DWAF Report No. P WMA 17/E10/00/1409

DEPARTMENT OF
WATER AFFAIRS
AND FORESTRY

Feasibility Study for the Raising of Clanwilliam Dam

Irrigation Development and Water Distribution Options

Final

February 2009

NINHAM SHAND
CONSULTING SERVICES

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JAKOET &
ASSOCIATES

DEPARTMENT OF WATER AFFAIRS AND FORESTRY
DIRECTORATE OPTIONS ANALYSIS

FEASIBILITY STUDY FOR THE RAISING OF THE CLANWILLIAM DAM

IRRIGATION DEVELOPMENT AND WATER DISTRIBUTION OPTIONS

Final

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Prepared by:

Ninham Shand (Pty) Ltd
PO Box 1347
Cape Town
8000
South Africa

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

Prepared for:

Director: Options Analysis
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. 2009. *Irrigation Development and Water Distribution Options*. Prepared by E van der Berg and K Hundley of Ninham Shand (Pty) Ltd as part of the Feasibility Study for the Raising of Clanwilliam Dam. DWAF Report No. PWMA 17/E10/00/1909.

Department of Water Affairs and Forestry
Directorate Options Analysis

FEASIBILITY STUDY FOR THE RAISING OF THE CLANWILLIAM DAM

APPROVAL

Title	:	Irrigation Development and Water Distribution Options
DWAF Report no.	:	PWMA 17/E10/00/1409
NS Report no.	:	4425/400415
Authors	:	E van der Berg, K Hundley
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
Director: OA

EXECUTIVE SUMMARY

Report objective

This report focuses on the distribution options of additional yield that is made available through the raising of Clanwilliam Dam. It investigates the range of available options to productively and cost-effectively use and distribute the additional water, and describes the analysis, conceptual design and costing thereof. The advantages and disadvantages of these distribution options are compared to assess their viability.

Findings

The main conclusions that can be drawn are the following:

Availability of land, crops and requirements for irrigation

It can be deduced that the availability of land with suitable soil for irrigated agriculture is not a limiting factor to the expansion of irrigation in the study area. Due to the advanced farming technology and management skills that exist in the intensely developed sections of the basin, most of the inherent soil limitations do not pose any serious constraints on irrigation development.

Permanent crops make up 80% of the planted area and cash crops (20%) are mainly grown in the winter. There are a variety of cash crops, with vegetables and wheat being the significant cash crops. Vineyards for the producing of wine and citrus are the main permanent crops. Drip is the method of irrigation for most of the permanent crops. The irrigation systems used in the area are centre pivots, drip systems, micro sprinklers and flood irrigation.

The net average irrigation requirement (excluding leaching requirement) increases from 850 – 1000 mm in the Keerom to Bulshoek Weir section to 1 000 - 1 200 mm in the Bulshoek Weir to the coast section. Peak monthly net irrigation water requirement increases from 200 mm/month in the upper to a maximum of 225 mm/month in the lower Olifants River Basin. A leaching component of 10% to 20% is recommended for saline soils in the drier areas.

Increased assurance of supply of the ORGWS

Farmers currently receive water at an unacceptably low assurance of supply. The yield analysis undertaken for this study estimates current assurance of supply at around the 1:10 year level, although it may be lower in practice. LORWUA has expressed the need to increase the overall assurance of supply for the ORGWS. This would benefit current and future irrigators during periods of drought and provide for more assured agricultural planning, so that they can be certain of obtaining preferably their full quota, but at least an increased percentage of their quota in very dry years. This could have a significant socio-economic benefit to the area.

Region 1: Area upstream of Clanwilliam Dam

Expansion of existing farms or new farms (from river and off-channel dams)

The expansion of citrus farming upstream of the Clanwilliam Dam (i.e. irrigation development on individual farms), or the development of new farms is not envisaged to be profitable, mainly due to the expected relatively high cost of irrigation infrastructure, specifically the need for off-channel farm dams, as farmers are relying on run-of-river flow. There may though be opportunities for some farmers who wish to fully utilise infrastructure.

Rosendaal Dam, as alternative combined balancing dam

The proposed Rosendaal Dam, if built, would provide storage for winter water, to be released for use in summer. Existing infrastructure could be utilised by the Citrusdal WUA, however similar infrastructure would need to be provided for new users. The farmers downstream of this potential dam, but upstream of the Clanwilliam Dam, would benefit from the additional storage provided by the proposed dam, as an alternative to building many small additional farm dams. The dam would have to make provision for the ecological Reserve, which would have to be more accurately determined, to be able to refine the cost estimate and available yield. If Clanwilliam Dam would be raised, the viability of building another dam on the Olifants River would diminish.

The dam could potentially increase the yield to upper-Olifants irrigators, as well as increasing their assurance of supply. Release of irrigation water from Rosendaal Dam 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.

Region 2: Area downstream of Clanwilliam Dam, and upstream of Bulshoek Weir
Expansion of existing farms, or development of new farms (pumping from river)

This area has the advantage that users are not reliant on bulk distribution infrastructure. Water can be pumped directly from the river for irrigation, because their water is stored in the Dam upstream. Farmers in this area have sound experience and thus know-how as far as the production and marketing strategies of the potato branch is concerned. It seems to be a viable option to expand existing citrus farms in this region, in combination with potato production (real IRR of 6.38% per year). Year cropping (i.e. potato production in this case) can have a considerable positive effect on the cash flow of farms. The establishment of new farms is marginally profitable (real IRR of 4.19% per year).

Region 3: Area downstream of Bulshoek Weir to the estuary
Expansion of existing farms, or development of new farms in the Melkboom/Trawal area (pumping from canal)

The typical mixed farming situation in the Melkboom/Trawal region is at present under financial stress. Possible contributing factors to this finding are, *inter alia*:

- Relatively small farms (i.e. 35 ha relative to 60 ha in Klawer/Vredendal) and thus the negative impact of higher unit overhead costs;
- A decline in prices as far as the main enterprise, i.e. wine grapes is concerned.

The analysis further shows that an expansion of the mixed farming situation in Melkboom/Trawal to 50 ha should lead to increased profitability (i.e. a real IRR of 5.42 % per year).

The expansion of table grape farming in the Melkboom/Trawal region seems to be the most viable option in the study area, from a financial point of view, and should be pursued (real IRR of 28.76% per year).

Expansion of existing farms, or development of new farms in the Klawer/Vredendal area (pumping from canal)

The expansion of existing irrigation farming in the Klawer/Vredendal region would be profitable for:

- Mixed farming, i.e. wine grapes and tomatoes (real IRR of 10.26% per year); and
- Table grape farming (real IRR of 11.24% per year).

New irrigation farms in the Klawer/Vredendal region, would be marginally profitable but is not recommended, as it would not be affordable, for:

- A new mixed farm, i.e. wine grapes and tomatoes (real IRR of 4.93% per year);
- A new table grape farm (real IRR of 5.24% per year).

Additional water supplied through the current main canal

There is very little scope to release more water through the Trawal canal section during the peak demand month of January. As a result this option of releasing additional water down the canal for direct use is not particularly viable. One way of using more water would be to introduce alternative crop types that have a different water requirement, with peak demands at different times to those currently grown. However, this option is not popular with farmers, because of the high risk involved in ensuring that there is a reliable market available for the alternative crops at the right time.

Increasing the capacity of the canal system by raising the canal

If the canal had a larger carrying capacity, more water could be made available for irrigation downstream of Bulshoek Weir. The new sections would otherwise have to be joined to and supported by the existing badly degraded concrete lining, which is not advisable. Therefore, it is not recommended that the canal profile should be increased in order to increase its capacity.

Replacement of the canal system

The cost estimate for lining the entire canal (pre-cast concrete lining or cast concrete) is extremely high and certainly does not seem feasible, however, it may be worthwhile investigating the costs of replacing certain portions of the canal on an annual basis. The option of a steel pipe as alternative implies a pipe with a very large diameter. It may however be impractical to implement this option, as it would mean closing down the scheme, possibly for years.

Reducing losses in the canal / refurbishment of the canal system

Undertaking of short-term and medium-term repairs are regarded as essential, as not doing so would impinge on the functionality of the scheme. This would increase operational costs, but there is likely no alternative. This option would also have the benefit of limiting losses from the canal.

Provision of an additional balancing dam/s along the canal

Should a large balancing dam be built somewhere along the canal system, it would increase the yield of the system, or the assurance of supply. A significant benefit may be realised during a drought. Having to pump water from the dam into the canal system would add to the cost. Although no specific site has yet been identified for this option, it is at face value believed to be a costly option. The Provincial Department of Agriculture is in support of further investigation of this option.

Additional farm dams along canal

This option could increase the yield from the system, although it is not considered to have much potential, mainly as a result of the limited land availability due to the small farm sizes.

Releasing water downriver from Bulshoek and pumping into canal sections to use spare capacity in identified canal sections

This option could utilise the spare capacity in the canal, created by abstractions further upstream, for additional irrigation, either to expand current irrigation or potentially for new irrigation. A disadvantage from time to time would be the poorer water quality, as a result of mixing in the river with Doring River water, compared to current water quality, when there are occasional flows in the Doring River during the irrigation season. This would not be a problem for the Karoovlakte option, where the quality would be acceptable, but the water quality for the Vredendal option would potentially not be acceptable to farmers. The Vredendal option would also necessitate a higher leaching %. The additional infrastructure and need to pump would lead to increased input costs. As a result, the establishment of new farms may become unprofitable, while the expansion of existing irrigation may be marginal. Further investigation into the financial viability of this option, as a result of the increased input cost, would be needed.

Zypherfontein Irrigation Scheme

The Zypherfontein Scheme provides an option for a large new development downstream of Bulshoek Weir, but above the confluence with the Doring River, to avoid poorer water quality. While schemes that include resource-poor farmers may be phased in over time, this provides an opportunity for much faster uptake of the water. LORWUA has indicated that it would strongly support such a scheme. The specific crops to be planted could be critical and need to be carefully assessed. Because it is a large scheme, with much of the irrigation scheme located further away from the river, costs are expected to be slightly higher than for small schemes located closer to the river. There may however be other, smaller, benefits in the scale of the project. Depending on crop type, such a scheme would likely be viable, but a further, more detailed investigation into financial viability is needed.

Ebenhaezer community supply

Available suitable land and bulk water supply for irrigation is for now adequate. The current water supply is under-utilised. Internal distribution of irrigation water through unlined canals that are not properly maintained, is deemed unacceptable, and requires attention. There is a need to investigate the potential to supply each of the plots with a reliable supply of water, and better agricultural and community management is needed.

Provision of water to non-agricultural users

The total listed use from the LORGWS for all non-agricultural use is 8.4 million m3/a. Current use is about 60% of listed use. It is recommended that future growth be accommodated.

Recommendations

Based on the findings, the following recommendations are made:

i) Because the availability of land with suitable soil for irrigated agriculture is not a limiting factor to the expansion of irrigation in the study area, the further identification of suitable farms or projects to potentially take up additional water can to a large extent be left to the implementing agency and the potential users of future water requirements, although potential resource-poor farmers would need specific support. Final cost estimates of specific development options must be obtained, based on the cost of the dam, and the available yield for allocation to new irrigation development. Exclude any possible options based on other considerations.

ii) Because the findings in this study, on financial viability of irrigation farming for different study areas and crop mixes, were based on average cost inputs, for typical farms and market conditions, at a specific time, any potential identified opportunities for future irrigation would need to be evaluated in terms of the conditions and costs relating to that specific opportunity.

iii) The LORWUA should indicate to what extent they wish to take up a portion of the increased yield of the LORGWS, to improve the assurance of supply of the scheme.

iv) Establish an Olifants River Development Agency, or other relevant implementation vehicle, which could vary in scale of influence, to:

   - Develop a common vision for the catchment/scheme;
   - Identify possible development opportunities and partnerships;
   - Develop an allocation schedule and business plan for ensuring the support of resource poor farmer and other broad based black economic empowerment opportunities;
   - Co-ordinate and support the proposed developments;

- Monitor the progress of the proposed developments and make changes when necessary or in reaction to new opportunities.

v) A business plan for the uptake of additional yield from a raised Clanwilliam Dam should address:

- Funding and cost-related issues;
- Salient features of the raised dam scheme and a summary of the most relevant other supporting information from this study;
- How to meet the objectives of water allocation reform;
- Recommended models for the allocation of water;
- How to convey the message on opportunities to potential future users;
- Mechanisms of support for potential resource-poor farmers;
- A guideline for potential applicants;
- Clarification of the roles and responsibilities that various Government organisations and other organisations would have;
- The proposed implementation vehicle to guide the uptake of additional water, such as e.g. a Development Corporation.

vi) Develop a clear mandate on how the additional water will be allocated.

vii) A desktop or pre-feasibility study should be undertaken into the potential for one (or more) large new scheme for the uptake of additional yield, such as the Zypherfontein Scheme, for example. While such a scheme presents the opportunity to settle a larger number of resource-poor farmers on land simultaneously, there may be many pitfalls and sensitivities that need to be carefully unpacked and evaluated.

viii) Applications from non-agricultural users would have to be evaluated on merit, but some allowance should be made for future uptake of non-agricultural use. The uptake on non-agricultural use that can benefit the poor would need special attention to ensure that it does not fall through the cracks.

ix) The potential raising of Clanwilliam Dam provides a unique opportunity for water to be used successfully to promote water reform and the development of previously disadvantaged individuals in the area. This will, however, not be an easy process as it is important to consider a range of opportunities. This will require a substantial commitment from the DWAF and other spheres of Government.

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GLOSSARY AND ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
EWR	ecological water requirements
ha	Hectare
IRR	Internal rate of return
LORGWS	Lower Olifants River Government Water Scheme
LORWUA	Lower Olifants River Water User Association
MAR	Mean annual runoff
Mg/l	Milligrams per litre
Mm^3/a	million cubic metres
m^3	cubic meter (equal to 1 kilolitre or 1 000 litres)
m^3/a	cubic metres per annum
$m^3/ha/a$	cubic metres per hectare per annum
m^3/s	cubic metres per second
mm	millimetres
ODCMA	Olifants Doring Catchment Management Agency
ORGWS	Olifants River Government Water Scheme
%	percentage
TDS	total dissolved solids
VAT	Value added Tax
WUA	Water User Association

1. INTRODUCTION

1.1 Study background and objective

The Clanwilliam Dam is situated close to the town of Clanwilliam, on the Olifants River in the Western Cape Province. The Dam was completed in 1935 and has since been raised to its current full supply level. Stored water from the Dam is mainly used for irrigation, with a small percentage being used for domestic and mining purposes. It is estimated that an irrigated area of approximately 13 000 ha is currently being supplied by releases from the Dam.

Clanwilliam Dam requires remedial work for dam safety reasons, which presents an opportunity to cost-effectively and concomitantly raise the Dam by up to 15 m.

The aim of the study is to verify the technical, environmental, social, economic and financial viability of raising the Clanwilliam Dam, at feasibility level. A preferred raising height would also be recommended, should the raising be feasible.

1.2 Report objectives

This report focuses on the distribution options of additional yield that is made available through the raising of Clanwilliam Dam. It investigates the range of available options to productively and cost-effectively use and distribute the additional water, and describes the analysis, conceptual design and costing thereof. The advantages and disadvantages of these distribution options are compared to assess their viability.

The following aspects were investigated:

a. Irrigation use

- Availability of suitable agricultural land to expand existing farms or to start new farms;
- Available yield for use within defined irrigation areas;
- Technical and financial analyses of bulk water distribution infrastructure;
- Economic viability to farm the potential new or expanded irrigated areas; and
- Various financial implementation scenarios.

b. Other uses

- Increased supply to municipalities;
- Increased mining and industrial use;
- Hydro-power.

1.3 Study area

For the purpose of this study, the study area of the Olifants River catchment has been divided into three relatively homogenous regions, namely:

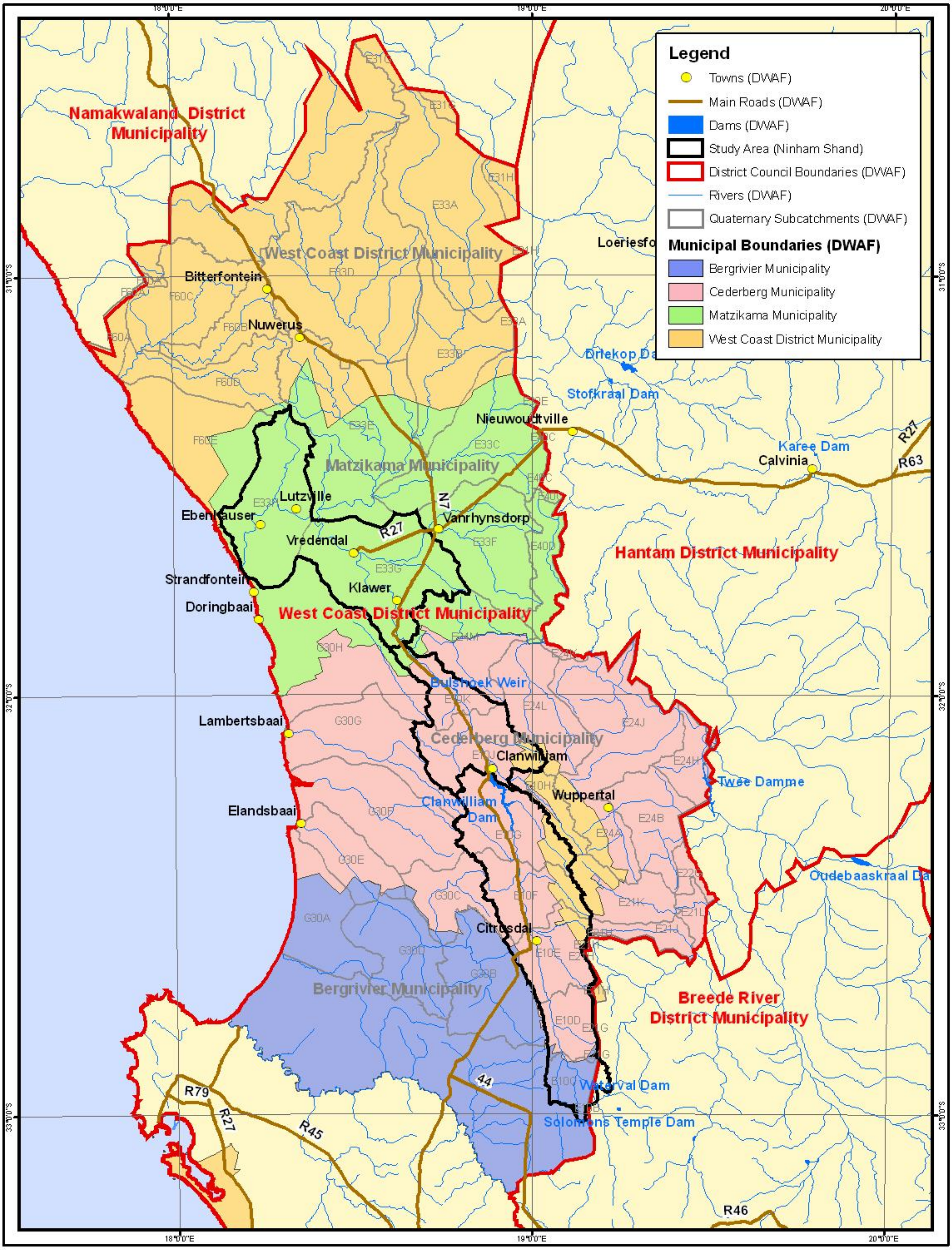
- Region 1: Catchment area upstream of Clanwilliam Dam

- Region 2: Catchment area downstream of Clanwilliam Dam and upstream of Bulshoek Weir.
- Region 3: Catchment area downstream of Bulshoek Weir to the estuary.

The study area, showing the three study regions is shown in **Figure 1.1**.

1.4 Report sections

This report starts with a description of the existing water storage and distribution infrastructure in the three regions, in **Section 2**. **Section 3** addresses the potential for the expansion of existing farms or the establishment of new farms. **Section 4** forms the largest part of the report, and contains descriptions of the distribution options relating to irrigation water use for each of the three regions. **Section 5** describes other potential uses of additional water, by sectors other than agriculture. **Section 6** describes the findings of the study, and recommendations are given in **Section 7**.



Project:

CLANWILLIAM DAM RAISING FEASIBILITY STUDY

Drawing Title:

Study Area Zones and Municipalities of the Oilfants/Doorn WMA

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Figure No.:

1.1

2. EXISTING DISTRIBUTION INFRASTRUCTURE AND OPERATING RULES

2.1 Overview

Irrigation infrastructure in the Olifants Doring Catchment Management Agency (ODCMA) consists of irrigation directly out of the river, water pumped out of the river and stored in off-channel dams, and diversions of the river into irrigation canals. The Olifants River is used as the main conveyance system. Surface water drains from the upper and middle Olifants River into the Clanwilliam Dam. The water is stored in the Dam before it is released down the river to the Bulshoek Weir. Downstream of the Bulshoek Weir, the water is diverted to the Lower Olifants Canal, which is the main conveyance system.

The Upper Olifants Area can abstract water from the Olifants River for irrigation. Up to 50% of their water allocation can be stored in off-channel storage dams. The extent of these dams is summarised in a report *Estimation of Volumes of Farm Dams Upstream of the Clanwilliam Dam* by the Department of Water Affairs and Forestry (DWAF). The various water user associations in the area are shown in **Figure 2.1** on the following page.

The existing water-related infrastructure in the three regions is discussed in the three following sections.

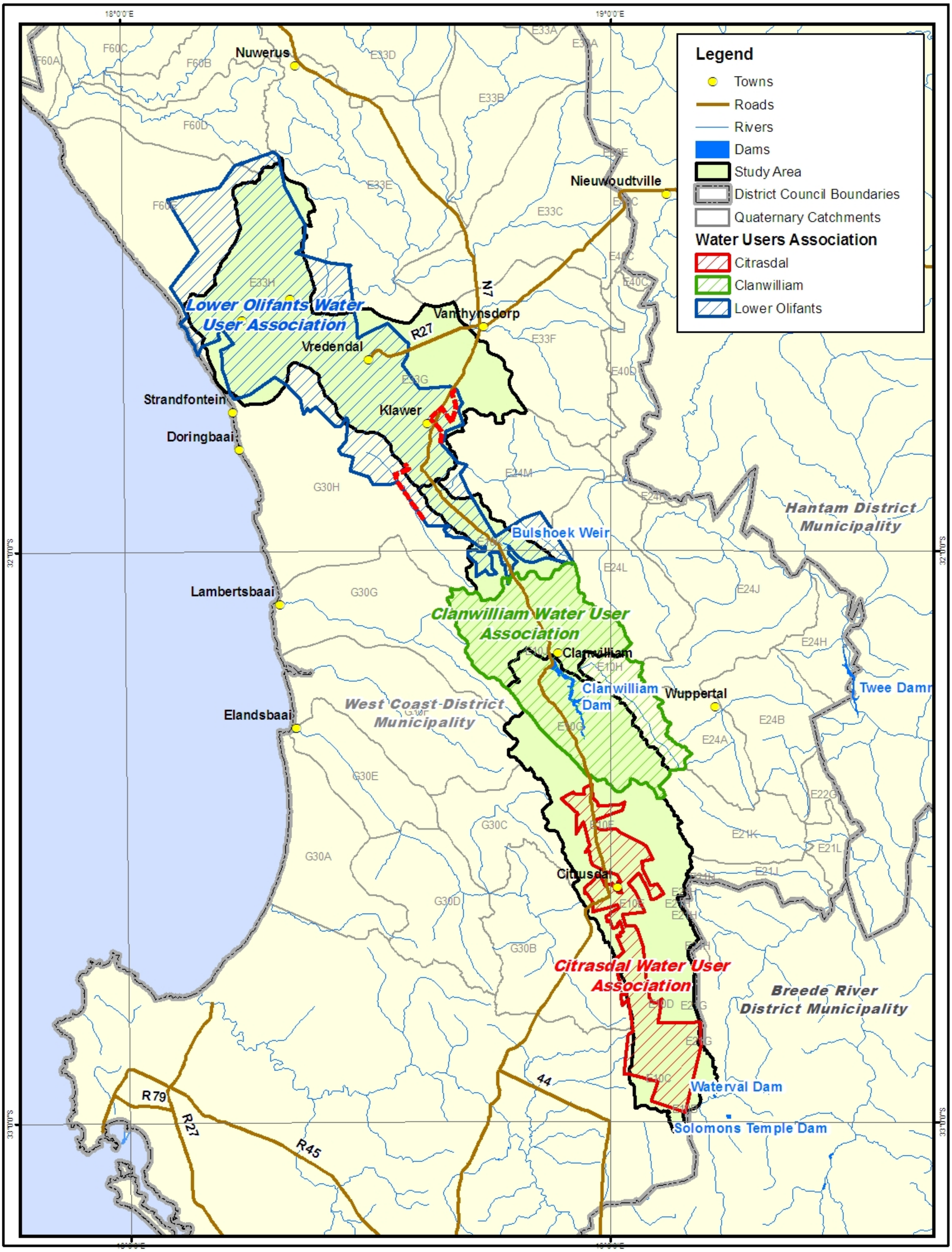
2.2 The Lower Olifants River Government Water Scheme

The Lower Olifants River Government Water Scheme (LORGWS) supplies raw water from the Clanwilliam Dam to farmers, municipalities, mines and industries in the Olifants River valley between the Dam and the estuary.

The construction of the Clanwilliam Dam was completed in 1935 with a capacity of 69,86 million m^3. In 1962, it was decided to raise the Clanwilliam Dam by 6,10 m to increase the capacity to 128 million m^3. The Dam basin has a live storage capacity of 122 million m^3.

The original Clanwilliam Dam was a mass gravity concrete structure with a centrally situated overspill section, 117 m long. During the raising, from 1962 to 1966, the overspill crest was increased in length, re-modelled and raised by the addition of 3,05 m of mass concrete to the top of the crest and the installation of 13 crest gates, each 7,77 m wide by 3,05 m high. The non-overspill flanks were raised 4,88 m by means of mass concrete. A bridge superstructure was built across the dam to provide access for the operating of the gates. For stability, the dam is tied to its foundation by means of post-tensioned cables positioned along the centreline of the dam, spaced from 1,52 m in the middle section, to 3,05 m on the flanks.

The Bulshoek Weir is located 30 km downstream of the Clanwilliam Dam on the Olifants River. The Construction of the Bulshoek Weir commenced in 1913 and was completed in 1924. The full supply capacity of the dam was determined as 5,754 million m^3. The catchment area of the Bulshoek Weir is 2 679 km^2 in extent. Bulshoek Weir is a stone-masonry gravity structure. The dam wall consists of a series of connected arches and buttresses that support a bridge deck and a gantry for the gate hoists. The Stoney-gates are positioned on top of the ogee-shaped crests between the buttresses. The Weir is operated at close to full supply capacity in order to divert water into the irrigation canal.



Project: CLANWILLIAM DAM RAISING FEASIBILITY STUDY

Drawing Title: *Water User Associations in the Study Area*

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Figure No.: 2.1

Most of the surface flows originate in the Cederberg Mountains and are carried to the Atlantic Ocean by the Olifants and Doring Rivers (only the Olifants is a perennial river). The catchment area of the Clanwilliam Dam is 2 033 km^2 in extent. The mean annual runoff (MAR) of the Olifants River, above the Clanwilliam Dam, is 368 million m^3. The historic firm yield of the LORGWS (Clanwilliam Dam and Bulshoek Weir) at current development levels is 124 million m^3/a.

The Jan Dissels River is a tributary river flowing into the Olifants River below the Clanwilliam Dam, but upstream of the Bulshoek Weir. The mean annual runoff of the Jan Dissels River is estimated as 43 million m^3 and other tributaries contribute another 34 million m^3.

Spills from the Clanwilliam Dam flow into the Bulshoek Weir. The seepage of the Bulshoek Weir is during dry periods pumped back into the canal supplying water to the Lower Olifants River Water User Association (LORWUA).

2.3 ORGWS Canals and Clanwilliam Canal

Downstream of the Bulshoek Weir, the water is diverted to the Lower Olifants Canal, which is the main conveyance system. Construction of the canal system in the LORWUA started in 1913-1914 and was completed in 1923. The main canal, which has a capacity of 7 m^3/s, runs on the left bank of the river for approximately 25 km, until it splits and then runs on both banks of the river. These canals continue to the vicinity of Lutzville becoming progressively smaller downstream. Water is abstracted at numerous points along the canal and is distributed from near Lutzville towards the coast by means of secondary canals. The area currently under irrigation is 13 911 ha. The river flow time from Citrusdal to the Clanwilliam Dam is in the order of 23 hours. The lead-time for water from the Bulshoek Weir to the last point (Ebenhaezer) takes approximately three days.

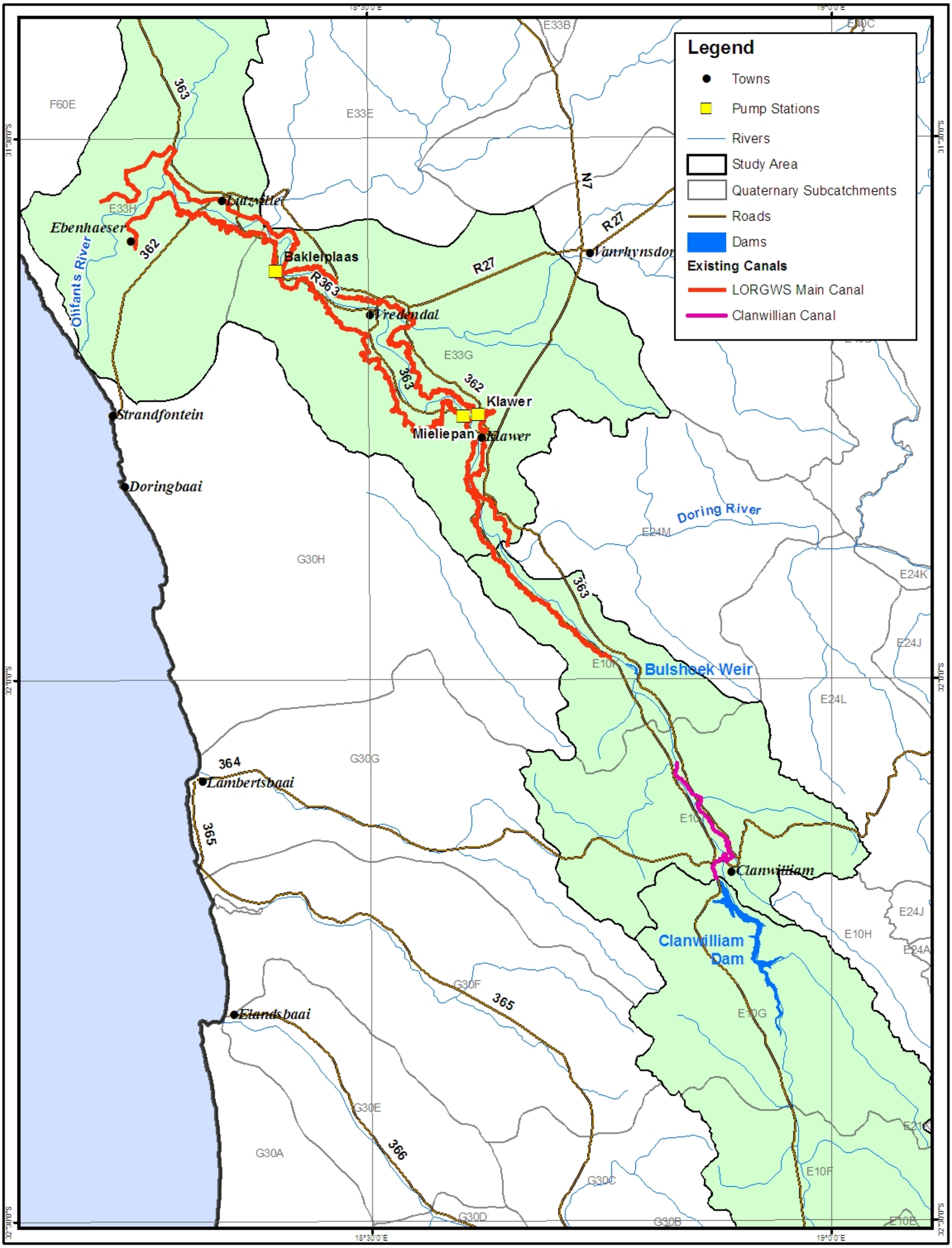
A canal was built during 1940 to supply water for irrigation and to Clanwilliam Town. This canal originates at the Clanwilliam Dam wall, passes through town, and crosses the Jan Dissels River.

Figure 2.2 on the following page shows the extent of the LORGWS main canals and the Clanwilliam canal.

2.3.1 Report by Element Consulting Engineers

A complete study of the canal, as operated and maintained by LORWUA, was done by Element Consulting Engineers and reported on in the report*, Investigation into the rehabilitation of the canal downstream of Bulshoek Weir*, for LORWUA. The report entails a survey of the canal system and focuses on three aspects of the canal system, namely:

- The hydraulic components of the canals;
- A visual inspection and structural investigation of the canal, to determine the short and long-term rehabilitation requirements; and
- An economic investigation evaluated the different rehabilitation scenarios in terms of their net present value.



Project:

CLANWILLIAM DAM RAISING FEASIBILITY STUDY

Drawing Title:

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Figure No.:

2.2

2.4 Region 1: Area upstream of Clanwilliam Dam

The catchment area upstream of the Clanwilliam Dam consists of natural mountain streams and rivers. During the winter, rainfall and snow in the Cederberg Mountains create runoff. Only the Olifants River is perennial and the summer flow is very low. In order to irrigate all year round, the farmers have constructed off-channel storage dams (farm dams). These farm dams are filled during the winter by pumping runoff water out of the mountain streams and rivers.

From the origin of the Olifants River to the downstream boundary of the farm Grootfontein 514, the water allocation is 9 400 m^3/ha/a. The amount of water that may be stored is restricted to half of the annual allocation, therefore 4 700 m^3/ha/a. The total storage volume available upstream of Grootfontein in the off–channel storage dams is 13 232 000 m^3 (2 815 ha allocation) according to the DWAF report of this study, *Estimation of Volumes of Farm Dams Upstream of the Clanwilliam Dam*. The water allocation according to Section 62 (2E)(c) is 900,2 ha and according to Section 62 (2E)(d) is 112 ha (Section 62 of the Water Act of 1956), totalling 1 012,2 ha.

The water allocation is 12 200 m^3/ha/a, from the downstream boundary of the farm Grootfontein 514 to the downstream boundary of the farm Middelkraal 263 (upper limits of the Clanwilliam Dam). The amount of water stored is restricted to half the annual allocation, therefore 6 100 m^3/ha/a. The total storage volume available from Grootfontein to Middelkraal in off-channel storage dams is 25 775 000 m^3 (4 225 ha allocation) according to the report *Estimation of Volumes of Farm Dams Upstream of the Clanwilliam Dam*. The water allocation according to Section 62 (2E)(c) is 4 457.55 ha and according to Section 62 (2E)(d) is 1 943 ha (Section 62 of the Water Act of 1956), totalling 6 400.55 ha.

When the lower-end users (towards the dam) do not get water, upstream users restrict themselves in terms of use by setting rules for pumping run-of-river flow.

In the Witzenberg area, farm dams are located in the Olifants River and in its tributaries. A total of 250 000 m^3 storage per farm is allowed in this area and the farmers must apply to store water. In the other areas, the farm dams are not on the tributaries and do not influence the river flow.

Previously, a significant part of the Olifants River was a Government Water Control Area. Many small tributaries were, however, excluded and the irrigation next to these rivers can only be estimated.

Citrusdal uses 1,2 million m^3 of water per annum and is supplied by a pipeline from the Boschkloof Wellfield. Citrusdal Water Users' Association (WUA) have an allocation of 17 063 ha. This area is located between Grootfontein and the upper reaches of the Clanwilliam Dam.

2.5 Region 2: Area downstream of Clanwilliam Dam and upstream of Bulshoek Weir

The water distribution infrastructure in the Clanwilliam Water Users Association area consists of abstraction directly from the Clanwilliam Dam basin, a lined canal from the Clanwilliam Dam, and natural streams and rivers. The main river flowing into the Olifants River downstream of Clanwilliam Dam is the Jan Dissels River.

All water users between the Clanwilliam Dam and Bulshoek Weir are members of the Clanwilliam WUA. Water users abstract their water either from farm dams filled by pumping from the Clanwilliam Canal, or by pumping directly out of the Olifants River. Farmers between the Dam and Weir are not scheduled under the scheme but abstract compensation water from the releases.

The Clanwilliam Canal system, currently operated by the Clanwilliam WUA, starts at the Dam and supplies water to Clanwilliam town and some 750 ha irrigation. This canal was built in 1940 and is currently run at full capacity. Irrigators using the canal operate on a request basis and the current canal losses are estimated at 30%.

Farmers next to the Jan Dissels River fall under the Clanwilliam WUA and irrigate directly from the river. The Ratel River development, in the upper Olifants River, forms part of the Clanwilliam WUA.

Specific releases are only occasionally made for use by towns. No specific releases are generally made for irrigators between the Clanwilliam Dam and the Bulshoek Weir. Potato farmers below the confluence with the Jan Dissels River might however need some specific releases in winter, when there is no flow in the Jan Dissels River.

All pumps between Clanwilliam Dam and Bulshoek Weir have been equipped with water meters, which are read and billed according to use.

2.6 Region 3: Area downstream of Bulshoek Weir to the estuary

Three larger farm dams receive water by pumping out of the river. These dams have a combined capacity of approximately 3 million m^3. The Lutouw Dam, with a capacity of 4,2 million m^3, can also receive water out of the canal.

Considering the history of the scheme, the full quota of 12 200 m^3/ha/a has never been supplied to the farmers. The canal system is unused for ±12 weeks per year and is operational continuously from about end August to end May. The canal runs full from mid-October to end of February. The farmers use their off-channel dams (night-dams) to store water pumped out of the canal for overnight storage. The maximum allowable storage volume for irrigation from the canal is 35% of the quota.

The Ebenhaezer Balancing Dam at the end of the canal has a capacity of 140 000 m^3.

The Namakwa Sands mine has a balancing dam just after the canal take-off, and their main balancing dam is situated near the mine. The off-take(s) for the Sandveld towns are towards the bottom end of the canal.

Problems are also experienced during peak periods when the demand exceeds the supply capacity of the canal. It was found that during these peak periods only 85% of the scheduled area could be serviced.

The canal inlet capacity of 7,4 m^3/s at Bulshoek Weir is a further limiting factor when it comes to providing water to farmers. Currently, the maximum abstraction rate is 325 m^3/week/ha, which relates to a canal duty of 0.89 l/s/ha for a 24 hour, 5-day week, allowing for 15 % losses. At this canal duty, about 8 300 ha could be irrigated from the canal, which is insufficient for the present summer crop of 9 892 ha, unless the canal is operated on the basis of a 6 day week.

The irrigation area could be increased to 11 700 ha, should the canal be operated for a 24 hour, 7 day week. This scenario will, however, require the farmers to construct bigger night-dams on their farms.

2.7 Operating rules

2.7.1 Upper Olifants River Area

During winter, if the river flows, irrigators upstream of the Clanwilliam Dam may abstract water from the river to fill their farm dams. The maximum allowable capacities of these farm dams are 50% of the allocated water. During summer, these farmers use the water stored in the farm dams.

2.7.2 Clanwilliam WUA

Clanwilliam Dam stores the water for the downstream water users. The water quota allocated to them is calculated from the amount of water available in the dam.

2.7.3 LORWUA

Irrigation supplies in most years are curtailed to less than the full theoretical requirement. Clanwilliam Dam is operated at a draft that exceeds its historical firm yield and is drawn down to between 5% and 20% of its full supply capacity in most years. As its capacity is only 33% of the present day runoff, it fills during the wet winter months in most years. Releases from the Clanwilliam Dam are dependent on water demand from LORWUA.

The Bulshoek Weir is currently still the responsibility of the DWAF, but LORWUA takes charge of the daily operation of the sluice gates. Currently, all the sluice gates are in need of repair and any infrastructure-related costs, such as the upgrading and major repairs to sluice gates, are the DWAF's responsibility until the dam is in a proper state of readiness for transfer to LORWUA. There is also leakage from the dam.

LORWUA is responsible for the operation and management of the existing waterworks infrastructure at the Bulshoek Weir, and for the water distribution system from Bulshoek to the Ebenhaezer community and Koekenaap. It is not responsible for managing the internal distribution system of the Ebenhaezer small-scale farmers.

Two quotas are used in LORWUA, namely a weekly and an annual quota. The annual quota is 12 200 m^3/ha/a and the weekly quota (also called the maximum extraction rate) is 325 m^3/ha for all irrigators. In years of water restrictions both quotas are reduced.

The canal operates for about 40 weeks of the year (it actually varies between 38 and 42 weeks). The other weeks are used to do maintenance on the canal.

The existing system only allows abstractions from the canal as requested by the users. These flows are controlled by sluices, which are opened for specific time periods. The flow rate over a V-notch is measured, but the specific quantity of water is not measured accurately. The flow rates are not recorded formally or audited to verify the allocations. Since there is no payment for actual use, but rather for registered water use, a proper water balance is not required for the present operation of the canal system. This discontinuous measurement of flow in the canal and flow to the various users makes it difficult to do a proper water balance on the system.

2.7.4 Restrictions

During years of drought, the Clanwilliam Dam does not fill up and then restrictions are placed on the irrigation water users. The uncertainty of the quota for the next year causes the farmers to be more conservative in their irrigation development.

In an event when water restrictions have to be implemented, Schedule 1 water users are given the highest priority. If there is insufficient water to meet the full irrigation requirements, the existing use will be reduced by a percentage, according to the water available. In a year of drought, there is a need to balance the amount of water available between the different WUAs.

The Upper-Olifants WUAs are restricted by the amount of water that farmers can store in their farm dams and by the time period allocated for pumping water out of the river. The Lower-Olifants WUAs restricts the quota available to each farmer.

3. POTENTIAL FOR EXPANSION OF IRRIGATION IN THE CATCHMENT

3.1 Potential for areas with suitable soils to be used for irrigated crops

An expert system approach was used to evaluate the potential of the different soil complexes for the production of annual and perennial crops. Findings are documented in the report: *Soils, Water Requirements and Crops Report*, by Lambrechts, *et al*.

Based on these evaluations about 2 000 ha are recommended for perennial crops (e.g. citrus and wine grapes) in the southern section of the basin from Keerom to Bulshoek Weir. Another 19 000 ha are marginally and conditionally recommended, provided that subsoil limitations are properly ameliorated. About 8 600 ha of this class has a potential rating that is near the upper limit of the conditionally recommended class. The main limitations in this class are wetness and shallow underlying weathering rock combined with low clay content. These limitations are relatively easy to ameliorate and with judicious irrigation practices approximately 10 000 ha can be used for economic viable production of citrus and wine grapes. Within the lateral extent of the survey approximately 10 000 ha is available in the Keerom to Bulshoek section for any combination of irrigated annual (tuberous and non-tuberous) and perennial (citrus, wine grapes, mangos) production.

The soils in the surveyed area from Bulshoek to the coast differ greatly from those in the southern section in terms of the dominant limitation(s). Deep, well-drained red sandy soils can be highly recommended for irrigated tuberous and non-tuberous crops without any subsoil amelioration measures. However, these soils are only conditionally recommended for perennial crops due to the very sandy nature and risk of sandblasting. Non-tuberous crops are conditionally recommended, while perennial crops are recommended on these soils after amelioration of subsoil limitation. In this section there is approximately 105 000 ha that can be recommended for the production of perennial crops after amelioration of subsoil limitations, in particular hardpans, and provision is made for leaching and drainage to remove soluble salts from saline environments. Most of the areas recommended for perennial crops can also be used for irrigated non-tuberous annual crop production. In addition to these areas, certain soil complexes that are not recommended for perennial crops due the very sandy nature of the soils can be recommended for irrigated tuberous crops.

It can therefore be deduced that availability of land with suitable soil, for irrigated agriculture, is not a limiting factor to the expansion of irrigation in the study area.

3.2 Current and potential crops

Climate and soil suitability are the most critical factors that will determine the potential expansion of sustainable, economic viable irrigation in the Olifants River Basin. Due to the advanced farming technology and management skills that exist in the intensely developed sections of the basin, most of the inherent soil limitations do not pose any serious constraints on irrigation development.

3.2.1 Crops currently grown

Climatically adapted crops currently grown in the study area include the following:

- Maize (especially sweet corn) is widely planted from Keerom to the coast.
- Most vegetable crops (e.g. onions, potatoes, tomatoes, sweet potatoes, watermelons, cantaloupes and butternuts) are climatically well adapted and extensively planted. Planting date is determined by climate. Cabbage, cauliflower, chillies, lettuce, pumpkin, squash and green beans are planted on a small scale for the open market.
- Bitter Seville, citron, lemons, clementine, navel, valencia, satsuma and mandarin are mainly planted in the Clanwilliam-Citrusdal region.
- Grapes are adapted to the climatic conditions along the Olifants River and have a variety of marketing possibilities (e.g. wine, table grapes, raisins, preserving, and "gasohol"). Specific climate sub-zones in the Olifants River Basin have specific advantages in terms of grape production.

Other climatically adapted crops that can be recommended are the following:

- Vegetables crops such as garlic, beetroot, rhubarb and eggplant.
- Subtropical fruit such as avocado, mango, papaya, persimmon, granadilla, figs and guavas.
- Nuts such as macadamias, almonds and pecan.

Permanent crops make up 80% of the planted area and cash crops (20 %) are mainly grown in the winter. There are a variety of cash crops, with vegetables and wheat being the significant cash crops. Vineyards for the producing of wine and citrus are the main permanent crops. **Table 3.1** summarise the crops produced per area as taken out of the *System Analysis Report* of this study, for all areas except for LORWUA, which was obtained from the Water User Association.

Table 3.1 Types of crops planted in the ODCMA (ha)

Crop	Witzenberg Area	Boschkloof	Citrusdal	Clanwilliam	LORWUA	TOTAL (ha)
CASH CROPS						
Tomatoes Processing					521	521
Tomatoes Table					321	321
Wheat			1 310	104	221	1 635
Pastures	300		18	183		501
Vegetables	239	534	561	2 000	1 325	4 665
Nursery	52			32		84
Other Cash			395	262	128	785
PERMANENT CROPS						
Vineyards – Table			316	388	668	1 372
Vineyards - Processing (Dry, Wine)			0		9 458	9 458
Lucerne			0	77	391	468
Olives and Papaya			0		467	467
Deciduous fruit	666	541	62	39		1 308
Citrus			5 669	2 214	391	8 274
Rooibos Tea			1 963	3 926	20	5 909
FALLOW AND NOT CLASSIFIED						
Irrigated Fallow			855	630		1 485
Non Irrigated Fallow						0
Not Classified						0
TOTAL	**1 257**	**1 075**	**11 155**	**9 855**	**13 911**	**37 253**

Current irrigated crops, from updated land use information, and potential crops, from the soil survey and assessment of suitability of land for irrigation, are shown in **Figure 3.1** to **Figure 3.3** on the following pages.

3.2.2 Method of irrigation and efficiency

Drip is the method of irrigation for most of the permanent crops. In Ebenhaezer, flood irrigation is still being used. In the rest of the area flood irrigation has been phased out.

The irrigation systems used in the area are centre pivots, drip systems, micro sprinklers and flood irrigation. Relevant information is currently only available for the Clanwilliam WUA and for the LORWUA, whereas the information for Citrusdal WUA was estimated as shown in **Table 3.2**.

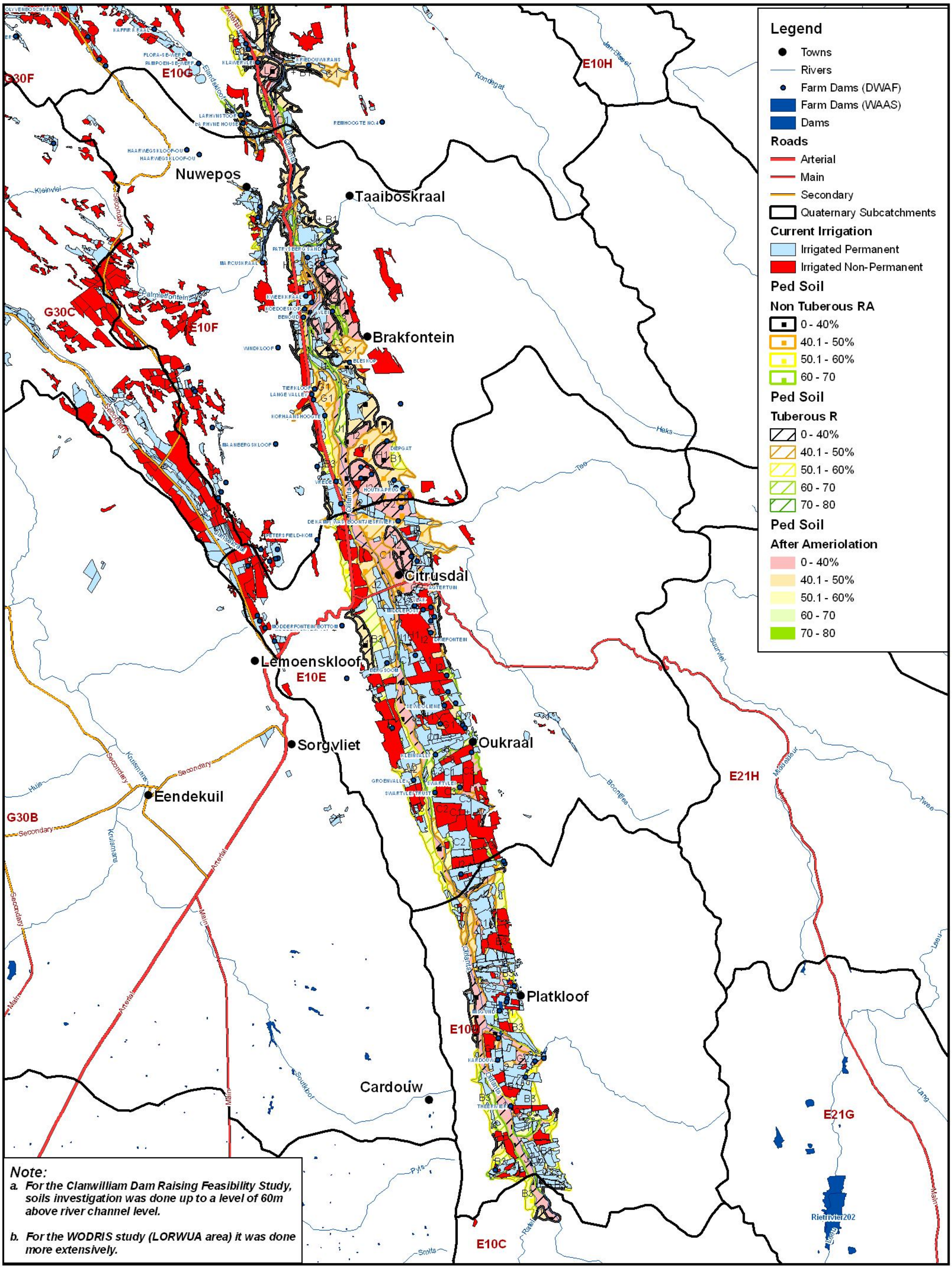
Table 3.2 ODCMA Irrigation methods percentage

Sub-Area	Total developed area (ha)	Drip Irrigation (%)	Center Pivot (%)	Sprinkler and Flood Irrigation (%)	Micro-jet Irrigation (%)
Witzenberg Area	1 257			100	
Boschkloof	1 075			100	
Citrusdal (estimated)	11 155	15	0	2	83
Clanwilliam WUA	9 855	15	20	35	30
LORWUA	13 911	80	0	15	5
TOTAL	**37 253**				

The efficiency of the different systems is shown in **Table 3.3**.

Table 3.3 Efficiency of different systems

Irrigation method	Efficiency factor
Centre pivot	85
Flood: basin and sprinkler: dragline	75
Sprinkler: micro-jet	90
Sprinkler: drip system	95



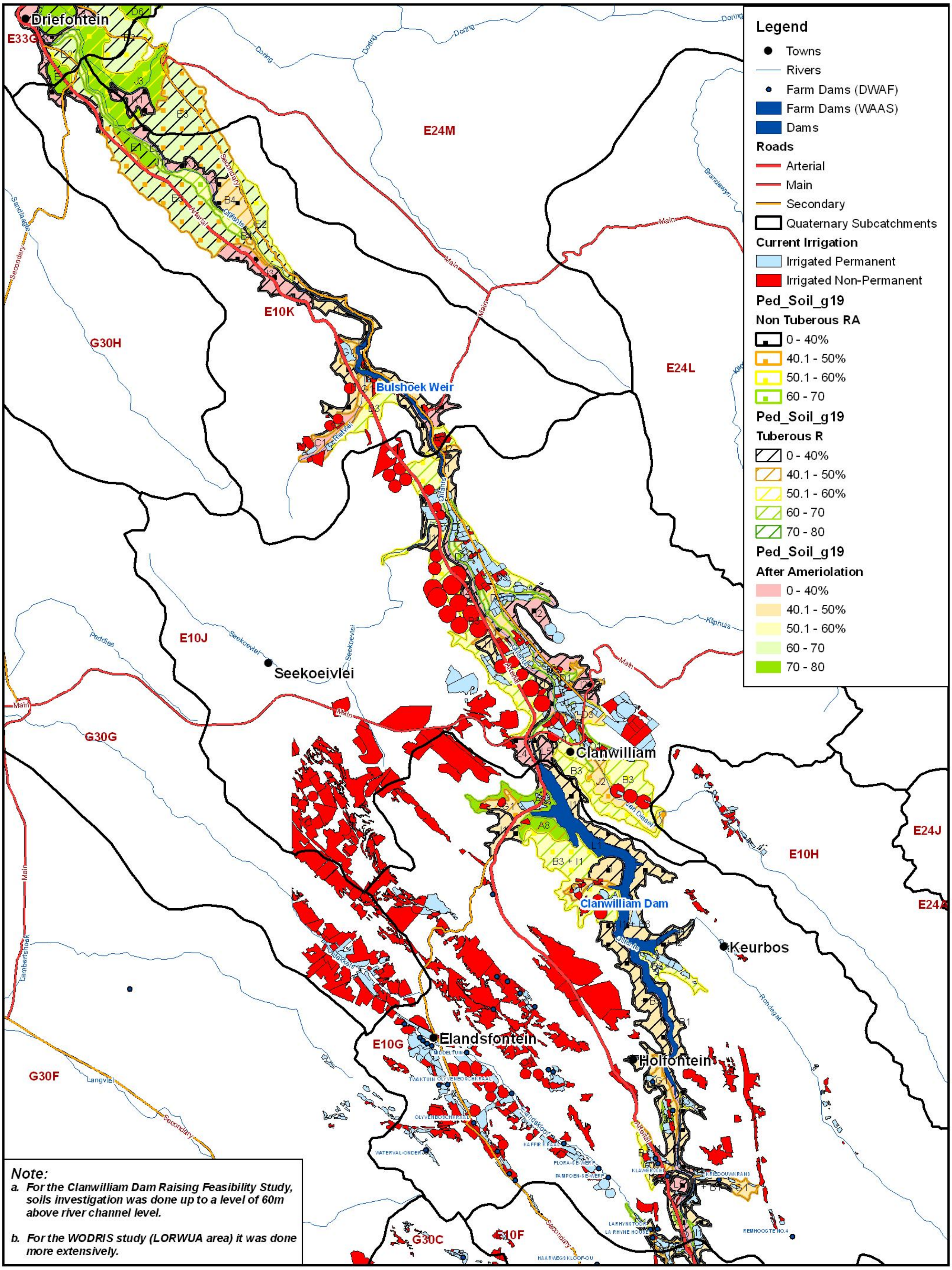
Project:
CLANWILLIAM DAM RAISING FEASIBILITY STUDY

Drawing Title:
Current Irrigated Crops and Potential for further Irrigation

Scale: 1 0 1 2 3 4 5 6 7 8 km
1 : 170 000

Path:
i:/hydro/400415/gis_projects/rep_16/fig3.1_A3

Figure No.:
3.1



Note:
a. For the Clanwilliam Dam Raising Feasibility Study, soils investigation was done up to a level of 60m above river channel level.
b. For the WODRIS study (LORWUA area) it was done more extensively.

Project: CLANWILLIAM DAM RAISING FEASIBILITY STUDY

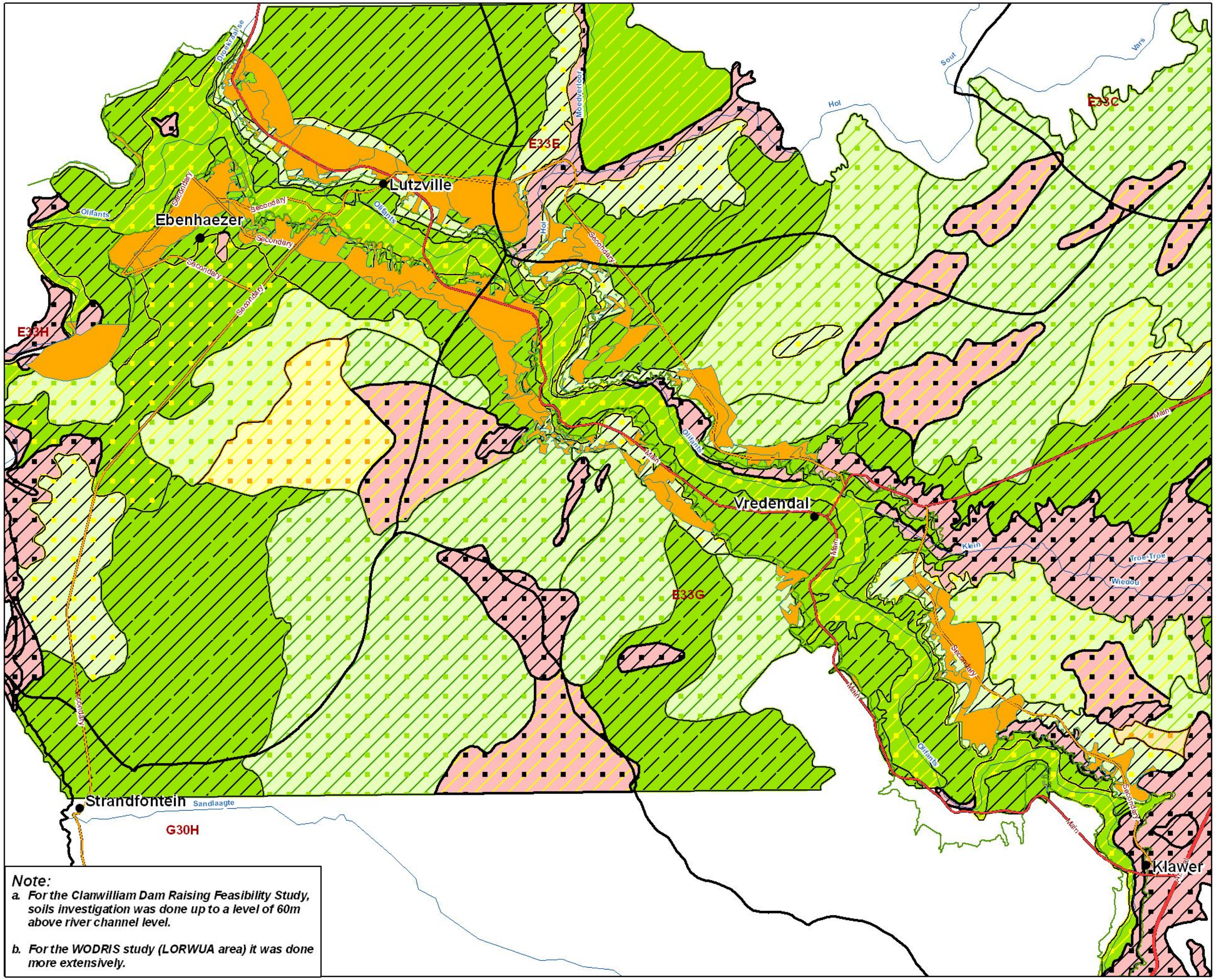
Drawing Title: *Current Irrigated Crops and Potential for further Irrigation*

Scale: 1 0 1 2 3 4 5 6 7 8 km

1 : 170 000

Path: i:/hydro/400415/gis_projects/rep_16/fig3.2_A3.mxd

Figure No.: 3.2



Note:

a. *For the Clanwilliam Dam Raising Feasibility Study, soils investigation was done up to a level of 60m above river channel level.*

b. *For the WODRIS study (LORWUA area) it was done more extensively.*

Legend

- Quaternary Subcatchments
- Towns

Roads

- Arterial
- Main
- Secondary
- Rivers
- Existing Canals
- Current Irrigation Available (WODRIS)

Ped Soils
Non Tuberous RA
- 0 - 40%
- 40.1 - 50%
- 50.1 - 60%
- 60 - 70

Ped Soils
Tuberous R
- 0 - 40%
- 40.1 - 50%
- 50.1 - 60%
- 60 - 70
- 70 - 80

Ped Soils
After Ameriolation
- 0 - 40%
- 40.1 - 50%
- 50.1 - 60%
- 60 - 70
- 70 - 80

SCALE

1 0 1 2 3 4 km

1 : 130 000

CONSULTANT :

NINHAM SHAND CONSULTING SERVICES

CLIENT :

Department of Water Affairs and Forestry

TITLE :

CLANWILLIAM DAM RAISING FEASIBILITY STUDY

Current Irrigated Crops and Potential for further Irrigation

FIGURE NO. :

3.3

3.3 Current irrigation water requirements

The net average irrigation requirement (excluding leaching requirement) increases from 850 – 1 000 mm in the Keerom to Bulshoek Weir section to 1 000 - 1 200 mm in the Bulshoek Weir to the coast section. Peak monthly net irrigation water requirement increases from 200 mm/month in the upper to a maximum of 225 mm/month in the lower Olifants River Basin. A leaching component of 10% to 20% is recommended for saline soils in the drier areas. Under the harsh and variable climatic conditions along the middle and lower reaches of the Olifants River Basin long-term average values should not be used. It is recommended that for design purposes average + standard deviation A-pan values should be used for those months with peak irrigation requirement.

Net water requirement calculated from class A-pan evaporation values and crop conversion factors only represents water lost through evapotranspiration. The gross "on-land" water requirement can be significantly greater as a function of the type of irrigation system, irrigation scheduling and the leaching fraction (up to 10% - 20%). Based on the information submitted by farmers/producers the gross water application at Citrusdal for citrus is 8 000 and 10 000 m^3/ha/a for drip and micro irrigation respectively, while the net requirement for wine grapes is 7 500 and 8 500 m^3/ha/a at Lutzville and Vredendal, respectively.

The irrigation water requirements for each of the crops of the study area are summarised in **Table 3.4.**

Table 3.4 Irrigation Water Requirements

Crop	Planted (ha)	Benchmark (mm/ha)	Flood Basin Sprinkler Dragline	Sprinkler Centre Pivot	Sprinkler Micro	Sprinkler Drip	Irrigation Water Requirement (Mm^3/a)
Irrigation efficiency			75%	85%	90%	95%	
CASH CROPS							
Tomatoes Processing	521	6 330	30	30	0	40	3 872
Tomatoes Table	321	9 900	20	20	0	60	3 602
Wheat	1 635	4 300	50	50	0	0	8 823
Pastures	501	11 870	70	30	0	0	7 649
Vegetables	4 665	6 206	30	30	0	40	33 987
Nursery	84	7 320	0	0	100	0	683
Other Cash	785	6 649	25	25	25	25	6 098
PERMANENT CROPS							
Vineyards – Table	1 372	12 260	10	0	30	60	18 473
Vineyards- Processing (Dry, Wine)	9 458	11 050	10	0	30	60	114 779
Lucerne	468	12 060	60	20	0	20	7 032
Olives and Papaya	467	11 490	30	0	30	40	6 194
Deciduous fruit	1 308	10 725	0	0	50	50	15 177
Citrus	8 274	10 640	30	0	40	30	102 142
Rooibos Tea	5 909	4 860	60	0	20	20	35 402
FALLOW AND NOT CLASSIFIED							
Irrigated Fallow	1 485	6 206	100		0	0	11 565
Non Irrigated Fallow	0	0	0	0	0	0	0
Not Classified	0	0	0	0	0	0	0
TOTAL	**37 253**						**375 476**

3.4 Financial viability of irrigation farming by region

The report *Financial viability of irrigation farming* by Prof Laubscher deals with the evaluation of the financial viability of existing irrigation farming as well as the envisaged expansion of irrigation farming in relevant regions of the Olifants River system, that may utilise additional irrigation water, following the potential raising of the Clanwilliam Dam. The envisioned expansion of irrigation farming addresses the option of the expansion of existing irrigation farms as well as the developing of new irrigation farms. The financial analyses were done at constant 2005/06 price levels.

3.4.1 Methodology

Typical farming situations were modelled for each of the regions of the study area, with the assistance of leading farmers and other industry experts. It was assumed that the financial results that are associated with the typical farming models of each region would also apply to the total irrigated area of that region. It was further assumed that the managerial inputs on each of the typical farms in the different regions of the study area would be optimal.

The financial viability of irrigation farming was evaluated with the aid of a computer model and by applying the following decision-making criteria, namely:

a. profitability
   - internal rate of return (IRR) on capital employed in real terms

b. affordability
   - expected cash-flow and break-even year at different own-to-loaned capital ratio's

c. relative "efficiency" of the utilisation of irrigation water
   - annuity of the net financial benefits per m^3 irrigation water applied
   - number of jobs created per 1000 m^3 of irrigation water applied

As far as the profitability criterion is concerned, an internal rate of return (IRR) of at least 4% per year in real terms (*i.e.* an IRR of 10% per year in nominal terms at an inflation rate of, say, 6% per year) can be seen as a benchmark. At a benchmark IRR of 10% per year in nominal terms (*i.e*. an IRR of 4% per year in real terms at an inflation rate of, say, 6% per year) the following irrigation farming situations that were analysed, seem to be financially viable.

Profitability was shown to be as follows:

3.4.2 Existing irrigation farming

Citrusdal region:
- Citrus farming (real IRR of 4.55% per year)

Clanwilliam region:
- Citrus farming with potatoes (real IRR of 7.54% per year)

Melkboom/Trawal region:
- Table grape farming (real IRR of 34.44% per year)

Klawer/Vredendal region:

- Mixed farming, i.e. wine grapes and tomatoes (real IRR of 10.34% per year)
- Table grape farming (real IRR of 9.57% per year)

3.4.3 Expansion of existing irrigation farming

Clanwilliam region:

- Citrus farming with potatoes (real IRR of 6.38% per year)

Melkboom/Trawal region:

- Mixed farming, i.e. wine grapes and tomatoes (real IRR of 5.42% per year)
- Table grape farming (real IRR of 28.76% per year)

Klawer/Vredendal region:

- Mixed farming, i.e. wine grapes and tomatoes (real IRR of 10.26% per year)
- Table grape farming (real IRR of 11.24% per year)

3.4.4 New irrigation farms

Clanwilliam region:

- Citrus farming with potatoes (real IRR of 4.19% per year)

Melkboom/Trawal region:

- Table grape farming (real IRR of 11.05% per year)

Klawer/Vredendal region:

- New mixed farm, i.e. wine grapes and tomatoes (real IRR of 4.93% per year)
- New table grape farm (real IRR of 5.24% per year)

It is clear from the financial analysis that, given the assumptions made, existing irrigation farming is quite profitable in the relevant regions of the study area. The main contributing factors in this regard are, *inter alia*:

- well developed and well managed farms;
- sound supporting marketing structures for produce;
- sound profitability levels for the major farming branches due to efficient farming practices and favourable price levels for produce; and
- the availability of affordable irrigation water (at R2 046 per listed hectare under irrigation).

4. DISTRIBUTION OPTIONS FOR AGRICULTURE

4.1 Range of identified options

It should be noted that additional yield from a raised Clanwilliam Dam could be used for irrigation anywhere in the Olifants River catchment, within the restrictions of available and suitable irrigable land, and any infrastructural and financial constraints. Should licences be granted for new or additional irrigation upstream of the Dam, such use would simply reduce runoff to the dam and reduce the yield available for allocation from the dam.

4.1.1 Options to distribute or use water

The following range of options has been identified to distribute or use additional yield, created by the dam raising, to new or existing irrigators, within the three identified areas:

a. Potential options for Region 1: Area upstream of Clanwilliam Dam

- Expansion of existing farms or new farms (from river and off-channel dams);
- Rosendaal Dam, as alternative combined balancing dam.

b. Potential options for Region 2: Area downstream of Clanwilliam Dam, and upstream of Bulshoek Weir

- Expansion of existing farms, or development of new farms (pumping from river);
- Increased assurance of supply.

c. Potential options for Region 3: Area downstream of Bulshoek Weir to the estuary

- Expansion of existing farms, or development of new farms in the Melkboom/Trawal area (pumping from canal);
- Expansion of existing farms, or development of new farms in the Klawer/Vredendal area (pumping from canal);
- Increased assurance of supply;
- Additional water supplied through the current main canal;
- Increasing the capacity of the canal system by raising the canal;
- Replacement of the canal system;
- Reducing losses in the canal/refurbishment of the canal system;
- Provision of a new balancing dam/s along the canal;
- Additional farm dams along canal;
- Releasing water downriver from Bulshoek and pumping into canal sections to use spare capacity in identified canal sections;
- Zypherfontein Irrigation Scheme;
- Ebenhaezer community supply.

4.1.2 Desktop-level evaluation of distribution options

The assessment of the various options available for development of new irrigation areas or the expansion of existing irrigation, in the study area, has been described hereunder. Options have been evaluated at desktop level, working from 1: 10 000 orthophotos. It is possible that some of these costs may be conservative, and that small individual schemes may be identified that are more viable.

4.2 Region 1 Options: Area upstream of Clanwilliam Dam

4.2.1 Expansion or new farms (from river and off-channel dams)

This option allows additional pumping of runoff that would otherwise have been stored in Clanwilliam Dam.

The option was assessed by selecting two typical farm scenarios in the Citrusdal region and undertaking a costing exercise to establish the anticipated cost of supplying irrigation water to the field edge. This information was then used in the financial analysis, described in **Section 3.4** of this report, in order to determine the financial viability of the typical farming scenarios. The two scenarios, based on the Citrusdal area (Region 1), were as follows:

- New Farm = 70 ha citrus
- Expansion = 20 ha citrus (from existing 50 ha)

The first step in determining the bulk water infrastructure required for supplying irrigation water to the field edge was to establish the peak crop water demand in order to estimate the pump and pipeline requirements.

The crop water requirements, obtained from Tables 3.2 and 3.4 in the report entitled *Soils, Water Requirements and Crops*, are as follows:

- Total irrigation requirements per year = 1 138 mm/annum
- Max net irrigation requirements (NIR_m) = 225 mm/month

The scheme flow rates were calculated assuming the worst-case situation with no rainfall during the peak period.

The following design assumptions were then made to determine the required pump requirements for each scenario, taking typical topography of the area into account:

- Distance from River to Dam = 200 m
- Elevation from River to Dam = 20 m
- Distance from Dam to Field = 100 m
- Elevation from Dam to field = 15 m
- Cycle length = 7 days
- Type of irrigation = Micro
- Irrigation efficiency = 90%

The detailed calculation sheets for the pumping requirements are attached in **Appendix A**.

There is currently a very limited amount of available water in the river during the dry months when the irrigation demand is at its peak. Due to this region being situated above the Clanwilliam Dam farms cannot benefit from the storage provided by the Clanwilliam Dam. It was therefore necessary to add the cost of off-channel storage to the typical schemes in this region. It was assumed that the schemes would require off-channel storage volumes equivalent to 60% of the annual water requirements. The required pumping rates into the dams were calculated by assuming that the dams would be filled during the wet season by running the pumps 22 hours/day for six months of the year.

Two alternative costings were done for the off-channel dams, by assuming two different embankment-volume to storage-volume ratios. Given that the majority of the efficient dam sites have already been utilised, the two ratios used were 1:3 and 1:4. The cost of the dams was then calculated by dividing the required storage volume by the ratio to get the embankment volume and then multiplying by an all-inclusive rate of R40/m^3, which was estimated from past experience of similar embankment dam costs.

The results of the costings are summarised in **Table 4.1**. More detail can be found in **Appendix A**.

Table 4.1 Citrusdal typical schemes : Summary of bulk water costings

NEW FARM - 70 ha Citrus	Conservative Estimate (excl. VAT)	Less Conservative Estimate (excl. VAT)
Total Irrigation Pumps and Mainlines	R 488,000	R 488,000
Total River Abstraction Pumps and Mainlines	R 298,000	R 298,000
Total Dam Cost Estimate	R 6,720,000	R 5,040,000
TOTAL CAPITAL COST ESTIMATE	**R 7,506,000**	**R 5,826,000**
Total cost per hectare - Water to field edge	R 107,229	R 83,229/ha
EXPANSION - 20 ha Citrus		
Total Irrigation Pumps and Mainlines	R 167,000	R 167,000
Total River Abstraction Pumps and Mainlines	R 124,000	R 124,000
Total Dam Cost Estimate	R 1,536,000	R 1,152,000
TOTAL CAPITAL COST ESTIMATE	**R 1,827,000**	**R 1,443,000**
Total cost per hectare – water to field edge	R 91,350	R 72,150/ha

The aim of the costings is to give an order of magnitude cost of supplying bulk irrigation water to the field edge. The costings do not include any infield irrigation costs. Infield costs have been taken into account for the financial analysis described in **Section 3** of this report.

4.2.2 Rosendaal Dam

The proposed Rosendaal Dam is a dam, which was investigated, in the late 1980s to early 1990s. This proposed 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, as shown in **Figure 4.1**.

	Rosendaal	Visgat
Naturalised MAR	32 Mm³/a	64 Mm³/a
Present Day MAR	26 Mm³/a	59 Mm³/a
Dam Capacity	26 Mm³	?
Yield	14 Mm³	?

References:
Olifants Doring River Basin Study

Figure 4.1 Rosendaal Dam site

a. **Engineering and Financial**

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 releases for the riverine ecology). The crest length would be 435 m.

For the purposes of this report, the original cost estimates were obtained from the following reports and updated to July 2007 prices:

- *Beplanningsverslag oor Voorgestelde Rosendaaldam*, Oktober 1989. Report No. 1586/5080. Ninham Shand.
- *Cost Analysis of the proposed Rosendaal Dam on the Upper Reaches of the Olifant***s** *River,* August 1989. Department of Water Affairs and Forestry.

Figure 4.2 below shows the capital cost curve, which was derived from the updated cost estimates.

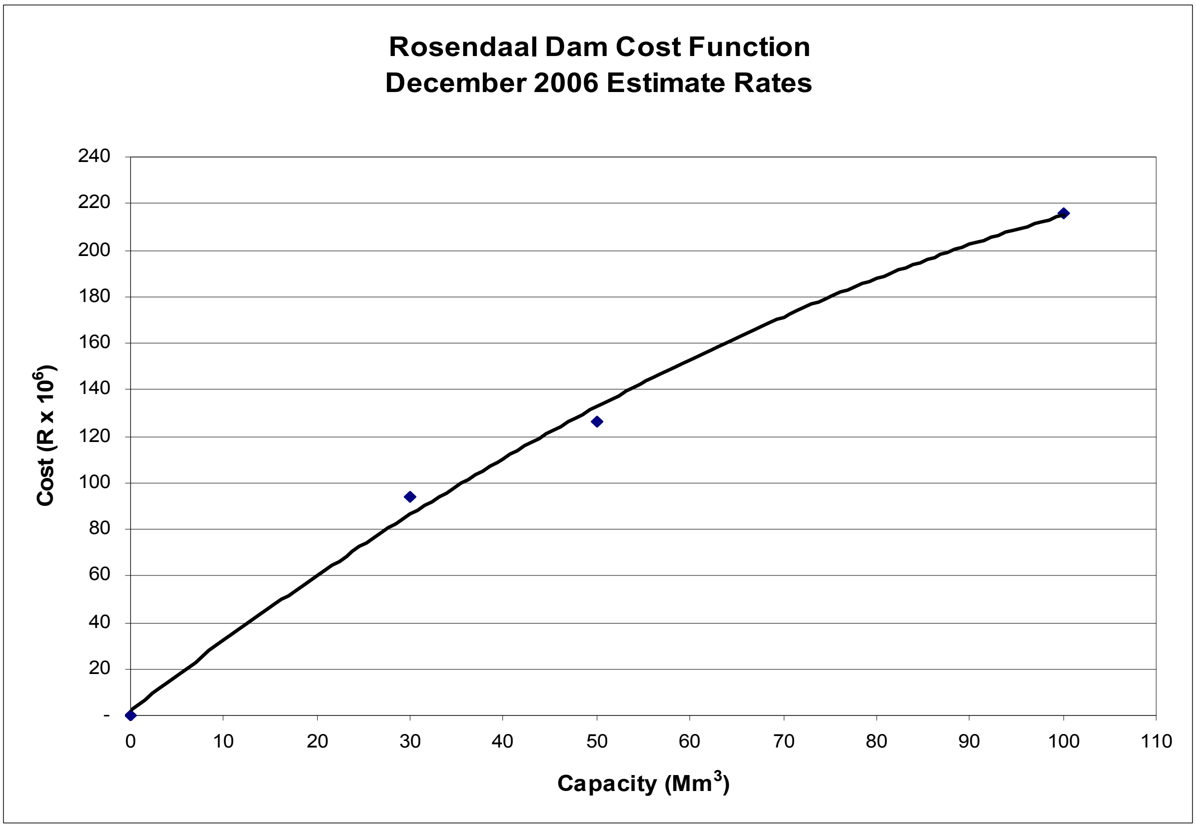


Figure 4.2 Rosendaal Dam capital costs versus storage capacity

The graph indicates that a dam with a storage volume of approximately 30 million m^3 would cost in the region of R90 million and one of 50 Mm^3 would cost in the region of R130 million.

The cost associated with the construction of a 26 million m^3 dam is shown in **Table 4.2**, for a yield that does not take the Reserve into account.

Table 4.2 Rosendaal Dam yield and cost

Yield Mm^3/a	Dam size (Mm^3)	Construction Cost	Ref Date (Year)	Cost: Yield Ratio
14	26	R73 million	2006	5.2

It is important to note that this dam was originally planned before the 1998 Water Act, which defines the need to determine requirements for ecological releases. In addition to the normal flow releases, an on-channel dam of this size would require an outlet works capable of flood releases to comply with the requirement of the Reserve. Further investigation would be required to determine the expected dam yield, taking into account the requirements of the Reserve. The yield shown in **Table 4.2** above is a gross yield, before provision for the Reserve. The yield would reduce when the Reserve is taken into account, making the dam unattractive.

b. 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 waterfalls, the dam would have a very limited 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.

c. Beneficiaries, infrastructure requirements and environmental Impacts

This dam could be built as an alternative to building many small additional farm dams.

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

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 750 ha, 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 re-instate 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.

4.3 Region 2 Options: Clanwilliam Dam to Bulshoek Weir

4.3.1 Expansion of existing farms, or development of new farms (pumping from river)

This option was assessed in terms of typical farms as in **Section 4.2.1** above. The major difference between the schemes for this region and Region 1 is that this region is below the Clanwilliam Dam and therefore no additional off-channel storage is required. Timed releases could be made from the Clanwilliam Dam to the Bulshoek Weir. These schemes could abstract water directly from the river onto the fields. It may be necessary for the schemes to have a small amount of buffer storage for management purposes, but it is expected that this would be a minor additional cost.

The two scenarios, based on the Clanwilliam area (Region 2), were as follows:

- New Farm = 50 ha citrus
  50 ha potatoes
- Expansion = 20 ha citrus
  25 ha potatoes

The crop water requirements, obtained from Tables 3.2 and 3.4 in the report entitled *Soils, Water Requirements and Crops*, are as follows:

Citrus
- Total Irrigation requirements per year = 971 mm/annum
- Max net irrigation requirements (NIR_m) = 225 mm/month

Potatoes
- Total irrigation requirements per year = 550 mm/annum
- Max net irrigation requirements (NIR_m) = 222 mm/month

The following design assumptions were then made to determine the required pump requirements for each scenario, taking topography of the area into account:

New Farm
- Distance from river to field = 200 m
- Elevation from river to field = 30 m

Expansion
- Distance from river to field = 400 m
- Elevation from river to field = 30 m
- Cycle length = 7 days
- Type of irrigation - citrus = Micro

- Irrigation efficiency - citrus = 90%
- Type of irrigation - potatoes = Centre Pivot
- Irrigation efficiency - potatoes = 85%

The detailed calculation sheets for the pumping requirements are attached in **Appendix B**. The results of the costings are summarised below. More detail can be found in **Appendix B**.

Table 4.3 Clanwilliam typical schemes : Summary of bulk water costings

NEW FARM - 50 ha Citrus, 50 ha Potatoes	**Estimate**
Citrus: Irrigation Pumps and Mainlines	R 590,000
	R 11,800/ha
Potatoes: Irrigation Pumps and Mainlines	R 617,000
	R 12,340/ha
TOTAL CAPITAL COST ESTIMATE – New Farm	**R 1,207,000**
EXPANSION - 20 ha Citrus, 25 ha Potatoes	
Citrus: Irrigation Mainlines	R 354,000
	R 17,700/ha
Potatoes: Irrigation Mainlines Cost Estimate	R 418,000
	R 16,720/ha
TOTAL CAPITAL COST ESTIMATE – Expansion	**R 772,000**

Farmers in this area have sound experience and thus know-how as far as the production and marketing strategies of the potato branch is concerned. It seems to be a viable option to expand existing citrus farms in this region, in combination with potato production (real IRR of 6.38% per year). Year cropping (i.e. potato production in this case) can have a considerable positive effect on the cash flow of farms. The establishment of new farms is marginally profitable (real IRR of 4.19% per year).

4.3.2 Increased assurance of supply

This addresses the need for existing irrigators to increase their assurance of supply from the LORGWS, so that they can be certain of obtaining preferably their full quota, but at least an increased percentage of their quota in very dry years.

While the perception of assurance of supply by users is that it is lower than what is needed, which may have been exacerbated by the recent drought years, it may be that other factors, such as illegal water use, contribute to a lowered assurance of supply. There is a clearly expressed need by farmers and their representatives, that some water be set aside for an increased assurance of supply.

An evaluation of actual use from Clanwilliam Dam and Bulshoek Weir, from 1980, is as illustrated in **Figure 4.3.** A calculation of average use from 1980 to 2006 shows that average use was as shown in **Table 4.4**. The years 2003 to 2005 were drought years.

Table 4.4 Average use from the LORGWS

Source of supply	Average use (Mm^3/a)
Between Clanwilliam and Bulshoek	21
Clanwilliam Canal	10
LORGWS Canal	139
Total current supply	**170**

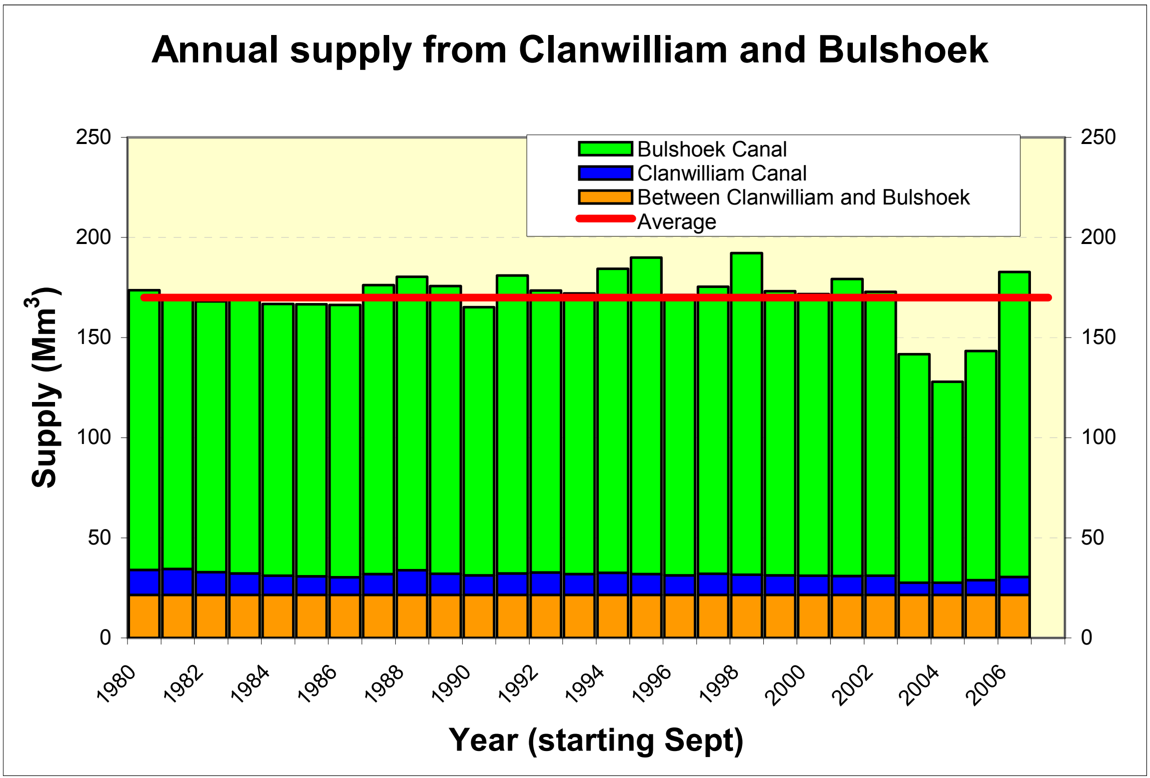


Figure 4.3 Annual supply from Clanwilliam Dam/Bulshoek Weir

An annual quota of 12 200 m^3/ha/a from the Clanwilliam Dam is allowed in theory to LORWUA irrigators. This quota was cut to 7 400 m^3/ha/a during 1998 and then increased again to 8 300 m^3/ha/a in 2003. (Basin Study Phase II). Farmers however invariably receive less than this, from the current dam. The planting of permanent crops in the LORWUA area is restricted to 70% of the irrigation area allocated.

An analysis of assurance of supply for the current system and use indicates the following:

- Current firm yield of 146 million m^3/a
- At 1:20 year failure: 166 million m^3/a
- At 1:10 year failure: 172 million m^3/a
- At 1:5 year failure: 182 million m^3/a

Modelled yield values indicate that that, at current water requirement levels, the system is being operated at about a 1:10 year risk of failure, but keeping in mind that no releases are being made for the Reserve. Should the baseflow requirements of the Reserve be met, this assurance becomes worse than a 1:5 year risk. In practice indications are that the assurance of supply for the current dam may however already be at about a 1:5 year risk of failure, due to illegal use, for instance. Note however, that the baseflow release shown in the graph relates to the full ecological water requirement (EWR), while the drought EWR is recommended for the current dam, should it not be raised (a difference of 5 million m^3/a yield).

This is illustrated in the graph in **Figure 4.4**.

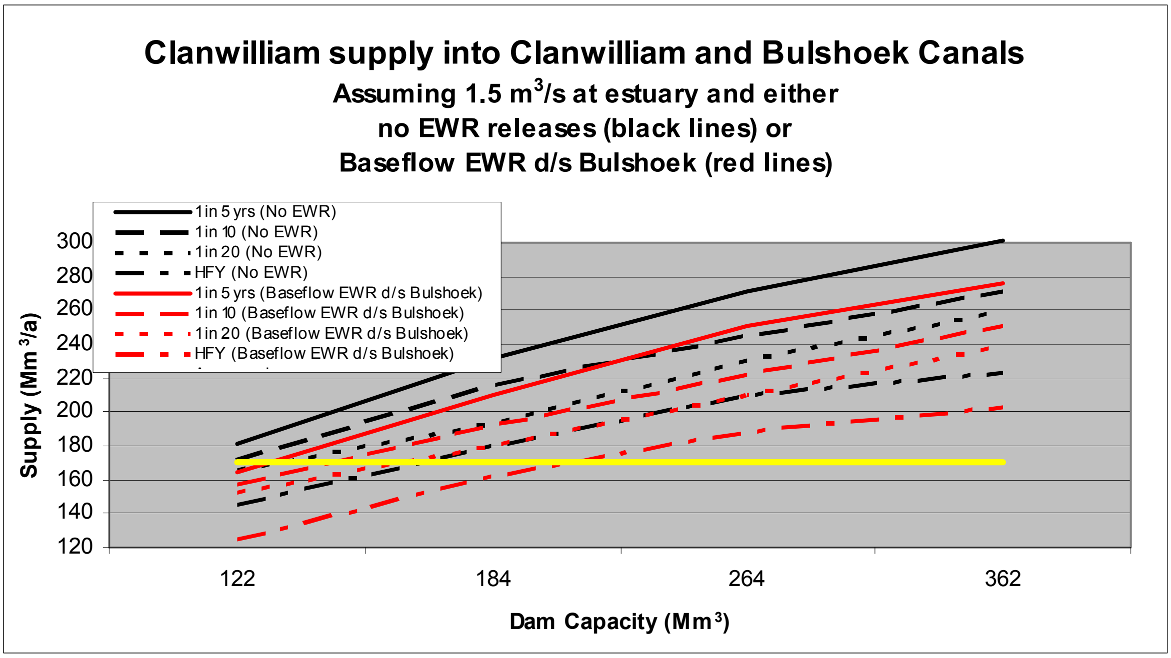


Figure 4.4 Yield of Clanwilliam/Bulshoek at various assurances of supply

It is therefore recommended that some of the additional yield be set aside for improvement of assurance of supply, for those irrigators wishing to do so. The current extent of this need is not clear, and would have to be determined. It would however be difficult to distinguish between users who wish to improve their assurance of supply, and users who wish to establish new irrigation. It may be best to increase assurance of supply for the full scheme (including the raising) to an acceptable level.

For example, for a 15 m raising, the following applies:

- Firm yield of 203 million m^3/a
- At 1:20 year failure: 239 million m^3/a
- At 1:10 year failure: 251 million m^3/a
- At 1:5 year failure: 276 million m^3/a

For Scenario 2, where the implementation of the Reserve is absorbed by existing users, the increase in yield of for example a 15 m raising would be 73 million m^3/a. Should the current use from the Scheme be increased to (170 + 73) = 243 million m^3/a, users would receive water from the scheme at an assurance of supply of between a 1:10 and 1:20 year assurance of supply. Should the users (current and future) wish to improve the LORGWS's assurance of supply further, such cost would be borne by all users (current and future). It would however be up to the users, in combination with the DWAF, to decide how much water should be allocated for the increased assurance of supply of the scheme. A complicating issue is that the existing canal system below Bulshoek Weir has insufficient capacity to supply the peak water requirements.

4.4 Region 3 Options: Area downstream of Bulshoek Weir to the estuary

4.4.1 Expansion of existing farms, or development of new farms in the Melkboom/ Trawal area (pumping from canal)

This option was assessed in terms of typical farms as in **Section 4.3.1**. An assumption was made that typical farms in this area would obtain irrigation water from the existing canal. As for Region 2, it may be necessary for the schemes to have a small amount of buffer storage for management purposes, but it is expected that this would be a minor additional cost.

For this region, upon consultation with the local farmers, it was decided to calculate the costs of new and expanded schemes for two cropping scenarios, namely, table grapes and wine grapes with small areas of tomatoes.

The four scenarios, based on the Melkboom/Trawal area (Region 3), were as follows:

- New Farm 1 = 45 ha wine grapes
  5 ha tomatoes
- Expansion 1 = 12 ha wine grapes
  3 ha tomatoes
- New Farm 2 = 25 ha table grapes
- Expansion 2 = 5 ha table grapes

The crop water requirements, obtained from Tables 3.2 and 3.4 in the report entitled *Soils, Water Requirements and Crops*, are as follows:

Table Grapes
- Total irrigation requirements per year = 930 mm/annum
- Max net irrigation requirements (NIR_m) = 238 mm/month

Wine Grapes
- Total irrigation requirements per year = 1 087 mm/annum
- Max net irrigation requirements (NIR_m) = 299 mm/month

Tomatoes
In order to simplify the costing process, it was assumed that the tomato irrigation scheme would form part of the wine grape system and therefore the peak design demand was the same as for wine grapes.

The following design assumptions were then made to determine the required pump requirements for each scenario, taking into account the topography of the area:

Table Grapes
- Distance from canal to field = 200 m
- Elevation from canal to field = 30 m
- Cycle length = 7 days
- Type of irrigation - grapes = Drip
- Irrigation efficiency - grapes = 95%

Wine Grapes/Tomatoes

- Distance from canal to field = 200 m
- Elevation from canal to field = 15 m
- Cycle length = 7 days
- Type of irrigation - grapes/tomatoes = Drip
- Irrigation efficiency - grapes/tomatoes = 95%

The detailed calculation sheets for the pumping requirements are attached in **Appendix C**. The results of the costings are summarised below. More detail can be found in **Appendix C**.

Table 4.5 Melkboom/Trawal typical schemes : Summary of bulk water costings

NEW FARMS	Estimate
25 ha table grapes	
Irrigation pumps and mainlines	R 316,000
	R 12,640 /ha
45 ha wine grapes and 5 ha tomatoes	
Irrigation pumps and mainlines	R 565,000
	R 11,300 /ha
TOTAL CAPITAL COST ESTIMATE	**R 881,000**
EXPANSIONS	
5 ha table grapes	
Irrigation pumps and mainlines	R 102,000
	R 20,400 /ha
12 ha wine grapes and 3 ha tomatoes	
Irrigation pumps and mainlines	R 223,000
	R 14,867 /ha
TOTAL CAPITAL COST ESTIMATE	**R 325,000**

4.4.2 Expansion of existing farms, or development of new farms in the Klawer/ Vredendal area (pumping from canal)

The Klawer/Vredendal area, which also forms part of Region 3, was considered with similar assumptions to those made for the Melkboom/Trawal area. It was also assumed that abstraction would take place from the existing canals. If large volumes of additional irrigation water are however required in this area, canal sections would need to be re-filled as described in **Section 4.4.8**. The costs of re-filling the canal would then need to be distributed between the farmers with the additional irrigation areas. This section provides cost estimates for supplying water from the canal to the field edge only and does not include the additional cost of re-filling the canal, which is described in **Section 4.4.8**.

The four scenarios, based on the Klawer/Vredendal area (Region 3), were as follows:

- New Farm 1 = 60 ha wine grapes
  15 ha tomatoes
- Expansion 1 = 15 ha wine grapes
- 5 ha tomatoes
- New Farm 2 = 25 ha table grapes
- Expansion 2 = 5 ha table grapes

The crop water requirements, obtained from Tables 3.2 and 3.4 in the report entitled *Soils, Water Requirements and Crops*, are as follows:

Table Grapes

- Total irrigation requirements per year = 1 033 mm/annum
- Max net irrigation requirements (NIR_m) = 405 mm/month

Wine Grapes

- Total irrigation requirements per year = 1 212 mm/annum
- Max net irrigation requirements (NIR_m) = 455 mm/month

Tomatoes

In order to simplify the costing process, it was assumed that the tomato irrigation scheme would form part of the wine grape system and therefore the peak design demand was the same as for wine grapes.

The peak water requirements for this area are substantially higher than the peaks for the other areas. Although it is felt that further investigation is required to establish if these peak requirements are representative of the actual water requirements in the area, it was decided to undertake the costings using these values. The reader should take note that these requirements are higher than one would expect.

The following design assumptions were then made to determine the required pump requirements for each scenario:

Table Grapes

- Distance from canal to field = 200 m
- Elevation from canal to field = 20 m
- Cycle length = 7 days
- Type of irrigation - grapes = Drip
- Irrigation efficiency - grapes = 95%

Wine Grapes/Tomatoes

- Distance from canal to field = 200 m
- Elevation from canal to field = 20 m
- Cycle length = 7 days
- Type of irrigation - grapes/tomatoes = Drip
- Irrigation efficiency - grapes/tomatoes = 95%

The detailed calculation sheets for the pumping requirements are attached in **Appendix D**. The results of the costings are summarised below. More detail can be found in **Appendix D**.

Table 4.6 Klawer/Vredendal typical schemes : Summary of bulk water costings

NEW FARMS	Estimate
25 ha table grapes	
Irrigation pumps and mainlines	R 425,000
	R 17,000 /ha
60 ha wine grapes and 15 ha tomatoes	
Irrigation pumps and mainlines	R 1,196,000
	R 15,947 /ha
TOTAL CAPITAL COST ESTIMATE	**R 1,621,000**
EXPANSIONS	
5 ha table grapes	
Irrigation pumps and mainlines	R 138,000
	R 27,600 /ha
10 ha wine grapes and 5 ha tomatoes	
Irrigation pumps and mainlines	R 266,000
	R 17,733 /ha
TOTAL CAPITAL COST ESTIMATE	**R 404,000**

4.4.3 Increased assurance of supply

This addresses the need for existing irrigators to increase their assurance of supply so that they can be certain of obtaining their full quota (within infrastructural constraints) in very dry years. This has been covered in **Section 4.3.2**.

4.4.4 Additional water through the main canal

An investigation was done to determine the potential for releasing more water down the existing Lower Olifants canal system. The detailed write-up of the methodology used is given in the *System Analysis Report* of this study, and is summarised here.

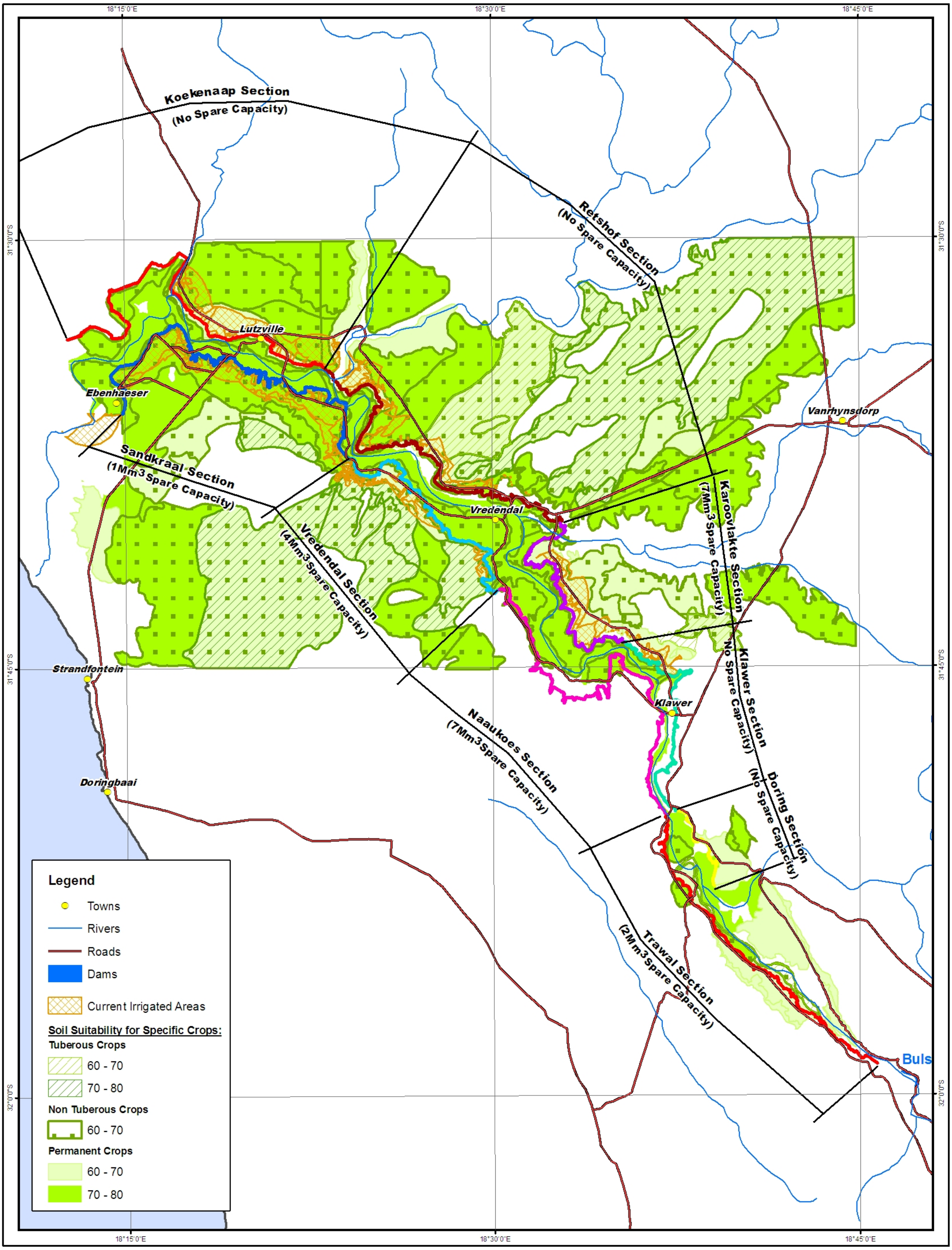
The existing canal system is described earlier in this report, and is illustrated in more detail in **Figure 4.5**.

The capacities of the canal sections were obtained from an existing report (LORWUA, 2004). These values are given in **Table 4.7**. It should be noted that the canal runs at 90% of the capacities listed. The figures assume that the canal is operated for five days per week.

Table 4.7 Capacities of the canal sections

Canal Section	Capacity (m^3/month)
Sandkraal	3 328 594
Vredendal	8 477 083
Naauwkoes	14 786 535
Koekenaap	3 813 190
Retshof	5 137 063
Karoovlakte	14 971 875
Klawer	7 780 287
Doring River	1 250 779
Trawal	22 957 745

The observed monthly flow at the start of the canal system was obtained from the DWAF flow gauging database, and an average flow was obtained from the data. An average theoretical water demand for each month was modelled, based on the crop types used at each section on the canal and the relevant crop factors. A comparison of the two sets of monthly volumes at the start of the Trawal canal section is shown in **Figure 4.6**.



	Project: CLANWILLIAM DAM RAISING FEASIBILITY STUDY	Scale: 6 3 0 6 Km — 1 : 220 000	Figure No.: **4.5**
	Drawing Title: ***LORGWS Canal Sections***	Path: i:/hydro/400415/gis/gis_projects/rep_4/canals_fig4_5.mxd	

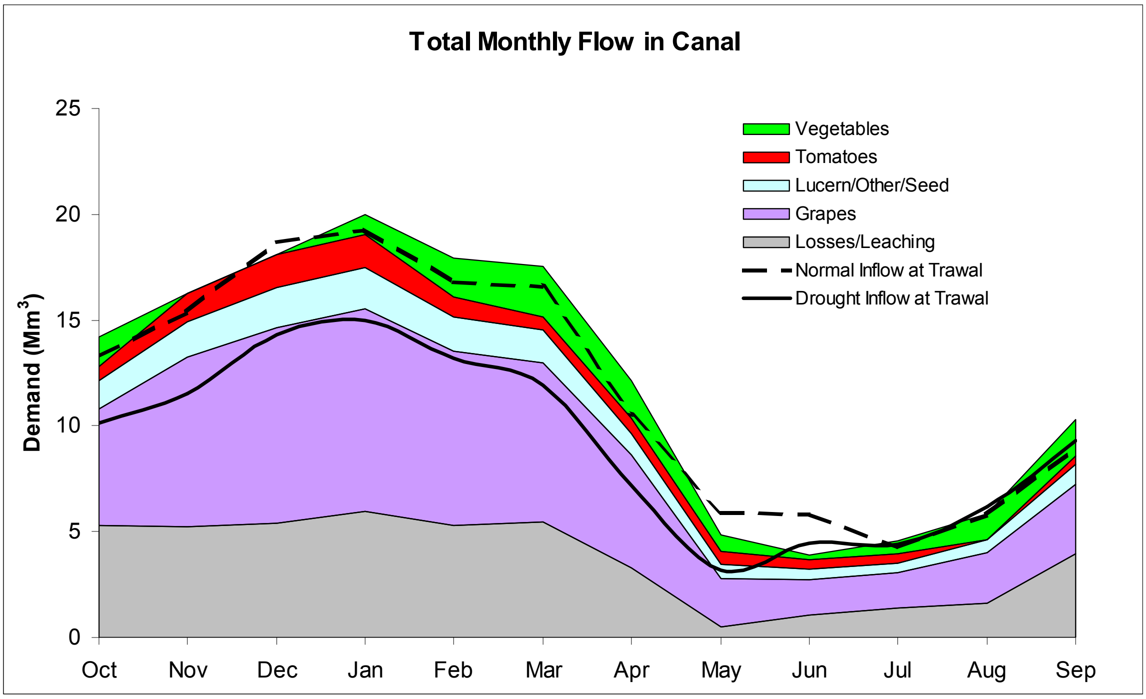


Figure 4.6 Comparison of observed and theoretical flows in canal at Trawal

Figure 4.8 below shows that there is fairly close correlation between the two sets of values. If one compares the flow in the canal at this point to the capacity of approximately 21 million m^3 (90% of 23 million m^3 from **Table 4.7**), it is evident that significant spare capacity is available in the winter months, but there is very little spare capacity during the peak month of January.

The possibility of introducing alternative crop types that have a different water requirement, with peak demands at different times to those currently grown, was considered. However, this option is not popular with farmers because of the high risk involved in ensuring that there is a market available for the alternative crops at the right time. This option was therefore not considered further at this stage.

The monthly values for flow in the canal sections are given in **Table 4.8** below.

Table 4.8 Estimated average monthly flow in the canal system per section

Canal Sections	Monthly flow in million m^3												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Combined:													
Trawal	14.205	16.276	18.098	20.004	17.918	17.555	12.131	4.829	3.915	4.565	5.822	10.290	145.607
Lower West Bank:													
Sandkraal	1.556	1.988	2.276	2.478	2.146	2.031	1.426	0.602	0.483	0.512	0.604	0.964	17.067
Vredendal	3.144	3.891	4.455	4.833	4.213	3.997	2.913	1.224	0.988	1.047	1.245	1.963	33.913
Naauwkoes	5.534	6.856	7.470	8.101	7.109	7.119	5.010	1.997	1.704	1.792	2.241	3.390	58.323
Lower East Bank:													
Koekenaap	2.323	2.569	2.936	3.266	2.911	2.827	2.044	0.990	0.679	0.787	1.263	1.713	24.308
Retshof	3.725	3.913	4.491	5.016	4.510	4.366	3.061	1.363	0.960	1.262	1.772	2.711	37.150
Karoovlakte	5.517	5.857	6.733	7.546	6.844	6.627	4.631	2.048	1.449	1.864	2.546	4.227	55.890
Klawer	6.207	6.627	7.448	8.346	7.569	7.330	5.177	2.196	1.594	2.075	2.764	4.741	62.074
Doring River	0.706	0.753	0.875	0.971	0.885	0.818	0.565	0.264	0.192	0.219	0.306	0.525	7.079

The values from the above **Table 4.8** for each canal section, for the month of January, have been plotted in **Figure 4.7** to show what spare capacity is available.

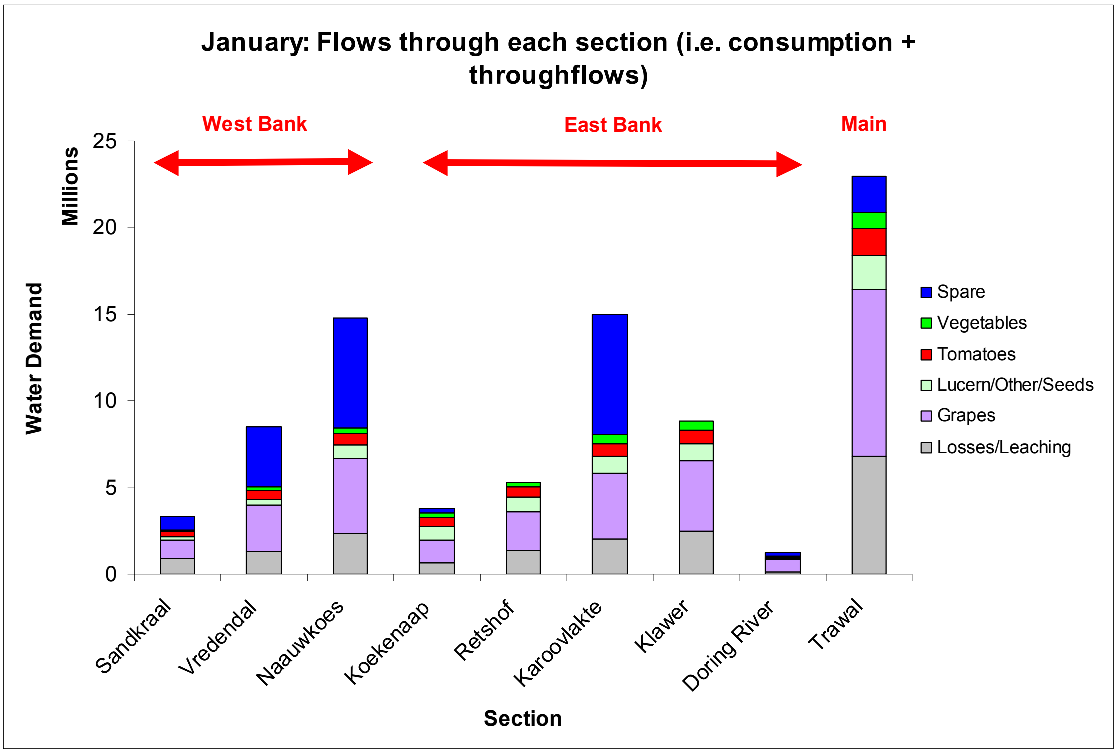


Figure 4.7 Spare capacity available in the canal sections during the peak demand month of January (assuming canal flows at 100% capacity)

As previously stated, under the present method of operation (i.e. 5 days irrigation week) there is very little scope to release more water through the Trawal section during the peak demand month of January. This restriction means that this option of releasing additional water down the canal for direct use is not particularly viable. Storage is required to make use of the spare capacity in the canal system in off-peak months. Alternatively, water could be released down the river and pumped into the canal to make use of the significant spare capacity in the Naauwkoes section on the East Bank, and the Karoovlakte section on the West Bank during January. These alternative options are discussed in the **Sections 4.4.8** to **4.4.10.**

4.4.5 Increasing the capacity of the Lower Olifants Canal system

Some sections of the canal is currently fully utilised. There are many areas with irrigable areas that are not currently under irrigation, due to a lack of available water. If the canal had a larger carrying capacity, more water could be made available for irrigation downstream of Bulshoek Weir.

It may be possible to raise the canal over the sections that are fully utilised. The sides of the canal could be built up using in-situ earth and then adding a concrete lining at the top of the existing profile (or the canal capacity could be increased in other ways). This does not seem feasible unless these sections are first repaired or refurbished, as described in **Sections 4.4.6** and **4.4.7**. The new sections would otherwise have to be joined to and supported by the existing badly degraded concrete lining.

In terms of increasing the capacity in the canal, it is expected that any refurbishment work would not only reduce the canal losses, but also reduce the canal friction coefficient substantially, which would in turn increase velocities and lower the water level in the canal, thereby increasing its capacity. Therefore, it is not recommended that the canal profile should be increased in order to increase its capacity.

4.4.6 Replacement of the canal system

The report entitled *Investigation into the Rehabilitation of the Canal Downstream of Bulshoek Dam*, which was written by Element Consulting Engineers in July 2004, proposes a long-term rehabilitation programme whereby three long-term rehabilitation options were addressed.

All three of these options listed below would effectively replace the current canal over a period of time:

- Lining the existing canal with in-situ cast concrete;
- Lining the existing canal with pre-cast concrete panels;
- The installation of a steel pipe in the canal to convey the water.

More detailed descriptions of these options can be found in the report mentioned above.

The report provides a cost estimate for lining the canal with in-situ cast concrete and states that the cost of pre-cast concrete lining would be very similar to that of the cast concrete option. The total cost estimate for lining the entire canal was R633 million, excluding VAT (2004 prices).

This cost is extremely high and certainly does not seem feasible, however, it may be worthwhile investigating the costs of replacing certain portions of the canal on an annual basis.

No cost or details were provided for the steel pipe option. In terms of capacity, the steel pipe would have to have a very large diameter if it was to convey the same amount of water as the larger sections of the canal under gravity feed. It may however be possible to pressurise the pipeline in order to achieve the required volumes of supply. This option would need to be investigated further before it could be considered as a viable option.

It may however be impractical to implement this option as it would mean closing down the scheme, possibly for years. It is also likely to be very expensive.

4.4.7 Reducing losses in the canal/ Refurbishment of the canal system

Water Demand Management and irrigation practices must be evaluated before further resource development should be considered.

In 2004, an investigation by Element Consulting was undertaken into the rehabilitation of the LORGWS main canal. A report entitled *Investigation into the Rehabilitation of the Canal Downstream of Bulshoek Dam* was produced during the study. They *inter alia* concluded the following:

- *The average existing water balance in the report shows that only 52% (80% of the maximum allowed abstractions) of the total flow in the canal goes to the abstractions through sluices;*
- *Structural defects exist on 63 % of the length of the canal;*
- *The defects are not limited to certain sections of the canal;*
- *All the joints in the canal are in a poor condition and need urgent rehabilitation.*

A detailed water balance undertaken for this study, as documented in the *Yield Analysis Report*, however, concluded that losses are more in the region of 30%, while LORWUA uses 27% in their water balance calculations.

The Element report proposed short and medium-term rehabilitation work, which would result in reduced losses in the canal.

The short-term work, proposed in the report, includes repairing the defects which were listed during the visual survey undertaken in 2004. The cost estimate, which was based on a quotation from a local concrete repair specialist, was R 2,5 million, excluding VAT (2004 prices).

The medium-term work, which was proposed in the report, includes the repair of critical sections of the canal. Test results of the core drills suggest that the concrete, in portions of the canal, has served its lifespan and relining is required. However, the scope of this relining needs to be re-evaluated and quantified with more core drills and strength tests. The following items were listed for the critical sections:

- Patch repairs to floors;
- Patch repairs to walls;
- Expansion joint repairs;
- Complete replacement of structural elements;
- Stabilising and cleaning of embankments.

The cost estimate for the medium-term work was R35,5 million, excluding VAT (2004 prices). This would entail repairing and sealing all the joints in the canal with an approved polyurethane sealant.

More detailed descriptions of the proposed repair work can be found in the report mentioned above.

The Clanwilliam Canal, which is currently run at full capacity in summer, has estimated current canal losses of 30%.

4.4.8 Provision of new balancing dam/s along the canal

Should a large balancing dam be built somewhere along the canal system, it could fill in winter and the water be used in summer. This would increase the yield of the system, up to the point where the canal cannot further accommodate the pumped flow from this dam. A significant benefit may be realised during a drought, but only if it is possible to adequately fill the balancing dam during the preceding winter. Having to pump water from the dam into the canal system would add to the cost.

No specific site has been identified for this option, and at face value it is believed to be a costly option.

4.4.9 Additional farm dams along canal

The provision of increased farm dam storage along the canal is seriously hampered by the lack of land due to the small plots, as well as leakage from dams. Plots would generally have to be consolidated, to be able to provide increased storage. This option is therefore not considered to have much potential, as an option to increasing the yield from the system.

4.4.10 Releasing downriver from Bulshoek Weir and pumping into canal sections

a. Identification of canal spare capacity

One of the scenarios being investigated as an alternative to increasing the capacity of the canal system, is to release water from the Bulshoek Weir down the Olifants River, abstracting it further downstream and pumping it into the canal system. This option utilises the spare capacity in the canal, created by abstractions further upstream. The hydrological assessment identified two potential abstraction points, one at the start of the Vredendal irrigation area and one at the start of the Karoovlakte irrigation area. These sections are shown in **Figure 4.5**.

b. Capital cost estimates for filling the canal

Capital cost estimates were calculated for the options of abstracting water from the river at the start of the Karoovlakte section and at the start of the Vrendendal section. It may also be possible and more preferable to abstract at the start of the Naauwkoes canal, as this would provide irrigation water with a much lower TDS count. The desktop investigation has indicated that there should be enough spare capacity in the Naauwkoes canal section to convey the additional water to the Vredendal section, however, a detailed survey would be required to confirm this.

It was assumed that low concrete weirs would be required at the abstraction points in the Olifants River. The required length of the weirs was estimated using satellite photographs of the area. If this option is chosen as a favoured water utilisation option, further analysis should be undertaken in order to improve the accuracy of the estimates and to determine the most suitable weir type for the particular abstraction sites.

The abstraction flow rates were based on the estimates of spare canal capacity in the summer months, while keeping the annual requirements of the schemes below 10 million m^3/a. These water volumes were used to estimate the potential areas that could be irrigated, by making use of the spare capacity in the canal sections. The purpose of estimating an irrigation area was to establish a cost per hectare, which could be added to the typical costs for irrigation in this region. Assuming total transmission losses (canal and river) of 20%, the resulting potential irrigation areas were as follows:

- Karoovlakte Section = 660 ha
- Vredendal Section = 454 ha

The potential irrigation areas were calculated using conservative estimates of crop water requirements for wine grapes in the Vredendal area. The areas would vary according to the crop type and the peak and annual water requirements. It is expected that it would be possible to irrigate larger areas with good crop selection and management practices which would reduce the cost per hectare of re-filling the canal.

Table 4.9 summarises the capital cost estimates for infrastructure to re-fill the canal at the start of the Vredendal and Karoovlakte sections. The detailed estimate for the concrete weir is attached in **Appendix E**.

Table 4.9 Cost estimates for infrastructure required to fill the canal

KAROOVLAKTE SECTION	Estimate
Pump station cost – 431 kW	R 9,488,000
Pipeline cost – 200 m of 1000 mm diameter	R 894,000
Weir cost	R 1,200,000
TOTAL CAPITAL COST ESTIMATE	R 11,582,000
	R 17,474/ha
VREDENDAL SECTION	
Pump station cost – 245 kW	R 6,300,000
Pipeline cost – 815 m of 900 mm diameter	R 3,093,000
Weir cost	R 1,200,000
TOTAL CAPITAL COST ESTIMATE	R 10,593,000
	R 23,358/ha

The costs per hectare should be added to the typical farm costs where there is insufficient capacity in the canal to increase the existing irrigation volumes. These estimates indicate the rough capital costs involved, however, the costs may vary substantially depending on the abstraction sites chosen.

c. Assessment of water quality implications

A first order assessment was done of the potential impacts of such a scheme on the salinity of the irrigation water supplied to the end users. For the assessment, water quality data collected by the DWAF were utilised. The DWAF has four key monitoring points in the affected area:

- E1R001Q01 situated at Bulshoek Dam near the dam wall;
- E1H007Q01 situated at the Bulshoek canal, left bank;
- E2H003Q01 situated at the Doring River at Melkboom;
- E2H016Q01 situated at the Olifants River at Lutzville.

The total dissolved solids (TDS) data at Bulshoek Weir was used to characterise the current water quality in the Dam and the quality supplied to end-users. The monitoring point at E2H003Q01 was used to characterise the salinity that enter the Olifants River from the Doring River, and the monitoring point on the Olifants River at Lutzville, E2H016Q01, was used to characterise the water quality at the downstream end of the irrigation scheme.

For the first order assessment the most sensitive period were identified as the month of January, during which the water demands are the highest. Very low or no flow occurs naturally in the Doring River and irrigation return flows to the Olifants River would probably have the greatest impact on the water quality of the Olifants River. In the month of January, water quality would be classified as "Ideal" in Bulshoek Weir and the canal (average TDS = 62 ± 9.6 mg/l), "Acceptable" in the Doring River (average TDS = 419 ± 199 mg/l), and "unacceptable" for irrigation in the lower Olifants River at Lutzville (average TDS = 2950 ± 604 mg/l). Water with a TDS less than 260 mg/l is classified as "Ideal" for irrigation, 260 – 585 mg/l is "Acceptable", 585 – 1755 mg/l is "tolerable", and greater than 1755 mg/l is regarded as "unacceptable" for irrigation purposes.

The high salt load recorded at Lutzville is mainly the result of irrigation return flows discharged into the Olifants River. For the first order assessment, the salt load at Lutzville was distributed amongst the upstream irrigation areas, proportional to the area under irrigation. In discussions with the hydrologist of the project team it was decided to exclude the Sandkraal and Koekenaap irrigation areas from the total irrigated area calculation. The irrigation areas therefore contributing salt to the Olifants River upstream of the Karoovlakte abstraction point is the Trawal (7.7%), Doring (9.44%), Klawer (3.86%) and 40% of the Naauwkoes (23.19%) irrigation areas (if Sandkraal and Koekenaap is excluded from the total irrigation area). The area contributing salts to the Olifants River between the Karoovlakte and Vredendal abstraction points are 60% of the Naauwkoes (23.19%) and the Karoovlakte (22.07%) irrigation areas. The total salt load at Lutzville in January was therefore distributed proportionally amongst these areas based on the percentage of the total irrigation area.

For the first order assessment it was assumed that water released from Bulshoek into the Olifants River would accumulate salts from irrigation return flows and the Doring River before it is pumped into the canal. In the canal the river water would be mixed with the low salinity canal water resulting in a final salt concentration that is then delivered to the end-users.

It was assumed that during January there is no flow in the Doring River and the salt load discharged from the irrigation areas was a very concentrated stream (near zero flow but high salt concentrations). Three January release options were evaluated:

- A volume of 3.8 Mm^3/month released into the river and abstracted at Karoovlakte;
- A volume of 2.6 Mm^3/month released into the river and abstracted at Vredendal;
- A volume of 6.4 Mm^3/month released into the river of which 3.8 million m^3 was abstracted at Karoovlakte and the remainder at Vredendal.

These options resulted in the following TDS in the river and in the canal sections, as described in **Table 4.10**.

Table 4.10 TDS concentrations in river and canal sections

Option	Olifants River		Canal		
	Released volume (Mm^3/month)	Mean river TDS concentration at the abstraction point (mg/l)	Volume in canal (Mm^3/month)	Mean canal TDS concentration upstream of transfer (mg/l)	Mean canal TDS concentration downstream of transfer (mg/l)
Karoovlakte abstraction	3.8	696	7.55	56	270
Vredendal abstraction	2.6	2104	4.83	56	772
Karoovlakte and Vredendal abstractions	6.4	436[1]	7.55	56	183[1]
		1548[2]	4.83	56	578[2]

Note: 1 – at the Karoovlakte abstraction point, 2 – at the Vredendal abstraction point

Conclusions on water quality considerations

The first order assessment indicates that salinity in the canal would probably deteriorate after being mixed with water abstracted from the river. The water in the canal at the Karoovlakte abstraction point would be classified as "Acceptable" falling within the 260 – 585 mg/l TDS range. Water in the canal at the Vredendal abstraction point would be classified “Tolerable” because it falls in the 585 – 1755 mg/l TDS range.

If the combined volume were released from Bulshoek Weir for abstraction at Karoovlakte and Vredendal, then the resulting TDS at the start of the Karoovlakte canal would fall in the "Ideal" class (0 – 260 mg/l TDS), and at the Vredendal canal would just fall in the "Acceptable" class.

This was a conservative assessment. The assessment above assumed no flow in the Doring River which is generally the case during January. If flows occur in the Doring River, it would dilute the elevated TDS concentrations in the Olifants River resulting in lower TDS concentrations in the canals downstream of the transfer points.

Should this option warrant further investigation, it is strongly recommended that more accurate estimates of the TDS concentrations be made. Such an investigation should be supported by monitoring in the Olifants River between Bulshoek Weir and Lutzville to obtain better estimates of return flow salt loads from the different irrigation areas. The investigation should also consider the additional water demand required for leaching as a result of the higher salt concentrations in the irrigation water supplied to end-users.

d. Potential impacts on indigenous fish species

An investigation into the likely impact of low weirs in the Olifants River, at the described sites, was evaluated to estimate the impact it may have on fish movement.

Current status of the habitat downstream of Bulshoek Weir

Instream habitat for the indigenous fish species is severely degraded downstream of the Bulshoek Weir. A substantially attenuated flood regime as a result of regulation by Bulshoek Weir, reduced sediment supply and cultivation on flood terraces has transformed the river channel here from a braided system to a single-thread channel. Consequently, the main channel comprises a series of deep pools connected by shallow riffles and sandbed runs (dry for most of the low flow period) that have been invaded by reeds and palmiet. Connectivity between pools is thus limited over the migration period, preventing fish from accessing the little remaining suitable reproductive habitat. Intensive farming of the Olifants River floodplain downstream of the Doring River confluence to the estuary (90 km) has resulted in entrenchment of the river channel and reduced water quality. The Bulshoek Weir is an impassable barrier to fish, restricting access by fish in the lower Olifants River to potential spawning habitat upstream.

Fish distributions in the Lower Olifants and Doring Rivers

Redfin minnow (*Psuedobarbus phlegethon*, *Barbus calidus*) and Austroglanidid catfish (*Austroglanis gilli*, *Austraglanis barnardi*) populations are extinct in the Olifants River mainstem both upstream and downstream of Bulshoek. Clanwilliam yellowfish *Labeobarbus capensis* occur downstream of Bulshoek, and have been collected from Cascade Pools.

However, yellowfish occur in such low densities that it is unlikely that the lower Olifants River between the Bulshoek Weir and the estuary sustain viable populations of this species.

There are only two official reports of sawfin occurring in the mainstem of the lower Olifants River in the last 50 years: one caught in a tributary flowing into the Bulshoek reservoir in 1972 (**Figure 4.8**; collections database Albany Museum) and sawfin caught close to the mouth of the estuary in the 1980s (Day 1981). The latter were collected downstream of the weir at Olifantsdrif near the town of Lutzville, 15 km from the estuary mouth.

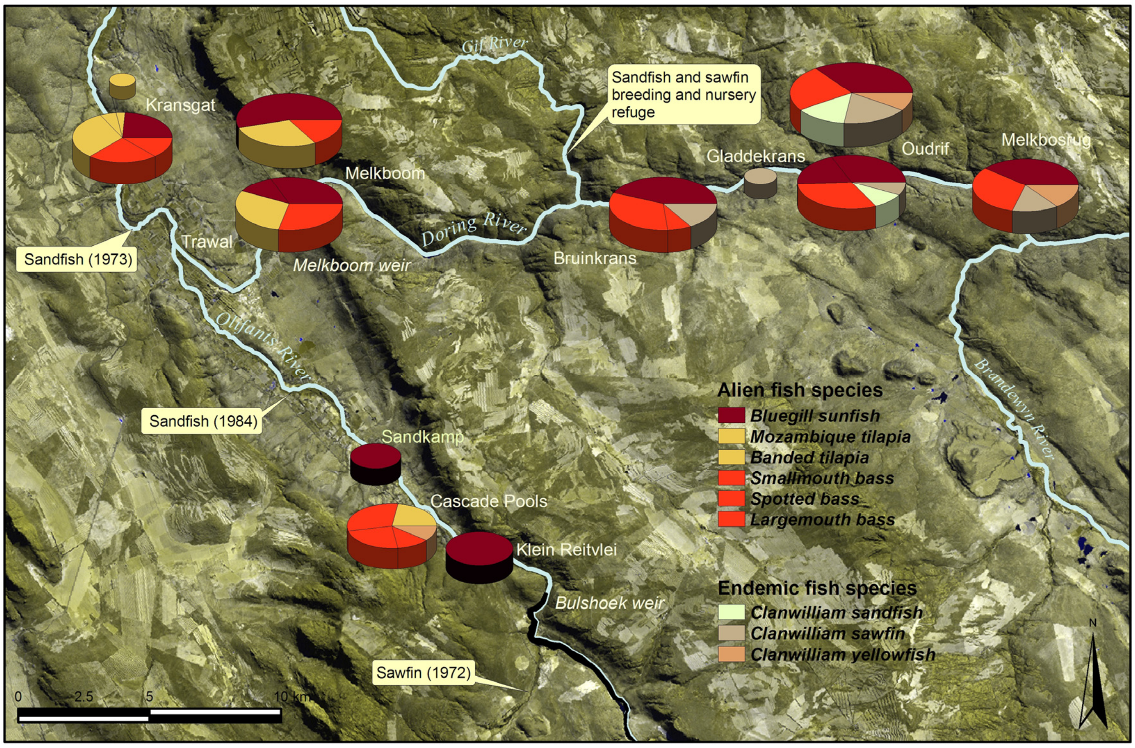


Figure 4.8 Proportional representation of alien and indigenous fish species abundances in the lower Olifants and Doring Rivers compiled from fish surveys conducted between 2001 and 2003 on the Doring River

Similarly, records of sandfish in the lower Olifants date from 1973. This sandfish was collected 3 km downstream of the confluence in the vicinity of Kransgat (**Figure 4.8).** The last sandfish to be collected from the lower Olifants River was caught in 1984 downstream of the Bulshoek Weir.

Recent surveys undertaken in the lower Olifants River (2001 – 2003) covered six sites between the Bulshoek Dam and the estuary and only two individuals representing an indigenous species – the Clanwilliam yellowfish – were caught at Cascade Pools (**Figure 4.8**; Paxton *et al*. 2002; PGWC 2004; Birkhead *et al*. 2005). In contrast, alien fish species were found to dominate the fish community in this part of the catchment. These species include: largemouth bass *Micropterus salmoides*; smallmouth bass *Micropterus dolomieu*, spotted bass *Micropterus dolomieu*; bluegill sunfish *Lepomis macrochirus,* as well as banded tilapia *Tilapia sparrmanii* and Mozambique tilapia *Oreochromis mossambicus*. In addition to these species it appears that sharptooth catfish *Clarias gariepinus* have been introduced into the Bulshoek Weir (Dean Impson, Cape Nature Conservation Board, *pers. comm*.).

In the lower reaches of the Doring River, Clanwilliam yellowfish were last recorded between Melkboom and the confluence in 1992 (**Figure 4.8**). However, further upstream the indigenous fish community in the Doring River is in comparatively better condition than the Olifants River with all three of the larger cyprinids (Clanwilliam yellowfish, sawfin and sandfish) occurring upstream of Bruinkrans (**Figure 4.8**). Although very limited recruitment takes place in the mainstem of the Doring, Bills (1998) identified the Gif River, 13 km upstream of Melkboom, as an important recruitment refuge for sawfin and sandfish. A single juvenile sandfish was captured at Melkboom in 2003 suggesting that individuals of this species may occasionally find their way into the Olifants River, but that these may be isolated instances due to the very high numbers of invasive species here.

Conclusions and recommendations: fish movement

The severely degraded instream habitat downstream of the Bulshoek Weir on the Olifants River has facilitated invasion and expansion of alien fish populations to the detriment of indigenous species. Unless the opportunity presents itself for improving conditions for the indigenous fish species, preserving fish connectivity between these reaches for the benefit of occasional migrants from the Doring River appears unnecessary. The construction of a weir at Trawal is therefore not expected to significantly compound the existing impacts to indigenous fish in the lower Olifants River. In some instances weirs may benefit local species where they prevent upstream invasion by alien species. However, invasion of downstream reaches is possible when the weir overtops during floods. Thus a weir will not prevent sharptooth catfish from invading the lower Olifants, and from there the Doring, should they find there way into the Olifants from the Bulshoek reservoir. Little is known about jump heights of indigenous fish, but amongst the larger species and during low flows it is unlikely to exceed 1.5 m. Weir height below this value would not appear to effect negotiability by fish. Weirs of 1.5 m or higher would only be negotiable to large fish at high flows and negotiability would depend on the site-specific details such as discharge, morphology of the river channel and the swimming ability of the fish.

e. Conclusions

The Karoovlakte option is less costly, as a shorter pipe section is required. Water quality is also significantly better for the Karoovlakte option, in comparison to the Vredendal option. If water for the Vredendal option can also be pumped at the Karoovlakte abstraction point, and there is adequate capacity downstream in the canal for conveyance, water quality would be just acceptable. The Vredendal option would also necessitate a higher leaching %. The Karoovlakte option is definitely the better of the two.

The additional input costs may mean that new farms could become unprofitable, while expansions of existing farms may be marginal, but an investigation into the financial viability would be needed, to clarify whether this is so.

4.4.11 Zypherfontein Irrigation Scheme

A potential development area has been identified just upstream of the confluence of the Doring and Olifants Rivers. The potential irrigation area, situated adjacent to the Olifants River, is approximately 1 200 ha in size. A map showing the position of the proposed area is shown in **Figure 4.9**. It is envisaged that the scheme could be developed as a large-scale irrigation scheme for previously disadvantaged farmers.

There are a multitude of crop types and scheme options which could be considered for developing this area into a large-scale irrigation scheme. For the purposes of this report, a very broad-brush approach was taken to get a feel for the costs involved in establishing bulk water supply from the Olifants River to possible irrigation blocks. It was decided to base the proposed scheme on a scheme with predominantly wine grapes supplemented by tomatoes. If this water use option were found to be favourable, further more detailed study would be required to establish the most suitable crop types for the scheme.

The crop water requirements used to calculate the irrigation system capacity were the same as the requirements used for the Melkboom/Trawal typical farm options, as discussed in **Section 4.4.1** above. These requirements are more than likely higher than what the actual requirements would be, which should result in a conservative indication of the overall costs involved in establishing the bulk water supply.

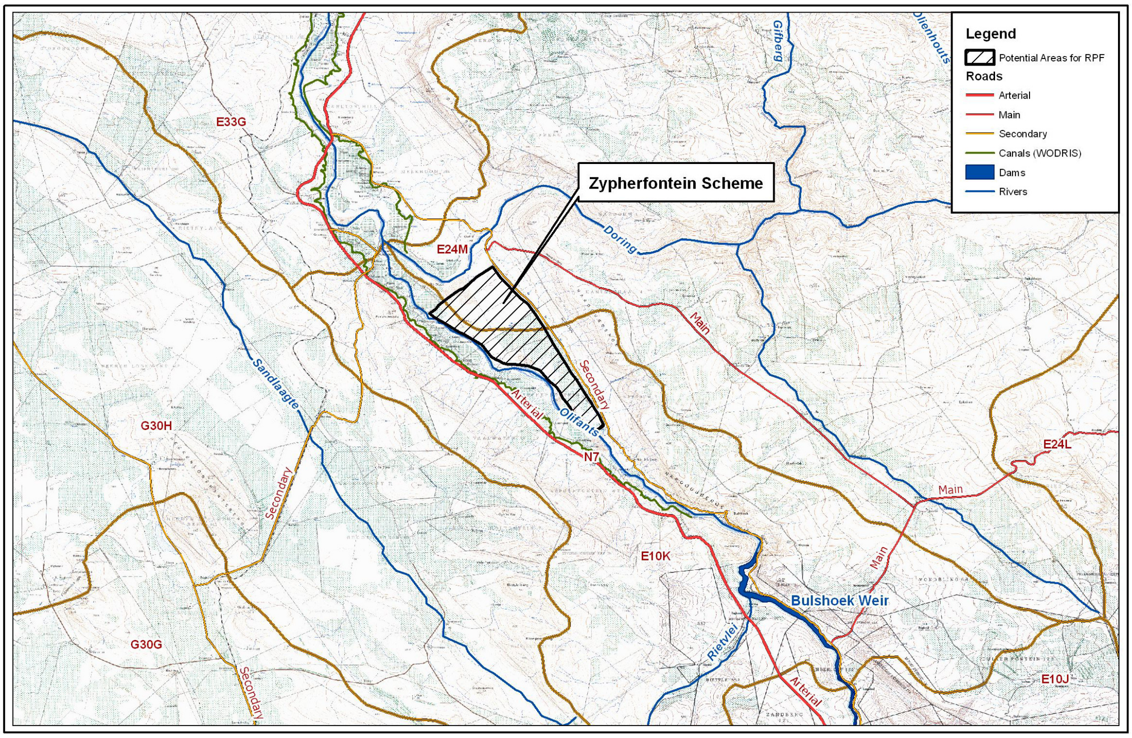


Figure 4.9 Location of the Zypherfontein Scheme

The reader should also consider that the proposed scheme, which the costings were based on, assumes that the irrigation water would be pumped from the river to the irrigation blocks. Further detailed investigations may result in a more economical method of transferring bulk water to the irrigation blocks, such as a combination of low lift pumps and canals.

The pumping heads were estimated using the contours on the 1:50 000 topographic map and the following design parameters were assumed:

- Cycle length = 7 days
- Type of irrigation - Grapes/Tomatoes = Drip
- Irrigation efficiency - Grapes/Tomatoes = 95%

The area was broken up into three irrigation blocks, each having its own pump station and network of mainlines. The block sizes and design flow rate estimates are detailed below:

- Block 1 = 598 ha, 3852 m^3/h;
- Block 2 = 295 ha, 1900 m^3/h;
- Block 3 = 295 ha, 1900 m^3/h.

The detailed design discharge calculation sheets for the three blocks are attached in **Appendix F.** The results of the costings are summarised below. More detail can be found in **Appendix F**.

Table 4.11 Zypherfontein Irrigation Scheme: Bulk Water Costing Summary

BLOCK 1	**Estimate**
598 ha Table Grapes	
Pumping Size	677 kW
Mainline Length	6,780 m
Irrigation Pumps and Mainlines Cost Estimate	R 22,719,000
	R 37,992 /ha
BLOCK 2	
295 ha Table Grapes	
Pumping Size	314 kW
Mainline Length	2,180 m
Irrigation Pumps and Mainlines Cost Estimate	R 10,449,000
	R 35,420 /ha
BLOCK 3	
295 ha Table Grapes	
Pumping Size	282 kW
Mainline Length	3,200 m
Irrigation Pumps and Mainlines Cost Estimate	R 10,453,000
	R 35,434 /ha
TOTAL BULK WATER SUPPLY CAPITAL COST ESTIMATE	R 43,621,000

This scheme of 1 188 ha would therefore have an average capital cost for bulk infrastructure of R36,718/ha. This cost gives an order of magnitude for what could be expected, however, if this scheme is seen as a potential scheme, a more detailed analysis needs to be undertaken to determine the viability of the scheme.

Depending on crop type, such a scheme would likely be viable, but a further, more detailed investigation into financial viability is needed. Selection of crop type, and the potential for the crop market to assimilate the additional produce would be critical.

4.4.12 Ebenhaezer community supply

The Ebenhaezer families were moved from Lutzville to the current location, further down the Olifants River near the estuary, at the end of the canal system. The community recently won a breakthrough land claim to the value of R100 million, involving 53 private owners (Business Report, March 17, 2005). The claim is to be awarded over a period of 5 years, in terms of a development plan, which was to be formulated during 2006. There are hopes to enable the community to return to some of the more fertile land along the Olifants River from which they were removed. This, along with the repair of the Ebenhaezer canal and the construction of a balancing dam of 140 000 m^3 in 2003, should result in the upliftment of the community. According to LORWUA, about 3 million m^3 passed through the balancing dam in the previous year, which was already an improvement. The total population is estimated at 3 500 people, mostly coloured, Afrikaans speaking descendants of the original Ebenhaezer families.

According to the socio-economics study conducted by Anchor Environmental Consultants (2006), the new location of 1925 did not enjoy the same agricultural potential due to soil characteristics.

Nonetheless, 257 ha of irrigable land were divided among the then-150 residents. These divided plots were too small for commercial agriculture and, with time, and increased salinisation levels, farming activities have ceased, apart from a few small subsistence farming activities. Maintenance is inadequate and there is strife between users. Economic activity in Ebenhaezer is declining.

Ebenhaezer residents rely on subsistence farming and fishing. According to Anchor Environmental Consultants, approximately 33% of households are involved in subsistence farming, growing potatoes, sweet potatoes, beans, pumpkin, onions and seasonal garden vegetables. The remaining two thirds of households either do not have access to suitable land, or lack the capital and tools necessary for start-up. Approximately 18% of households have some form of livestock. Improved management of these activities is needed in order to realise the full potential of the area.

The experience of previous equity projects has shown that unemployment and the provision of water for irrigation is insufficient to motivate for successful agricultural development. In the Ebenhaezer community, for example, there has been little productive irrigated agriculture taking place, despite having sufficient access to land and a substantial entitlement to water (Seshoka *et al.*, 2004). It is hoped that the community's recent successful land claims settlement and the construction of a balancing dam will lead to a more productive use of the allocated water.

A recent study on soil characteristics showed that Ebenhaezer has good soil, as well as an adequate water supply. Jan Lambrechts of the University of Stellenbosch has conducted studies in the area and notes that the soil is of a similar quality to that on which the surrounding irrigation farmers are irrigating, although management of the irrigation systems at Ebenhaezer may need improvement.

It can be concluded that there is adequate land and water available, and that the current water supply is under-utilised. The provision of water through unlined canals that are not properly maintained is not deemed acceptable, and some users do not receive an adequate supply. There is a need to investigate the potential to supply each of the plots with a reliable supply of water. Such an initiative should be taken up by the LORWUA, but it is likely that Government funding would have to be sought. Better agricultural and community management is also needed to realise the full social and economic potential of the area.

5. OTHER USERS

The total listed use from the LORGWS for all non-agricultural use is 8.4 million m^3/a. Current use is about 60% of listed use. It is recommended that future growth be accommodated.

5.1 Domestic water use on farms

About 480 farms receive untreated water for domestic use or irrigation of gardens on farms, via 20 mm off-takes from the canal, which could amount to 2.4 million m^3/a, at 5 000 m^3/a each.

5.2 Urban and industrial use

The Lower Olifants River Government Water Scheme supplies raw water for domestic and industrial use to the towns of Vredendal, Lutzville, Vanrhynsdorp, Klawer, Ebenhaezer, Strandfontein and Doringbaai, and to the Namakwa Sands Mine, and, in small quantities, to several wine cellars and a number of small mining activities in the form of gypsum, lime, marble and granite quarries.

Klawer has a licence to abstract 0.95 million m^3/a from the canal on the right bank of the Olifants River, which is used for both irrigation and domestic, commercial and industrial use. Vredendal, as well as supplying consumers within the town, also supplies Vanrhynsdorp and domestic consumers in areas adjacent to Vredendal. Lutzville abstracts from the canal system.

Ebenhaezer, Strandfontein and Doringbaai are supplied with potable water by a scheme operated by the West Coast District Council. Water is abstracted from the canal system near Ebenhaezer and distributed to the towns and consumers in the surrounding area.

A few light industries receive individual water supplies from the Olifants Canal.

There has been a positive, but slow, growth rate for the West Coast (average of 2.35% per annum over the past 11 year period), Cederberg (2.81%) and Matzikama (1.27%), between 1995 and 2006.

There is currently an increase in the growth of other small industrial demands in the Vredendal area. Increasing the allocation of water to these emerging Small, Micro and Medium Enterprises, mainly through increasing the allocation to the Municipality, must be considered in the light of promoting local economic development in the area, and provision must be made for this. Planning must allow for possible growth trends. Having said this, urban and light industries are not large individual users of water in the area. It is unlikely that such use will compete significantly with agriculture for any additional water made available by the raising of the dam wall.

There has been a request by Elands Bay and Lamberts Bay, during the public process of this study, to receive water from the LORGWS.

5.3 Mining

The Namakwa Sands Mine, a heavy metal mining operation, has a licence to abstract 2.38 million m^3/a from the right bank canal of the LORGWS at a point some 10 km north of Lutzville. The water is diverted to a 140 Ml storage dam whence some of it is pumped to a mineral separation plant approximately 6 km from the canal abstraction point, and the rest is pumped to the mine on the coast, some 40 km north-west of the abstraction point, via a 47 km long pipeline. The maximum freshwater requirement of the mine would be 2.8 million m^3/a.

The difference between the 2.38 million m^3/a allowed by the licence and the 2.8 million m^3/a that is required is made up by using an irrigation allocation under the LORGWS for a farm owned by the mining company.

Due to the location of the mine's off-take from the canal, it is unlikely that they could receive an increased allocation. They have recently instituted water demand management initiatives.

5.4 Hydro-power

A small hydro-power station is situated at Clanwilliam Dam. It uses water released for irrigation to generate some of the electricity requirements of the town of Clanwilliam. The electricity is sold under agreement to the Clanwilliam Town Council. Although hydro-power generation uses a substantial amount of water, it is secondary use from water that is released from the Dam through the turbine on its way to being used for other purposes downstream and is not, therefore, regarded in water balance calculations and future requirements. When the study commenced in 2005 the hydro-power station was non-functional and appeared to be decommissioned. However, the hydro-power station, which is privately owned, has recently been refurbished. A raising of the dam can be expected to increase the hydro-power generation capability of the existing station.

6. FINDINGS

The main conclusions that can be drawn are discussed under the following headings:

6.1 Availability of land, crops and requirements for irrigation

i) It can be deduced that the availability of land with suitable soil for irrigated agriculture is not a limiting factor to the expansion of irrigation in the study area. Due to the advanced farming technology and management skills that exist in the intensely developed sections of the basin, most of the inherent soil limitations do not pose any serious constraints on irrigation development.

ii) Permanent crops make up 80% of the planted area and cash crops (20 %) are mainly grown in the winter. There are a variety of cash crops, with vegetables and wheat being the significant cash crops. Vineyards for the producing of wine and citrus are the main permanent crops. Drip is the method of irrigation for most of the permanent crops. The irrigation systems used in the area are centre pivots, drip systems, micro sprinklers and flood irrigation.

iii) The net average irrigation requirement (excluding leaching requirement) increases from 850 – 1000 mm in the Keerom to Bulshoek Weir section to 1 000 - 1 200 mm in the Bulshoek Weir to the coast section. Peak monthly net irrigation water requirement increases from 200 mm/month in the upper to a maximum of 225 mm/month in the lower Olifants River Basin. A leaching component of 10% to 20% is recommended for saline soils in the drier areas.

6.2 Increased assurance of supply of the LORGWS

iv) Farmers currently receive water at an unacceptably low assurance of supply. The yield analysis undertaken for this study estimates current assurance of supply at around the 1:10 year level, although it may be lower in practice. LORWUA has expressed the need to increase the overall assurance of supply for the LORGWS. This would benefit current and future irrigators during periods of drought and provide for more assured agricultural planning, so that they can be certain of obtaining preferably their full quota, but at least an increased percentage of their quota in very dry years. This could have a significant socio-economic benefit to the area.

6.3 Region 1: Area upstream of Clanwilliam Dam

v) **Expansion of existing farms or new farms (from river and off-channel dams)**
The expansion of citrus farming upstream of the Clanwilliam Dam (i.e. irrigation development on individual farms), or the development of new farms is not envisaged to

be profitable, mainly due to the expected relatively high cost of irrigation infrastructure, specifically the need for off-channel farm dams, as farmers are relying on run-of-river flow. There may though be opportunities for some farmers who wish to fully utilise infrastructure.

vi) **Rosendaal Dam, as alternative combined balancing dam**

The proposed Rosendaal Dam, if built, would provide storage for winter water, to be released for use in summer. Existing infrastructure could be utilised by the Citrusdal WUA. However, similar infrastructure would need to be provided for new users. The farmers downstream of this potential dam, but upstream of the Clanwilliam Dam, would benefit from the additional storage provided by the proposed dam, as an alternative to building many small additional farm dams. The dam would have to make provision for the ecological Reserve, which would have to be more accurately determined, to be able to refine the cost estimate and available yield. If Clanwilliam Dam would be raised, the viability of building another dam on the Olifants River would diminish.

The dam could potentially increase the yield to upper-Olifants irrigators, as well as increasing their assurance of supply. Release of irrigation water from Rosendaal Dam 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.

6.4 Region 2: Area downstream of Clanwilliam Dam, and upstream of Bulshoek Weir

vii) **Expansion of existing farms, or development of new farms (pumping from river)**

This area has the advantage that users are not reliant on bulk distribution infrastructure. Water can be pumped directly from the river for irrigation, because their water is stored in the Dam upstream. Farmers in this area have sound experience and thus know-how as far as the production and marketing strategies of the potato branch is concerned. It seems to be a viable option to expand existing citrus farms in this region, in combination with potato production (real IRR of 6.38% per year). Year cropping (i.e. potato production in this case) can have a considerable positive effect on the cash flow of farms. The establishment of new farms is marginally profitable (real IRR of 4.19% per year).

6.5 Region 3: Area downstream of Bulshoek Weir to the estuary

viii) **Expansion of existing farms, or development of new farms in the Melkboom/ Trawal area (pumping from canal)**

The typical mixed farming situation in the Melkboom/Trawal region is at present under financial stress. Possible contributing factors to this finding are, inter alia:

- Relatively small farms (i.e. 35 ha relative to 60 ha in Klawer/Vredendal) and thus the negative impact of higher unit overhead costs;
- A decline in prices as far as the main enterprise, i.e. wine grapes is concerned.

The analysis further shows that an expansion of the mixed farming situation in Melkboom/Trawal to 50 ha should lead to increased profitability (i.e. a real IRR of 5.42% per year).

The expansion of table grape farming in the Melkboom/Trawal region seems to be the most viable option in the study area, from a financial point of view, and should be pursued (real IRR of 28.76% per year).

ix) **Expansion of existing farms, or development of new farms in the Klawer/Vredendal area (pumping from canal)**

The expansion of existing irrigation farming in the Klawer/Vredendal region would be profitable for:

- Mixed farming, i.e. wine grapes and tomatoes (real IRR of 10.26% per year); and
- Table grape farming (real IRR of 11.24% per year).

New irrigation farms in the Klawer/Vredendal region, would be marginally profitable but is not recommended, as it would not be affordable, for:

- A new mixed farm, i.e. wine grapes and tomatoes (real IRR of 4.93% per year);
- A new table grape farm (real IRR of 5.24% per year).

x) **Additional water supplied through the current main canal**

Under the present method of operation (i.e. 5 day irrigation week), there is very little scope to release more water through the Trawal canal section during the peak demand month of January. As a result, the option of releasing additional water down the canal for direct use is not particularly viable unless the farmers can be motivated to operate 6 days a week during periods of peak demand. One way of using more water would be to introduce alternative crop types that have a different water requirement, with peak demands at different times to those currently grown. This option is however not popular with farmers, because of the high risk involved in ensuring that there is a reliable market available for the alternative crops at the right time.

xi) **Increasing the capacity of the canal system by raising the canal**

If the canal had a larger carrying capacity, more water could be made available for irrigation downstream of Bulshoek Weir. The new sections would otherwise have to be joined to and supported by the existing badly degraded concrete lining, which is not advisable. Therefore, it is not recommended that the canal profile should be increased in order to increase its capacity.

xii) **Replacement of the canal system**

The cost estimate for lining the entire canal (pre-cast concrete lining or cast concrete) is extremely high and certainly does not seem feasible, however, it may be worthwhile investigating the costs of replacing certain portions of the canal on an annual basis. The option of a steel pipe as alternative implies a pipe with a very large diameter. It may, however, be impractical to implement this option, as it would mean closing down the scheme, possibly for years, and it is likely to be very expensive.

xiii) **Reducing losses in the canal / refurbishment of the canal system**

Undertaking of short-term and medium-term repairs is regarded as essential, as not doing so would impinge on the functionality of the scheme. This would increase operational costs, but there is likely no alternative. This option would also have the benefit of limiting losses from the canal.

xiv) **Provision of a additional balancing dam/s along the canal**

Should a large balancing dam be built somewhere along the canal system, it would increase the yield of the system, or the assurance of supply. A significant benefit may be realised during a drought. Having to pump water from the dam into the canal system would add to the cost. Although no specific site has yet been identified for this option, it is at face value believed to be a costly option. The Provincial Department of Agriculture is in support of further investigation of this option.

xv) **Additional farm dams along canal**

This option could increase the yield from the system, although it is not considered to have much potential, mainly as a result of the limited land availability due to the small farm sizes.

xvi) **Releasing water downriver from Bulshoek and pumping into canal sections to use spare capacity in identified canal sections**

This option could utilise the spare capacity in the canal, created by abstractions further upstream, for additional irrigation, either to expand current irrigation or potentially for new irrigation. A disadvantage is the poorer water quality, as a result of mixing in the river with Doring River water, compared to current water quality. This would not be a problem for the Karoovlakte option, where the quality would be acceptable, but the water quality for the Vredendal option would potentially not be acceptable to farmers. The Vredendal option would also necessitate a higher leaching percentage. The additional infrastructure and need to pump would lead to increased input costs. As a result, the establishment of new farms may become unprofitable, while the expansion of existing irrigation may be marginal. Further investigation into the financial viability of this option, as a result of the increased input cost, would be needed.

xvii) **Zypherfontein Irrigation Scheme**

The Zypherfontein Scheme provides an option for a large new development downstream of Bulshoek Weir, but above the confluence with the Doring River, to avoid poorer water quality. While schemes that include resource-poor farmers may be phased in over time, this provides an opportunity for much faster uptake of the water. LORWUA has indicated that it would strongly support such a scheme. The specific crops to be planted could be critical and need to be carefully assessed. Because it is a large scheme, with much of the irrigation scheme located further away from the river, costs are expected to be slightly higher than for small schemes located closer to the river. There may however be other, smaller, benefits in the scale of the project. Depending on crop type, such a scheme would likely be viable, but a further, more detailed investigation into financial viability is needed.

xviii) **Ebenhaezer community supply**

Available suitable land and bulk water supply for irrigation is for now adequate. The current water supply is under-utilised. Internal distribution of irrigation water through unlined canals that are not properly maintained, is deemed unacceptable, and requires attention. There is a need to investigate the potential to supply each of the plots with a reliable supply of water, and better agricultural and community management is needed.

6.6 Provision of water to non-agricultural users

xix) The total listed use from the LORGWS for all non-agricultural use is 8.4 million m^3/a. Current use is about 60% of listed use. It is recommended that future growth be accommodated.

7. RECOMMENDATIONS

Based on the findings, the following recommendations are made:

i) Because the availability of land with suitable soil for irrigated agriculture is not a limiting factor to the expansion of irrigation in the study area, the further identification of suitable farms or projects to potentially take up additional water can to a large extent be left to the implementing agency and the potential users of future water requirements, although potential resource-poor farmers would need specific support. Final cost estimates of specific development options must be obtained, based on the cost of the dam, and the available yield for allocation to new irrigation development. Exclude any possible options based on other considerations.

ii) Because the findings in this study, on financial viability of irrigation farming for different study areas and crop mixes, were based on average cost inputs, for typical farms and market conditions, at a specific time, any potential identified opportunities for future irrigation would need to be evaluated in terms of the conditions and costs relating to that specific opportunity.

iii) The LORWUA should indicate to what extent they wish to take up a portion of the increased yield of the LORGWS, to improve the assurance of supply of the scheme.

iv) Establish an Olifants River Development Agency, or other relevant implementation vehicle, which could vary in scale of influence, to:

- Develop a common vision for the catchment/scheme;
- Identify possible development opportunities and partnerships;
- Develop an allocation schedule and business plan for ensuring the support of resource poor farmer and other broad based black economic empowerment opportunities;
- Co-ordinate and support the proposed developments;
- Monitor the progress of the proposed developments and make changes when necessary or in reaction to new opportunities.

v) A business plan for the uptake of additional yield from a raised Clanwilliam Dam should address:

- Funding and cost-related issues;
- Salient features of the raised dam scheme and a summary of the most relevant other supporting information from this study;
- How to meet the objectives of water allocation reform;
- Recommended models for the allocation of water;
- How to convey the message on opportunities to potential future users;
- Mechanisms of support for potential resource-poor farmers;
- A guideline for potential applicants;
- Clarification of the roles and responsibilities that various Government organisations and other organisations would have;
- The proposed implementation vehicle to guide the uptake of additional water, such as, for example, a Development Corporation.

vi) Develop a clear mandate on how the additional water will be allocated.

vii) A desktop or pre-feasibility study should be undertaken into the potential for one (or more) large new scheme for the uptake of additional yield, such as the Zypherfontein Scheme, for example. While such a scheme presents the opportunity to settle a larger number of resource-poor farmers on land simultaneously, there may be many pitfalls and sensitivities that need to be carefully unpacked and evaluated.

viii) Applications from non-agricultural users would have to be evaluated on merit, but some allowance should be made for future uptake of non-agricultural use. The uptake for non-agricultural use that can benefit the poor would need special attention to ensure that it does not fall through the cracks.

ix) The potential raising of Clanwilliam Dam provides a unique opportunity for water to be used successfully to promote water reform and the development of previously disadvantaged individuals in the area. This will, however, not be an easy process as it is important to consider a range of opportunities. This will require a substantial commitment from the DWAF and other spheres of government.

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APPENDIX A

Typical Scheme Inputs and Cost Summaries : Citrusdal Area

400415 - Clanwilliam Dam - Irrigation Schemes

Irrigation Requirement

Area	**Citrusdal**	**New Farm**
Land Size	70.00	ha
Crop 1	Citrus	
Area 1	70.00	ha
Allocation 1	12000	m3/ha
Crop 2	-	
Area 2	0.00	ha
Allocation 2	0.00	mm
Block Size (A_t)	10.00	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Micro	
Irrigation Efficiency	90%	
Total Irrigation requ per year	1138	mm
Max nett Irrigation Requ (NIR_m)	225	mm/month
NIR_d	7	mm/day
Cycle Length (t_c)	7	days
NIR_c	51	
GIR_c	57	mm/cycle
System Flow (m3/h)	236	m^3/h
System Flow (l/s)	66	l/s

Assumptions

Crop Water requirements

See report : Feasibility Study for the Raising of Clanwilliam Dam

Crop water requirement	From Table 3.2, pg 53
Max monthly requirement	From Table 3.4, pg 54

Dams

Water balance for storage calculation

Water allocation (m3/a)	840,000	m3
Percentage Storage allowance	60%	
Current allowable storage volume	504,000	m3

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**Citrusdal**	**New Farm**
Irrigated area	70	ha
Crop 1	70	Citrus
Crop 2	0	-
System Flow Rate	236	m^3/h
Distance from River to Dam	200	m
Elevation from River to Dam	20	m
Distance from Dam to Field	100	m
Elevation from Dam to Field	15	m

		Conservative Estimate	**Not so conservative estimate**
IRRIGATION PUMPS			
Cost Estimates		Amount	
Pump station	27 kW	R 412,000	
Pipeline - 250 mm	100 m	R 76,000	
Total Irrigation Mainlines Cost Estimate		R 488,000	R 488,000
RIVER PUMPS			
Cost Estimates		Amount	
Pump station	10 kW	R 184,000	
Pipeline - 200 mm	200 m	R 114,000	
Total Capital Cost Estimate		R 298,000	R 298,000
DAM			
Storage to Embankment ratio 1:		3	4
Storage		504,000 m^3	504000 m^3
Embankment Volume		168,000 m^3	126000 m^3
Total Dam Cost Estimate	R 40 /m^3 all-in	R 6,720,000	R 5,040,000
TOTAL CAPITAL COST		**R 7,506,000**	**R 5,826,000**
Total cost per hectare - Bulk Water Supply		R 107,229 /ha	R 83,229 /ha

OPERATING COSTS		**Irrigation**	**River Pumps**
Mechanical and Electrical	4% per annum	R 9,000	R 4,000
Civils	0.25% per annum	R 300	R 200
Pipeline	0.50% per annum	R 400	R 400
Dam	0.20% per annum	R 13,440	R 13,440
Electricity	20 c/kWh	R 18,000	R 13,000
		R 41,140	R 31,040
Total operating costs for Bulk Supply (R/annum)		**R 72,180**	

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**Citrusdal**	**Expansion**
Irrigated area	20	ha
Crop 1	20	Citrus
Crop 2	0	-
System Flow Rate	68	m^3/h
Distance from River to Dam	200	m
Elevation from River to Dam	20	m
Distance from Dam to Field	100	m
Elevation from Dam to Field	15	m

			Conservative Estimate	**Not so conservative estimate**
IRRIGATION PUMPS				
Cost Estimates			Amount	
Pump station	7.7	kW	R 124,000	
Pipeline - 150 mm	100	m	R 43,000	
Total Irrigation Mainlines Cost Estimate			R 167,000	R 167,000
RIVER PUMPS				
Cost Estimates			Amount	
Pump station	3.5	kW	R 65,000	
Pipeline - 100 mm	200	m	R 59,000	
Total Capital Cost Estimate			R 124,000	R 124,000
DAM				
Storage to Embankment ratio 1:			3	4
Storage			144,000	144000
Embankment Volume			48,000	36000
Total Dam Cost Estimate	R 32	$/m^3$ all-in	R 1,536,000	R 1,152,000
TOTAL CAPITAL COST			**R 1,827,000**	**R 1,443,000**
Total cost per hectare - Bulk Water Supply			R 91,350	R 72,150 /ha

			Irrigation	**River Pumps**
OPERATING COSTS				
Mechanical and Electrical	4%	per annum	R 3,000	R 2,000
Civils	0.25%	per annum	R 100	R 100
Pipeline	0.50%	per annum	R 300	R 300
Dam	0.20%	per annum	R 3,072	R 3,072
Electricity	20	c/kWh	R 6,000	R 5,000
			R 12,472	R 10,472
Total operating costs for Bulk Supply (R/annum)			**R 22,944**	

Note: The rate per m^3 for the dam was lowered from $R40/m^3$ to $R32/m^3$ due to the smaller dam size

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

Area	**Citrusdal**	**Expansion**
Land Size	20.00	ha
Crop 1	Citrus	
Area 1	20.00	ha
Allocation 1	12000	m3/ha
Crop 2	-	
Area 2	0.00	ha
Allocation 2	0.00	mm
Block Size (A_t)	2.86	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Micro	
Irrigation Efficiency	90%	
Total Irrigation requ per year	1138	mm
Max nett Irrigation Requ (NIR_m)	225	mm/month
NIR_d	7	mm/day
Cycle Length (t_c)	7	days
NIR_c	51	
GIR_c	57	mm/cycle
System Flow (m3/h)	68	m^3/h
System Flow (l/s)	**19**	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Crop water requirement	From Table 3.2, pg 53
Max monthly requirement	From Table 3.4, pg 54

Dams
Water balance for storage calculation

Water allocation (m3/a)	240,000	m3
Percentage Storage allowance	60%	
Current allowable storage volume	144,000	m3

APPENDIX B

Typical Scheme Inputs and Cost Summaries : Clanwilliam Area

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

Area	**CLANWILLIAM**		
Land Size	100.00	ha	
Crop 1	Citrus		
Area 1	50.00	ha	
Crop 2	Potatoes		
Area 2	50.00	ha	

	Citrus	Potatoes	
Block Size (A_t)	7.14	25.00	ha
Operating hours per day	24	24	hr/day
Operating hours per cycle	168	48	hr
Irrigation Type	Micro	Pivot	
Irrigation Efficiency	90%	85%	
Total Irrigation requ per year	971	550	mm
Max nett Irrigation Requ (NIR_m)	225	222	mm/month
NIR_d	7	7	mm/day
Cycle Length (t_c)	7	2	days
NIR_c	51	14	
GIR_c	57	17	mm/cycle
System Flow (m3/h)	169	177	m^3/h
System Flow (l/s)	**47**	**50**	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Crop water requirement	Potatoes - Sapwat - Augsberg station Citrus - From Table 3.2, pg 53
Max monthly requirement	Potatoes - Sapwat - Augsberg station Citrus - From Table 3.4, pg 54

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**CLANWILLIAM**	**New Farm**
Irrigated area	100	ha
Crop 1	50	Citrus
Crop 2	50	Potatoes
Total System Flow Rate	346	m^3/h
Distance from River to Field	200	m
Elevation from River to Field	30	m

IRRIGATION PUMPS

Citrus

Cost Estimates			Amount
Pump station	29	kW	R 476,000
Pipeline - 200 mm	200	m	R 114,000
Citrus Irrigation Mainlines Cost Estimate			**R 590,000**
			R 11,800 /ha

Potatoes

Cost Estimates			Amount
Pump station	31	kW	R 503,000
Pipeline - 200 mm	200	m	R 114,000
Potatoes Irrigation Mainlines Cost Estimate			**R 617,000**
			R 12,340 /ha

OPERATING COSTS			**Citrus**	**Potatoes**
Mechanical and Electrical	4%	per annum	R 10,000	R 11,000
Civils	0.25%	per annum	R 400	R 400
Pipeline	0.50%	per annum	R 600	R 0
Electricity	20	c/kWh	R 17,000	R 10,000
Total operating costs for Mainline (R/annum)			**R 28,000**	**R 21,400**
			R 49,400	

400415 - Clanwilliam Dam - Irrigation Schemes

Irrigation Requirement

Area	**CLANWILLIAM**	Expansion
Land Size	45.00	ha
Crop 1	Citrus	
Area 1	20.00	ha
Crop 2	Potatoes	
Area 2	25.00	ha

	Citrus	Potatoes	
Block Size (A_t)	2.86	12.50	ha
Operating hours per day	24	24	hr/day
Operating hours per cycle	168	48	hr
Irrigation Type	Micro	Pivot	
Irrigation Efficiency	90%	85%	
Total Irrigation requ per year	971	550	mm
Max nett Irrigation Requ (NIR_m)	225	222	mm/month
NIR_d	7	7	mm/day
Cycle Length (t_c)	7	2	days
NIR_c	51	14	
GIR_c	57	17	mm/cycle
System Flow (m3/h)	68	89	m^3/h
System Flow (l/s)	**19**	**25**	l/s

Assumptions

Crop Water requirements

See report : Feasibility Study for the Raising of Clanwilliam Dam

Crop water requirement	Potatoes - Sapwat - Augsberg station
	Citrus - From Table 3.2, pg 53
Max monthly requirement	Potatoes - Sapwat - Augsberg station
	Citrus - From Table 3.4, pg 54

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**CLANWILLIAM**	**Expansion**
Irrigated area	45	ha
Crop 1	20	Citrus
Crop 2	25	Potatoes
Total System Flow Rate	157	m^3/h
Distance from River to Field	400	m
Elevation from River to Field	30	m

IRRIGATION PUMPS

Citrus

Cost Estimates			Amount
Pump station	12	kW	R 185,000
Pipeline - 150 mm	400	m	R 169,000
Citrus Irrigation Mainlines Cost Estimate			**R 354,000**
			R 17,700 /ha

Potatoes

Cost Estimates			Amount
Pump station	17	kW	R 249,000
Pipeline - 150 mm	400	m	R 169,000
Potatoes Irrigation Mainlines Cost Estimate			**R 418,000**
			R 16,720 /ha

OPERATING COSTS			**Citrus**	**Potatoes**
Mechanical and Electrical	4%	per annum	R 5,000	R 6,000
Civils	0.25%	per annum	R 200	R 200
Pipeline	0.50%	per annum	R 900	R 900
Electricity	20	c/kWh	R 7,000	R 6,000
Total operating costs for Mainline (R/annum)			**R 13,100**	**R 13,100**
			R 26,200	

APPENDIX C

Typical Scheme Inputs and Cost Summaries : Melkboom/Trawal Area

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	New Farm	
Area	**MELKBOOM/TRAVAL**	
Land Size	25.00	ha
Crop	Table grapes	
Area	25.00	ha
	Table grapes	
Block Size (A_t)	3.57	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	930	mm
Max nett Irrigation Requ (NIR_m)	238	mm/month
NIR_d	8	mm/day
Cycle Length (t_c)	7	days
NIR_c	54	
GIR_c	57	mm/cycle
System Flow (m3/h)	85	m^3/h
System Flow (l/s)	24	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Table Grapes - Crop water requirem Table 3.2 pg 53 - Saayman
Table Grapes - Max monthly require Table 3.4 pg 54 - Saayman

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**MELKBOOM /TRAVAL**	**New Farm**
Irrigated area	25	ha
Crop 1	25	Table grapes
Total System Flow Rate	85	m^3/h
Distance from River to Field	200	m
Elevation from River to Field	30	m

IRRIGATION PUMPS AND PIPELINES

Cost Estimates			Amount	
Pump station	15	kW	R 230,000	
Pipeline - 150 mm	200	m	R 86,000	
Irrigation Mainlines Cost Estimate			**R 316,000**	
			R 12,640	/ha

OPERATING COSTS			
Mechanical and Electrical	4%	per annum	R 6,000
Civils	0.25%	per annum	R 200
Pipeline	0.50%	per annum	R 500
Electricity	20	c/kWh	R 8,000
Total operating costs for Mainline (R/annum)			**R 14,700**

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	Expansion	
Area	**MELKBOOM/TRAVAL**	
Land Size	5.00	ha
Crop	Table grapes	
Area	5.00	ha

Design for Wine grapes as one system

	Table grapes	
Block Size (A_t)	0.71	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	930	mm
Max nett Irrigation Requ (NIR_m)	238	mm/month
NIR_d	8	mm/day
Cycle Length (t_c)	7	days
NIR_c	54	
GIR_c	57	mm/cycle
System Flow (m3/h)	17	m^3/h
System Flow (l/s)	**5**	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Table Grapes - Crop water requirem Table 3.2 pg 53 - Saayman
Table Grapes - Max monthly require Table 3.4 pg 54 - Saayman

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**MELKBOOM/TRAVAL**	**Expansion**
Irrigated area	5	ha
Crop	5	Table grapes
Total System Flow Rate	17	m^3/h
Distance from River to Field	200	m
Elevation from River to Field	30	m

IRRIGATION PUMPS AND PIPELINES

Cost Estimates			Amount
Pump station	3	kW	R 49,000
Pipeline - 90 mm	200	m	R 53,000
Irrigation Mainlines Cost Estimate			**R 102,000**
			R 20,400 /ha

OPERATING COSTS

Mechanical and Electrical	4%	per annum	R 2,000
Civils	0.25%	per annum	R 100
Pipeline	0.50%	per annum	R 300
Electricity	20	c/kWh	R 2,000
Total operating costs for Mainline (R/annum)			**R 4,400**

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	New Farm	
Area	**MELKBOOM/TRAVAL**	
Land Size	50.00	ha
Crop 1	Tomatoes	
Area 1	5.00	ha
Crop 2	Wine grapes	
Area 2	45.00	ha

PLAN IRRIGATION AS ONE SYSTEM FOR BOTH TOMATOES AND WINE GRAPES
ASSUME WATER USE FOR DESIGN IS WINE GRAPE USE

	Tomatoes and Wine Grapes	
Block Size (A_t)	7.14	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	1087	mm
Max nett Irrigation Requ (NIR_m)	299	mm/month
NIR_d	10	mm/day
Cycle Length (t_c)	7	days
NIR_c	68	
GIR_c	71	mm/cycle
System Flow (m3/h)	212	m^3/h
System Flow (l/s)	**59**	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day
Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**MELKBOOM /TRAVAL**	**New Farm**
Irrigated area	50	ha
Crop 1	5	Tomatoes
Crop 2	45	Wine grapes
Total System Flow Rate	212	m^3/h
Distance from River to Field	200	m
Elevation from River to Field	15	m

IRRIGATION PUMPS AND PIPELINES

Tatoes adW Gaps

Cost Estimates			Amount
Pump station	24	kW	R 385,000
Pipeline - 250 mm	200	m	R 180,000
Irrigation Mainlines Cost Estimate			**R 565,000**
			R 11,300 /ha

OPERATING COSTS			**Tomatoes and Wine Grapes**
Mechanical and Electrical	4%	per annum	R 9,000
Civils	0.25%	per annum	R 300
Pipeline	0.50%	per annum	R 900
Electricity	20	c/kWh	R 13,000
Total operating costs for Mainline (R/annum)			**R 23,200**

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	Expansion	
Area	**MELKBOOM/TRAVAL**	
Land Size	15.00	ha
Crop 1	Tomatoes	
Area 1	3.00	ha
Crop 2	Wine grapes	
Area 2	12.00	ha

PLAN IRRIGATION AS ONE SYSTEM FOR BOTH TOMATOES AND WINE GRAPES
ASSUME WATER USE FOR DESIGN IS WINE GRAPE USE

	Tomatoes and Wine Grapes	
Block Size (A_l)	2.14	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	1087	mm
Max nett Irrigation Requ (NIR_m)	299	mm/month
NIR_d	10	mm/day
Cycle Length (t_c)	7	days
NIR_c	68	
GIR_c	71	mm/cycle
System Flow (m3/h)	64	m^3/h
System Flow (l/s)	**18**	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day
Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam
Irrigation cost estimates

Key Statistics

Scenario	**MELKBOOM /TRAVAL**	**Expansion**
Irrigated area	15	ha
Crop 1	3	Tomatoes
Crop 2	12	Wine grapes
Total System Flow Rate	64	m^3/h
Distance from River to Field	200	m
Elevation from River to Field	15	m

IRRIGATION PUMPS AND PIPELINES

Tomatoes and Wine Grapes

Cost Estimates			Amount
Pump station	7	kW	R 120,000
Pipeline - 200 mm	200	m	R 103,000
Irrigation Mainlines Cost Estimate			**R 223,000**
			R 14,867 /ha

OPERATING COSTS			**Tomatoes and Wine Grapes**
Mechanical and Electrical	4%	per annum	R 3,000
Civils	0.25%	per annum	R 100
Pipeline	0.50%	per annum	R 600
Electricity	20	c/kWh	R 4,000
Total operating costs for Mainline (R/annum)			**R 7,700**

APPENDIX D

Typical Scheme Inputs and Cost Summaries : Klawer/Vredendal Area

400415 - Clanwilliam Dam - Irrigation Schemes

Irrigation Requirement

	New Farm	
Area	**KLAWER/VREDENDAL**	
Land Size	25.00	ha
Crop 1	Table grapes	
Area 1	25.00	ha
	Table grapes	
Block Size (A_t)	3.57	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	1033	mm
Max nett Irrigation Requ (NIR_m)	405	mm/month
NIR_d	13	mm/day
Cycle Length (t_c)	7	days
NIR_c	91	
GIR_c	96	mm/cycle
System Flow (m3/h)	144	m^3/h
System Flow (l/s)	**40**	l/s

Assumptions

Crop Water requirements

See report : Feasibility Study for the Raising of Clanwilliam Dam

Table Grapes - Crop water requirem	Table 3.2 pg 53 - Saayman
Table Grapes - Max monthly requirer	Table 3.4 pg 54 - Saayman

400415 - Clanwilliam Dam
Irrigation cost estimates

	OPTION 1 - From Canal to Field	
Key Statistics		
	KLAWER/V	
Scenario	**REDENDAL**	**New Farm**
Irrigated area	25	ha
Crop 1	25	Table grapes
Total System Flow Rate	144	m^3/h
Distance from Canal to Field	200	m
Elevation from Canal to Field	20	m

IRRIGATION PUMPS AND PIPELINES
Table grapes

Cost Estimates			Amount
Pump station	19	kW	R 311,000
Pipeline - 200 mm	200	m	R 114,000
Table Grapes Irrigation Mainlines Cost Estimate			**R 425,000**
			R 17,000 /ha

OPERATING COSTS			**Table grapes**
Mechanical and Electrical	4%	per annum	R 7,000
Civils	0.25%	per annum	R 300
Pipeline	0.50%	per annum	R 600
Electricity	20	c/kWh	R 11,000
Total operating costs for Mainline (R/annum)			**R 18,900**

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	Expansion	
Area	**KLAWER/VREDENDAL**	
Land Size	5.00	ha
Crop 1	Table grapes	
Area 1	5.00	ha
	Table grapes	
Block Size (A_t)	0.71	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	1033	mm
Max nett Irrigation Requ (NIR_m)	405	mm/month
NIR_d	13	mm/day
Cycle Length (t_c)	7	days
NIR_c	91	
GIR_c	96	mm/cycle
System Flow (m3/h)	29	m^3/h
System Flow (l/s)	9	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Table Grapes - Crop water requirem Table 3.2 pg 53 - Saayman
Table Grapes - Max monthly requirei Table 3.4 pg 54 - Saayman

400415 - Clanwilliam Dam
Irrigation cost estimates

	From Canal to Field	
Key Statistics		
	KLAWER/V	
Scenario	**REDENDAL**	**Expansion**
Irrigated area	5	ha
Crop 1	5	Table grapes
Total System Flow Rate	29	m^3/h
Distance from Canal to Field	200	m
Elevation from Canal to Field	20	m

IRRIGATION PUMPS AND PIPELINES
Table grapes

Cost Estimates		Amount
Pump station	4 kW	R 79,000
Pipeline - 100 mm	200 m	R 59,000
Table Grapes Irrigation Mainlines Cost Estimate		**R 138,000**
		R 27,600 /ha

OPERATING COSTS		**Table grapes**
Mechanical and Electrical	4% per annum	R 2,000
Civils	0.25% per annum	R 100
Pipeline	0.50% per annum	R 300
Electricity	20 c/kWh	R 2,000
Total operating costs for Mainline (R/annum)		**R 4,400**

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	New Farm	
Area	**KLAWER/VREDENDAL**	
Land Size	75.00	ha
Crop 1	Tomatoes	
Area 1	15.00	ha
Crop 2	Wine grapes	
Area 2	60.00	ha

IRRIGATE TOMATOES WITH WINE GRAPES SYSTEM

	Wine Grapes and tomatoes	
Block Size (A_t)	10.71	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	1212	mm
Max nett Irrigation Requ (NIR_m)	455	mm/month
NIR_d	15	mm/day
Cycle Length (t_c)	7	days
NIR_c	103	
GIR_c	108	mm/cycle
System Flow (m3/h)	484	m^3/h
System Flow (l/s)	**135**	l/s

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day
Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam
Irrigation cost estimates

	From Canal to Field	
Key Statistics		
	KLAWER/V	
Scenario	**REDENDAL**	**New Farm**
Irrigated area	75	ha
Crop 1	15	Tomatoes
Crop 2	60	Wine grapes
Total System Flow Rate	484	m^3/h
Distance from Canal to Field	200	m
Elevation from Canal to Field	20	m

IRRIGATION PUMPS AND PIPELINES
W/grapes

Cost Estimates		Amount
Pump station	66 kW	R 1,001,000
Pipeline - 300 mm	200 m	R 195,000
Wine Grapes Irrigation Mainlines Cost Estimate		**R 1,196,000**
		R 15,947 /ha

OPERATING COSTS		**Wine grapes**
Mechanical and Electrical	4% per annum	R 23,000
Civils	0.25% per annum	R 700
Pipeline	0.50% per annum	R 1,000
Electricity	20 c/kWh	R 25,000
Total operating costs for Mainline (R/annum)		**R 49,700**

400415 - Clanwilliam Dam - Irrigation Schemes

Irrigation Requirement

	Expansion	
Area	**KLAWER/VREDENDAL**	
Land Size	15.00	ha
Crop 1	Tomatoes	
Area 1	5.00	ha
Crop 2	Wine grapes	
Area 2	10.00	ha

IRRIGATE AS ONE SYSTEM USING WINE GRAPES DEMAND

	Wine grapes and Tomatoes	
Block Size (A_t)	2.14	ha
Operating hours per day	24	hr/day
Operating hours per cycle	168	hr
Irrigation Type	Drip	
Irrigation Efficiency	95%	
Total Irrigation requ per year	1212	mm
Max nett Irrigation Requ (NIR_m)	455	mm/month
NIR_d	15	mm/day
Cycle Length (t_c)	7	days
NIR_c	103	
GIR_c	108	mm/cycle
System Flow (m3/h)	97	m^3/h
System Flow (l/s)	**27**	l/s

Assumptions

Crop Water requirements

See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day

Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam
Irrigation cost estimates

	From Canal to Field	
Key Statistics		
	KLAWER/V	
Scenario	**REDENDAL**	**Expansion**
Irrigated area	15	ha
Crop 1	5	Tomatoes
Crop 2	10	Wine grapes
Total System Flow Rate	97	m^3/h
Distance from Canal to Field	200	m
Elevation from Canal to Field	20	m

IRRIGATION PUMPS AND PIPELINES
W/grapes

Cost Estimates			Amount
Pump station	12	kW	R 180,000
Pipeline - 100 mm	200	m	R 86,000
Wine Grapes Irrigation Mainlines Cost Estimate			**R 266,000**
			R 17,733 /ha

OPERATING COSTS			**Wine grapes**
Mechanical and Electrical	4%	per annum	R 4,000
Civils	0.25%	per annum	R 200
Pipeline	0.50%	per annum	R 500
Electricity	20	c/kWh	R 5,000
Total operating costs for Mainline (R/annum)			**R 9,700**

APPENDIX E

Canal Refilling Concrete Weir : Cost Estimate

COST ESTIMATE FOR ABSTRACTION WEIR IN OLIFANTS RIVER

No	DESCRIPTION	UNIT	RATE 02-Jul-07 Rand	QUANTITY	AMOUNT Rand
1	**Clearing**				
	(a) sparse	m^2	5	120.000	600
	(b) bush	m^2	9	180.000	1,620
	(c) trees	m^2	18	300.000	5,400
2	**River diversion**	Sum	50,000	1	50,000
3	**Excavation**				
	(a) Confined				
	(i) all materials	m^3	50	80	4,000
	(ii) extra over for rock	m^3	400	33	13,200
	(b) Final Foundation Preparation	m^2	40	165	7,000
4	**Concrete Works**				
	(a) Formwork				
	(i) gang formed	m^2	170	0	0
	(ii) intricate	m^2	210	222	47,000
	(b) Concrete				
	(i) mass	m3	600		0
	(ii) structural	m3	850	240	204,000
	(c) Reinforcing	t	9,000	19	171,000
	SUB-TOTAL				503,820

No	DESCRIPTION	UNIT	RATE 02-Jul-07 Rand	QUANTITY	AMOUNT
5	**Landscaping** (% of 1-4)	%	5		25,191
6	**Miscellaneous** (% of 1-4)	%	20		100,764
	SUB TOTAL A				629,775
7	**Preliminary & General** (% of sub-total A)	%	30		188,933
8	**Preliminary works**				
	(a) Access road	km	100,000	0.50	50,000
	(b) Construction water to site	Sum			20,000
	SUB TOTAL B				888,708
9	**Contingencies** (% of sub total B)	%	15		133,306
	SUB TOTAL C				1,022,014
15	**Planning design & supervision** (% of sub total C)	%	12		122,642
	Total Cost Estimate (as at July 2007)				1,200,000

APPENDIX F

Proposed Zypherfontein Scheme:
Inputs and Cost Summaries

400415 - Clanwilliam Dam - Irrigation Schemes
Irrigation Requirement

	KLAWER/VREDENDAL	
Area	**ZYPHERFONTEIN FARM - Block 1**	
Land Size	598.00	ha
Crop 1	Tomatoes	
Area 1	50.00	ha
Crop 2	Wine grapes	
Area 2	548.00	ha

ASSUME SAME SYSTEM FOR TOMOTOES AND WINE GRAPES

	Wine Grapes and tomatoes	
Block Size (A_t)	85.43	
Operating hours per day	24	
Operating hours per cycle	168	
Irrigation Type	Drip	
Irrigation Efficiency	95%	
		Volume (m3)
Total Irrigation requ per year	930	5,561,400
Max nett Irrigation Requ (NIR_m)	238	
NIR_d	8	
Cycle Length (t_c)	7	
NIR_c	54	
GIR_c	57	
System Flow (m3/h)	2015	
System Flow (l/s)	**560**	

Assumptions
Crop Water requirements
See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day
Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam

ZYPHERFONTEIN FARM

BLOCK 1

Key Statistics

Irrigated area	598	ha Table Grapes
Total System Flow Rate	2015	m^3/h
Distance from Canal to Field	6780	m
Elevation from Canal to Field	50	m

IRRIGATION PUMPS AND PIPELINES

Cost Estimates			Amount
Pump station	677	kW	R 12,312,000
Pipeline - Variuos sizes	6780	m	R 10,407,000
Wine Grapes Irrigation Mainlines Cost Estimate			**R 22,719,000**
			R 37,992 /ha

OPERATING COSTS			**0.00**
Mechanical and Electrical	4%	per annum	R 237,000
Civils	0.25%	per annum	R 7,500
Pipeline	0.50%	per annum	R 52,100
Electricity	20	c/kWh	R 258,000
Total operating costs for Mainline (R/annum)			**R 554,600**

400415 - Clanwilliam Dam - Irrigation Schemes

Irrigation Requirement

	KLAWER/VREDENDAL	
Area	**ZYPHERFONTEIN FARM - BLOCK 2**	
Land Size	295.00	ha
Crop 1	Tomatoes	
Area 1	50.00	ha
Crop 2	Wine grapes	
Area 2	245.00	ha

ASSUME SAME SYSTEM FOR TOMOTOES AND WINE GRAPES

	Wine Grapes and tomatoes	
Block Size (A_t)	42.14	
Operating hours per day	24	
Operating hours per cycle	168	
Irrigation Type	Drip	
Irrigation Efficiency	95%	
		Volume (m3)
Total Irrigation requ per year	930	2,743,500
Max nett Irrigation Requ (NIR_m)	238	
NIR_d	8	
Cycle Length (t_c)	7	
NIR_c	54	
GIR_c	57	
System Flow (m3/h)	994	
System Flow (l/s)	**277**	

Assumptions

Crop Water requirements

See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day

Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam

ZYPHERFONTEIN FARM

BLOCK 2

Key Statistics

Irrigated area	295	ha Table Grapes
Total System Flow Rate	994	m^3/h
Length of Mainlines	2180	m
Elevation from river to highest on field	55	m

IRRIGATION PUMPS AND PIPELINES

Cost Estimates			Amount
Pump station	314	kW	R 7,287,000
Pipeline - Variuos sizes	2180	m	R 3,162,000
Wine Grapes Irrigation Mainlines Cost Estimate			**R 10,449,000**
			R 35,420 /ha

OPERATING COSTS			**0.00**
Mechanical and Electrical	4%	per annum	R 140,000
Civils	0.25%	per annum	R 4,400
Pipeline	0.50%	per annum	R 15,900
Electricity	20	c/kWh	R 118,000
Total operating costs for Mainline (R/annum)			**R 278,300**

400415 - Clanwilliam Dam - Irrigation Schemes

Irrigation Requirement

	KLAWER/VREDENDAL	
Area	**ZYPHERFONTEIN FARM - BLOCK 3**	
Land Size	295.00	ha
Crop 1	Tomatoes	
Area 1	50.00	ha
Crop 2	Wine grapes	
Area 2	245.00	ha

ASSUME SAME SYSTEM FOR TOMOTOES AND WINE GRAPES

	Wine Grapes and tomatoes	
Block Size (A_t)	42.14	
Operating hours per day	24	
Operating hours per cycle	168	
Irrigation Type	Drip	
Irrigation Efficiency	95%	
		Volume (m3)
Total Irrigation requ per year	930	2,743,500
Max nett Irrigation Requ (NIR_m)	238	
NIR_d	8	
Cycle Length (t_c)	7	
NIR_c	54	
GIR_c	57	
System Flow (m3/h)	994	
System Flow (l/s)	**277**	

Assumptions

Crop Water requirements

See report : Feasibility Study for the Raising of Clanwilliam Dam

Wine Grapes - Crop water requireme Table 3.2 pg 53 - Myburg 7 Day

Wine Grapes - Max monthly requirer Table 3.4 pg 54 - Myburg 7 Day

400415 - Clanwilliam Dam

ZYPHERFONTEIN FARM

BLOCK 3

Key Statistics

Irrigated area	295	ha
Crop 1	50	Tomatoes
Crop 2	245	Wine grapes
Total System Flow Rate	994	m^3/h
Length of Mainlines	3200	m
Elevation from river to highest on field	45	m

IRRIGATION PUMPS AND PIPELINES

Wine grapes

Cost Estimates			Amount
Pump station	282	kW	R 5,693,000
Pipeline - Variuos sizes	3200	m	R 4,760,000
Wine Grapes Irrigation Mainlines Cost Estimate			**R 10,453,000**
			R 35,434 /ha

OPERATING COSTS			**Wine grapes**
Mechanical and Electrical	4%	per annum	R 105,000
Civils	0.25%	per annum	R 3,300
Pipeline	0.50%	per annum	R 23,800
Electricity	20	c/kWh	R 106,000
Total operating costs for Mainline (R/annum)			**R 238,100**

FEASIBILITY STUDY FOR THE RAISING OF CLANWILLIAM DAM

Study Reports

No	Report name	DWAF Report numbers	NS Report numbers
1	Inception	No report number	4414
2	Screening of Options	P WMA 17/E10/00/0405	4415
3	Water Quality	P WMA 17/E10/00/0509	4416
4	System Analysis	P WMA 17/E10/00/0609	4417
5	Groundwater Resources	P WMA 17/E10/00/0709	4418
6	Environmental Scoping	P WMA 17/E10/00/0809	4419
7	Environmental Impact	P WMA 17/E10/00/0909	4420
8	Soils, Water Requirements and Crops	P WMA 17/E10/00/1109	4422
9	Water Management Plan for the Olifants-Doorn Catchment Management Area	P WMA 17/E10/00/1209	4423
10	Opportunities for the Supply of Water to Resource-poor Farmers	P WMA 17/E10/00/1309	4424
11	Irrigation Development and Water Distribution Options	P WMA 17/E10/00/1409	4425
12	Impacts on Roads and other Infrastructure	P WMA 17/E10/00/1509	4426
13	Financial Viability of Irrigation Farming	P WMA 17/E10/00/1609	4427
14	Socio-economic Impact Assessment	P WMA 17/E10/00/1709	4428
15	Financial Evaluation	P WMA 17/E10/00/1809	4455
16	Main	P WMA 17/E10/00/1909	4429

No	Reports by DWAF	DWAF Report numbers	NS Report numbers
17	Feasibility Design of Raising (Engineering Design) and Design Report Addendum	-	4430
18	First Engineering Geological Materials Report (Course Aggregate) For Proposed Raising (Council for Geoscience)	-	4431
19	Farm Dams (Options Analysis): include under Report 4 as Appendix	-	4432