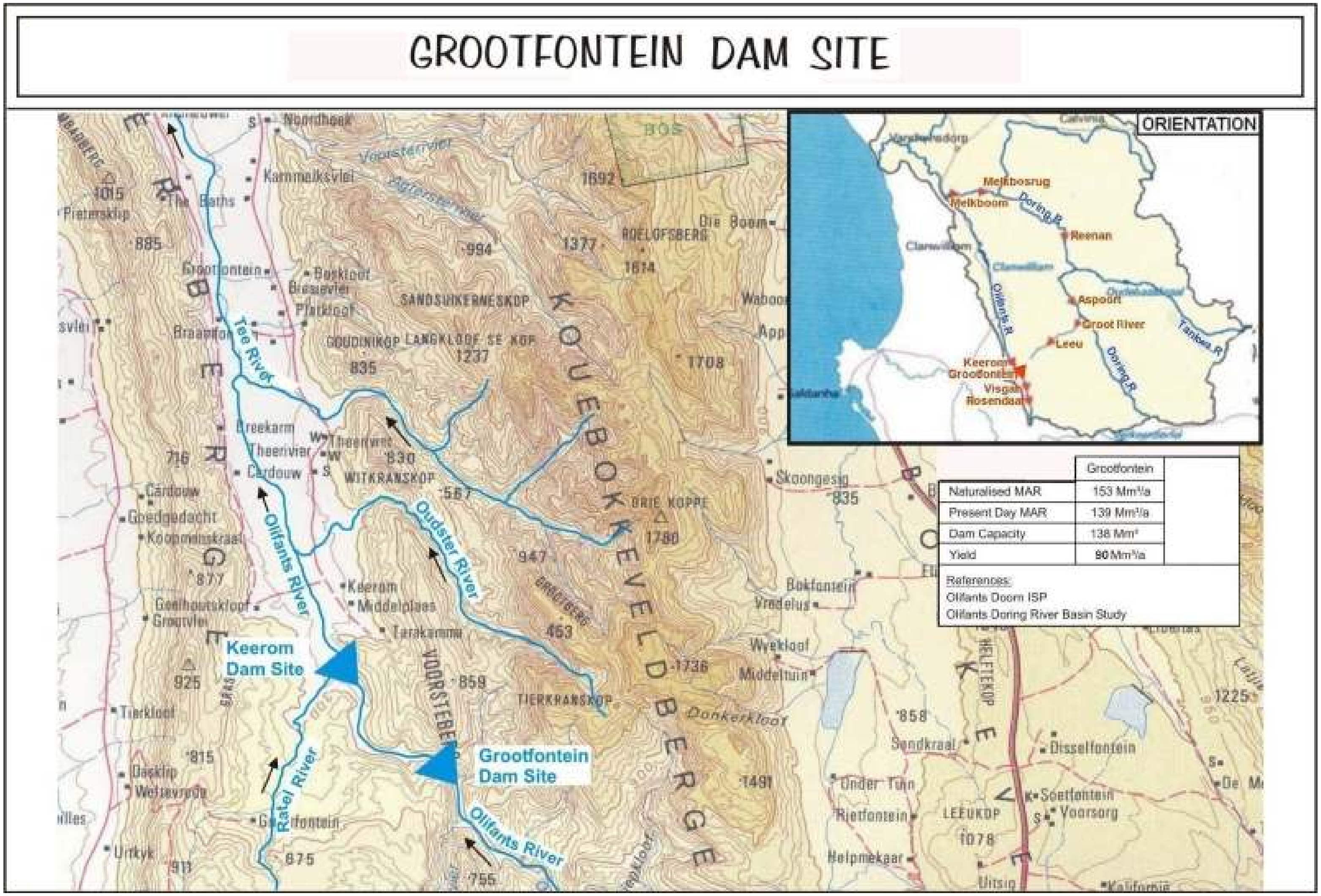


Figure 3.3 Grootfontein Dam Site

3.3 GROOTFONTEIN DAM SITE

3.3.1 Location

The Grootfontein Dam site is located approximately 6 km upstream of the confluence of the Olifants and Ratel Rivers. The site lies downstream of the Visgat gorge.

3.3.2 Engineering and Financial

The Grootfontein Dam was considered in the Olifants Doring River Basin Study (1998) as a possible storage dam to supply water to Cape Town, as well as to stabilise water supply for existing and expanded irrigation developments along the Olifants River, upstream of Clanwilliam Dam. The site is underlain by quartzitic sandstone, with shallow interbedded shale horizons.

A typical rollcrete gravity section with central spillway was considered. For a one MAR dam, a total dam height of 86 m is required, with a crest length of 330 m. The storage capacity of 138 million m^3 would yield about 90 million m^3/a (before any compensation releases). At present, farmers in the vicinity of Citrusdal are re-investigating this option. It is not presently considered to be financially viable as a source for augmenting Voëlvlei Dam, for benefit to Cape Town.

The financial costs associated with the dam are :

Yield Mm^3/a	Construction Cost	Ref Date (Year)	2004 Equivalent Cost (escalation @ 8% p.a.)	Cost:Yield Ratio
90	R257 million	1998	R408 million	4,5

(Ref : Olifants Doring River Basin Study)

3.3.3 Environmental Overview

At a workshop hosted by DWAF in 1991 to assess the impacts of proposed dams on the aquatic environment upstream of the Clanwilliam Dam, it was decided that the inundation of the Olifants River gorge was environmentally and socially unacceptable, due its geological and biological importance and its links to Gondwanaland. Further environmental issues relating to the proposed Grootfontein Dam include:

Barrier and Sediment Effects
Some barrier and sediment effects are anticipated.

Inundation Effects
The riverine vegetation is in good condition with relatively few infestations of *Acacia mearnsii* and *A. saligna*. There are a suite of interesting species occurring in the Mountain Fynbos adjoining the dam site, and on the Onderboschkloof property adjacent to or within the flood limits of the dam. These species include:

- *Agathosma insignus*, which is only know to this area;
- *Leucadendron diemontianum*, which is considered as being rare;

- *Macrostylis barbigera*, also considered rare;
- *Moraea barkerae*, considered rare, with Grootfontein farm identified as a locality for this species; and
- Serruria confragosa, considered rare, is found in a narrow band running north south in the upper Olifants River valley.

A further seven rare plant species have been recorded from the general area but without specific reference to the proposed dam site. The Grootfontein site would result in the inundation of much of the gorge. As mentioned above the inundation of the Olifants River gorge is considered environmentally and socially unacceptable.

Downstream Effects

The downstream effects would be similar to that of Rosendaal and Visgat (i.e. elevated summar flows and reduction of winter floods). The length of river immediately below the dam is in good ecological condition. However, the Olifants River deteriorates downstream of Keerom. The main effect would be the significant absorption and attenuation of floods probably necessitating the provision of large capacity outlet works to release at least the annual flood.

3.3.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The beneficiaries would be the irrigators served by the Citrusdal WUA who mainly grow citrus as discussed in Section 3.1.4 above. However the yield of the Grootfontein Dam would be considerably greater than the yields of Rosendaal or Visgat Dam and approximately 4200 ha of additional citrus could be irrigated. Alternatively there could potentially be slightly more water available for use below Clanwilliam Dam as discussed in Section 3.5.5 below.

The existing infrastructure of the Citrusdal WUA users could probably be utilized but new irrigators would require additional infrastructure as discussed in Section 3.1.4 above.

The summer low flows in the Olifants River downstream of Grootfontein Dam would be considerably increased above natural levels, probably to the detriment of the riverine environment. The additional 4200 ha of irrigated land would impact on natural veld, but again much of this is relatively degraded.

3.3.5 Resource Poor Farmers

The resource poor farmers in the reach of the Olifants River served by the Citrusdal WUA could benefit as described in Section 3.1.5 above, and probably also those below Clanwilliam Dam as described in Section 3.5.6 below. However the number of beneficiaries would potentially be considerably greater as some 4200 ha could be irrigated.

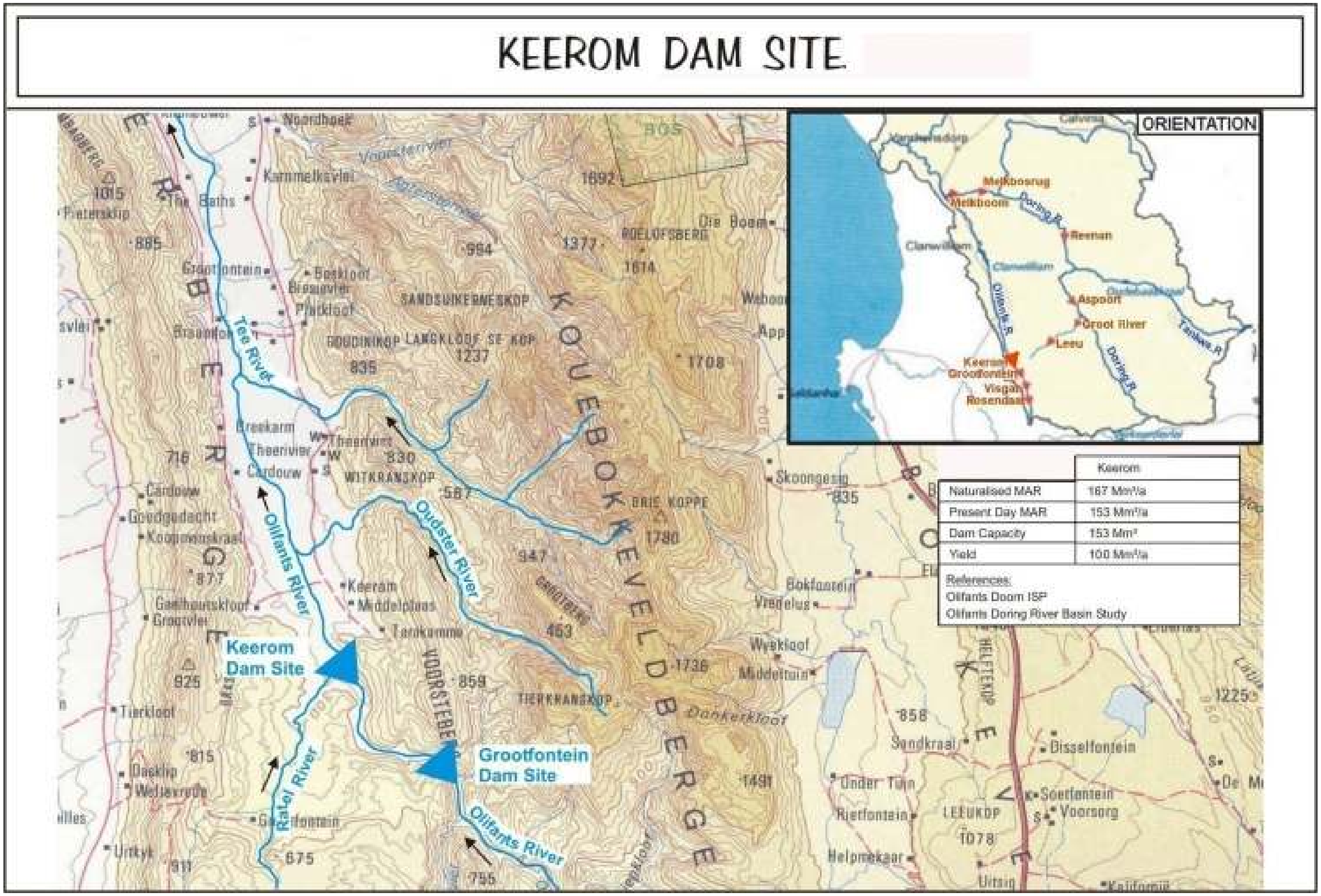


Figure 3.4 Keerom Dam Site

3.4 KEEROM DAM SITE

3.4.1 Location

This site is the most downstream new dam site option on the upper Olifants River. It was investigated in the Olifants Doring River Basin Study and based on cost, Grootfontein was considered the preferred option. The dam would be situated on the Olifants River, immediately upstream of the confluence with the Ratel River, and would span both rivers.

3.4.2 Engineering and Financial

The Keerom Dam would consist of a concrete gravity section. A one MAR dam would have a capacity of 153 million m^3 and yield 100 million m^3/a (before any compensation releases). The dam height would be 57 m for a one MAR dam with a crest length of 1 200 m. The site is located in an area underlain by quartzitic sandstone. Approximately 1,37 million m^3 of rollcrete would be required for the construction.

The financial costs associated with Keerom Dam are :

Yield Mm^3/a	Construction Cost	Ref Date (Year)	2004 Equivalent Cost (escalation @ 8% p.a.)	Cost:Yield Ratio
100	R466 million	1998	R740 million	7,4

(Ref : Olifants Doring River Basin Study)

3.4.3 Environmental Overview

The biophysical environment is similar to that of the Grootfontein Dam site. However, because the dam is not as high, the impacts on the sensitive gorge area would be reduced. Notwithstanding, at the 1991 DWAF Environmental Workshop the inundation of the Olifants River gorge was also deemed unacceptable.

Barrier and Sediment Effects
The dam would have similar effects to Grootfontein, but would also affect the Ratel River.

Inundation Effects
The riverine vegetation above the drift is in good condition. There has been some cultivation of the floodplain along the west bank while other parts are burnt periodically. The river bank supports a suite of individual plant species including yellowwood (*Podocarpus elongatus*), wild almond (*Brabejum stellatifolium*), rooiels (*Cunonia capensis*) and Cape willow (*Salix mucronata subsp. hursuta*). The area downstream of the site has been subjected to more disturbances with a concomitant infestation of alien plants.

Downstream Effects
See Grootfontein Dam (Section 3.3.3).

3.4.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The yield of Keerom Dam would be slightly greater than that of Grootfontein Dam and could supply about 4700 ha of irrigation. The dam would serve the same areas and have the same infrastructure requirements and impacts as those of the Grootfontein Dam as described in Section 3.3.4 above.

3.4.5 Resource Poor Farmers

The number of potential resource poor farmer beneficiaries would be slightly greater than those for the Grootfontein Dam as described in Section 3.3.5 above.

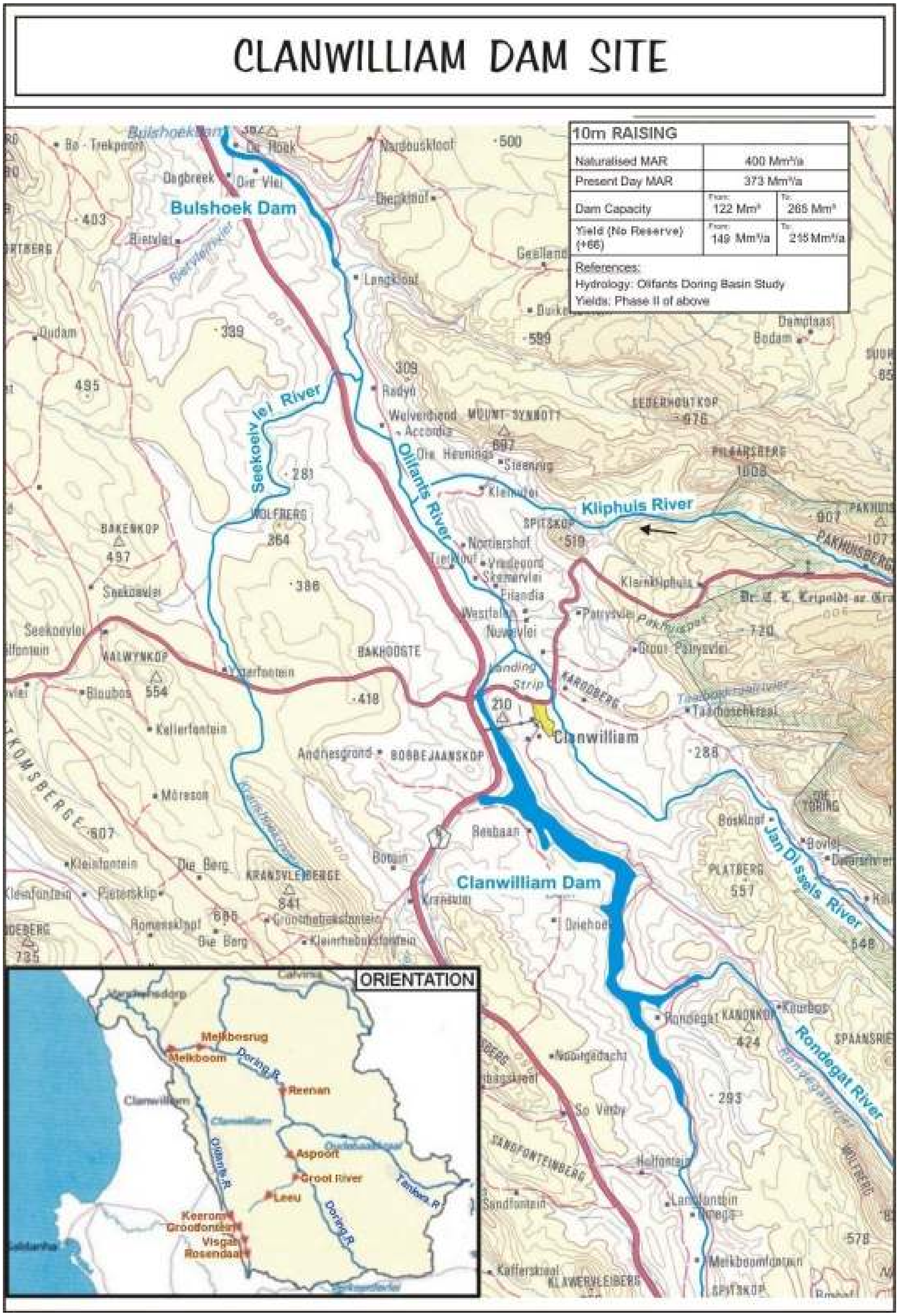


Figure 3.5 Clanwilliam Dam Site

3.5 RAISING CLANWILLIAM DAM

3.5.1 Location

The existing dam wall at Clanwilliam Dam could be raised by up to 15 m. This was investigated as part of Phase 2 of the Olifants/Doring River Basin Study (August 2003).

3.5.2 Engineering and Financial

DWAF is in the process of planning remedial work to the Clanwilliam Dam wall. This is necessary to ensure that the dam is able to comply with current dam safety standards. The option favoured to improve the stability of the structure is to add a rollcrete section to the downstream side of the wall. This offers an opportunity to simultaneously raise the dam wall and increase the yield at what appears to be a favourable incremental cost. The dam was last raised (by 6,1 m) in 1962 to provide its current storage capacity of 122 million m^3. The historical firm yield for three potential raisings with and without preliminary EFR (Reserve) scenarios are presented in Table 3.1.

Table 3.1 Historical Firm Yields for Clanwilliam Dam Raising

Raising	FSL (MRL)	Capacity (Mm^3)	Historical Firm Yield (Mm^3/a)			
			NO RESERVE		WITH PRELIMINARY RESERVE	
			Total Yield	Increase	Total Yield	Increase
0	104.41	122	149		131 [(1)]	
				36		15
5 m	109,41	185	185		146	
				66		**30**
10 m	114,41	265	215		161	
				86		40
15 m	119,41	362	235		171	

(Ref Possible Raising of Clanwilliam Dam Study, 2003)

(1) No releases for EWRs are currently made from Clanwilliam Dam. If the Preliminary Reserve Scenario used in Table 3.1 were to be applied to the existing dam, it would reduce the current yield by about 18 million m^3/a (from 149 to 131 million m^3/a)

From an engineering perspective, the costs associated with a raising of 5 m would not be economical. A 15 m raising on the other hand would have significant impacts in terms of land expropriation and re-alignment of existing main roads. Depending on the EFR, a 10 m raising would just meet the current demands. Any additional increase in yield could be taken up by the development of more irrigated areas. Furthermore, Water Conservation and Demand Management (WC/DM) in the agricultural sector must play its role in the provision of water to support further irrigation development.

Table 3.2 provides a comparison of the capital costs associated with each of the three raising options. These are based on the assumption of no Reserve.

Table 3.2 Comparative Capital Costs of Three Raising Options

Raising	Net Additional Yield (Mm^3/a) (1)	Construction Cost (2)	Ref Date (Year)	2004 Equivalent Cost (escalation @ 8% p.a.)	Cost:Yield Ratio (1)
5 m	36 (15)	R70 million	2003	R76 million	2,1 (5)
10 m	66 (30)	R106 million	2003	R115 million	1,7 (3,7)
15 m	86 (40)	R173 million	2003	R187 million	2,2 (4,7)

(1) Figures in brackets indicate the yields after Preliminary Reserve Estimates have been allowed for.

(2) Excludes cost of replacement of infrastructure and dam safety remediation costs.

3.5.3 Using Catchment Storage Draft Curves – Clanwilliam Example

As a cross check, the WR90 Catchment Storage Draft Curves were used to determine the incremental yield of a 10 m raising of Clanwilliam Dam, taking the existing catchment storage into account. The results were then compared to the raised Clanwilliam Dam yield reported in the ODRB Study, Phase 2 (2003).

For a 10m raising of Clanwilliam Dam, the incremental yield increase derived from the curves (98% assurance) is about 68 million m^3/a (see Figure 3.6 overleaf). This compares favourably with the figure of 66 million m^3/a reported in the Olifants Doring Phase 2 Study "*Possible Raising of Clanwilliam Dam*" (2003). Furthermore, that study indicated that the Preliminary Reserve has an impact on the net additional yield of between 42% and 46%, depending on the size of the raising (see Table 3.2 - Net Additional Yield).

To allow development options in this report to be compared on an equal basis, the EWRs have not been taken into account. This is due to the complexity associated with the many possible permutations, the uncertainties relating to river classification, the extent of available information and other factors. Where information is available on EWRs, this has been presented for completeness, and clearly indicated.

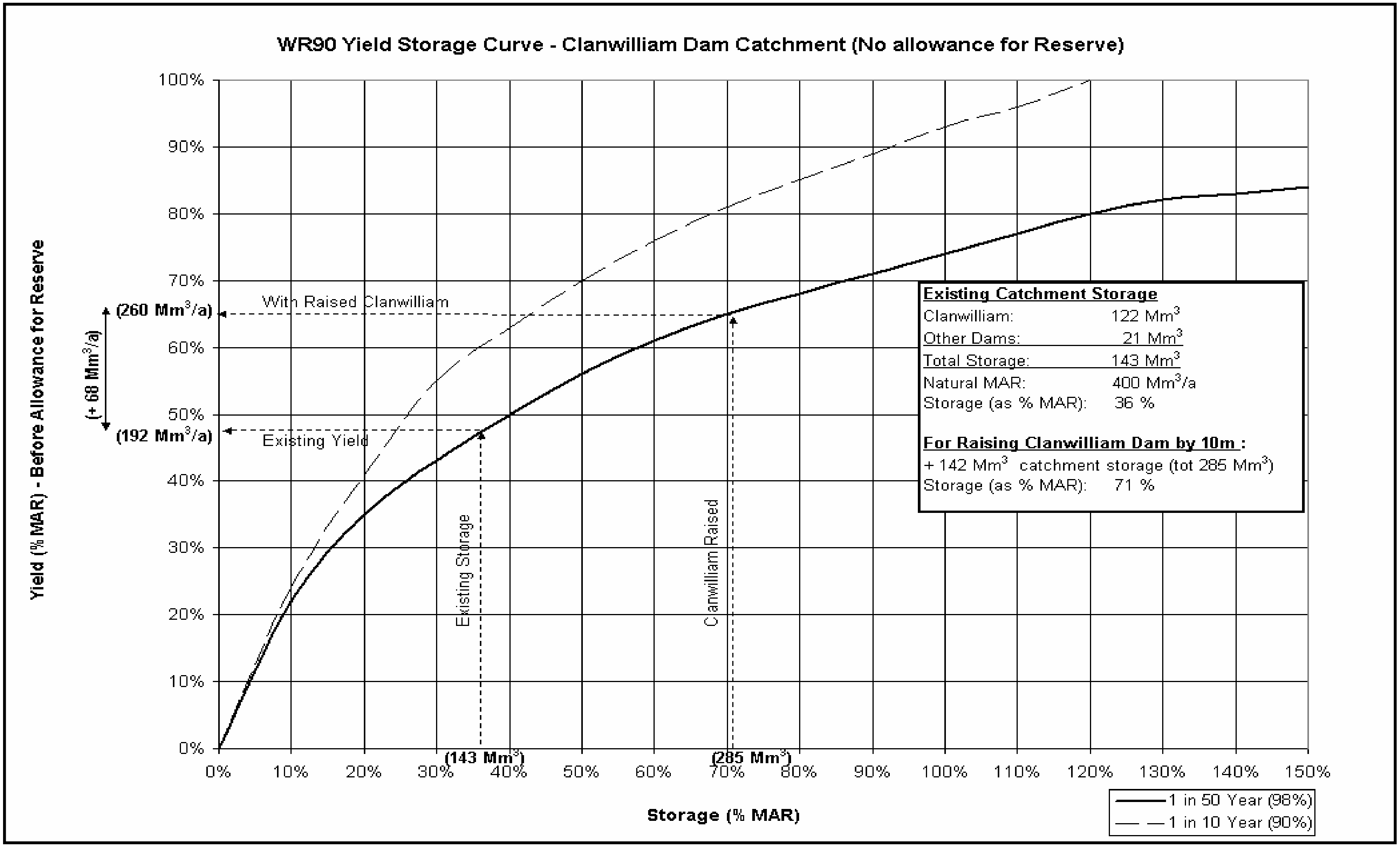


Figure 3.6 The WR90 Yield Storage Curve for the Clanwilliam Dam Catchment

3.5.4 Environmental Overview

Environmental issues associated with a raising of Clanwilliam Dam include:

Barrier and Sediment Effects

A small population of Clanwilliam yellowfish exists between the Clanwilliam Dam and Bulshoek Weir. The existing dam prevents migration of the fish to spawning grounds in the upper reaches of the Olifants River. Raising of the dam would not exacerbate this impact.

Although raising the dam would attenuate flood flows and reduce downstream flows, it would not have a significant effect on downstream sediment dynamics.

Inundation Effects

Depending on the height of the raising, limited areas of indigenous vegetation would be affected. However, irrigated lands, infrastructure (including the N7), and tourist facilities would be inundated.

The dam basin is rich in archaeological material. Many cultural heritage sites have already been lost when the original dam was constructed. Some rock art paintings would need to be removed or recorded, and certain deposits sampled if the dam was raised.

Downstream Effects

A raised dam would further absorb the small floods, which act as spawning cues for fish, unless specific releases were made as part of the Reserve requirements. Currently hypolimnetic water is released from the dam and is colder than the water entering the reservoir, retarding the onset of spawning behaviour in the Clanwilliam yellowfish. If the dam were to be raised, multilevel outlets could be installed which would reduce some of the existing impacts related to temperature and water quality.

The further attenuation of moderate and large floods is likely to have a detrimental effect on the ecologically important estuary and its associated salt marshes.

3.5.5 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The enhanced yield that would be obtained by raising Clanwilliam Dam (or that might be provided by the potential Rosendaal, Visgat, Grootfontein or Keerom Dams) could be utilised to improve the reliability of the supply to the existing irrigation area served by the Lower Olifants River Water User Association (LORWUA). The main crops irrigated are wine grapes, but some table grapes and some vegetables are also irrigated. If additional water were available this could be utilised to:

- expand the irrigated area between Clanwilliam Dam and Bulshoek Weir, and/or
- expand the irrigated area of the LORWUA downstream of Bulshoek Weir, or
- abstract from the river downstream of Bulshoek Weir, or
- use upstream of Clanwilliam Dam.

Irrigation between Clanwilliam Dam and Bulshoek Weir is served by river pump stations and pipelines owned by the individual farmers. Expansion of irrigation in this area would probably require the expansion of existing river pumping and pipeline schemes and/or the construction of additional schemes by individual farmers.

Irrigation below Bulshoek Weir is mainly via the LORWUA canal system, which extends for approximately 100km from Bulshoek Weir to Ebenhaeser, near the mouth of the Olifants River. This canal system is operated at full capacity during the summer months and there is limited spare capacity during the winter, taking maintenance downtime into account. The infrastructure options for distributing the additional yield are as follows:

- Increase canal usage during peak periods (i.e. operate for 168 hours/week).
- Utilise the limited spare canal capacity that is available in winter to convey and store water in existing dams or in additional dams for later utilization in summer.
- New canal option - not at all feasible due to associated high capital costs.
- Increase the capacity of the canal by raising the canal lining. This cost per meter length of canal would be high and therefore the infrastructure cost would be lower for developments near Bulshoek Weir and very high for a development in the vicinity of Ebenezer at the end of the canal system.
- Release water into the Olifants River below Bulshoek Weir for abstraction by pumping schemes or pipelines further down the river. This takes place currently to some extent but the supply would be more dependable if Clanwilliam Dam were raised. Summer and winter abstraction would be possible up to the confluence with the Doring River. However the poor water quality in the Olifants River below the Doring River confluence during the summer months may necessitate that releases are only made during the winter months when water quality is generally better, requiring more on-farm storage. Pump stations, pipelines would be required to distribute the water, and where water quality is problematic, also dams to store the additional winter water for release during the summer. In the latter case, some additional pumping and pipeline infrastructure is likely to be required to utilize the water in the summer.
- The WODRIS report on Bulk Water Conveyance Options for schemes in the lower reaches of the Doring River proposes that water is released down the Doring and Olifants Rivers for abstraction at a concrete weir at the Mieliepan site near Klawer. From there the water would be conveyed by a new pump station, pipeline and canals to potential available land for irrigation development at Klawer (2 226 ha), and in the Coastal 1 (4 262 ha) and Coastal 2 (4 683 ha) areas. Not all of this land is proposed to be developed and is subject to water availability. The WODRIS report on water quality modelling has not yet been finalised. However, the study assumes that water quality in the Olifants River will be acceptable during the summer as far downstream as the proposed Mieliepan Weir.

The release of additional water from Clanwilliam Dam into the Olifants River during the summer would marginally increase the already contra-seasonal flow pattern in the Olifants River between Clanwilliam Dam and Bulshoek Weir. This would probably aggravate the already adverse impact of the summer irrigation releases on this riverine environment. On the other hand, additional winter and summer releases below Bulshoek Weir would probably be advantageous for this riverine environment, which would naturally have experienced higher summer and winter flows.

If additional areas are to be irrigated then this will result in more of the natural vegetation of this arid area being removed, whereas merely improving the assurance of supply to existing irrigators would have no impact.

3.5.6 Resource Poor Farmers

The Terms of Reference of the Feasibility Study for the Raising of Clanwilliam Dam stress that the water made available by this scheme should be utilized for the benefit of resource poor farmers. Representatives of DWAF, the Department of Agriculture and the Department of Land Affairs comprise the Coordinating Committee for Agricultural Water (CCAW) charged with facilitating the needs of resource poor farmers and in particular access to land, water, finance and expertise.

A number of schemes have been investigated for assisting resource poor farmers, including the Aspoort Scheme and various options identified by the WODRIS. Other investigations have focussed on resource poor communities including facilitating access to municipal commonage for farming activities.

Resource poor farmers in the Olifants/Doring WMA have benefitted from a variety of schemes. The following are some of the possible ways that resource poor farmers could benefit from the additional water that would be made available by the raising of Clanwilliam Dam:

- Resource poor farmers could benefit from the additional water supply through joint ventures with existing commercial farmers. These joint ventures might have various forms such as:

    - The farmer would allocate a portion of his property to his farm workers. Finance for the water supply infrastructure and agricultural development might either be provided by the farmer or possibly from a state subsidy. The section of the farm allocated to the resource poor farmers would probably be farmed as a part of the main farm but separate accounts would be kept. The profits of that portion of the farm would be shared by the resource poor farmers.

    - The farmer might also allocate shares in his existing farm to his farm workers possibly in accordance with an agreement with DWAF that an additional water allocation would be made available to the farm.

- Resource poor farmers could be assisted to develop their own farms on land currently owned by them, or on land purchased from established commercial farmers. The WODRIS Social Assessment Report mentions that there are existing resource poor farming communities at Klawer, Vredendal and Ebenhaeser. Restitution claims have been lodged around Lutzville in the Knersvlakte and some Coastal Region farms. The cost of upgrading the canal system as far downstream as these areas would be very high. Therefore the option of pumping winter water from the river into on-farm storage dams for use in summer, is likely to be more economically viable for these communities.

If citrus, wine grape or export table grape farming is to be undertaken, then joint venture farming is likely to be more successful on account of the high technology and relatively complicated marketing requirements (unless existing cooperative cellars are utilised). Cash crop vegetable farming is likely to be more easily practiced by individual resource poor farmers, provided that adequate economic returns can be achieved.

3.6 ADDITIONAL FARM DAMS IN THE OLIFANTS RIVER CATCHMENT

The draft Olifants/Doorn ISP (2005) has identified that up to 14 million m^3 of additional farm dam storage could be developed in the Upper Olifants (i.e. upstream of Clanwilliam Dam). This could be expected to yield an additional 10 million m^3/a. The draft ISP recommends that in terms of developing farm dam storage, only off-channel storage be implemented and that only surplus winter water be abstracted for storage. This is attributed to the fact that based on the existing infrastructure in place, the upper Olifants catchment is in balance and no surplus yield is available.

The development of small farm dams in the upper Olifants River catchment could avoid many of the environmental impacts associated with large on-channel structures. However, releases for the Reserve from farm dams are more difficult to manage and control, resulting in impacts on tributary streams that are potentially as severe as those of large dams. These dams are likely to decrease river flow, retard winter flood flows, and transform the headwater tributaries, resulting in loss of habitat for the small fish species inhabiting these reaches. However the collective impacts of farm dams may be less than those of large dams, if Reserve releases from farm dams can be managed.

There may also be opportunity to develop additional farm dam storage in the catchment of the Doring as described in Section 4.8 of this document.

3.6.1 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The Citrusdal WUA irrigators are currently allowed, in terms of their permit conditions, to construct off-channel farm dams with capacities equal to half their annual allocation to be filled by pumping during the winter months. Not all of the irrigators have provided such storage which has resulted in the summer flows being heavily impacted with the result that the expected Reserve requirements cannot be met. DWAF is supportive of efforts to reduce the need for summer pumping from the Olifants River, in order to pave the way for the eventual implementation of the Reserve. If the Clanwilliam Dam is raised, consideration could be given to increasing the allowable off-channel storage upstream to more than 50% of the annual allocation, in order to enable the summer Reserve requirement to be met, and possibly to increase the area under irrigation.

The main infrastructure would comprise the off-channel dams and possibly additional pipelines and pumping stations. The off-channel dams themselves would mostly impact on the local environment.

3.6.2 Resource Poor Farmers

In this predominantly high technology citrus farming region of the catchment, resource poor farmers would probably benefit most through joint ventures with existing commercial farmers although some individual resource poor farms have been established on Clanwilliam Municipality's commonage as discussed in Section 3.5.6 above.

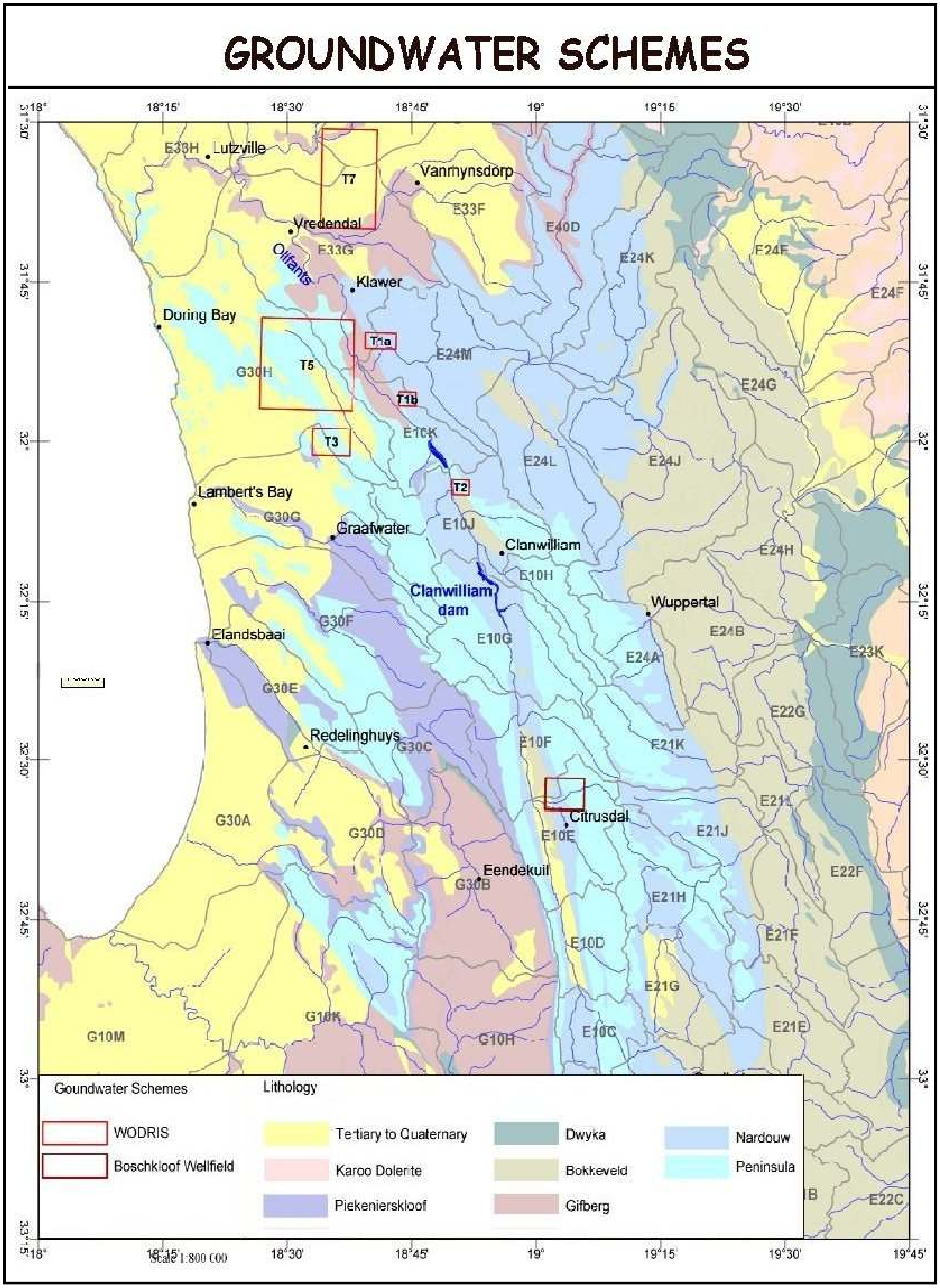


Figure 3.7 Groundwater Schemes

3.7 GROUNDWATER SCHEMES

3.7.1 The Bulshoek T2 Project - Conventional Wellfield

The target zone for wellfield T2 is situated close to the Bulshoek Barrage. It is conservatively estimated that this wellfield should yield 1,6 million m^3/a from five boreholes. In a realistic "safe" case, a yield of 2,1 to 3,2 million m^3/a, pumped over 8 months, is considered possible.

If the groundwater is to be piped into the Bulshoek Barrage, which has a capacity of 6 million m^3, it is preferable to pump only in the summer months (viz. November to April). However, distribution of this water may be limited by the capacity of the downstream canals at particular times.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
T2	3,2 min	11,16	0,41	0,35 (1)	Umvoto, 2005

1. URV based on 6% discount rate over 50 years.

Environmental aspects

The Upper Peninsula Formation, in which this wellfield is located, is in an area where the Klawer Fault and the Clanwilliam Fault meet in a splay extending to the east of the Bulshoek Barrage. There are anecdotal reports of significant springs along the Bulshoek transfer zone that potentially could be impacted on by large-scale abstraction in this target zone. Production would be from the relatively unconfined Peninsula Aquifer, and a management factor to consider is that the springs currently discharge into the Bulshoek Barrage. Consequently, it is possible that high levels of abstraction could induce flow from the dam into the aquifer. If considered as a conjunctive supply scheme the purpose would be to take advantage of the additional underground storage facility and the high recharge in the Krakadouw Mountains along the fault strike to the south-east.

3.7.2 The Skurfkop Syncline T3 Project - Conventional Wellfield

The target zone for wellfield T3 is situated at approximately 270 masl. It is conservatively estimated that four boreholes would be required to yield 1,26 million m^3/a. In a realistic case a yield of 1,7 to 2,5 million m^3/a, pumped over 8 months, is considered possible.

It is proposed that groundwater be pumped at a minimum rate of 40 λ/s by booster pump to cross a low divide of 380 masl from where the water can gravitate into the left bank canal of the Olifants River Government Water Scheme (ORGWS). This would require a rising main of approximately 9 500 m and a gravity section of 4 500 m. The pipeline route would follow the existing road.

Because the required infrastructure is expensive relative to the proposed wellfields T1 and T2, it may be preferable to develop this wellfield only for local use. This alternative is considered in a composite project, including Projects T1 and T2, titled Project T5 below.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
T3	2,5 min	14,19	0,33	0,49 (1)	Umvoto, 2005

1. URV based on 6% discount rate over 50 years

It should be noted that during a later stage of the WODRIS, it was indicated that T3 has been locally more exploited (confirmed during a hydrocensus) than previously considered.

Environmental aspects

The target zone lies along the Skurfkop Fault and this fault could allow sub-surface discharge from the TMG Aquifer into the sands of the G30H Quaternary catchment. This would effectively result in a natural inter-basin transfer from the E drainage basin into the G30H catchment. There could be hidden seep zones in this arid, poorly known and poorly documented area, although there is no apparent topographic expression of seep zones, other than the elongated upper valley of the Sandlaagte which is proposed as a storage facility in Project T5.

3.7.3 The Upper Sandlaagte Valley T5 Project - Aquifer Storage Recovery

This project is based on the storage potential in the palaeo valley of the Sandlaagte River. This storage capacity is viewed as three subsections (S1, S2, S3) of which S3 is currently being abstracted from. The three sections are assumed to be hydraulically connected but with zones of restricted transmissivity values dividing each section from the other. The total combined storage is estimated to be 80 to 90 million m^3 in S1 and S2.

All water supply from the proposed wellfields T1, T2 and T3 would be conveyed to a common point and then pumped over the water divide between the Olifants River and the Sandlaagte catchments so as to recharge the Sections 1 and 2 of this aquifer. If after a reasonable period of monitoring either the volumes pumped can be increased or the length of the pump cycle can be increased, it is anticipated that this yield could increase up to 20 million m^3/a.

The proposed point of abstraction from the Olifants River is south of Klawer and thus the volumes available for recharging the primary aquifer could include both water from the left bank canal of the ORGWS and the Olifants River as well as the Doring River during high flows. It is suggested that an off-channel pump sump delivering 1.3 m^3/s (i.e. 20 million m^3 over a 6 month pumping period) would pump water into a pipeline following an existing road over the low ridge northwest of Trawal (280 masl). From there it would gravitate to the recharge wellfield at approximately 220 masl.

Twenty six recharge boreholes could be situated 350 m apart, each injecting up to 50 λ/s. Abstraction of up to 50 λ/s would be via the same injection boreholes. The water would be reticulated using two rising mains to a level of 320 masl. This assumes that any future distribution canal would be constructed at this level in order to distribute to the arable land below.

In costing this project additional water from the surface supply options was not considered, although the storage capacity in S1 and S2 would allow for up to 90 million m^3 to be stored. This storage volume could be accumulated over a number of years, as confidence in the scheme developed and initial teething problems are resolved.

The purpose of this project or scheme would be to abstract up to 20 million m^3 from the TMG Aquifer in the winter months between March and November (or from surface water) and to artificially recharge the primary aquifer (S1 and S2) from which it can be abstracted during the summer.

The position of the recharge and/or abstraction boreholes would be based on more detailed investigation and characterisation of the aquifer as well as the potential irrigation areas identified.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
T5	20 min	422 (2)	20 (2)	0,82 (1)	Umvoto, 2005

1. URV based on a 6% discount rate over 50 years.
2. Costs include pumping of water from river and other wellfields into ASR Scheme.

Environmental aspects

Aside from "site footprint" (area of land impacted by the required wellfield infrastructure) considerations the primary environmental concern would be the impact of raising the water table in the unconfined to semi confined primary aquifer in the Sandlaagte Valley. It is not known if sensitive ecosystems or important biodiversity sites have been identified in the area. An ecological assessment of the area is required. It should be noted that significant changes in the natural habitat have already occurred as a result of dry land agriculture.

3.7.4 The Vanrhynsdorp T7 Project - Aquifer Storage Recovery

A storage capacity of 121 million m^3 in the fractured limestones was used for the calculation. An off-channel concrete pump sump on the Olifants River close to Vredendal is proposed with an abstraction rate of 7,7 m^3/s, i.e. 121 million m^3 pumped over six winter months using 8 pumps each delivering 1 m^3/s. The water would be pumped via a rising main to 154 injection wells spaced 500 m apart. Each well would inject water into the storage aquifer at a rate of 50 λ/s. The wellfield would be spread over a 5 km by a 7,5 km area. The same boreholes used for recharge would be used for abstraction.

The potential storage facility is the confined fractured limestones located beneath an older land surface covered by red aeolian sands. It is situated around the divide between the Vars and the Troe-Troe Rivers' channels west of Vanrhynsdorp in an extremely arid area. The rivers flow during flash floods and the aquifer is apparently no longer being actively recharged and as yet no farfield lateral recharge potential has been identified.

The primary cost component is the winter and summer pumping and the extensive pipe network for the distribution and collection of water.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
T7	121 ave	150 (2)	4,42 (2)	0.12 (1)	Umvoto, 2005

1. URV based on 6% discount rate over 50 years.
2. Costs exclude pumping of water from river into ASR Scheme.

Environmental aspects

It is suggested that the greatest environmental impact would be the site footprint resulting from the development. This development would occur in an area of new agricultural development which is already undergoing complete change. The groundwater development scheme would likely be obscured within the agricultural development. There could be aquifer ecology impacts arising from the different chemistries (acidic and unbuffered) and possibly microbiologies and microfauna of the waters (surface and TMG) being pumped into the alkaline and buffered waters of the limestone aquifer.

The T7 Scheme was not considered during WODRIS due to the problems associated with the water quality within the limestone aquifer.

3.7.5 Conjunctive Use

During the CAGE project the Water Resources Yield Model (WRYM) for the catchment area above Clanwilliam Dam was run using different operating rules. In one extreme, groundwater from the Peninsula Aquifer of the TMG was always pumped to the Clanwilliam Dam and, in the other extreme, only when the dam was empty. The effective exploitable storage for these reservoirs, *viz*. east, central and west are 200, 750 and 80 million m^3, respectively. The eastern and western reservoirs are unconfined and the central is confined.

The study concluded that conservatively 45 million m^3/a would be available to the four Water Users Associations without negative environmental impact if conjunctive use was implemented, which would give an increase in the historic firm yield of the Clanwilliam Dam of 20%.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
CAGE	45 min	-	-	-	Umvoto, 2000

Environmental aspects

Over wide areas in the middle part of the E10 catchment, the potentiometric surface may be hundreds of metres above the buried top of the Peninsula aquifer. Locally, drawdowns very much larger than 10 m are theoretically possible (at least up to a maximum economic pumping depth of ~100 m) without in any way impacting on the aquifer's saturated thickness. Furthermore, with sufficient knowledge of other aquifer properties such as hydraulic conductivity, well field sites can be strategically selected to ensure that, during the summer pumping season, the surrounding cones of depression rarely, if ever, impact on exposed aquifer boundaries where base flow at springs can be affected. In the event that this occurred, it would be appropriate to supplement surface flows accordingly or evaluate the cost benefit and most water efficient approach to storage.

3.7.6 Citrusdal-Boschkloof Wellfield in confined Peninsula Aquifer

This wellfield has been partially developed to supply Citrusdal. It could be expanded to supply other users. The CAGE Study (1998) estimated that the existing abstraction from this wellfield was 1,5 to 2,0 million m^3/a.

Regrettably this study has not been able to obtain actual URV costs for this wellfield nor current information on usage and management of the wellfield. Current costs based on hard data for the Hermanus wellfield result in a URV of 70 c/m^3. Even if the costs of undertaking development of a regional monitoring infrastructure and monitoring protocols (for which the costs should not strictly be assigned to a particular scheme), and costs for development further away from existing infrastructure are added, the URV will not be more than 100 c/m^3.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
Citrusdal-Boschkloof	1,48 (Umvoto Report)	J.Conradie will look for	Not available	Not available	Deon Wasserman of Municipality 027-4828000 Johan Conradie (KweziV3) 022-7132288

4. SURFACE WATER AND GROUNDWATER SCHEME OPTIONS : DORING RIVER CATCHMENT

Unless otherwise stated, the yields of the potential surface water schemes presented in 4.1 to 4.8 do not include any allowance for EWRs nor any allowance for downstream compensation releases.

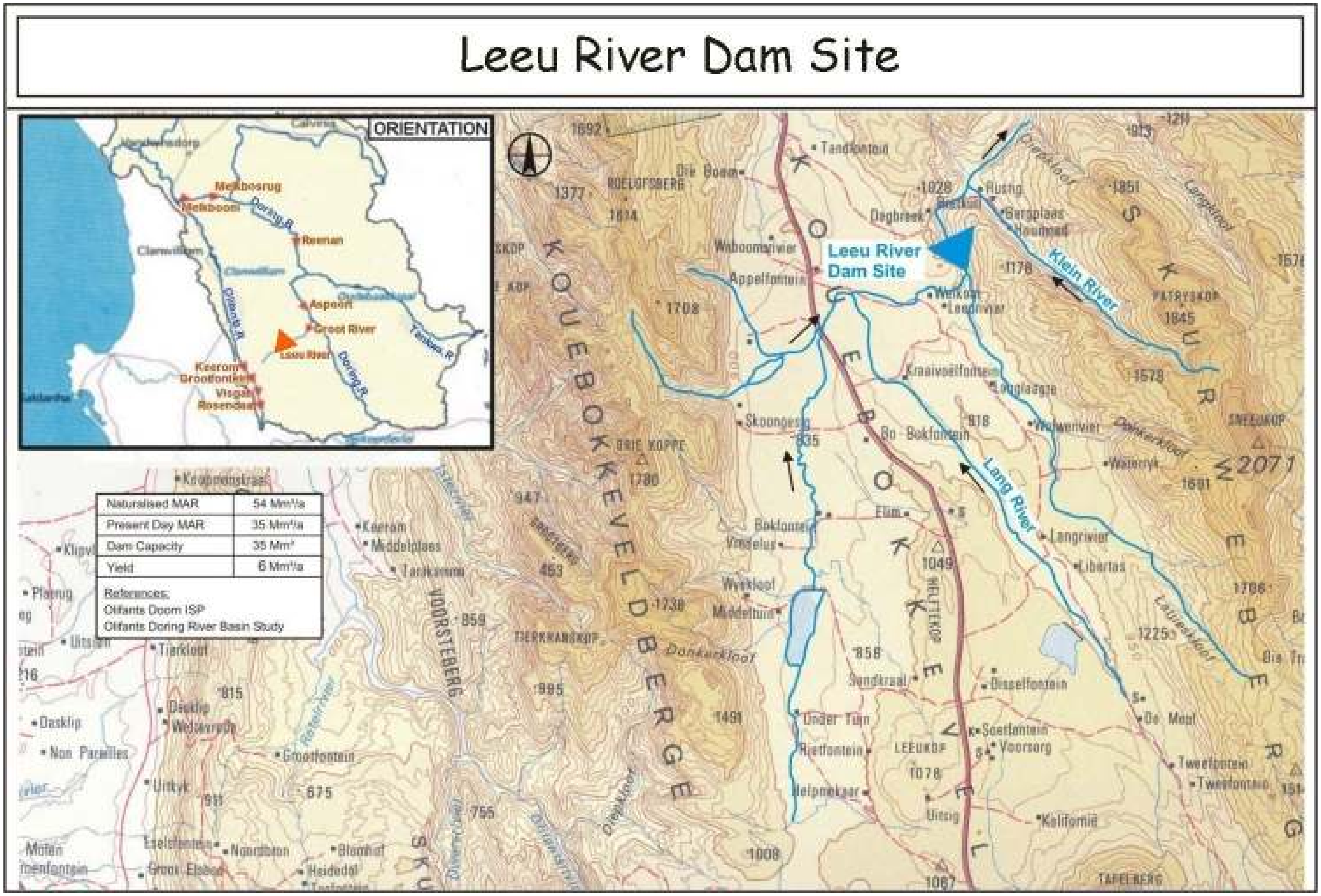


Figure 4.1 Leeu River Dam Site

4.1 LEEU RIVER DAM SITE

4.1.1 Location

A potential dam site had been previously identified in the Kouebokkeveld, on the Leeu River tributary of the Groot River. The Groot River is a major tributary of the Doring River. This is the uppermost dam site identified within the Doring River catchment. The site is located just upstream of the confluence of the Leeu and Klein Rivers.

4.1.2 Engineering and Financial

Mention is made of this site in the Olifants/Doring River Basin Study (1998), but no financial information is provided. A 1 MAR dam would have a capacity of 35 million m^3 and would yield only 6 million m^3/a (before any compensation releases). The low net yield being attributed to evaporation losses of 12 million m^3/a. Consequently, this is not considered to be a very favourable site.

4.1.3 Environmental Overview

There does not appear to be any previous screening of this development option.

4.1.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The Leeu River dam site is situated far downstream in the Kouebokkeveld. Water could probably be pumped back upstream into the Kouebokkeveld, but at the high cost of pumping this is likely to make this option economically not viable. Alternatively, water could be released for abstraction a considerable distance downstream in a remote area where there is currently little development and the potential for development is very uncertain. Therefore the potential benefits of developing this scheme are also very uncertain.

The main impacts of the scheme would be the inundation and barrier effects and the effect on the riverine environment including the impacts on floods. The increased summer releases would probably replace some of the summer flows lost on account of the construction of dams in the Kouebokkeveld, however the irrigation releases would result in some reversal of seasonality.

4.1.5 Resource Poor Farmers

The establishment of resource poor farmers in joint venture with commercial farmers or as independent farmers is more likely to be viable in the Kouebokkeveld, where there are well established farms and farming practices, than further downstream where there is little or no development.

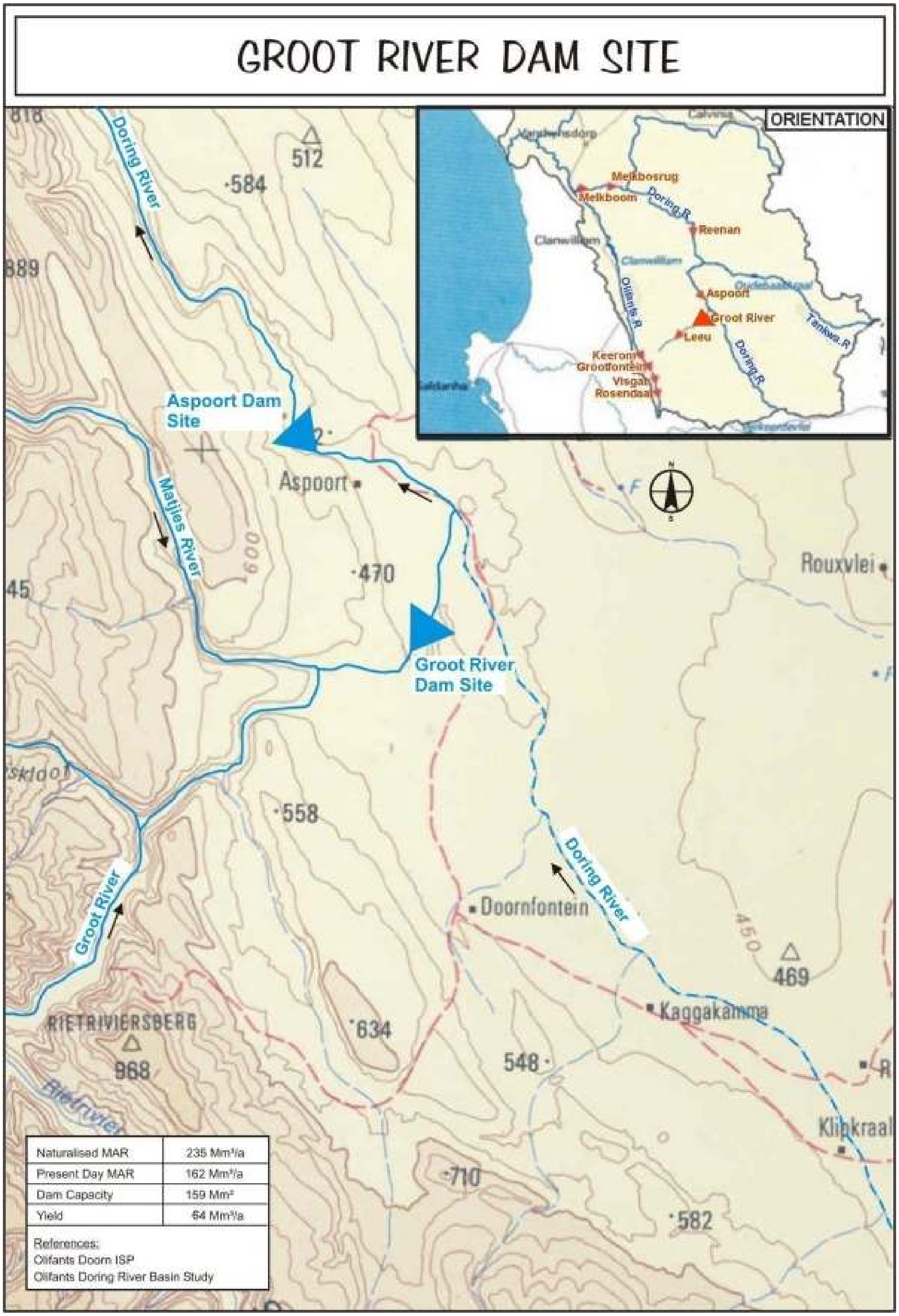


Figure 4.2 Groot River Dam Site

4.2 GROOT RIVER DAM SITE

4.2.1 Location

The Groot River Dam site is situated on the Groot River, the major tributary of the Doring River. The site lies downstream of the confluence with the Matjies River on the farm Elandsdrift.

4.2.2 Engineering and Financial

The potential dam was investigated during the Olifants/Doring River Basin Study as an alternative to Aspoort Dam. It would supply water to the proposed Aspoort Scheme along the Doring River or to the Tanqua Scheme in the Tanqua River valley.

A concrete gravity section and central spillway were considered. A 1 MAR dam would be 75 m high and have a storage capacity of 159 million m^3 and yield about 64 million m^3/a (before any compensation releases). The dam would have a total crest length of 2 900 m. Approximately 348 000 m^3 of rollcrete would be required for the construction and about 65 000 m^3 of excavation.

The financial costs associated with the dam are :

Yield Mm^3/a	Construction Cost	Ref Date (Year)	2004 Equivalent Cost (escalation @ 8% p.a.)	Cost:Yield Ratio
64	R129 million	1998	R205 million	3,2

(Ref : Olifants Doring River Basin Study)

4.2.3 Environmental Overview

The Groot River provides the major freshwater input into the Doring River system. Almost half of the annual flow in the Doring River, at its confluence with the Olifants River, is generated within the catchment of the Groot River.

Environmental issues associated with the potential Grootrivier Dam include:

Barrier and Sediment Effects
The height of the proposed dam wall would preclude the passage of fish between the Doring and Groot Rivers. The migration in the Doring River of the three large cyprinid fish species endemic to the Olifants-Doring system would be halted. The spawning areas upstream of the dam would be unavailable to these fish. Fish trapped upstream of the dam would not be able to migrate downstream to their over-wintering areas in the lower Doring and Olifants Rivers. The dam would therefore constitute a significant barrier. Sedimentation effects are not likely to be severe due to the relatively low sediment loads.

Inundation Effects
The Groot River Dam would inundate areas of indigenous terrestrial and riparian vegetation. The dam would inundate some cultural heritage sites and may affect unique and highly important archaeological sites downstream.

Downstream Effects

The Groot River provides almost half of MAR of the Doring River. A dam on the Groot River would result in winter floods being delayed, attenuated or completely removed. Less water entering the middle Doring would reduce the dilution effect of the saline water from the upper Doring, Tankwa and other rivers draining the Tankwa Karoo. The increased salinity could have a negative effect on flora and fauna sensitive to salinity changes.

4.2.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The Groot River Dam site is situated in a remote area where there is little or no existing development. The construction of a dam at this site would probably preclude the construction of further dams on the Doring River or off-channel dams to be filled from the Doring River, such as the Brandewyn Dam, which is described in Section 4.7 below. As mentioned above, the Groot River Dam would be an alternative to the Aspoort Dam for serving the proposed Aspoort scheme where suitable soils are available. Water would be released down the Doring River and abstracted at a weir downstream of Elandsvlei from where it would be pumped to a balancing dam and also directly to the land to be irrigated. About 2800 ha of table grapes, wine grapes and citrus could be irrigated from this dam.

The water released down the river for abstraction might reinstate some of the lost summer flows over the reach of river between the dam and the diversion weir, but might also result in elevated summer flows that are detrimental to the riverine environment. The irrigated areas at Aspoort as well as pumping, pipeline and possibly also canal infrastructure would impact directly on certain natural areas.

4.2.5 Resource Poor Farmers

The Northern Cape Provincial Government was interested in establishing a substantial irrigation development for resource poor farmers at the proposed Aspoort Irrigation Scheme. The Groot River Dam would serve this proposed farming development, however the Aspoort Dam was found to be economically more favourable if zero value was placed on the much higher evaporation losses of the Aspoort Dam. That dam was investigated in some detail as described in Section 4.3.5 below.

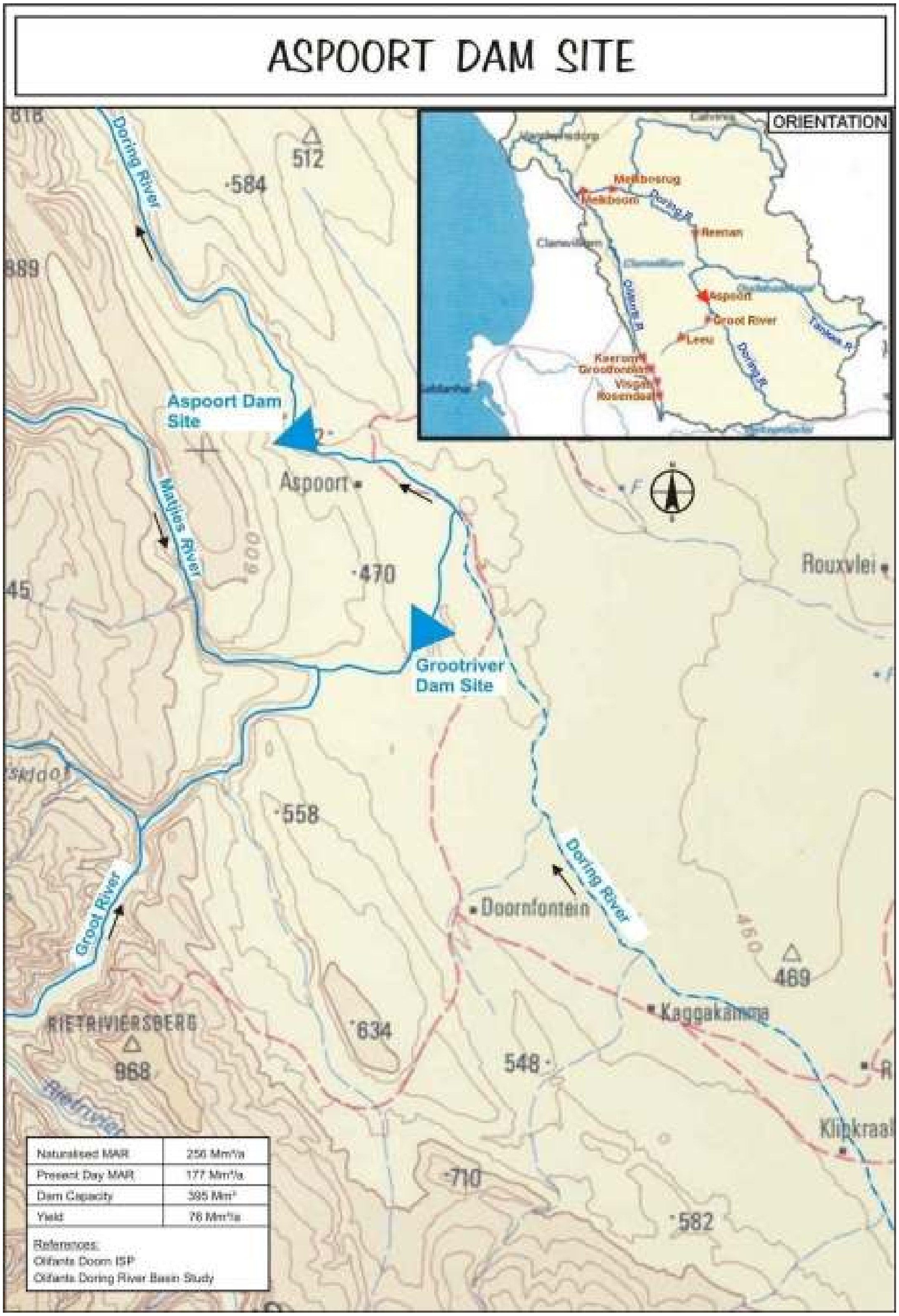


Figure 4.3 Aspoort Dam Site

4.3 ASPOORT DAM SITE

4.3.1 Location

The potential Aspoort Dam would supply water to the proposed Aspoort Irrigation Scheme. The dam site is located at the head of a canyon, downstream of the confluence of the Groot River and the usually dry Upper Doring River.

4.3.2 Engineering and Financial

The proposed Aspoort Dam would consist of a rollcrete gravity section, a main spillway and an emergency spillway embankment on the right flank. A dam of 395 million m^3 capacity would yield approximately 76 million m^3/a (before any compensation releases), assuming no further upstream development. This is equivalent to a 2,2 present day MAR dam, which would be approximately 44 m high. Depending on the height of the dam, any dam with a storage level above 401 masl would require one or more saddle embankments on the right bank, from about 2 km to 8 km upstream of the dam.

The financial costs associated with the dam are :

Yield Mm^3/a (1)	Construction Cost	Ref Date (Year)	2004 Equivalent Cost (escalation @ 8% p.a.)	Cost:Yield Ratio
76	R63 million	1998	R100 million	1,3

(Ref : Olifants/Doring River Basin Study)
1. For a 2,2 MAR dam.

The most cost effective dam at Aspoort would be one with a capacity of about 200 million m^3/a. This would have a yield of 58 million m^3/a assuming no further upstream development.

4.3.3 Environmental Overview

Environmental issues associated with the potential Aspoort Dam include:

Barrier and Sediment Effects
The proposed dam wall would preclude fish passage. The migration in the Doring River of the three large cyprinid fish species endemic to the Olifants-Doring River system would be halted as the spawning areas upstream of the dam would be unavailable to these fish. Fish trapped upstream of the dam would not be able to migrate downstream to their over-wintering areas in the lower Doring and Olifants Rivers.

The water of the Doring River is rich in sediment. The dam would trap large amounts of sediment that would be detrimental to the river course downstream of the dam.

Inundation Effects

The flat floodplain of the proposed dam site is currently utilised for dry-land agriculture and grazing. Succulent and low karroid shrubs are prevalent in the area. This vegetation is widespread upstream of the proposed dam basin.

Areas of unique rock paintings and stone-age sites are located within the proposed dam basin, which should be seen as cohesive units rather than many sites. The cultural impacts associated with the dam are considered to be significant

Downstream Effects

The Aspoort Dam impoundment would be wide and shallow, leading to higher rates of evaporation thus requiring more water from the system to achieve the same yield as Groot River Dam. High rates of evaporation would also lead to increased salinity in the dam water. Furthermore, abstraction of the low salinity water would have major implications for downstream salinities with concomitant impacts on aquatic fauna and vegetation as well as other agricultural and other users. Although the proposed dam is far from the estuary, a reduction in freshwater and flood inflows is expected to have a negative impact.

4.3.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

In 1996, the Northern Cape Government investigated six options for the development of a large area of irrigation in the Ceres Karoo area. The proposed development would extend over the farms Morêster, Gemsbokkloof, Zandfontein and Draaikraal, on the right hand bank of the Doring River, downstream of the confluence with the Tanqua River. The scheme would also supply an existing 350 ha irrigation development at Elandsvlei. With no further allocation of water for expansion of existing irrigation development in the Koue Bokkeveld, the maximum size of the Aspoort Scheme would be 3 650 ha with this value decreasing to 3 050 ha should limited development take place in the Koue Bokkeveld. However, if the maximum expansion of the Koue Bokkeveld took place, irrigation at Aspoort would be precluded.

The potential irrigation area is characterised by sparse Succulent Karoo vegetation mainly consisting of low succulents and typical karroid shrubs. The species diversity is considered to be low in comparison to other areas evaluated, and some of the vegetation may be conserved in the Tanqua National Park. The irrigation area may be a barrier to animal migration routes between the Eastern Cederberg and Tanqua.

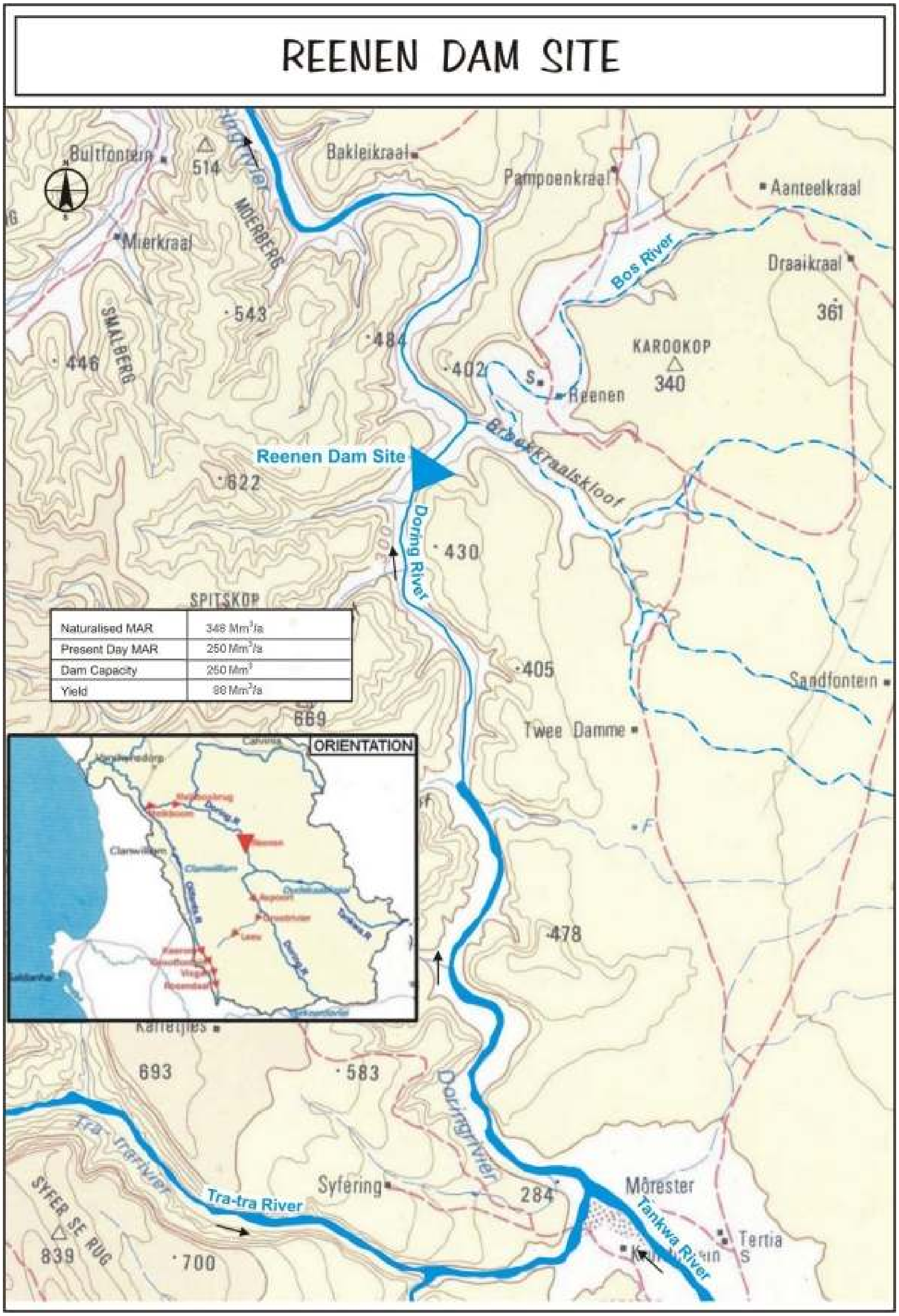
Water would be released down the Doring River and abstracted at a weir downstream of Elandsvlei from where it would be pumped to a balancing dam and also directly to the land to be irrigated. Apart from the impact of the dam itself on the riverine environment and on the inundated area as described above, the releases from the dam into the reach of river between the dam and the diversion weir would be counter-seasonal and would probably significantly exceed the summer flows lost on account of farm dam development in the Kouebokkeveld. The other main impacts would arise from the development of the proposed Aspoort irrigation area of nearly 4000 ha.

If the Doring River is used as a conduit for irrigation water, then the usual aquatic impacts associated with large changes in seasonality would occur.

A scheme at Aspoort would likely have different effects on the estuary to a scheme lower down the Doring River, as irrigation return flows are unlikely to increase the summer base flows at the estuary, as the return flows will either be abstracted downstream or evaporate.

4.3.5 Resource Poor Farmers

The Northern Cape Provincial Government was interested in establishing a substantial irrigation development for resource poor farmers at Aspoort. The Aspoort Dam was considered to be the most favourable of the options for serving the 4000 ha of table grapes, wine grapes and citrus, which would be irrigated. The remoteness of the area and the lack of similar farming enterprises and infrastructure in the vicinity makes the development of this scheme more uncertain. The Northern Cape Provincial Government in 1998 stated its intention to undertake a pilot study in the area proposed for the major irrigation development. There has been no progress on this to date.



Naturalised MAR	346 Mm^3/a
Present Day MAR	250 Mm^3/a
Dam Capacity	250 Mm^3
Yield	98 Mm^3/a

Figure 4.4 Reenen Dam Site

4.4 REENEN DAM SITE

4.4.1 Location

The potential Reenen dam site was previously identified on the Doring River, approximately 2 km upstream of the confluence of the Doring and Bos Rivers.

4.4.2 Engineering and Financial

Originally, this option had been proposed to supply water to the Aspoort Irrigation Scheme. A dam of 1 MAR would have a capacity of 250 million m^3/a and a yield of 88 million m^3/a (before any compensation releases). It was rejected after a brief investigation in the Olifants Doring River Basin Study (1998) because of the relatively high costs associated with the dam, the conveyance infrastructure and associated energy costs.

Figure 4.5 Melkbosrug Dam Site

4.5 MELKBOSRUG DAM SITE

This site was investigated in the 1998 Olifants/Doring River Basin Study and re-assessed in the 2004 Western Cape Olifants/Doring River Irrigation Study (WODRIS).

4.5.1 Location

The potential Melkbosrug Dam site is located on the Lower Doring River, approximately 34 km upstream of its confluence with the Olifants River. The Olifants/Doring Basin Study proposed that the dam should supply water to the Urionskraal Irrigation Scheme. However, WODRIS proposed that the dam, possibly together with a wellfield, supply water to a number of areas along the Lower Olifants River, as described in Section 4.5.4 below.

4.5.2 Engineering and Financial

The WODRIS provides cost estimates for potential dam sizes of 1, 1,5 and 2 MAR. For the purpose of this document, a 1 MAR (400 million m^3/a) dam is assumed. For costing purposes, rollcrete options were costed.

The Olifants/Doring River Basin Study (1998) reported a yield of 116 million m^3/a for a dam of 400 million m^3 capacity. Subsequent information (presented in Table 4.1) from the WODRIS indicates the following yields for two possible ecological classes for the Doring River. The yields are considered in terms of potential upstream development.

Table 4.1 Comparison of Yield Scenarios - Melkbosrug Dam Site (400 million m^3 dam)

Reserve Scenario	Yield (Mm^3/a)		
	No development upstream	1 900 ha development in Kouebokkeveld (KBV) *	Aspoort development plus 1 900 ha in KBV *
No Reserve	116 **	Not available	Not available
Class B Doring River	98 *	80,6	45,3
Class A Doring River	69,5 *	52	17

(Ref : * WODRIS, 2004
** ODRB Study , 1998)

The WODRIS concludes that any development at Aspoort is unlikely. The impact is, however, indicated in Table 4.1 for completeness.

The construction costs associated with a 1 MAR dam (400 million m^3 storage) and yield of 116 million m^3/a (no Reserve) are:

Yield Mm^3/a	Construction Cost (excl. VAT)	Cost: Yield Ratio
116 **	R659 million *	5,7

(Ref : * WODRIS 2004
** ODRB Study, 1998)

4.5.3 Environmental Overview

Environmental issues associated with the potential Melkbosrug Dam include:

Barrier and Sediment Effects

The high dam wall would act as a barrier to fish, preventing migration of the three large cyprinid fish species endemic to the Olifants-Doring River system. This is regarded as a significant ecological impact. Furthermore, the dam is likely to trap large volumes of sediment, which is likely to result in increased erosion of the riverbed and banks downstream of the dam. The river is used for river rafting in the winter. The dam would impact on this activity.

Inundation Effects

The riparian vegetation along the Doring River from below the confluence with the Groot River to the confluence with the Olifants River is unusual in the that it has a mixture of saline or drought tolerant karoid together with fynbos related riparian plants generally found under sweet to acid water conditions. Flooding of the dam basin (1 MAR dam) will lead to a loss of over 45 km of riverine and riparian habitat from the proposed Gifberg Biosphere Reserve and a loss of continuity between the proposed Gifberg and Cederberg Biosphere Reserves. Furthermore the area is rich in cultural heritage sites, including burial sites, which will require additional permits for disturbance. There is a concern that the context of the rock paintings will be lost if the area is inundated.

Downstream Effects

The dam will result in a loss of perennial flow in this section of the river. Spillage from the dam would be infrequent during winter, other than the possible environmental releases. The loss of winter flushing floods is likely to increase the salinity levels of the lower Olifants River. During summer, sub-surface flow below the river bed takes place and intermittent pools are found. Releases from the dam in summer would lead to a reversal of seasonality in that continuous surface flow would occur.

4.5.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The Melkbosrug Dam was identified by the Olifants/Doorn River Basin Study as a suitable source of water for the Urionskraal Irrigation Scheme where suitable soils were identified in the Upper Troe-Troe valley. During the WODRIS, the Melkbosrug Dam was identified as being able to supply existing irrigation areas as well as new schemes, namely, the Melkboom irrigation area, the Klawer irrigation area and the two Coastal Region irrigation areas. WODRIS did not consider the environmentally sensitive Atties Karoo irrigation area as a potential area for further irrigation development. The proposed Melkboom irrigation area of 514 ha is located between the Olifants/Doring River confluence in the west and the Gifberg and Nardouwsberg Mountains in the east. The Klawer irrigation area of 2 226 ha is located just north-west of Klawer between the N7

National Road, the R362 Regional Road between Klawer and Vredendal, and south of the Wiedouw River. The proposed Coastal 1 and Coastal 2 areas would comprise up to 4 262 ha and 4 683 ha of irrigable areas respectively.

The preferred development scenarios described in the WODRIS reports comprise combinations of wellfields operated conjunctively with the proposed Melkbosrug Dam or other dams (Melkboom or Brandewyn River), and a large number of distribution options. These proposed bulk distribution infrastructure options include extensive combinations of canals, pump stations and pipelines and a diversion weir on the Olifants River at Mieliepan near Klawer.

The summer releases into the Doring and Olifants Rivers would be contra-seasonal particularly in the case of the Doring River which is currently relatively pristine, and in the case of the Olifants River would probably be in excess of the natural low flow which has been cut off by the Bulshoek Weir and which will reduce as a result of recent repairs to that dam.

The canal infrastructure would impact on the environment mainly on account of the barrier effect, however the greatest impact would arise from the development of natural veld as agricultural land. WODRIS indicates that subject to water availability and irrigable land potential, Melkbosrug Dam could supply about 7 500 ha.

4.5.5 Resource Poor Farmers

The Lower Olifants River is in a unique position in that there is a mix of well-established commercial farmers who have sound technical farming knowledge and aspirant farmers without the commercial expertise, but the desire to start irrigation farming. Various farming models could be applied in this region including joint ventures between emerging farmers and private enterprise to expand existing farms, joint ventures on new developments, the rehabilitation and expansion of existing irrigation schemes or conventional new irrigation schemes. It was recommended in the WODRIS that the crops that are selected for expanded irrigation agriculture be those that have already undergone commercialisation and are therefore based on an established industry. These include wine grape, table grape, vegetable and limited lucerne production.

Figure 4.6 Melkboom Dam Site

4.6 MELKBOOM DAM SITE

As is the case for the Melkbosrug Dam site, the Melkboom Dam site was also investigated in both the Olifants Doring River Basin Study (1998) and the WODRIS (2004).

4.6.1 Location

The potential Melkboom Dam site is located on the Lower Doring River, approximately 11 km upstream of the confluence with the Olifants River. The dam is intended to supply new irrigation developments at Melkboom, Klawer, the Coastal Region, or some combination of these developments. WODRIS has not considered further irrigation development in the environmentally sensitive Atties Karoo Region.

4.6.2 Engineering and Financial

As for the Melkbosrug site, the WODRIS also provides cost estimates for various sizes of a potential Melkboom Dam. A 1 MAR dam (400 million m^3) would provide a yield of 121 million m^3/a before any allowance for the Reserve. Based on the WODRIS, estimates of yield for two Reserve scenarios are shown in Table 4.2.

Table 4.2 Comparison of Yield Scenarios - Melkboom Dam Site (400 million m^3 dam)

Reserve Scenario	Yield (Mm^3/a)		
	No development upstream	1 900 ha development in Kouebokkeveld (KBV) *	Aspoort development plus 1 900 ha in KBV *
No Reserve	121 **	Not available	Not available
Class B Doring River	98 *	80,6	45,3
Class A Doring River	69,5 *	52	17

(Ref : * WODRIS, 2004
** ODRB Study , 1998)

The financial costs associated with a 1 MAR dam (400 million m^3 storage) and a yield of 121 million m^3/a (no Reserve) are :

Yield Mm^3/a	Construction Cost (excl. VAT)	Cost: Yield Ratio
121 **	R667 million *	5,5

(Ref : * WODRIS, 2004
** ODRB Study , 1998)

4.6.3 Environmental Overview

By virtue of the fact that there are currently no impoundments along the Doring River, the river system is a unique one in the area. Environmental issues associated with the potential Melkboom Dam include:

Barrier and Sediment Effects
Similar to Melkbosrug Dam. Refer to Section 4.5.3.

Inundation Effects
Similar to Melkbosrug Dam. Refer to Section 4.5.3. A notable exception being that the inundation length will be less (39 km) with less infrastructure to be inundated than for Melkbosrug Dam.

Downstream Effects
Similar to Melkbosrug Dam. Refer to Section 4.5.3.

4.6.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The Olifants/Doring River Basin Study proposed that the Melkboom Dam be developed to supply a new 4 000 ha irrigation scheme at either Klawer or the Coastal Region. The WODRIS investigated this dam and also the Melkbosrug and Brandewyn River Dams as options to be operated conjunctively with wellfields for supplying up to about 7 500 ha of new irrigated areas. The beneficiaries, distribution infrastructure requirements and environmental impacts would be the similar to those described in Section 4.5.4 above.

The environmental effects of the various development options on the Olifants River estuary is dependent on where in the catchment dams are built and where the additional yield is utilised. The water from the proposed Meklboom Scheme would likely be utilised downstream of the confluence between the Olifants and Doring Rivers, and irrigated in relatively close proximity to the river channel. Summer base flows in the estuary would therefore increase due to irrigation return flows. The increased base flows could result in lower salinities in the estuary during the summer, and saline water would not penetrate as far upstream as presently. The Melkboom Dam would likely attenuate the magnitude and frequency of major floods, and trap sediment. This is likely to result in increased scour and a deepening of the estuary.

4.6.5 Resource Poor Farmers

This scheme would serve resource poor farmers as described for Melkbosrug Dam, see Section 4.5.5.

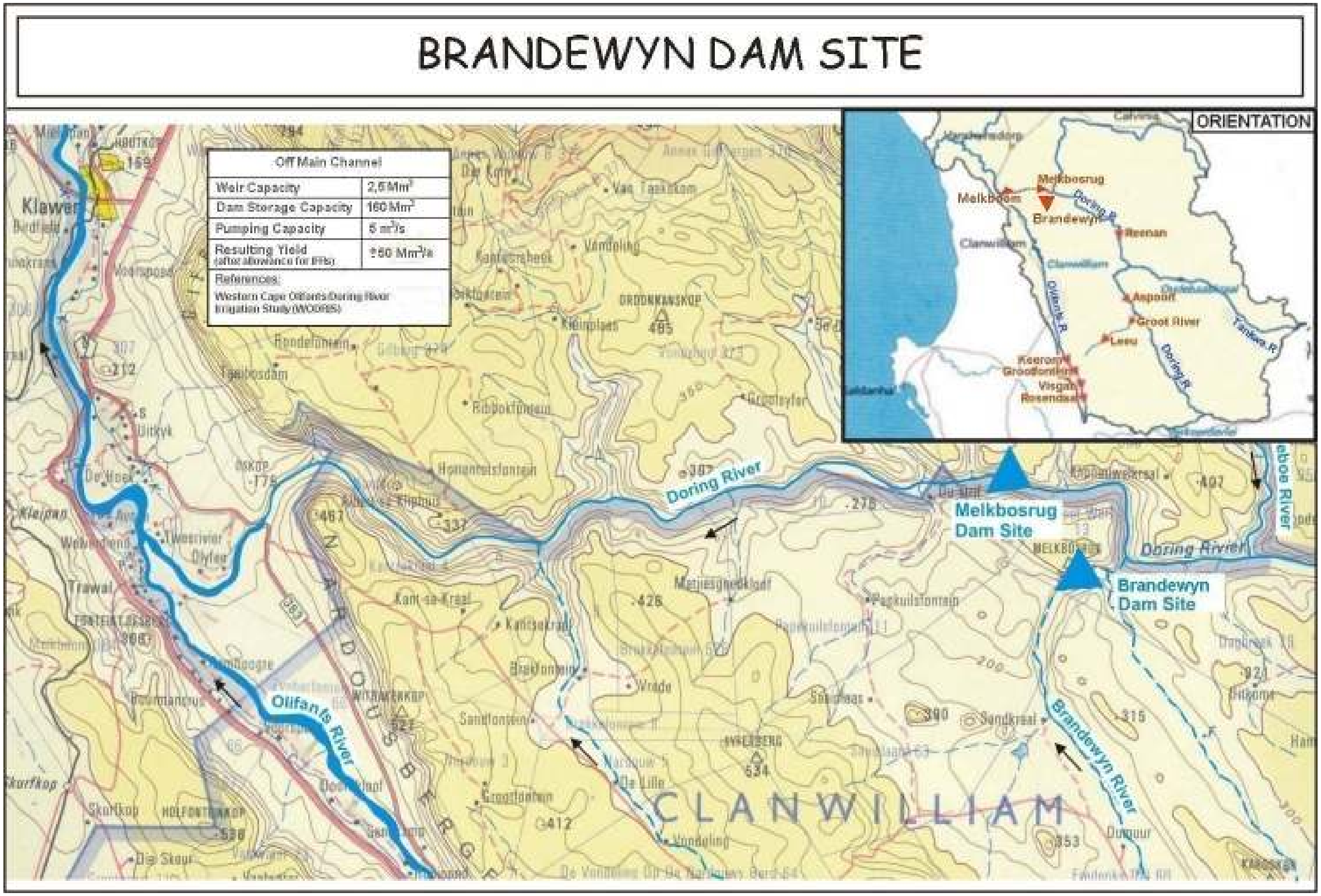


Figure 4.7 Brandewyn Dam Site

4.7 BRANDEWYN DAM SITE

This site was investigated in the WODRIS (2004). The information available on yield calculations *includes* an allowance for instream flow requirements.

4.7.1 Location

The potential Brandewyn Dam is located on the Brandewyn River, approximately 1,9 km upstream of the confluence of the Doring and Brandewyn Rivers. The dam would serve as an alternative to either the Melkbosrug or Melkboom Dams, both of which are on the main stem Doring River. A small diversion weir on the Doring River would be required, from which water will be pumped into the potential Brandewyn Dam.

4.7.2 Engineering and Financial

The engineering assessment is based on the assumption that the Doring River is an Environmental Management Class B and that the EFR associated with that class is met via control of the pumping operation. In so doing, no releases are required from Brandewyn Dam as the EFR is accounted for at the point of abstraction. Table 4.3 indicates the range of potential yields available from the dam for

- various diversion weir capacities
- various pumping capacities
- various storage capacities

Table 4.3 Historical Firm Yields for Proposed Brandewyn Dam

Diversion Weir Capacity (Mm^3)	Pump Capacity (m^3/s)	Brandewyn Dam Storage (Mm^3)	Historical Firm Yield (Mm^3/a) (1)
0	0,5 to 5,0	120 to 220	19 to 52
2	5,0	160	± 50
10	0,5 to 5,0	25 to 250	25 to 68
20	0,5 to 5,0	25 to 280	25 to 78

(1) After Allowance for IFRs as per WODRIS.

The WODRIS concluded that to limit the vertical obstruction of the weir as well as the inundation impact of a 280 million m^3 storage dam, the following limitations were proposed :

- a weir capacity of 2,5 million m^3, allowing for 0,5 of dead storage, and a weir height of approximately 12 m.
- a gross capacity of the Brandewyn Dam of 160 million m^3 (FSL at 181,3 masl).
- a 5 m^3/s pump station.

The resulting firm yields for the above limitations are shown in Table 4.4.

Table 4.4 Firm Yields for Proposed Brandewyn Dam (2,5 million m^3 diversion weir capacity, 5 m^3/s pump station)

Gross Capacity (Mm^3)	Firm Yield (Mm^3/a)
6	7
15	18
26	26
55	41
78	44
112	48
160	52

(Ref : WODRIS, 2004)

The WODRIS proposed that if the Brandewyn Dam option were to be considered, a diversion weir of 2,5 million m^3 storage and a dam of 160 million m^3 would be suitable. This would yield about 50 million m^3/a at an assurance of supply of about 1:120 years.

Earthfill and/or rockfill of sufficient quality is unlikely to be available within the dam basin to construct an embankment dam. Considering that the diversion weir will be concrete and would fall under the same contract as the dam, the concrete option is used for the purpose of cost estimates.

For a rollcrete gravity dam (160 million m^3) and a 2 million m^3 weir on the Doring River, the following construction costs are estimated :

Yield (1) Mm^3/a	Construction Cost (excl. VAT)	Cost: Yield Ratio (2)
50	R351 million	7,0

(1) After allowance for IFRs determined in WODRIS.
(2) Annual pumping costs are likely to be significant, increasing the cost : yield ratio.

4.7.3 Environmental Overview

The Brandewyn Dam was proposed as an alternative to either the Melkboom or Melkbosrug Dams. The effects of constructing the Brandewyn Dam would be similar to constructing the Melkboom or Melkbosrug Dams, however the significance for the system as a whole would be reduced, due to the much smaller scale of the structure and smaller area of inundation. In the WODRIS, the Brandewyn Dam was considered to have less of an overall impact on the environment than either the Melkboom or Melkbosrug Dams. This is achieved by the reduced effect on the flora and archaeological aspects. Specific environmental issues include:

Barrier and Sediment Effects

A pumping weir located on the Doring River would be a relatively low structure, and its barrier effect could therefore be mitigated through the construction of a fish ladder. Sediment effects are likely to be problematic for the downstream reaches.

Inundation Effects

The river vegetation along the lower rocky reaches of the dam basin is typical of that found along footslope mountain streams in. the Fynbos Biome. Construction of the Brandewyn Dam would result in the loss of riparian and valley vegetation of the Brandewyn River and part of the poorly researched Karoid shale vegetation intrusion into the mountain area of the proposed Cederberg Biosphere Reserve complex. These communities do however occur elsewhere in the region. However, the loss of individuals of three rare and endangered plant species is likely.

The extent of the inundation would be 16 km along the Brandewyn River and 5 km along the Doring River. Some 38 cultural heritage sites were located within or near the proposed dam site. Construction of the dam would require the disturbance of two sites containing graves and human remains.

Downstream Effects

The construction of the pumping weir will result in the transformation of the flow regime downstream of the dam and weir, in the Doring River. Medium to large floods would, however, pass through largely unattenuated. Furthermore, the dam is likely to facilitate the invasion of alien fish species.

4.7.4 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The WODRIS investigated this dam as an option operating conjunctively with wellfields for supplying up to about 5 000 ha of new irrigated areas. The beneficiaries, distribution infrastructure requirements and impacts would be similar to those described for the Melkbosrug Dam, in Section 4.5.4

4.7.5 Resource Poor Farmers

This scheme would serve resource poor farmers as described for the Melkbosrug Dam, in Section 4.5.5.

4.8 ADDITIONAL FARM DAMS IN THE KOUEBOKKEVELD

The Olifants/Doorn ISP identified that up to 8 million m^3 of additional farm dam storage could be developed in the Kouebokkeveld. This could be expected to yield an additional 5 million m^3/a. In the ODRB Study, such development was determined to be the most cost effective of all the development options considered. The ISP recommends that in terms of developing additional farm dam storage, releases should be provided for the Reserve at each dam. Nevertheless, these dams are likely to decrease river flow, retard winter flood flows, and further transform the headwater tributaries, resulting in loss of habitat for the small fish species inhabiting these reaches. The combined effect of farm dams is of concern in that it is difficult to manage/ensure Reserve releases. For a single large dam the environmental Reserve releases are more readily enforced.

4.8.1 Beneficiaries, Infrastructure Requirements and Environmental Impacts

The beneficiaries would be the existing commercial farmers, which mainly irrigate deciduous fruit and potatoes. Opportunities could be provided for resource poor farmers.

4.8.2 Resource Poor Farmers

In this predominantly high technology farming region of the catchment, resource poor farmers would probably benefit most through joint ventures with existing commercial farmers rather than purchasing farms for individual or groups of resource poor farmers (although in the Olifants River catchment some individual resource poor farms have been established on Clanwilliam Municipality's commonage as discussed in 4.1.5 above).

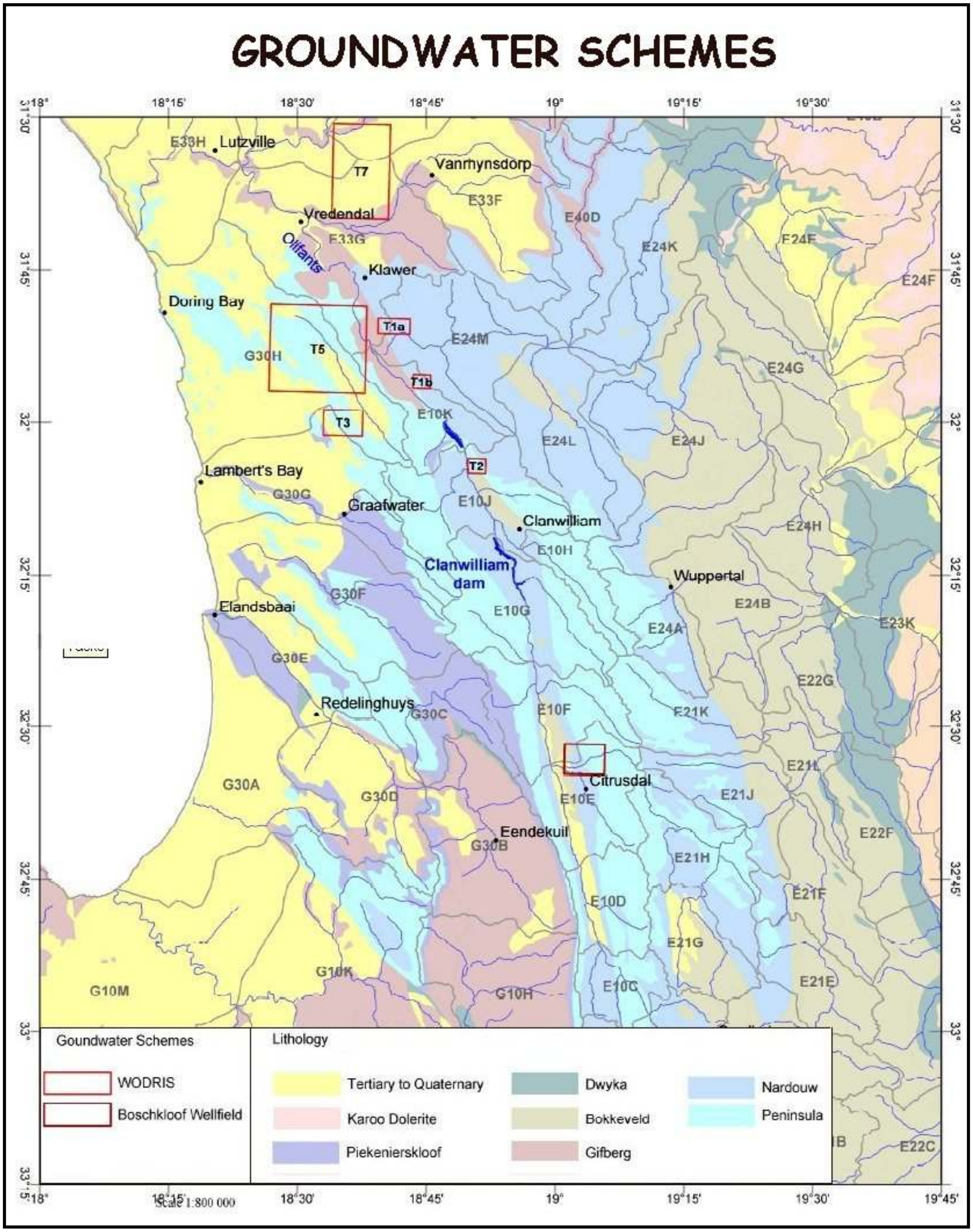


Figure 4.8 Groundwater schemes

4.9 GROUNDWATER SCHEMES

4.9.1 The Klawer Fault T1 Project - Conventional Wellfield

This project comprises two proposed wellfields (T1a and T1b) positioned on the Klawer Fault to abstract groundwater from the Peninsula Formation. It is very conservatively estimated that the combined yield should be over 2,5 million m^3/a from eight boreholes, four in each wellfield. The realistic case is considered to be 2 to 3 times this yield (namely 3,4 to 5,0 million m^3/a over an 8 month pump cycle).

Wellfield T1a is located adjacent to the Doring River and close to the right bank canal of the Olifants River Government Water Scheme (ORGWS) along the Olifants River and so any groundwater abstracted can be pumped directly into the river or the canal with minimal pipework required.

Wellfield T1b is located between the Bulshoek Barrage and the confluence of the Doring River with the Olifants River. It is situated close to the left bank canal of the OGWSS and thus a short length of pipe work would be required to discharge directly into the canal.

For both of these proposed wellfields it was proposed that the water should be pumped and conveyed during the time of the year when there is spare capacity in the canal (March – November). This would require the provision of balancing storage. The alternative being to enlarge the canal.

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
T1a	5 min	12	0,49	0,25 (1)	Umvoto, 2005
T1b	5 min	10,5	0,49	0,23 (1)	Umvoto, 2005

1. URV based on 6% discount rate over 50 years.

Environmental aspects

The production shall be from the confined Peninsula Aquifer. There is no indication in the current data set that this sector of the aquifer contributes to the base flow either via springs or via sub-surface flow. Consequently, it is not expected that abstraction in this area would result in unacceptable impact for either the terrestrial or the aquatic ecology. To enable a more detailed understanding of the surface groundwater interaction in the study area, a detailed and focussed study would be required. It is recommended that datum measurement and monitoring and detailed field inspection of sensitive eco-systems and important biodiversity sites should be undertaken before groundwater production commences.

APPENDIX B

Summary of Groundwater Screening Inputs

CLANWILLIAM DAM RAISING STUDY

SPECIALIST SCREENING WORKSHOP

23 NOVEMBER 2004

Summary of Groundwater Screening Input

TABLE OF CONTENTS

Page No.

1. INTRODUCTION 1

2. GEOLOGY AND HYDROGEOLOGY 2

3. INTEGRATED WATER RESOURCE MANAGEMENT DOMAINS 5

4. PREVIOUS STUDIES 7

5. IDENTIFIED SCHEMES 9

5.1 PROJECT T1 CONVENTIONAL WELLFIELD 11
5.2 PROJECT T2 CONVENTIONAL WELLFIELD 11
5.3 PROJECT T3 CONVENTIONAL WELLFIELD 12
5.4 PROJECT T5 AQUIFER STORAGE RECOVERY 12
5.5 PROJECT T7 AQUIFER STORAGE RECOVERY 13
5.6 CONJUNCTIVE USE 14
5.7 CITRUSDAL-BOSCHKLOOF WELLFIELD IN CONFINED PENINSULA AQUIFER 15

6. CONCLUSIONS 17

7. RECOMMENDATIONS 20

LIST OF TABLES

TABLE 1 COINCIDENT HYDROSTRATIGRAPHIC UNITS OF WESTERN TMG 2
TABLE 2 THE RELATIONSHIP BETWEEN IWRM DOMAINS AND WMA SUBAREAS 6
TABLE 3 SUMMARY OF GROUNDWATER RESOURCE ESTIMATES IN EXISTING REPORTS 8
TABLE 4 SUMMARY OF IDENTIFIED GROUNDWATER DEVELOPMENT SCHEMES 16

LIST OF FIGURES

Figure 1 The location of groundwater resource schemes identified to date 10
Figure 2 Simplified diagrammatic sketch illustrating the hydrogeological setting of the three modelled aquifer reservoirs in the Olifants River Basin 15

I:\HYDRO\400415 Clanwilliam Dam R\R25 Screening Process\Workshop Document\App B-SCREENING OF OPTIONS.doc

1. INTRODUCTION

This report aims to contextualise existing groundwater resource data and to qualitatively summarise the cost/benefit of documented and possible groundwater schemes in the light of the feasibility study to raise the Clanwilliam Dam wall. The report also provides Integrated Water Resource Development and Management recommendations for the greater Clanwilliam Dam area.

The report has drawn on previous investigations, resource estimates and identified groundwater schemes in the greater Clanwilliam Dam area.

Clanwilliam Dam, which is the major dam in the Olifants/Doring River Basin, is situated on the Olifants River upstream of Bulshoek Barrage. This dam is used to provide water for the Olifants River Government Water Scheme (ORGWS). Water is released from the Clanwilliam Dam to Bulshoek Barrage, from where it is abstracted into an extensive canal system providing water to downstream irrigators and towns such as Clanwilliam, Klawer, Vanrhynsdorp and Vredendal.

About 85% of the total river flow volume occurs during the winter months. In contrast, over 60% of the annual urban demand and 90% of the irrigation demand occurs in summer. This pattern necessitates high levels of assurance in water resource development and management. Consequently, considerable storage capacity is required to store the winter surplus for use in summer.

2. GEOLOGY AND HYDROGEOLOGY

The Clanwilliam Dam is located within a roughly N-S trending syncline in the Table Mountain Group (TMG) known as the Orange River Syncline (ORS). NW-SE-striking faults crossing the area form sub-parallel, continuous, interconnected systems, extending over distances of more than 100 km. Together these systems constitute "megafault" zones (Umvoto, 2000).

The reader is referred to the Citrusdal Artesian Groundwater Exploration (CAGE) study report for a comprehensive description and illustration of the geology and the hydrogeological patterns, particularly the hydrotects or megafaults that dominate regional movement of groundwater in the area as well as the surface groundwater interactions.

The main hydrostratigraphic units represented in the study area belong to the Table Mountain Group (**Table 1**). The Table Mountain Group (TMG) exerts the main lithological control on the groundwater flow regime throughout the length and breadth of the Olifants River valley as well as in the hinterland and the coastal plain.

The **Peninsula Formation** constitutes the middle aquifer in the TMG, and is a topographically dominant unit, building most of the high mountain ranges. It is *hydrogeologically most important* because of its:

- *wide areal extent* in the areas of maximum precipitation and recharge potential; and
- *high sub-surface volume* of permeable fractured rock.

The Peninsula Formation is approximately 550 m thick in the Cape Peninsula area but reaches approximately 1 300 m in the Citrusdal region.

Table 1 Coincident hydrostratigraphic units of western TMG

Super-units	Units	Sub-units
Bokkeveld	Gydo Mega-aquitard	
Table Mountain Super-aquifer	Nardouw Aquifer	Rietvlei Sub-aquifer
		Verlorenvallei Mini-aquitard
		Skurweberg Sub-aquifer
	Winterhoek Mega-aquitard	Goudini Meso-aquitard
		Cedarberg Meso-aquitard
		Pakhuis Mini-aquitard
	Peninsula Aquifer	Platteklip Sub-aquifer
		Leeukop Sub-aquifer
	Graafwater Meso-aquitard	(30-180 m thickness)
	Piekenierskloof Aquifer	(not yet identified)
Saldanian	Basement aquifuge	

The Peninsula Formation is overlain by the **Pakhuis Formation**, which is a thin (generally less than 50 m), poorly sorted, compact and impermeable unit. The argillaceous **Cedarberg Formation** succeeds it conformably. Hydrogeologically, the Pakhuis-Cedarberg sequence is an effective aquitard, grading upwards into intercalated siltstones and fine-grained sandstones.

The overlying **Nardouw Sub-group** consists of three sandstone-dominated formations. The Clanwilliam Dam wall is situated within the Nardouw Sub-group.

The lower **Goudini Formation** is characterised by repeated sandstone-siltstone cyclicity, and reddish-brown weathering due to iron-oxide content. The new mapping of the TMG in the Western Cape Olifants/Doring River Irrigation Study (WODRIS) area shows the Goudini Formation to wedge out in a northerly direction.

The middle Nardouw unit, the **Skurweberg Formation**, consists of thick, cross-bedded quartzitic sandstones and is a potentially important fractured-rock aquifer. It is approximately 330 m thick near latitude 32°S, and decreases to approximately 150 m on the Matzikama Mountains, to the north of the study area.

Thinner bedding, subdued weathering pattern, closely spaced jointing and denser vegetation distinguish the **Rietvlei Formation***,* and result in distinctive tones on aerial photographs. It is about 200m thick in the Clanwilliam area.

Both the Peninsula and the Skurweberg Aquifers are currently little exploited although they constitute the largest natural storage facility in the area. The reason for this pattern has been limited scientific or professional input to the development of groundwater resources by local farmers who are the primary users.

The Cage study estimated that approximately 12 million m^3/a were abstracted from the Nardouw Aquifers by local farmers. At that time (1998) there was limited abstraction from the Peninsula Aquifer viz. 1,5 – 2,0 million m^3/a from the Boschkloof Wellfield. Abstraction from the primary aquifers along the coast are excluded from further consideration in this report other than in association with development of the TMG aquifers and surface water in Aquifer Storage Recovery Schemes (ASR).

The CAGE study (Umvoto, 2000) concluded that from a hydrogeological perspective, the major structural features of the area include the following:

- There is a close kinematic relationship between folding along slightly N-S axial trends on the dominant NW-SE faulting.
- The structural geometry of major folds, such as the Olifants River Syncline (ORS) is such that large volumes of aquifer formations are located at depths up to 3 km below sea-level in box-like configurations.
- Four major “megafault” systems cross the study area along roughly NW-SE directions, and are linked to each other by numerous connecting splay-and cross-faults (two of these “megafault” systems occur in the vicinity of the Clanwilliam Dam).

- Fracture-trace analysis on Landsat and SPOT imagery reveals five principal joint sets, covering the exposed areas of the TMG and other formations between the (generally eroded and superficially covered) major fault traces.

The fractures in the quartzitic Peninsula Formation and the similarly quartzitic Nardouw Sub-group are of primary interest for long-term groundwater supply, because they impart to the otherwise relatively impermeable rock a so-called “secondary” permeability.

There are three major sets of fracture structures, along north-west/south-east, west/east and north-east/south-west directions. In general, the fracturing is similarly orientated in both the Peninsula and the Nardouw Formations, but there is variability in fracture spacing, depending on bedding thickness differences and proximity to major fault zones.

In parts of the study area, the more thinly bedded Nardouw Sub-group is intensely fractured by closely-spaced but relatively discontinuous structures. Large-scale, continuous, widely-spaced master joints are characteristic of parts of the more massively bedded Peninsula Formation. Sub-horizontal or dipping bedding planes and formational contacts can contribute to the secondary permeability and can, in combination with local structures and topography, control the occurrence and flow rate of springs.

Two formations viz. the Rietvlei and the Skurweberg are preferred aquifer targets and are drilled by the farming sector. The farmers use the groundwater to augment surface water supplies or for use as an emergency supply during summer, largely for the irrigation of citrus in the area upstream and downstream of the dam. The Clanwilliam Dam wall is situated on the Skurweberg Formation.

The textbook value of 0-10% recharge for fractured crystalline rocks is not applicable in the TMG terrain. A range of 5-50% infiltration given for vesicular basalt is more realistic, given the pseudokarstic character and endoreic drainage systems of the TMG at high altitude where most of the rain falls. The CAGE study indicates an average of 23% in a range of 8 to 52%. All recharge calculations suggest that the TMG super-aquifer delivers a substantial and sustainable yield.

3. INTEGRATED WATER RESOURCE MANAGEMENT DOMAINS

As a component of the National Water Resources Strategy (NWRS), the Minister of Water Affairs and Forestry established the boundaries of the Olifants/Doorn WMA, which is comprised of 88 quaternary sub-catchments.

These have been sub-divided into key *surface*-water sub-areas “in order to improve management” (ISP, 2004).

From a groundwater perspective (Vegter, 2001), the Olifants/Doorn WMA straddles six “groundwater regions” (numbers and names below after Vegter, 2001, Figure 2 and associated tables), namely:

- Northern part of No 57 – Swartland
- No 48 – North-western Cape Ranges
- No. 56 – Knersvlakte
- Southern part of No. 27 – Namaqualand
- No. 36 – Hantam
- No. 37 – Tanqua Karoo

A relatively simple refinement of the six groundwater regions in the Olifants/Doorn WMA (Umvoto, 2004a), linked to quaternary catchment boundaries and better reflecting patterns of groundwater storage/flow and surface-groundwater interaction, recognizes two main hydrogeological provinces (Adamastor and Western Karoo, respectively), each sub-divided into two sub-provinces that facilitate integrated ground and surface water quantification objectives (**Table 2**). These are described as Integrated Water Resource Management (IWRM) Domains.

The distribution of the TMG Peninsula Aquifer is the main determinant of the eastern boundary between the Cederberg and Tankwa sub-provinces, which is here made to coincide approximately with the TMG-Bokkeveld contact while respecting quaternary boundaries (except in the E24K instance). This proposed modification of the “groundwater regions” concept represents a development towards a hierarchy of aquifer-related spatial domains relevant and useful to Integrated Water Resources Management (IWRM) purposes.

IWRM domains facilitate the integration of surface and groundwater resource allocation, regulation, conjunctive use and management at WMA, CMA and Departmental level. It is proposed that an IWRM strategy that would underpin resource development (Screening) and management decisions, requires a comprehensive understanding of the available natural and man-made storage options available as well as the time and space scale of surface and groundwater interaction.

Table 2 The Relationship between IWRM Domains and WMA Subareas

Province	Sub-province	Situational Assessment sub-areas
Adamastor	Cederberg	Sandveld (G30 A – H) Upper Olifants (E10 A – K) W Kouebokkeveld (E21G, H, J, K) W Lower Doring (E24A, J, L, M, lower part of E24K) Lower Oorlogskloof (E40D)
	Knersvlakte	Lower Olifants/Sout, Goerap
Western Karoo	Tankwa Karoo	Upper Doring E Kouebokkeveld (E21A-F, L) Tankwa E Lower Doring (E24B-H, upper part of E24K)
	Hantam	Upper Oorlogskloof (E40A-C) Hantams Kromme

Within these domains it would be a reasonable first step to develop conjunctive water resource development and management schemes that optimise natural storage and existing/potential surface facilities and their yield with patterns of rainfall (short to long term) and demand (time and space). This planning is critical given the current and the modelled impact of climate change.

4. PREVIOUS STUDIES

In general the studies that have been undertaken are regional studies. Other than in the CAGE Study and WODRIS, they do not contain aquifer specific, nor scheme specific information. Groundwater cannot be developed and schemes cannot be conceptualised without this information.

The data that has generally been used is that available in the WRC 90 records, the 1:250 000 geology map series of the Council of Geoscience (CGS) and the available DWAF hydrogeological map series (1:1M to 1:500 000). Thus the groundwater potential contained in the reports is largely generalised. It is useful for input in principle at a policy level. It is not meant to be a significant input to resource development and management decisions that would have any medium to long-term impact on water resource allocation and management in the WMA or within a Water User Association (WUA) area.

To evaluate the data available is beyond the scope and budget of this study but would be required if groundwater schemes were to be conceptualised, costed and evaluated on a par with identified surface water schemes.

However, the results of the different studies are summarized and compared in **Table 3** below. It is eminent that differences in resource evaluation are due to different approaches, methodologies and study areas. The aquifer recharge estimations vary between 22 million m^3/a for a portion of the Peninsula Aquifer alone and 138 million m^3/a for the TMG within the WODRIS area. The available groundwater for abstraction varies between 25 million m^3/a and 457 million m^3/a (as harvest potential). Only two studies yielded estimates for the effective storage.

The decision at this stage is :

- whether the natural storage of water that has proven to be accessible and from which reliable yields are cost effective over periods of time warrants investment; and
- whether IWRM in the area can be achieved without this investment.

The impact of climate change that is apparent in this area must be considered in the evaluation of storage of water or so-called scheme options (dams in the case of surface water and aquifer development in the case of groundwater or both) in both resource development and management decisions.

Table 3 Summary of groundwater resource estimates in existing reports

Study	GW Reservoir (Domain)	Effective storage (Mm^3)	Recharge (Mm^3/a)	Available groundwater (Mm^3/a)
CAGE, 2000	East (unconfined) Central (confined) West (unconfined) Peninsula Aquifer only	200 750 80	22	45
ISP, 2004	Upper Olifants (E10A-G) Aquifer specific	Not used	120 (73 Peninsula 39 Nardouw)	36
WODRIS, 2003	Peninsula Aquifer in E10G-E10J, E24A, E24L, E24M	Storage capacity 80 –200	80 Peninsula 58 Nardouw (Includes more Quats)	The yield was estimated for specific target areas
GEOSS Consortium (DANIDA), 2003	Upper Olifants (Entire E10D, E10E, E10F as well as portions of E10C and –G),	Not used	Mean Annual Effective Recharge (MAER) – 32.87	25.18
Water Resources Situation Assessment, 2002 DWAF	Upper Olifants (E) TMG Aquifer not included	Not used		79.8
Seymour and Seward, 1996*	Upper Olifants	Not available		Harvest Potential 457 (for E10A-G).
WSM, 2000*	Upper Olifants (E10A-G)			Exploitation Potential 308

Note: * It is not possible to understand or evaluate the discrepancies in earlier estimates because of the scale differences in the data available and insufficient published information on the assumptions governing the data at the quaternary catchment and aquifer specific scale.

5. IDENTIFIED SCHEMES

There has been significant investment in the study area to identify all surface water supply schemes. This effort has not been applied to the significant groundwater potential in the area. The locations of groundwater resource development schemes identified to date are shown in **Figure 1**. The potential yields, and estimated capital, operational and relative costs of these schemes are shown in **Table 4**. The setting as well as engineering and environmental aspects of each of these schemes is described as the information was available.

The identification of all potential groundwater schemes in the area is beyond the scope and budget of this study.

A number of schemes were identified in the course of the WODRIS. The target zones/schemes were defined by the geological settings and the potential of abstracting and or storing groundwater of good quality and of sufficient amount in a sustainable manner. The target zones/schemes for abstraction and storage are situated outside proposed irrigation schemes and are summarised below. The reader is referred to the reports of the WODRIS for further details and graphic illustration. It must be noted that a groundwater scheme *per se* comprises a number of different wellfield or ASR projects.

GROUNDWATER SCHEMES

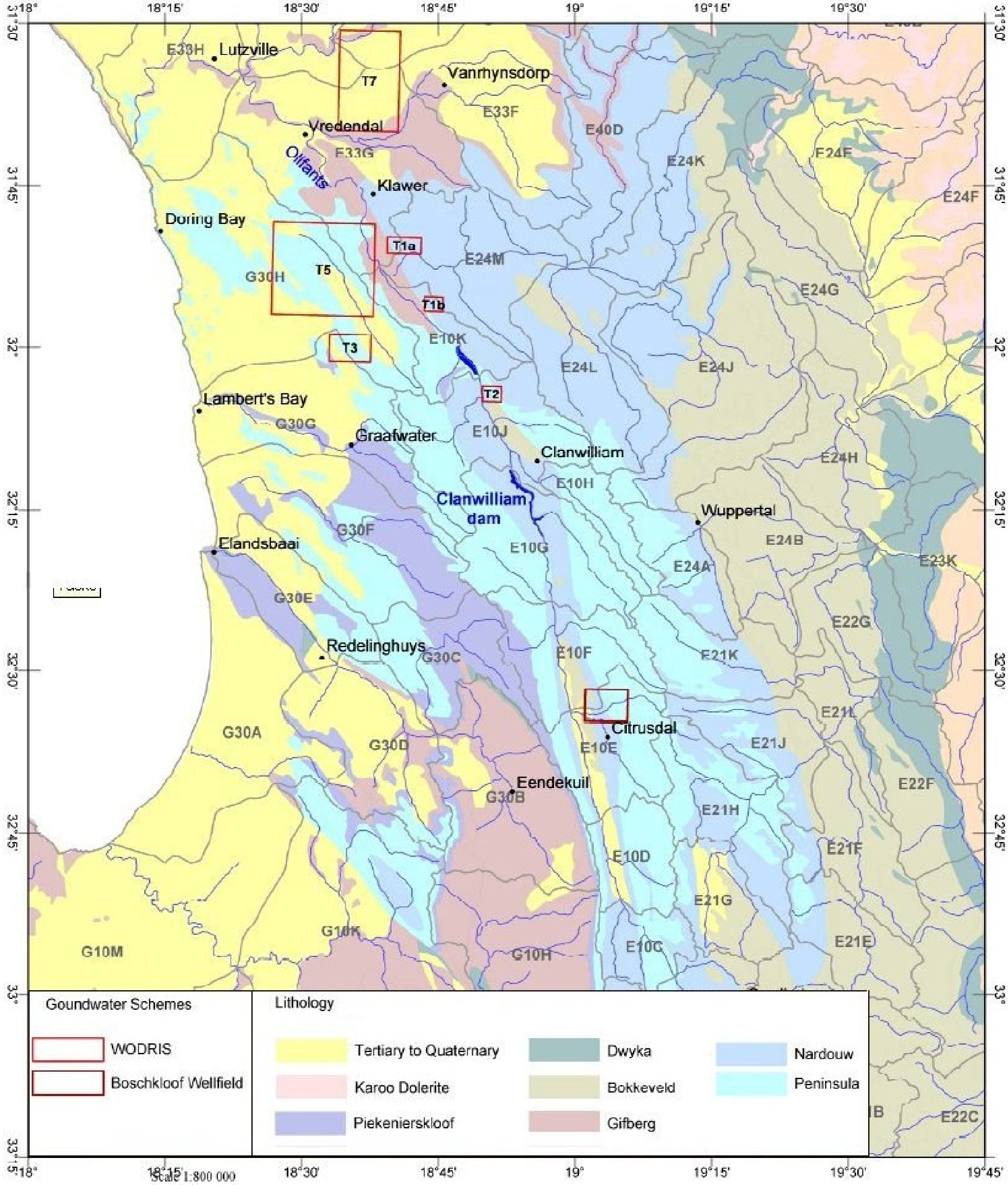


Figure 1 The location of groundwater resource schemes identified to date

5.1 PROJECT T1 CONVENTIONAL WELLFIELD

This project comprises two proposed wellfields (T1a and T1b) positioned on the Klawer Fault to abstract groundwater from the Peninsula Formation. It is very conservatively estimated that the combined yield should be over 2,5 million m^3/a from eight boreholes, four in each wellfield). The realistic case is considered to be 2 to 3 times this yield (namely 3,4 to 5,0 million m^3/a over an 8 month pump cycle).

Wellfield T1a is located adjacent to the Doring River and close to the right bank canal of the ORGWS along the Olifants River. Consequently, any groundwater abstracted can be pumped directly into the river or the canal with minimal pipework required.

Wellfield T1b is located between the Bulshoek Barrage and the confluence of the Doring and Olifants Rivers. It is situated close to the left bank canal of the ORGWS and thus a short length of pipe work would be required to discharge directly into the canal.

For both of these proposed wellfields it was proposed that the water should be pumped and conveyed during the time of the year when there is spare capacity in the canal (March – November).

Environmental aspects

- The production shall be from the confined Peninsula Aquifer.
- There is no indication in the current data set that this sector of the aquifer contributes to the base flow, either via springs or via sub-surface flow.
- It is not expected that abstraction in this area would result in unacceptable impact for either the terrestrial or the aquatic ecology.
- More detailed understanding of the surface groundwater interaction in the study area would require a detailed and focused study.
- It is recommended that datum measurement and monitoring and detailed field inspection of sensitive eco-systems and important biodiversity sites should be undertaken before groundwater production commences.

5.2 PROJECT T2 CONVENTIONAL WELLFIELD

The target zone for wellfield T2 is situated close to the Bulshoek Barrage. It is conservatively estimated that this wellfield should yield 1.6 million m^3/a from five boreholes. In a realistic case a yield of 2,1 to 3,2 million m^3/a, pumped over 8 months, is considered possible.

If the groundwater is to be piped into the Bulshoek Barrage, which has a capacity of 6 million m^3, it is preferable to pump only in the summer months (viz. November to April), however, distribution of this water may be limited by the capacity of the downstream canals at particular times.

Environmental aspects

- The Upper Peninsula Formation is in an area where the Klawer Fault and the Clanwilliam Fault meet in a splay extending to the east of the Bulshoek Barrage.
- There are anecdotal reports of significant springs along the Bulshoek transfer zone that potentially could be impacted by large-scale abstraction in this target zone.
- Production would be from the relatively unconfined Peninsula Aquifer.

- A management factor to consider is that the springs discharge into the Bulshoek Barrage.
- It is possible that high levels of abstraction could induce flow from the dam into the aquifer.
- Taken as a conjunctive supply scheme the purpose would be to minimise evaporation from the Bulshoek Barrage (shallow dam in a hot windy area) by taking advantage of the additional underground storage facility and the high recharge in the Krakadouw Mountains along the fault strike to the south-east.

5.3 PROJECT T3 CONVENTIONAL WELLFIELD

The target zone for wellfield T3 is situated at approximately 270 masl. It is conservatively estimated that four boreholes would be required to yield 1,26 million m^3/a. In a realistic case a yield of 1,7 to 2,5 million m^3/a, pumped over 8 months, is considered possible.

It is proposed that groundwater be pumped at a minimum rate of 40 ℓ/s by booster pump to cross a low divide of 380 masl from where the water can gravitate into the left bank canal of the ORGWS. This would require a rising main of approximately 9 500 m and a gravity section of 4 500 m. The pipeline route would follow the existing road.

Because the required infrastructure is expensive relative to the proposed wellfields T1 and T2, it may be preferable to develop this wellfield only for local use. This alternative is considered in a composite project, including T1 and T2, titled T5 below.

Environmental aspects

- The target zone lies along the Skurfkop Fault.
- This fault could allow subsurface discharge zone from the TMG Aquifer into the Quaternary sands.This would result in a natural interbasin transfer from the E drainage basin into the G30H catchments.
- There could be hidden seep zones in this arid, poorly known and poorly documented area, although there is no apparent topographic expression of such other than the elongated upper valley of the Sandlaagte which is proposed as a storage facility in Project T5.

5.4 PROJECT T5 AQUIFER STORAGE RECOVERY

This project is based on the storage potential in the palaeo valley of the Sandlaagte River. This storage capacity is viewed as three subsections (S1, S2, S3) of which S3 is currently being abstracted from. The three sections are assumed to be hydraulically connected but with zones of restricted transmissivity (T) values dividing each section from the other. The total storage is estimated to be 80 to 90 million m^3 in S1 and S2.

All water supply from the proposed wellfields T1, T2 and T3 would be conveyed to a common point and then pumped over the water divide between the Olifants River and the Sandlaagte catchments so as to recharge the Sections 1 and 2 of this aquifer. If after a reasonable period of monitoring either the volumes pumped can be increased, or the length of the pump cycle can be increased, it is anticipated that this yield could increase up to 20 million m^3/a.

The proposed point of abstraction from the Olifants River is south of Klawer and thus the volumes available for recharging the primary aquifer could include both water from the left bank canal of the ORGWS and the Olifants River as well as the Doring River during high flows. It is suggested that an off-channel pump sump delivering 1,3 m^3/s (i.e. 20 million m^3 over a 6 month pumping period) would pump water into a pipeline following an existing road over the low ridge north-west of Trawal (280 masl). From there it would gravitate to the recharge wellfield at approximately 220 masl.

Twenty six recharge boreholes could be situated 350 m apart, each injecting up to 50 ℓ/s. Abstraction would be via the same boreholes and at the same rate as injection. The water would be reticulated using two rising mains to a level of 320 masl. This assumes that any future distribution canal would be constructed at this level in order to distribute to the arable land below.

In costing this project, additional water from the surface supply options was not considered, although the storage capacity in S1 and S2 would allow for up to 90 million m^3 to be stored. This storage volume could be accumulated over a number of years, as confidence in the scheme developed and initial teething problems are resolved. There are international and national projects from which knowledge and expertise could be drawn.

The purpose of this project or scheme would be to abstract up to 20 million m^3 from the TMG Aquifer in the winter months between March and November (or from surface water) and to artificially recharge the primary aquifer (S1 and S2) from which it can be abstracted during the summer.

The position of the recharge and/or abstraction boreholes would be based on more detailed investigation and characterisation of the aquifer as well as the potential irrigation areas identified.

Environmental aspects

- Aside from site footprint considerations the primary environmental concern would be the impact of raising the water table in the unconfined to semi confined primary aquifer in the Sandlaagte Valley.
- It is not known if sensitive ecosystems or important Biodiversity sites have been identified in the area. An ecological assessment of the area is required.
- Significant changes in the natural habitat have already occurred as a result of dry land agriculture.

5.5 PROJECT T7 AQUIFER STORAGE RECOVERY

A storage capacity of 121 million m^3 in the fractured limestones was used for the calculation. This is equivalent to the yield of the potential Melkboom Dam.

An off-channel concrete pumping sump on the Olifants River close to Vredendal is proposed with an abstraction rate of 7,7 m^3/s, i.e. 121 million m^3 pumped over six winter months using 8 pumps each delivering 1 m^3/s. The water would be pumped via a rising main to 154 injection wells spaced 500 m apart. Each well would inject water into the storage aquifer at a rate of 50 ℓ/s. The wellfield would be spread over a 5 km by a 7,5 km area. The same boreholes used for recharge would be used for abstraction.

The primary cost component is the winter and summer pumping and the extensive pipe network for the distribution and collection of water.

Environmental aspects

- The potential storage facility is the confined fractured limestones located beneath an older land surface covered by red aeolian sands.
- It is situated around the divide between the Vars and the Troe-Troe Rivers' channels, west of Vanrhynsdorp in an extremely arid area.
- The rivers flow during flash floods and the aquifer is apparently no longer being actively recharged and as yet no farfield lateral recharge potential has been identified. It is suggested that the greatest environmental impact would be the site footprint resulting from the development.
- These would occur in an area of new agriculture development and thus already undergoing complete change.
- The groundwater development scheme would be obscured within the agriculture development.
- There could be aquifer ecology impacts arising from the different chemistries (acidic and unbuffered) and possibly microbiologies and microfauna of the waters (surface and TMG) being pumped into the alkaline and buffered waters of the limestone aquifer.

5.6 CONJUNCTIVE USE

During the CAGE project the Water Resources Yield Model (WRYM) for the catchment area above Clanwilliam Dam was run using different operating rules. In one extreme, groundwater from the Peninsula Aquifer of the TMG was always pumped to the Clanwilliam Dam and, in the other extreme, only when the dam was empty. A number of intermediate scenarios were also considered.

The Peninsula Aquifer was modelled as three interconnected rectangular reservoirs represented as three separate nodes in the WRYM. The effective exploitable storage for these reservoirs viz. east, central and west are 200, 750 and 80 million m^3, respectively. The eastern and western reservoirs are unconfined and the central is confined. Recharge to only the unconfined eastern and western reservoirs was conservatively calculated as 332 and 22 million m^3/a, respectively. Combined fountain flow from both unconfined reservoirs was estimated as 3 million m^3/a. Interflow relationships between the groundwater reservoirs are critical and confidence in initial estimates needs to be improved. Similarly, the relationship between spring flow and drawdown in the individual model reservoirs was presented by a relationship, which requires verification.

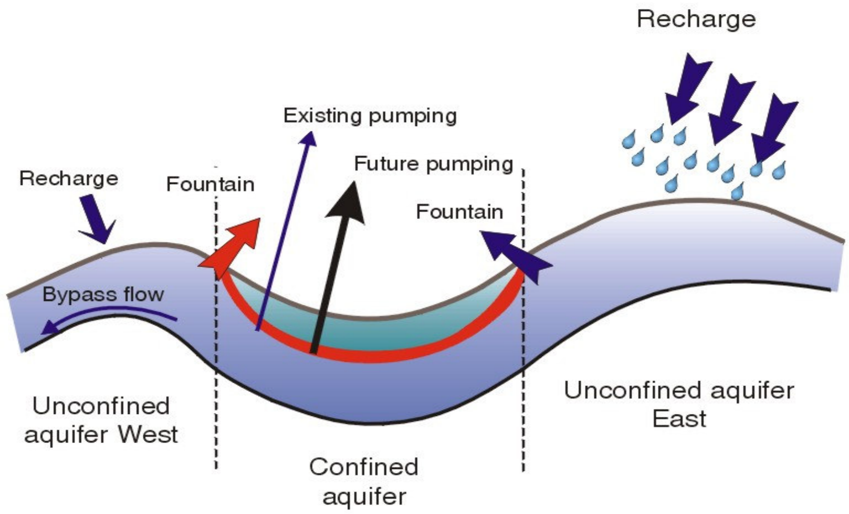


Figure 2 Simplified diagrammatic sketch illustrating the hydrogeological setting of the three modelled aquifer reservoirs in the Olifants River Basin

The study concluded that **conservatively** 45 million m^3/a would be available to the Olifants River WUA without negative environmental impact if conjunctive use was implemented without impact on the environment, which would give an increase in the historic firm yield of the Clanwilliam Dam of 20%.

Environmental aspects

Over wide areas in the middle part of the E10 catchment, the potentiometric surface may be hundreds of metres above the buried top of the Peninsula aquifer. Locally, drawdowns very much larger than 10 m are theoretically possible (at least up to a maximum economic pumping depth of ~100 m) without in any way impacting on the aquifer's saturated thickness. Furthermore, with sufficient knowledge of other aquifer properties such as hydraulic conductivity K, wellfield sites can be strategically selected to ensure that, during the summer pumping season, the surrounding cones of depression rarely, if ever, diffuse to exposed aquifer boundaries where base flow at springs can be affected. In the event of this occurring it would be appropriate to supplement surface flows accordingly or evaluate the cost benefit and most water efficient approach to storage.

5.7 CITRUSDAL-BOSCHKLOOF WELLFIELD IN CONFINED PENINSULA AQUIFER

Regrettably, this study has not been able to obtain actual URV costs for this wellfield nor current information on usage and management of the wellfield. Current costs based on hard data for the Hermanus wellfield result in a URV of 70 c/m^3. Even if the costs of undertaking development of a regional monitoring infrastructure and monitoring protocols (which such costs should not strictly be assigned to a particular scheme), and costs for development further away from existing infrastructure are added, the URV will not be more than 100 c/m^3.

Table 4 Summary of identified groundwater development schemes

Scheme Name	Yield (Mm^3/a)	Costs			Date and source of information
		Capital (R million)	Operation & Maintenance (R million/a)	Relative Cost or URV (R/m^3)	
Citrusdal-Boschkloof	1.48 (Umvoto Report) 1,5-2,0 (Table 2.4 from NS)	Not available	Not available	Not available	Deon Wasserman of Municipality 027-4828000 Johan Conradie (KweziV3) 022-7132288
WODRIS T1a	5 min	12.0	0.49	0.25	Umvoto, 2005
WODRIS T1b	5 min	10.5	0.49	0.23	Umvoto, 2005
WODRIS T2	3.2 min	11.16	0.41	0.35	Umvoto, 2005
WODRIS T3	2.5 min	14.19	0.33	0.49	Umvoto, 2005
WODRIS T5 (1)	20 min	422	20	0.82	Umvoto, 2005
WODRIS T7 (2)	121 ave	150	4.42	0.12	Umvoto, 2005
CAGE	45 min	-	-	-	Umvoto, 2000

(1) Costs include pumping of water from the river and other wellfields into the ASR Scheme
(2) Costs exclude pumping of water from the river into the ASR Scheme.

6. CONCLUSIONS

The reader is further referred to the CAGE study (Umvoto, 2000) as many of the conclusions are relevant to this report.

1. Substantial potential (100 – 190 million m^3/a) exists for the sustainable abstraction of relatively large quantities of water from the TMG aquifers. This could be possible without having significant negative impacts on the environment or on users of surface and of groundwater but such would require further study.

2. The rural nature of the population suggests that groundwater could contribute to widespread provision of the basic human need, as well as an allocation for irrigation and empowerment via conjunctive use schemes, with or without the raising of the Clanwilliam Dam.

3. The water quality in the TMG is good to excellent for domestic use. The TMG aquifer is currently neither vulnerable to pollution nor over-abstraction[1].

4. Conjunctive use of surface and groundwater holds the possibility that the variability of flow in the rivers could be increased with a consequent upgrade in environmental management of the river systems.

5. Aquifer extents and the surface boundaries of recharge domains ("groundwater catchments") locally and regionally exhibit marked departures from the surface-water catchment divides. The combined surface/groundwater system is an open system; i.e. what is abstracted from the groundwater storage within a particular catchment is not necessarily "lost" to the surface water system in the same catchment, neither is it necessarily discharged within the same catchment if it remains unabstracted. There are most likely significant losses of TMG water to the sea via the hydrotects.

6. An evaluation of storage potential and thereafter the reliability of the sustainable yield that is achievable from surface and groundwater is needed. This requires a conjunctive approach to the management of storage that necessitates a new platform and approach.

7. Preliminary storage models were prepared in the CAGE Study and WODRIS for sectors of the TMG aquifers. These illustrate that in the area up gradient of the Clanwilliam Dam,

[1] The Peninsula and Skurweberg Aquifers are recharged in the high mountain areas that are uninhabited and not used for agriculture. The pattern of land use in the area means that there is no to very limited source of pollution into these aquifers. In the event that the aquifers are developed, aquifer protection is an essential component of any management scheme.

The Skurweburg is a confined subartesian aquifer and is at present unexploited. Given the difference between the demand and potential supply it is currently under no threat of over abstraction. The Peninsula aquifer is saturated and the volume of water in storage is significantly greater than the current predicted demand.

approximately 100 million m^3/a is available from the Peninsula Aquifer alone, if used independently as well as in conjunction with Clanwilliam Dam and other dams. In the area below Clanwilliam Dam approximately 50 - 100 million m^3/a is available from the Peninsula Aquifer. Similar models for the Skurweberg Aquifer are not available.

8. At present potential schemes above the Clanwilliam Dam have not been identified. Since the TMG dominates the terrain and the hydrotects transect the terrain in a general NW trend there are no significant limitations on access to the water.

9. The aquifer management strategy proposed for the TMG aquifers is that of summer pumping and winter recharge, *viz*. drawdown of the groundwater table in summer in order to enhance recharge in the winter and make optimum use of the evaporation free storage. This is another approach to water banking because winter floods can be stored in an aquifer. This opportunity is borne out by isotopic results that indicate that up to 90% of floods consist of rejected groundwater recharge in these areas.

10. When normal winter recharge and aquifer recovery does not occur fully during exceptional drought periods, and surface water reservoirs are seriously depleted or empty, the deep wellfields should in principle also be capable of “mining” the TMG groundwater resource over several summer-winter cycles. Such mining of the deep strategic groundwater reserve should be effected with minimal or no impact on the surface environment, until the drought is broken and full recovery is assured.

11. In order to accomplish this form of water resource management, the time lag between the onset of pumping and the radial expansion of the induced depression in the potentiometric surface to the borders of the recharge area should be in the order of months or years. Such extended time lags in (spring or well) discharge responses to recharge from distant precipitation are indeed possible where deep regional flow systems exist (Domenico and Schwartz, 1990, p. 262).

12. In view of the evident potential for adverse global climate change in the 21st Century, there is a long-term strategic importance in developing the deep groundwater reserve. It is an added insurance against losses consequent on prolonged drought cycles, which could trigger disastrous economic downturns. In the longer run, such episodic losses could potentially dwarf the cumulative recurrent costs of operation (e.g., pumping) and maintenance.

13. The general consensus is that surface water is more vulnerable to climate change and variability than groundwater. Thus the integration of the TMG resource becomes a matter of strategic planning and importance for the area.

14. Aquifer Storage and Recovery (ASR) or Artificial Recharge and Recovery (ARR) technology has advanced in recent years and is currently implemented in a number of developed and developing countries. It has gained acceptance worldwide as an effective method of conserving water for future use, for enhancing water quality and for averting saline water intrusion. The primary aim of ASR as a water supply resource is to replenish aquifers with surplus water, water that would otherwise be lost through natural processes or through evaporation in dams.

15. In order for the full spectrum of IWRM options to be evaluated and considered, it is essential that the knowledge base for all water resource options is sufficiently developed to allow for meaningful quantitative modelling and comparisons of sustainable water yields and cost benefits.

16. Conjunctive water resource development and management schemes will optimise natural (aquifers) and existing surface storage facilities and their yield with patterns of rainfall (short to long-term) and demand (time and space).

7. RECOMMENDATIONS

1. Artesian basin(s) such as the Peninsula and Skurweberg Aquifers must be developed in a planned coherent manner. This may mean that different sub areas can be developed before others, but that the whole is strategically understood, planned and undertaken from a resource evaluation, monitoring, data base development, technology and management approach. Where to start is dictated by demand, existing infrastructure, available information and relative cost/benefit. Such incremental development mitigates real and perceived risks associated with groundwater and has the advantage that the downstream developments benefit from experience and insight arising from the monitoring of such schemes.

2. The storage capacity of any aquifer (be it a wellfield or ASR development) is a crucial parameter for the long-term management of groundwater usage. Field reconnaissance, and site-specific study as well as storage models and exploration drilling would be required for any of the schemes identified in order to move from a desk top pre-feasibility stage to a feasibility level.

3. The recharge estimation used to evaluate sustainability of the fractured rock schemes indicates that it is pertinent to calibrate the recharge model by means of other methods, such as SVF / CRD and chloride and isotope analysis.

4. Integrated Water Balances should be developed for the Integrated Water Resource Management Domains to establish the potential for groundwater development within the constraints of natural variation and existing surface water developments and dependence.

5. The development and implementation of a comprehensive monitoring programme is strongly suggested. To do so would be to the benefit of both surface and groundwater development and management.

REFERENCES

Department of Water Affairs and Forestry. 2003. Terms of Reference. *Feasibility Study for the raising of the Clanwilliam Dam in the Western Cape.*

GEOSS Consortium. 2003. *IWRM – Groundwater Guidelines: Trial Implementation and Testing – Olifants – Doorn Management Area.* December 2003.

Provincial Government Western Cape. 2003a. *Western Cape Olifants/Doring River Irrigation Study. Hydrogeological Reconnaissance Report.* Prepared by Umvoto Africa (Pty) Ltd in association with ARCUS GIBB (Pty) Ltd. Cape Town. February 2002.

Provincial Government Western Cape. 2003b. *Western Cape Olifants/Doring River Irrigation Study. Groundwater: Hydrocensus Report.* Prepared by Umvoto Africa (Pty) Ltd in association with ARCUS GIBB (Pty) Ltd. Cape Town. December 2003.

Semour, A and Seward, P. 1996. *Groundwater Harvest Potential of the Republic of South Africa.* Map and explanation prepared for the Department of Water Affairs and Forestry.

Umvoto Africa. 2000. *Reconnaissance investigation into the development and utilisation of the Table Mountain Group artesian groundwater, using the E10 Catchment as a pilot study area: Final report.* Umvoto Africa, cc.

Umvoto Africa. 2004a. *Internal Strategic Perspective (ISP) of the Olifants Doorn WMA – Groundwater Overview.* Prepared for the Department of Water Affairs and Forestry. (Unpublished report).

Umvoto Africa. 2004b. *Oudtshoorn Agricultural Water Feasibility Study Phase 1 – Synoptic indication of the potential artesian/underground water in the study area and also in the adjacent areas.* (Draft unpublished report).

APPENDIX C

Minutes of the Key Stakeholder Workshop (10 February 2005)

NINHAM SHAND CONSULTING SERVICES

Item	Notes of Meeting	Action
	Feasibility Study for the Raising of the Clanwilliam Dam **Reference Group Meeting on the Screening of Options Report** **held on 10 February 2005** **at the Clanwilliam Bowling Club, Clanwilliam** **STUDY TEAM ATTENDENCE** Dr M Shand — Ninham Shand — (MJS) Mr E van der Berg — Ninham Shand — (EvdB) Mr M Luger — Ninham Shand — (MKL) Mr G English — Ninham Shand — (GE) Mr A West — Ninham Shand — (AW) Mr D Wilson — ASCH Consulting — (DW) Mr E Jakoet — Jakoet and Associates — (EJ) Ms D Februarie — Nosipho Consultancy — (DF) Mr W Enright — DWAF — (WE) Mr A Parker — DWAF — (AP) Mr F van Heerden — DWAF — (FvH)	
1	**WELCOME AND SETTING CONTEXT – PLENARY SESSION** DF welcomed the members of the study team and introduced them to the Reference Group. MJS provided an overview of the purpose of the Screening Phase and anticipated outcomes, and provided participants with a brief overview of the Olifants/ Doring Catchment. EvdB provided participants with an overview of the Feasibility Study for the Raising of Clanwilliam Dam, and an overview of the Screening Phase and key outcomes of the Screening Workshop. He then explained that there would be two breakaway sessions after lunch, in order to facilitate further debate of the findings of the Screening Workshop and the associated Screening of Options report. A participant wanted to know if the total costs for the dam raising took into account the cost of the remedial work? EvdB responded that the costs associated with the raising of the dam were incremental, that is, the costs over and above the cost of undertaking the requisite remedial work. Mr du Toit raised a query regarding the rating of the screening of the Leeu River Dam, stating that there are existing dams on the Leeu River, and there was potential for further dam development. MKL responded that the screening of options was based on the suite of previous work undertaken. The Olifants Doring Basin Study Phase 1 had assessed the Leeu River option and rated it poorly. However, the assessment may have been based on a worst-case scenario, as it was not possible as part of the Screening Phase to optimise all of the options from a technical and environmental perspective. Mr Joubert asked if water from the Clanwilliam Dam was supplied to either Lamberts Bay or Doring Bay? The study team responded that Doring Bay gets water from Clanwilliam Dam, but that Lamberts Bay was supplied from groundwater. Clarity was sought on the difference between storage (capacity) and yield of a dam.	

Item	Notes of Meeting	Action
	EvdB explained that storage was the total volume of water that the dam could hold, while yield was the average volume of useable water that a dam could supply. The bigger a dam, the less the chance of the dam being filled every year, and therefore the yield of a large dam is less than the storage. A question was raised regarding the investigation of impacts at the mouth of the Olifants River and impacts on fishermen. The study team responded that the Reserve determination study was investigating the estuary, and looking at fish and the quantity of water required to maintain the fish life as well as social impacts. The results of the Reserve determination study would be incorporated into the Clanwilliam Dam Raising Feasibility Study. Participants wanted to know by when the dam had to be stabilised. The study team responded that the Department wanted to complete the work within the next five years. The feasibility study would determine if the dam should be raised and by how much.	
2	**NOTES OF THE OLIFANTS RIVER BREAKAWAY SESSION** Erik van der Berg and Mike Shand chaired the Olifants River breakaway discussion session. EvdB reiterated that the purpose of the breakaway discussion group was to further debate the recommendations of the Screening Phase and for participants to provide further inputs. The floor was then opened for general discussion and questions.	
3	**QUESTIONS AND GENERAL DISCUSSION FROM THE OLIFANTS RIVER BREAKAWAY SESSION**	
3.1	The first question raised was clarification on how the benefits of irrigation were rated in the Screening of Options report. The facilitators responded that a four-point scale was used, where one equated to neutral or positive, and four was very negative. If many people could benefit from a scheme, then the scheme was given a positive rating.	
3.2	It was questioned whether further farm dams could also be developed, should the Clanwilliam Dam be raised. The project team responded that off-channel dams upstream of the Clanwilliam dam remained a favourable option for expansion of water capacity. The practice does not necessarily conflict with the raising of Clanwilliam Dam, and in fact both options could be utilized conjunctively to achieve the greatest benefit.	
3.3	Mr Basson wanted to know what effect farm dams in the upper catchments were having on the ability to fill Clanwilliam Dam, as the dam has not filled in the last two years. The project team responded that there appears to be a relationship between the two issues. However, DWAF has already given rights to the upstream farmers to store up to 60% of their allocation in farm dams.	
3.4	Ms Graaf wanted to know what the likelihood was of the Grootfontein Dam being developed, if Clanwilliam Dam was raised and further farm dams were constructed in the upper Olifants River catchment. The project team responded that the Reserve determination process would dictate the volume of water required from the Olifants and the Doring Rivers, to maintain the ecological functioning of the river and estuary. This will ultimately dictate whether further dams in the catchment could be accommodated.	
3.5	Mr Geyer raised a concern that dams upstream of Citrusdal would supply water to Cape Town. MJS responded that the Western Cape Systems Analysis had investigated this option. This was regarded as highly unlikely due to the high transfer costs involved. Cape Town had a suite of options available and it was much more likely that water from more favourable schemes in other areas would be utilized to supply Cape Town.	
3.6	Mr van der Westhuizen questioned the likelihood of the T7 aquifer being further developed. MJS reported that there was insufficient capacity in the well field for much	

Item	Notes of Meeting	Action
	utilization. The most likely scenario would be the pumping of water from another scheme for temporary storage in the aquifer. The advantages of low evaporative losses would have to be weighted against the pumping costs. *Umvoto Africa provided input subsequently, and their inputs are reflected in italics - To clarify, the T7 is an Aquifer Storage and Recovery scheme in the Van Rhynsdorp Aquifer, which is a limestone or karstic aquifer. The purpose was to store excess winter water from the Olifants River in the evaporation free aquifer which has significant storage capacity. There are considerations about the mixing of different waters that require further investigation since concerns have been expressed about relative alkalinity between the surface water and the host aquifer water chemistry. The water from the Olifants River however is not known to be singularly acidic or corrosive. Given the land use potential in this area as well as the water shortage, it is considered a viable scheme.*	
3.7	It was questioned whether or not the raising of Clanwilliam Dam would have an effect on groundwater in the Sandveld? MJS responded that there was currently a study underway investigating groundwater in the Sandveld. As part of the Feasibility Study, the team is investigating the impacts of the emergence of springs due to the dam raising. If it were determined to be a problem, then a further investigation would be undertaken. However, there did not appear to be a link to or impact on the Sandveld. *It has been postulated that the groundwater in the TMG aquifers underlying the dam are hydraulically connected to subsurface TMG that underlies the Sandveld in places. Any dam overlying fractured rock must induce enhanced recharge within the dam area. Changing the local groundwater table will impact down-gradient. Current knowledge suggests that the groundwater gradient is in a northwesterly direction parallel to the primary structural trends. The main regional fault underlying the dam is the so-called Twee Riviere-Liepoldtville Megafault Zone that extends underneath parts of the Sandveld. There are a number of current studies supported by DWAF whose purpose is to establish the groundwater reserve in the Sandveld as well as whether the hydraulic connection along the regional hydrotects is continuous between the Kouebokkeveld and the Sandveld.*	
3.8	Mr Basson queried the effect of drilling new boreholes on the existing springs, aquifer and other borehole users. EvdB responded that the effects were dependent on a range of parameters including the depth of the borehole, rate of pumping etc. A new borehole could have a negative impact on other users. *To clarify, it is the abstraction of water from boreholes that has an impact on other users, but not necessarily an unacceptably negative impact. How it impacts is a function of aquifer and well field management. A borehole drilled into one aquifer cannot generally impact on a borehole drilled into a different aquifer. In the study area different aquifers overly each other and lie alongside each other. This is a function of both topography and geology. The current challenge is for users to coordinate and cooperate on aquifer monitoring and management much the same as they do for monitoring and management of surface water stored in a dam. In as much as surface water must be fairly and reasonably allocated so too with groundwater.*	
3.9	He further wanted to know how much water could be pumped from a borehole on average. The project team responded that each borehole had a yield specifically related to it, which was dependent on the geological formation in which the borehole was located, movement of water etc. In order to determine the yield a modelling exercise would be undertaken. The groundwater specialists may be able to provide further inputs. *The yields from boreholes differ depending upon where they are sited and generally the*	

Item	Notes of Meeting	Action
	insight of the person who sited the borehole. The relevant number is not what can be pumped from a borehole but what can be pumped from the aquifer. We consider that with good and informed borehole siting, wellfield planning and aquifer management in place that the aquifer can yield 20 – 50 Mm^3/a with wellfield yields of 2 – 5 Mm^3/a, this number being based on an average borehole yield of 20 l/s.	
3.10	A member of the Reference Group asked whether the capital / yield ratio for Clanwilliam Dam had been calculated based on the cost including or excluding the remedial work costs? The project team responded that the capital / yield ratio was calculated excluding the remedial work costs.	
3.11	The project team was asked their opinion on the likelihood of the Clanwilliam Dam being raised. DWAF and the project team responded that the possibility of raising the dam under one of the three raising options within the next five years (time within which Clanwilliam Dam has to satisfy its safety requirements) was very high due to the concurrent need to satisfy its safety requirements and the consequent cost saving. The particular raising option which would eventually be chosen was highly dependant upon the availability of users willing to fund and the utilize the additional water from the raising.	
3.12	What is the assurance of supply on the raising (for example 15m raising, 66 Mm^3 yield) and why? EvdB responded that the additional yield was calculated at 98% level of assurance of supply. More water could be made available but at a lower assurance. It should be borne in mind that the requirements of the Reserve still have to be taken into account, i.e. the actual yield would likely be reduced.	
3.13	Mr September asked how many more farm dams upstream of Citrusdal could be constructed in the next 5 years? WE reiterated that upstream users have an existing right to store up to 60% of their allocation. MJS added that farmers could stored winter water and undertake no pumping in the summer. The Feasibility Study would investigate the effect of increased winter storage on the Clanwilliam Dam. EvdB mentioned that the Feasibility Study would investigate the impact that farm dams would have on the yield of Clanwilliam Dam. This would take place through the verification of actual off-channel dam storage upstream of Citrusdal, in a modelling exercise.	
3.14	A participant noted that it appears that a large proportion of the water generated from the dam raising would go towards meeting the Reserve requirements. He wanted to know who would pay for this? The project team responded that if the Reserve were to be implemented and the dam not raised, the users would lose access to some 30% of the flow. However, the raised dam allows the Reserve requirement to be offset by the increased yield, and the users would share the cost.	
3.15	A question was raised regarding sedimentation of the Clanwilliam Dam. The team responded that sedimentation was not a problem in the catchment, and would not be further investigated.	
3.16	One of the delegates stated that in the areas upstream of Citrusdal, irrigation areas were expanded as more water was stored. This ultimately leads to increased pressure on the system. Mr Bredenkamp responded that the upstream users did not have a dam to rely on and therefore had to build farm dams in order to farm in the area. Mr Geyer added that he felt that control should be exercised over storage and the	

Item	Notes of Meeting	Action
	expansion of farming.	
3.17	Francois van Heerden raised the issue of groundwater and its effect on stream flow, and the uncertainties regarding the impacts on river flow through groundwater abstraction. He suggested that the issue might require further investigation.	
3.18	A question was raised regarding the utilisation of the T5 or T7 groundwater schemes for storage, and the extent of losses. The project team responded that there would be losses through an artificial recharge programme, but that the losses were likely to be less than evaporative losses. However, due to the geology of those aquifers, there would a reduction in water quality. The advantages of aquifer recharge included a reduction in evaporative loss, storage in close proximity to the end-users, and reduced environmental impacts. *The Aquifer Storage and Recovery schemes are proposed to reduce losses due to evaporation. While the main losses in surface water schemes are evaporative losses, underground storage is evaporation free. Potential losses due to change in hydraulic gradient or mixing waters of different quality are far less than evaporative losses and can be managed.* In Atlantis, for example, storm water is used to artificially recharge the aquifer, from which the water is later abstracted at different boreholes for use.	
3.19	Ms Graaf raised the issue of the mandate of the Reference Group in the process. What if the Reference Group supported an alternative option to the ones presented? The project team responded that the purpose of the screening phase was to determine whether any other options could complete with Clanwilliam raising and therefore whether the raising of Clanwilliam Dam should be studied any further. WE added that DWAF might look at other options in the future.	
3.20	Ms Graaf asked whether or not there would be sufficient water to raise Clanwilliam Dam and build the Grootfontein Dam. The project team responded it was unlikely that Grootfontein Dam would be economical, if Clanwilliam Dam was raised. Rosendaal Dam was a more viable option.	
3.21	Mr Basson enquired about water demand management measures in the catchment. EvdB responded that water demand management formed a small component of the Feasibility Study, and would therefore get some attention.	
3.22	A question was raised regarding how the Reserve determination results would fit into the Feasibility Study? EvdB responded that the Reserve determination results would feed into the Yield Analysis task and hence into the financial viability.	
3.23	The feasibility of providing water from the raised Clanwilliam Dam to Bitterfontein for potable use was raised. The project team responded that it would depend on the economics or affordability, as the users would have to pay. WE added that a study for investigating water supply for Bitterfontein was underway. The provision of desalinated water is likely the most feasible option.	
4	**NOTES OF THE DORING RIVER BREAKAWAY SESSION** MKL explained that in the breakaway session, the objective was to discuss the potential scheme options and how they could compete with the Raising of the Clanwilliam Dam, and if the raising would preclude any further water resource development on the Doring River from being pursued. The schemes discussed and ranked at the November 2004 Specialist Workshop were	

Item	Notes of Meeting	Action
	presented and the results of their ranking explained. Participants of the breakaway group were asked to indicate: • Whether or not they supported a Feasibility Study to assess the economic viability, social acceptability and environmental acceptability of raising the Clanwilliam Dam; and. • Whether or not they support the findings with respect to the development of further off-channel farm dams and groundwater. MKL handed out the “Comment Sheets” and asked that these be completed and returned by post or fax to Ninham Shand. MKL emphasized that the Screening Process was based on existing reports and that stakeholder input from those most familiar with the catchment was essential.	
5	**QUESTIONS AND GENERAL DISCUSSION FROM THE DORING RIVER BREAKAWAY SESSION**	
5.1	A participant asked if the proposal to raise Oudebaaskraal Dam and the construction of another dam in the same area had been taken into account? Judge Burger was the client and Charl Pienaar of BKS would have information on this. MKL mentioned that irrigation expansion in that area (Aspoort) had been identified as not being an economically viable option for the region.	
5.2	Mr Nel asked what had become of the interest expressed by the Northern Cape Provincial Administration to establish resource poor farmers at Aspoort. GE responded that the Northern Cape Provincial Administration had indicated (in 1998) an interest in undertaking a pilot study for major irrigation development in that area. There had however been no progress to date.	
5.3	Mr Love asked how Aquifer Storage Recovery at the potential T7 site would work.GE explained the concept of utilizing available storage underground and injecting surplus water into that storage. The purpose was to store excess winter water from the Olifants River in the evaporation-free aquifer, which has significant storage capacity. The same boreholes that would be used for injecting excess water could be used for abstracting water. There are considerations about the mixing of different waters that require further investigation, since concerns have been expressed about relative alkalinity between the surface water and the host aquifer water chemistry. The water from the Olifants River however is not known to be singularly acidic or corrosive. Given the land use potential in this area as well as the water shortage it is considered a viable scheme.	
5.4	Mr du Toit expressed concern that groundwater schemes located near to or in the Kouebokkeveld (KTSV) would impact on springs and lower the water table, impacting on farmer’s groundwater sources. MKL agreed that knowledge on the groundwater/surface water interaction was limited in some areas but that the necessary preliminary planning studies and monitoring would take place prior to incremental development. Monitoring data and model development would precede any groundwater development that could then be planned in a more informed manner.	
5.5	A participant stated the importance of implementing Water Conservation and Demand Management (WC/DM). It was stressed that this should not be considered as an alternative but implemented regardless of the other planned development options. This was agreed by all.	
5.6	A participant stated that LORWUA estimated that canal losses accounted for 28 % of their requirement. MKL stated that canal rehabilitation and alternative operation and management of the canals would form part of the Feasibility Study. GE reminded all that other interventions would also be considered, *inter alia* invasive alien plant removal, water trading, conjunctive use of groundwater.	

Item	Notes of Meeting	Action
5.7	Mr du Toit from Witzenberg, expressed concern that the raising of Clanwilliam Dam would benefit farmers lower down in the catchment, but that the canal infrastructure supporting these farmers contributed to high percentage losses. He asked if the study had looked at a pumping scheme out of the Twee Rivieren River. MKL stated that the study had not but had focused on a dam on the Groot River, which had appeared less favourable due to environmental concerns.	
5.8	Mr Love asked if the study would identify where resource poor farmers (RPFs) could be most economically established? He further stated that it was unlikely that RPFs would be able to afford the cost of water from large schemes. MKL acknowledged the importance of this issue and that RPFs would require subsidies. Groundwater and off-channel farm dams also appeared favourable options for supplying water to RPFs. MKL described the potential scheme options, namely Leeu River Dam, Groot River Dam, Aspoort Dam, Reenen Dam, Melkbosrug Dam, Melkboom Dam, Brandewyn Dam, farm dams and groundwater. It was agreed that with further development of farm dams and responsible development of groundwater, the raising of Clanwilliam Dam seemed favourable and that a Feasibility Study to investigate this option was supported. MKL emphasized that whilst the Feasibility Study would only address the raising of the Clanwilliam Dam, other options for development remain on the table but are less favourable than the raising.	
5.9	Mr du Toit stated that irrigation practices in the region were not as efficient as they should be. There was scope for the irrigation sector to make better use of the available water resources.	
5.10	Mr Nel asked whether the desperate water supply situation in Calvinia and surrounding areas would be addressed? GE explained that Calvinia was not supplied from Clanwilliam Dam and the responsibility for potable water supply to towns was that of the Municipality. MKL indicated that municipal funding mechanisms were in place to address such issues. *Mr Love requested a copy of the WODRIS Study. GE explained that the final report was not available from Ninham Shand but from Arcus Gibb. GE agreed to send the latest draft that he had to Mr Love. The final report would have to be acquired from Arcus Gibb.* Mr Love's address is PO Box 26, Ebenhaezer, 8149.	GE
6 6.1	**CONCLUSIONS** EvdB reiterated that the purpose of the workshop was to determine whether or not Clanwilliam Dam raising was a reasonable enough option, both financially as well as socially, to allow for the continuation of the study as well as the eventual raising. WE stated that it appeared that the general feeling was that the Clanwilliam Dam raising should take place, but that this would not preclude other options such as farm dams or groundwater, which could be implemented conjunctively. The meeting was concluded at 16:00	

APPENDIX D

Summary of issues and concerns submitted by members of the Reference Group in writing

	CLANWILLIAM DAM - SCREENING OF OPTIONS KEY STAKEHOLDER ENGAGEMENT											
No.	Individual	Organisation	Options Supported	Concern or comment	Address 1	Address 2	Post Code	Town	Tel	Fax	Mobile	Email
1	Nik Wullschelger	Swartruggens Conservancy	Supports the raising of Clanwilliam Dam, further groundwater development, but not further off-channel farm dams.	Would like to see water demand management further investigated in the Feasibility Study, specifically the 30% canal losses.	PO Box 145	Koue Bokkeveld	6836		023 347 7588	023 347 7588	083 735 2038	
2	Jan Hendriks	Suid Namakwaland GMA Forum	Supports the raising of Clanwilliam Dam and further groundwater development.	He is supportive of the proposed raising of Clanwilliam Dam, because his area is reliant on groundwater at the moment.	PO Box 52		8202	Molsvlei	027 632 5193			
3	Monica Graaff	Tierkranz Trust	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	Concerned about the possibility of Grootontein Dam being chosen as a dam site. Concerns regarding the cultural heritage and natural beauty of the site. Furthermore, they planning on building a property on the farm, which would be inundated should the dam be built.	7 Eyton Road	Claremont	7708	Cape Town	021 797 4678	021 797 1630		monicagraaff@iafrica.com
4	Mercia Kearns	Nama Karoo Forum	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	No comment	PO Box 177		8170	Vanrhynsdorp	027 219 1055	027 219 1440	084 776 7417	
5	Andreas Jantjies	Nama Karoo Forum	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	No comment	Veltevreedsirkel 532		8170	Vanrhynsdorp		027 219 1440	073 333 2884	
6	Francisco Fewskey	Suid Namakwaland GMA Forum	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	Wants to know if the people of his area can abstract water from the Olifants River? Since there is a pipeline to Namakwa Sands, why couldn't this pipeline be extended to his area, which is poor in water resources.	PO Box 139		8200	Bitterfontein		027 642 7417	083 877 8497	
7	Gerard Stone	Bokwater Boerdery	Supports the raising of Clanwilliam Dam, but does not support the further development of groundwater or the construction of off-channel farm dams.	Concerns relating to the volume of water available from groundwater, the influence that further groundwater development may have on existing boreholes, and the effects that off-channel dams will have on the availability of water in the Olifants River.	PO Box 286		8135	Clanwilliam	027 482 2187	02 482 2188		gjstotal@telkomsa.net
8	Joanne Joubert	Lutzville Landbouvereniging	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	The Olifants River valley is an important area from a fruit production and employment perspective. It makes sense to raise the dam, when the essential maintenance work is being undertaken.	PO Box 597		8165	Lutzville	027 217 1542	027 217 2552		sjoubert@kingsley.co.za
9	PJ Cloete	DWAF Clanwilliam Dam	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	We shouldn't let the last two dry seasons influence our decision of whether or not to raise the dam. The region needs an injection, and this will be brought about through job creation and tourism.	PO Box 405		8135	Clanwilliam	027 482 2400	027 482 2232		
10	H Noemdoe	Sandveld Investment and Development Company	Supports the raising of Clanwilliam Dam and further groundwater development.	No comment	PO Box 116		8120	Graafwater	027 422 1017	027 422 1017		
11	Sakkie du Toit	Koue Bokkeveld Water Forum	Supports the raising of Clanwilliam Dam and further off-channel dam development, but doesn't support the further development of groundwater.	Concerned regarding the increased farming activity and associated increased requirement for water. The constant abstraction of groundwater will have an effect on the acquifer in the long run.	PO Box 70	Koue Bokkeveld	6836		023 317 0004	023 317 0507		
12	Jannie Basson	Zandrug Ltd	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	Doesn't think that the downstream impact of the Clanwilliam Dam raising should be rated as high. Supply of water to the downstream reaches will be supplied by the Reserve allocation.	PO Box 161		8135	Clanwilliam	027 482 2517	027 482 2519		zandrug@iafrica.com
13	JJ Claase	Rainbow Farmers Gewasse Projek	Supports the raising of Clanwilliam Dam, further groundwater development and the construction of off-channel dams.	Leakage and unlawful abstraction from the canal are issues for concern.	116 Bloekomstraat		8165	Lutzville	027 217 1729		084 739 6340	
14	Gerrit Kalemeyer	Witzenberg Kleinboer Vereniging	Supports the development of groundwater and the further development of off-channel dams, but doesn't support the raising of Clanwilliam Dam.	If the wall is raised, farmers in the Witenberg valley will have to let more water pass down the river, which may land them in difficulties.	PO Box 92		6835	Ceres	023 313 3108			