DWS Report No. No number

water & sanitation

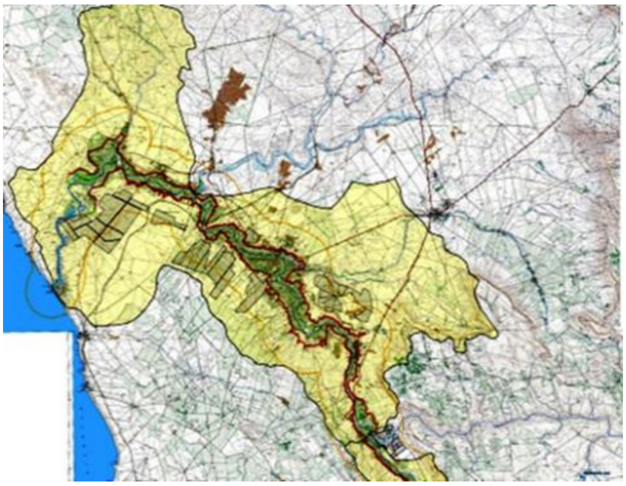
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam (WP0485)

Suitable Agricultural Areas and Land Ownership Report





February 2019

Department of Water and Sanitation
Directorate: Options Analysis

POST FEASIBILITY BRIDGING STUDY FOR THE PROPOSED BULK CONVEYANCE INFRASTRUCTURE FROM THE RAISED CLANWILLIAM DAM

APPROVAL

Title	:	Suitable Agricultural Areas and Land Ownership Report
Consultants	:	Aurecon South Africa (Pty) Ltd
Report status	:	Final
Date	:	February 2019

STUDY TEAM

Approved for Aurecon South Africa (Pty) Ltd:

....
E VAN DER BERG
Technical Director

DEPARTMENT OF WATER AND SANITATION
Directorate Options Analysis

DEPARTMENT OF WATER AND SANITATION
Directorate Options Analysis

Approved for Department of Water and Sanitation:

....
M MUGUMO
CHIEF ENGINEER: OA (South)

....
C FOURIE
DIRECTOR: OPTIONS ANALYSIS

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Report title		Suitable Agricultural Areas and Land Ownership Report				
Document ID			**Project number**		113834	
File path		\\Aurecon.info\shares\ZACPT\Projects\Projects\113834 Bridging Study Clanwilliam Dam\03 Prj Del\13 Reports\08 Suitable Agric Areas & Land Ownership (Sub-R)\Suitable Agricultural Areas and Land Ownership Sub-Report (final) signed.docx				
Client		Department of Water and Sanitation	**Client contact**		Mr M Mugumo	
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	14 Sep 2018	Draft	Aurecon	W Samodien N Rossouw K White	E v/d Berg	E v/d Berg
1	5 Oct 2018	Draft v2	Aurecon		E v/d Berg	E v/d Berg
2	23 Nov 2018	Draft v3	Aurecon		E v/d Berg	E v/d Berg
3	18 Feb 2019	Final	Aurecon		E v/d Berg	E v/d Berg
Current Revision		**3**				

Approval			
Author signature		Approver signature	
Name	Waseem Samodien	Name	Erik van der Berg
Title	Engineer	Title	Technical Director

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AND SANITATION

Directorate: Options Analysis

Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

SUITABLE AGRICULTURAL AREAS AND LAND OWNERSHIP REPORT

February 2019

Prepared by: Aurecon South Africa (Pty) Ltd
P O Box 494
Cape Town, 8000
South Africa

Tel: 021 526 5790
Fax: 086 526 9500
e-mail: erik.vanderberg@aurecongroup.com

Prepared for: Director: Options Analysis
Department of Water and Sanitation
Private Bag X313
Pretoria 0001
South Africa

Mr Menard Mugumo (CE: OA, South)
Tel: 012 336 6838
E-mail: mugumom@dws.gov.za

This report is to be referred to in bibliographies as:
Department of Water and Sanitation, South Africa. 2019. *Suitable Agricultural Areas and Land Ownership Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam.

Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

Reports produced as part of this project are indicated below.

Bold type indicates this report.

Report Index	Report Number	Report Title
1		Inception Report
2	P WMA 09/E10/00/0417/2	Capacity Building & Training Year 1
3	P WMA 09/E10/00/0417/3	Capacity Building & Training Year 2
4	P WMA 09/E10/00/0417/4	Water Requirements Assessment
5	P WMA 09/E10/00/0417/5	Distribution of Additional Available Water
6		Existing Infrastructure and Current Agricultural Development Sub-Report
7	P WMA 09/E10/00/0417/6	Existing Conveyance Infrastructure and Irrigated Land
8		**Suitable Agricultural Areas and Land Ownership Report**
9		Evaluation of Development Options Sub-Report
10	P WMA 09/E10/00/0417/10	Suitable Areas for Agricultural Development
11		Right Bank Canal Design Sub-Report
12		Conceptual Design Sub-Report
13		Environmental Screening Sub-Report
14		Jan Dissels and Ebenhaeser Schemes Design Sub-Report
15	P WMA 09/E10/00/0417/13	Feasibility Design
16	P WMA 09/E10/00/0417/7	Topographical Surveys
17	P WMA 09/E10/00/0417/8	Geotechnical Investigations
18	P WMA 09/E10/00/0417/9	Soil Survey
19		Financial Viability of Irrigation Farming Sub-Report
20	P WMA 09/E10/00/0417/11	Agricultural Production and Farm Development
21		Right Bank Canal Cost Analysis Sub-Report
22		Socio-Economic Impact Analysis Sub-Report
23	P WMA 09/E10/00/0417/12	Socio-Economic Impact Analysis
24	P WMA 09/E10/00/0417/14	Record of Implementation Decisions Report
25	P WMA 09/E10/00/0417/1	Main Report
26	P WMA 09/E10/00/0417/15	Historically Disadvantaged Farmers Report

Concise Description of the Content of Study Reports

Report Index	Report Number	Report Title and Description of Content
1		Inception The report forms part of the contract and stipulates the scope of work for the study, the contract amount and the contract period. It contains a detailed description of tasks and methodology, a study programme, human resource schedule, budget and deliverables. The Capacity Building and Training Plan has been included.
2	P WMA 09/E10/00/0417/2	Capacity Building & Training Year 1 Describes the range of capacity building and training activities planned for the study, and the activities undertaken during the first year of the study, including field-based training, training workshop 1 and mentorship of DWS interns through secondment.
3	P WMA 09/E10/00/0417/3	Capacity Building & Training Year 2 Describes the range of capacity building and training activities planned for the study, and the activities undertaken during the second year of the study, including field-based training, training workshop 2 and mentorship of DWS interns through secondment.
4	P WMA 09/E10/00/0417/4	Water Requirements Assessment Provides an analysis of the existing water use and current water allocations in the study area, and addresses ecological water requirements, water use for irrigated agriculture and projections for future use, current domestic and industrial water use and projections for future use, water use for hydropower and water losses in the water supply system.
5	P WMA 09/E10/00/0417/5	Distribution of Additional Available Water Confirms the volume of additional water available for development, after water has been reserved for the current water uses, as well as making recommendations on how the additional yield should be distributed among water use sectors and water users.
6		Existing Infrastructure and Current Agricultural Development Sub-Report Provides an overview of the extent and general condition of the current bulk water storage and conveyance infrastructure. This report also provides an overview of the locality and extent of the existing agricultural areas determined by reviewing Geographic Information System (GIS) data obtained from various sources.
7	P WMA 09/E10/00/0417/6	Existing Conveyance Infrastructure and Irrigated Land An update of the Sub-Report, providing a refinement of the current agricultural water requirements following evaluation of the current crop types, an assessment of the desirability of diverting releases for downstream irrigators via the Clanwilliam Canal and Jan Dissels River, to meet the summer ecological flows in the lower Jan Dissels River, and presents an Implementation Action Plan with costs.

Report Index	Report Number	Report Title and Description of Content
8		Suitable Agricultural Areas and Land Ownership Sub-Report Description of the collection of information and the preparation undertaken for the analysis of options, which includes a summary of existing irrigated areas and water use, cadastral information, land ownership, environmental sensitivity, soils suitability, water quality considerations and constraints, and the initiation of the process to identify additional areas suitable for irrigation.
9		Evaluation of Development Options Sub-Report Describes the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. This provides the background and an introduction to the discussions at the Options Screening Workshop held in December 2018.
10	P WMA 09/E10/00/0417/10	Suitable Areas for Agricultural Development Describes the supporting information, process followed and the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. Recommends the preferred options to be evaluated at feasibility level.
11		Right Bank Canal Feasibility Design Sub-Report Describes the Design Criteria Memorandum, based on best practice in engineering and complying with recognised codes and standards. Description of route alignments and salient features of the new Right Bank canal. Feasibility-level design of bulk infrastructure, including evaluation of capacities, hydraulic conditions, canal design, surface flow considerations, canal structures, power supply and access roads. Operational considerations and recommendations.
12		Conceptual Design Sub-Report Describes the scheme layouts at a conceptual level and infrastructure components to be designed, alternatives to consider or sub-options, and affected land and infrastructure, as well as the updated recommended schemes for new irrigation development.
13		Environmental Screening Sub-Report Describes and illustrates the opportunities and constraints, and potential ecological risks/impacts and recommendations for the short-listed bulk infrastructure development options at reconnaissance level. Describes relevant legislation that applies to the proposed irrigation developments.

Report Index	Report Number	Report Title and Description of Content
14		Jan Dissels and Ebenhaeser Schemes Feasibility Design Sub-Report Describes the Design Criteria Memorandum, based on best practice in engineering and complying with recognised codes and standards. Description of route alignments and salient features of the Jan Dissels and Ebenhaeser schemes. Feasibility-level design of bulk infrastructure, including evaluation of capacities, hydraulic conditions, intake structures, balancing dams and reservoirs, rising mains and gravity pipelines and trunk mains where relevant, power supply and access roads. Operational considerations and recommendations.
15	P WMA 09/E10/00/0417/13	Feasibility Design Description of the approach to and design of selected bulk infrastructure at feasibility level, with supporting plans and implementation recommendations.
16	P WMA 09/E10/00/0417/7	Topographical Surveys Describes the contour surveys for the proposed identified bulk infrastructure conveyance routes and development areas, the surveying approach, inputs and accuracy, as well as providing the survey information.
17	P WMA 09/E10/00/0417/8	Geotechnical Investigations Presents the findings of geotechnical investigations of the various identified sites, as well as the approach followed, field investigations and testing, laboratory testing, interpretation of findings and geotechnical recommendations.
18	P WMA 09/E10/00/0417/9	Soil Survey Describes the soil types, soil suitability and amelioration measures of the additional area covering about 10 300 ha of land lying between 60 to 100 m above river level, between the upper inundation of the raised Clanwilliam Dam and Klawer.
19		Financial Viability of Irrigation Farming Sub-Report Describes the findings of an evaluation of the financial viability of pre-identified crop-mixes, within study sub-regions, and advises on the desirability of specific crops to be grown in these sub-regions. It includes an evaluation of the financial viability of existing irrigation farming or expanding irrigation farming, as well as the identification of factors that may be obstructive for new entrants from historically disadvantaged communities.
20	P WMA 09/E10/00/0417/11	Agricultural Production and Farm Development This report will focus on policy, institutional arrangements, available legal and administrative mechanisms as well as the proposed classes of water users and the needs of each. This would include identifying opportunities for emerging farmers, including grant and other types of Government and private support, and a recommendation on the various options and opportunities that exist to ensure that land reform and water allocation reform will take place through the project implementation.

Report Index	Report Number	Report Title and Description of Content
21		Right Bank Canal Cost Analysis Sub-Report Provides an economic modelling approach to quantify the risk of the failure of the existing main canal and the determination of the economic viability of the construction of the new right bank canal to reduce the risk of water supply failure.
22		Socio-Economic Impact Analysis Sub-Report Describes the socio-economic impact analysis undertaken for the implementation of the new irrigation development schemes, for both the construction and operational phases. This includes a description of the social and economic contributions, the return on capital investment, as well as the findings of a fiscal impact analysis.
23	P WMA 09/E10/00/0417/12	Socio-Economic Impact Analysis Synthesis of agricultural economic and socio-economic analyses undertaken, providing an integrated description of agricultural production and farm development and socio-economic impact analysis, as well as the analysis of the right bank canal costs and benefits.
24	P WMA 09/E10/00/0417/14	Record of Implementation Decisions Describes the scope of the project, the specific configuration of the schemes to be implemented, the required implementation timelines, required institutional arrangements and the required environmental and other approval requirements and mitigation measures, to ensure that the project is ready for implementation.
25	P WMA 09/E10/00/0417/1	Main Report Provides a synthesis of approaches, results and findings from the supporting study tasks and interpretation thereof, culminating in the study recommendations. Provides information in support of the project funding motivation to be provided to National Treasury.
26	P WMA 09/E10/00/0417/15	Historically Disadvantaged Farmers Report Describes the activities undertaken by an independent consultant to evaluate existing HDI Farmers policies and legislative context, identify, map and analyse prospective HDI farmers and potential land for new irrigation, as well as propose a mechanism for the identification and screening of HDI farmers.

Executive Summary

In this report, the collection of information and the preparation undertaken for the analysis of options are described, which includes the identification of currently irrigated areas and water use, additional areas suitable for irrigation, and information relating to cadastral information and land ownership.

Information required for this report was obtained by conducting a literature review of previous studies done in the study area, and confirmation of additional information with key stakeholders and data owners. Available datasets have been described. The GIS shapefiles developed will support the identification of potential additional agricultural development areas.

The extent of existing agricultural development is discussed in this report following a review of GIS data obtained from various sources. The locality and extent of the existing agricultural areas is provided. The evaluation of the current agricultural development in the study area found that the existing irrigated areas totals 30 700 ha, i.e. 12 000 ha in Region 1, 2 900 in Region 2 and 15 800 ha in Region 3. The current agricultural water requirement for the existing irrigation areas in the study sub-areas is 240 million m^3/a in total, comprised of 98.91 million m^3/a in Region 1, 16.45 million m^3/a in Region 2 and 125.07 million m^3/a in Region 3.

Cadastral boundaries have been obtained and land ownership established and verified (public vs. privately owned).

Environmental No-go areas, which includes critical biodiversity areas (CBAs), national freshwater protection areas (NFEPAs) and the status of ecosystems are also highlighted.

Soil suitability maps for perennial, tuberous and non-tuberous crops are available. This report also gives a breakdown of the financial viability of crops for the various regions based on climate and soil types, as well as those crops which are tried and tested in different areas. A recommendation is made on the aggregated planning crop water requirements for planning purposes.

Recommended farm sizes and the viability of irrigation farming are available for the study sub-regions.

The report describes potential water distribution options and development areas, as well as water quality considerations and constraints.

Contents

Appendix A

Discussion Document: Crop Water Use Requirements

Figures

Tables

Acronyms

CBA	Critical biodiversity area
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
DMS	Dissolved major salts
DAFF	Department of Agricultures, Forestry and Fisheries
ESA	Ecological Support Areas
FOS	Factor of safety
GIS	Geographical information system
GWS	Government water scheme
HDPE	High density polyethylene
IRR	Internal Rate of Return
LORGWS	Lower Olifants River Government Water Scheme
LORWUA	Lower Olifants River Water User Association
ONAs	Other Natural Areas
MAR	Mean annual runoff
NFEPA	National Freshwater Ecosystem Priority Areas
NPAES	National Protected Area Expansion Strategy
NPV	Net present value
PA	Protected Areas
P&G	Preliminary and General
SAD	South African Dried Fruit Association
uPVC	Unplasticised polyvinyl chloride
VAT	Value added tax
WCDoA	Western Cape Department of Agriculture (Provincial)
WUA	Water User Association

1 Introduction

1.1 Study objectives

The objective of the *Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam* is to provide recommendations on the bulk conveyance infrastructure options (new developments/upgrading/rehabilitation) required for the equitable distribution of the existing and additional water from the raised Clanwilliam Dam, after investigation of:

- The existing water allocation and projections for the supply area,
- New areas for agricultural development,
- Options for the required conveyance infrastructure, and
- Appropriate farming models and cost of irrigation water.

1.2 Report Objectives

This report is focused on the tasks related to the identification of suitable areas for agricultural development and land ownership information. It further describes the other datasets required and shapefiles developed for the identification and evaluation of distribution options for bulk conveyance infrastructure.

The report more specifically addresses the following:

1. A summary of current bulk water infrastructure.
2. Information regarding current irrigation development, which includes:
    a. The locality and extent of existing irrigation areas;
    b. The potential for further irrigation development adjacent to the existing development and the suitability of these areas in terms of topography, soil type, crops, ownership, etc; and
    c. The water requirements and allocations for the various areas and reconciliation thereof with the information in terms of current water allocation and use as

described in the Water Requirements Assessment Report (report number P WMA 09/E10/00/0417/4) of this study.

3. The financial viability of crops and recommended farm sizes.
4. Water quality considerations and constraints.
5. No-go areas for further agricultural development, due to their environmental status, which include:
    a. Critical biodiversity areas (CBAs);
    b. National freshwater ecosystem priority areas (NFEPAs) watercourses and wetlands; and
    c. Ecosystems. Identifying areas based on their threat status (vulnerable, endangered or critically endangered).
6. Potential water distribution options and development areas.

2 Existing Bulk Water Infrastructure

Figure 2.1 provides an overview of the existing conveyance infrastructure discussed in this report.

2.1 Clanwilliam Dam

The Clanwilliam Dam, with a capacity of 69.86 million m^3, was originally constructed in 1935. The Dam was raised in 1962 by 6.1 m to increase the capacity to 128 million m^3. The current live storage capacity is 122 million m^3. The current mean annual runoff (MAR) at the dam is 360 million m^3. The dam currently supplies approximately 11 000 ha of scheduled water downstream of the dam. There are 318 ha scheduled allocations from the dam basin.

Due to proposed betterments to improve the safety of the dam wall, the opportunity to raise the dam was investigated. The Feasibility Study, concluded in 2008, found that a 13 m dam raising would be economically viable as a substantial increase in yield from the dam of 70 million m^3 (based on the increase in firm yield) could be achieved, thereby increasing the current storage volume to 344 million m^3, i.e. nearly a 1 MAR capacity dam.

2.2 Clanwilliam Canal

The Clanwilliam Canal, approximately 18 km in length, originates at the Clanwilliam Dam wall (**Figure 2.2**), passes through Clanwilliam town and crosses the Jan Dissels River.

In the Clanwilliam scheme, there are 564 ha scheduled allocations from the Clanwilliam Canal and 665 ha allocated from the Olifants River. Water from the canal to water users is supplied at a rate of 0.83 ℓ/s/ha, thus the maximum capacity required is 1685 m^3/h. However, the maximum carrying capacity of the canal is accepted to be only 1700 m^3/h (0.47 m^3/s), which means that during peak periods the canal is close to full capacity. Although, according to discussions with the Clanwilliam WUA in November 2017, the canal currently has some spare capacity. Canal losses are estimated as 20%.

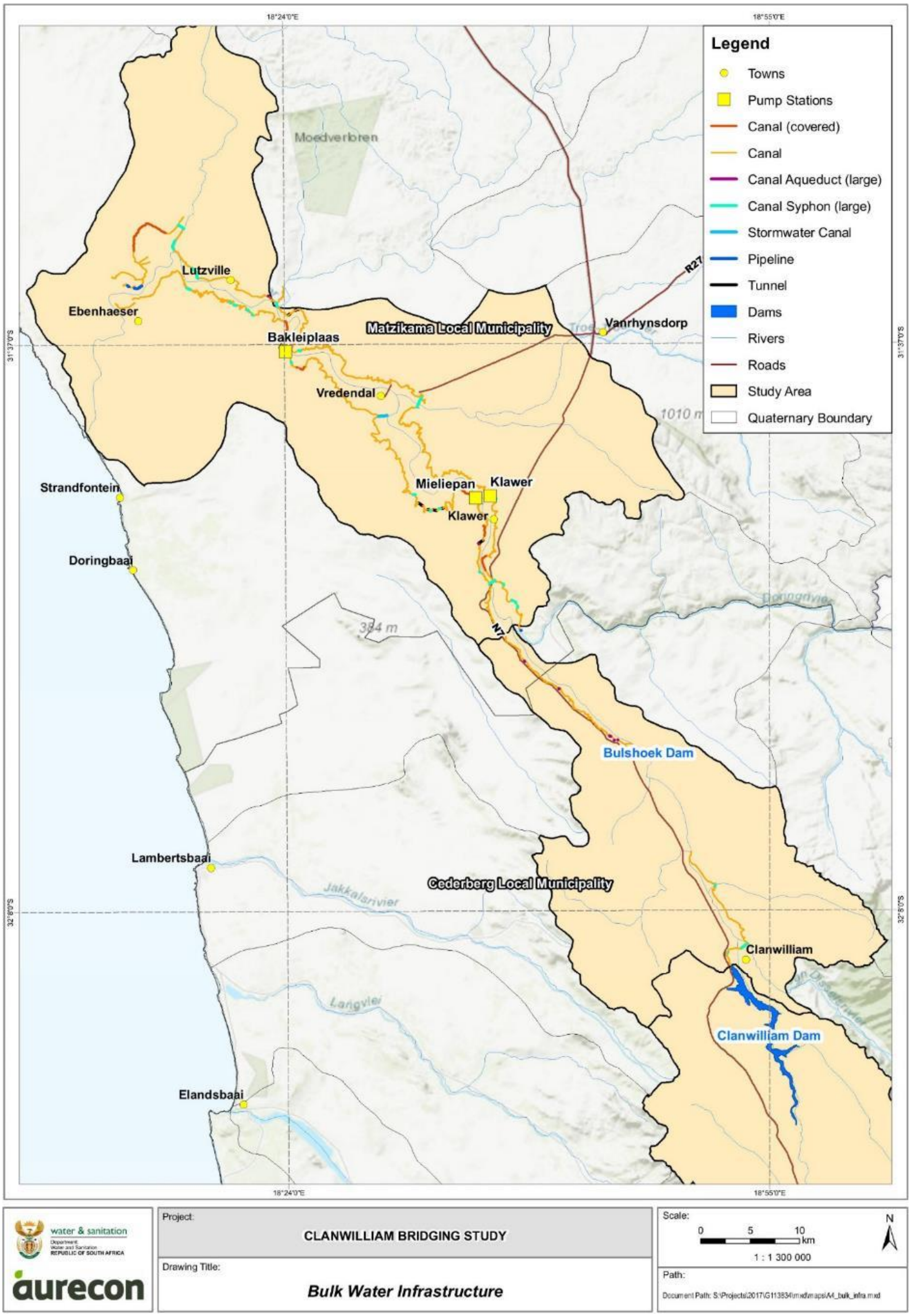


Figure 2.1 | Existing bulk water infrastructure

Figure 2.2 | Start of the Clanwilliam Canal

2.3 Olifants River (Vanrhynsdorp) Government Water Scheme

The Olifants River (Vanrhynsdorp) Government Water Scheme (ORGWS), which forms the backbone of the local economy, consists of the canal system fed from Bulshoek Weir with water released from the Clanwilliam Dam. The canal system (the Lower Olifants Canal) supplies irrigation, industrial, and domestic water to the Matzikama Municipality for the following towns and communities: Vredendal, Klawer, Lutzville, Koekenaap, Ebenhaeser, Papendorp, Strandfontein, Doring Bay and Vanrhynsdorp. The Tronox Mine at Brand-se-Baai and its smelter near Koekenaap are also supplied with water from the canal system.

2.4 Bulshoek Weir

The Bulshoek Weir was constructed across the Olifants River, about 26 km downstream of Clanwilliam town. The weir, with a capacity of 5.754 million m^3, together with a system of unlined canals, comprised the irrigation scheme for 8 500 ha of land along the Olifants River, Vanrhynsdorp District, which was completed in 1923. The weir's catchment area is 2 679 km^2 in extent. The Bulshoek Weir is a stone-masonry gravity structure (**Figure 2.3**). A series of connected arches and buttresses supporting a bridge deck and a gantry for the spillway gate hoists make up the dam wall. Sixteen gates are positioned between the buttresses on top of the ogee-shaped crests.

The dam is operated at close to its full supply capacity to divert water into the irrigation canal. Seepage through and under the Bulshoek Weir is pumped back into the canal supplying water to the LORWUA during dry periods.

Figure 2.3 | Bulshoek Weir

2.5 Lower Olifants Canal

Downstream of the Bulshoek Weir, water is diverted into the Lower Olifants Canal (**Figure 2.4**) which is the main conveyance system in the Olifants River (Vanrhynsdorp) Government Water Scheme (GWS). The canals and tunnels were mainly constructed during the 1930s.

Figure 2.4 | The Lower Olifants Canal

The canal runs on the left bank (western side) of the Olifants River for approximately 21 km, before it crosses the river with a siphon, and then runs on both sides of the river (**Figure 2.5**), with a small section of the canal running upstream along the right bank. The canals continue towards Lutzville, becoming gradually smaller downstream. Water is abstracted at numerous points along the canal (approximately 600 off-takes). Secondary canals distribute water from near Lutzville towards the coast. The lead time for water to travel in the canal from the Bulshoek Weir to the last point at Ebenhaeser is about three days. The total length of the canal system is approximately 237 km. (LORWUA, 2004).

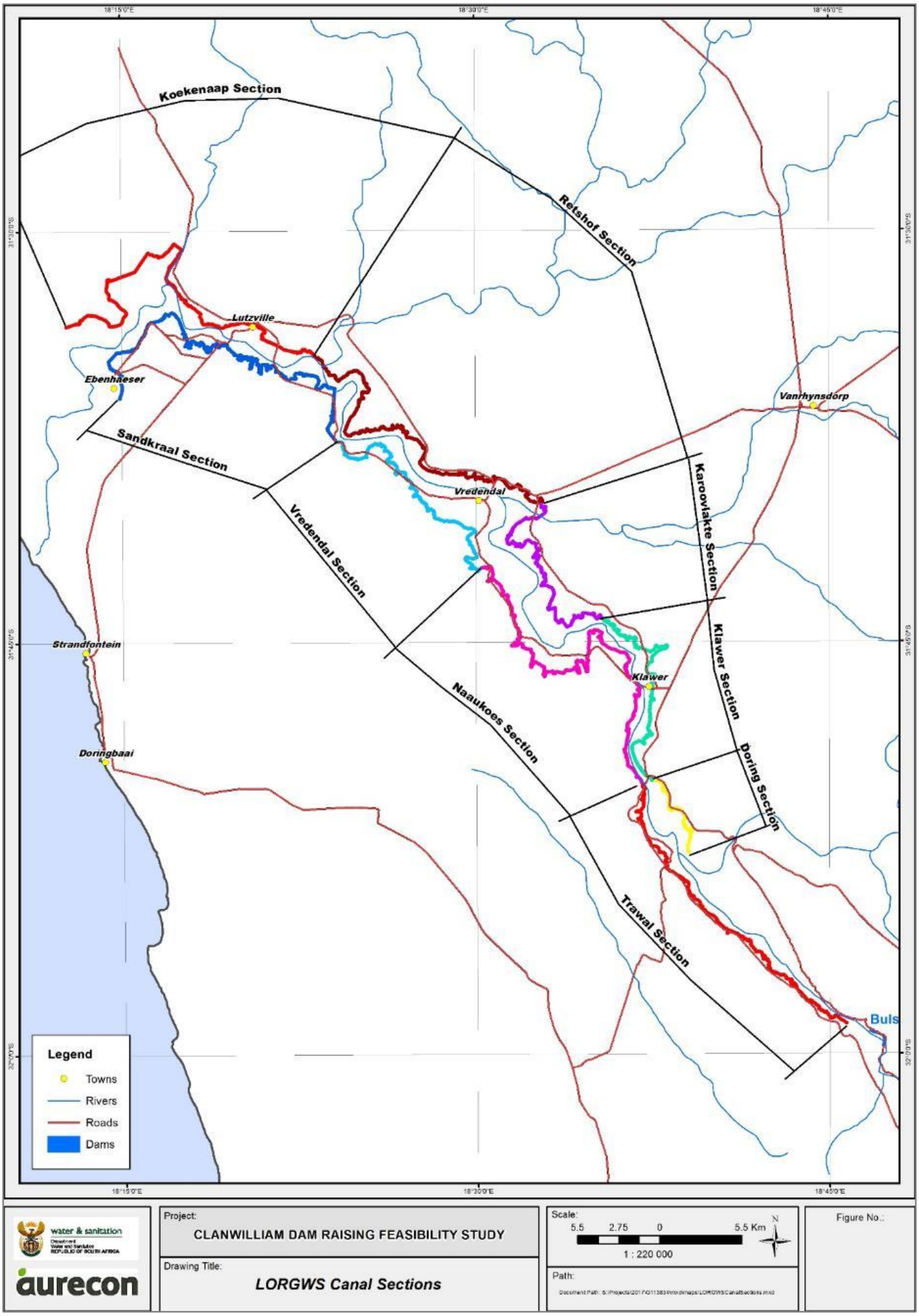


Figure 2.5 | The Lower Olifants Canal sections

2.6 Ebenhaeser

The LORGWS also provides water to the Ebenhaeser community irrigation project. The LORWUA operates and maintains the canal system up to the Ebenhaeser balancing dam. From there on, there is a canal to the Ebenhaeser community, which is operated and maintained by the community itself.

The LORWUA supplies water to Ebenhaeser at the Parshall measuring gauge at the start of the Ebenhaeser channel. The water supplied is subject to the water allocation Ebenhaeser is entitled to, as well as to any restrictions applicable to the entire LORWUA distribution system. Flow measurements are continuously and automatically monitored by the measuring gauge.

At a public meeting on 12 February 2018, the Ebenhaeser farmers claimed that they are not receiving their scheduled water allocations due to operational mismanagement by the LORWUA, i.e. no policing and monitoring of water abstraction along the canal is implemented. Several of the farmers criticised the LORWUA for its perceived lack of control over the water allocations. However, these views contrast with those of some DWS and WCDoA staff who have commented that there are some management challenges in the way the Ebenhaeser farmers operate the internal water distribution.

3 Suitable Areas for Agricultural Development

3.1 Locality and Extent of the Current Agricultural Areas

The existing agricultural areas located within the study area, were originally split into the three regions mentioned in previous reports. New findings have led to splitting the study area into 4 regions, as follows:

1. Region 1: Upstream of Clanwilliam Dam.
2. Region 2: Clanwilliam Dam to Bulshoek Weir.
3. Region 3: Bulshoek Weir to Lutzville, and
4. Region 4: Klawer to Coast.

Currently, the agricultural areas are divided into three categories, namely:

1. Cultivated irrigated areas.
2. Cultivated dry-land areas, and
3. Uncultivated or dry/arid area.

The existing agricultural land use areas, obtained from the National Department of Environmental Affairs (2013-2014) and updated with Bing Imagery (2016-2017) are summarised in **Table 3.1** below. Refer to **Figure 3.1** below for the location of the existing agricultural areas.

Table 3.1 | Existing agricultural areas per region

Study Area Region	Cultivated Irrigated (ha)	Cultivated Dryland (ha)	Uncultivated, Dry/Arid (ha)	Total (ha)
Region 1	12 000	16 000	225 000	253 000
Region 2	2 900	22 000	45 200	70 100
Region 3	8 500	21 000	115 600	145 100
Region 4	7 300	10 200	103 100	120 000
Total	**30 700**	**69 200**	**488 900**	**588 800**

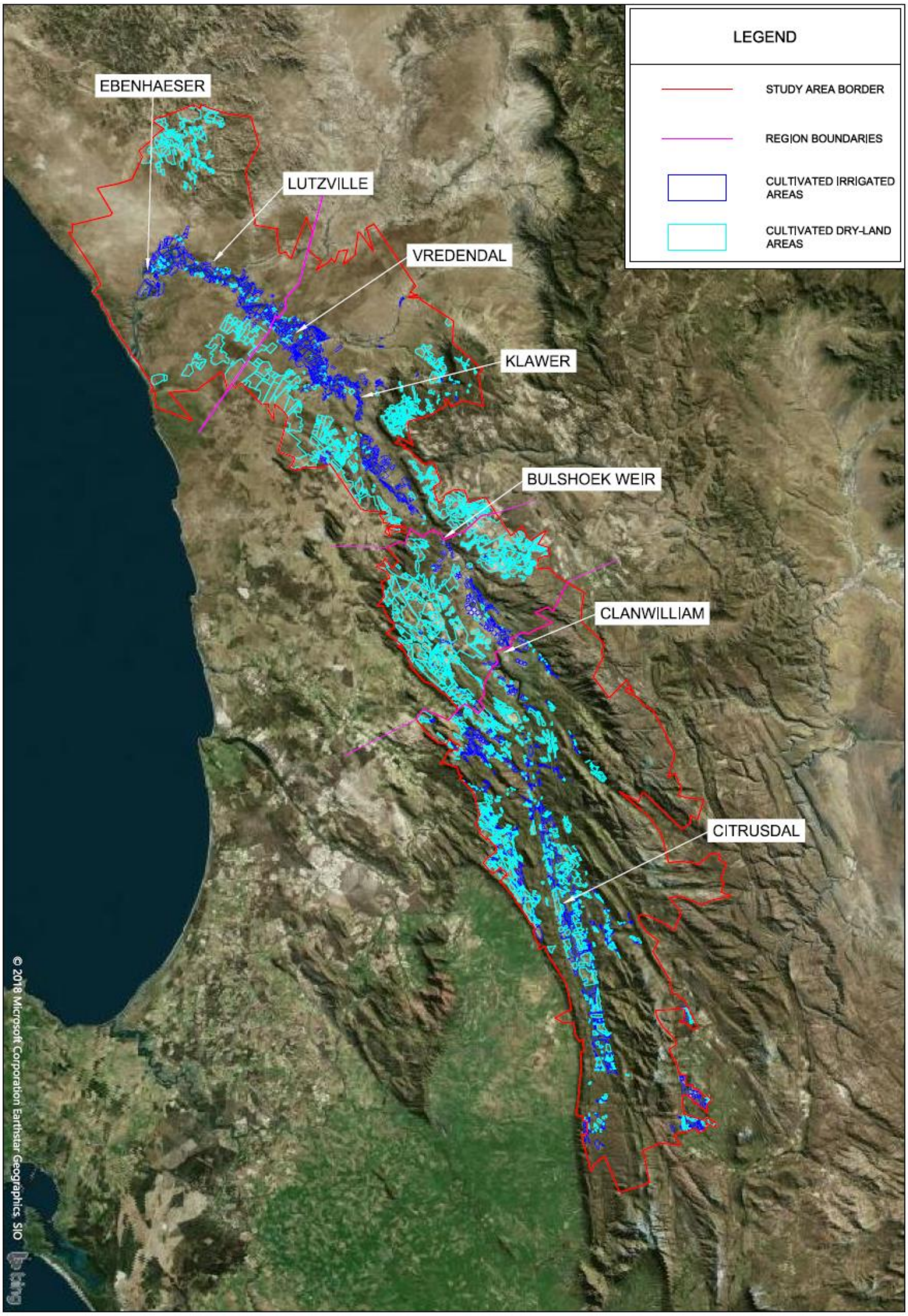


Figure 3.1 | Existing agricultural land use

3.2 Existing Agricultural Areas and Water Requirements

The tables and figures in this section indicate the crop types in the existing agricultural areas, the crop irrigation quotas and the total water requirements.

Figure 3.2 shows the distribution of crop types according to the Cape Farm Mapper Crop Census (2013) data. **Table 3.2** summarises the areas per crop type in each region downstream of the Clanwilliam Dam. **Table 3.3** shows the crop irrigation quotas relevant to each crop type in each of the respective regions as indicated the '*Financial Viability of Irrigation Farming*' sub-report. Finalised planning water requirements will be included in the report once available.

By applying the crop water requirements indicated in **Table 3.3** to the crop areas shown in **Table 3.2**, the total agricultural water requirements for each crop type per region could be determined, as summarised in **Table 3.4** (downstream of Clanwilliam Dam) and **Table 3.5** (upstream of Clanwilliam Dam).

The total agricultural water use for the area downstream of the Clanwilliam Dam (i.e. Region 2 and Region 3) is approximately 142 million m^3 for 14 500 ha, which is similar to the irrigation water usage of 140 million m^3 determined in the '*Current Water Use and Allocation*' Report. The total agricultural water use for all regions is 231 million m^3/a.

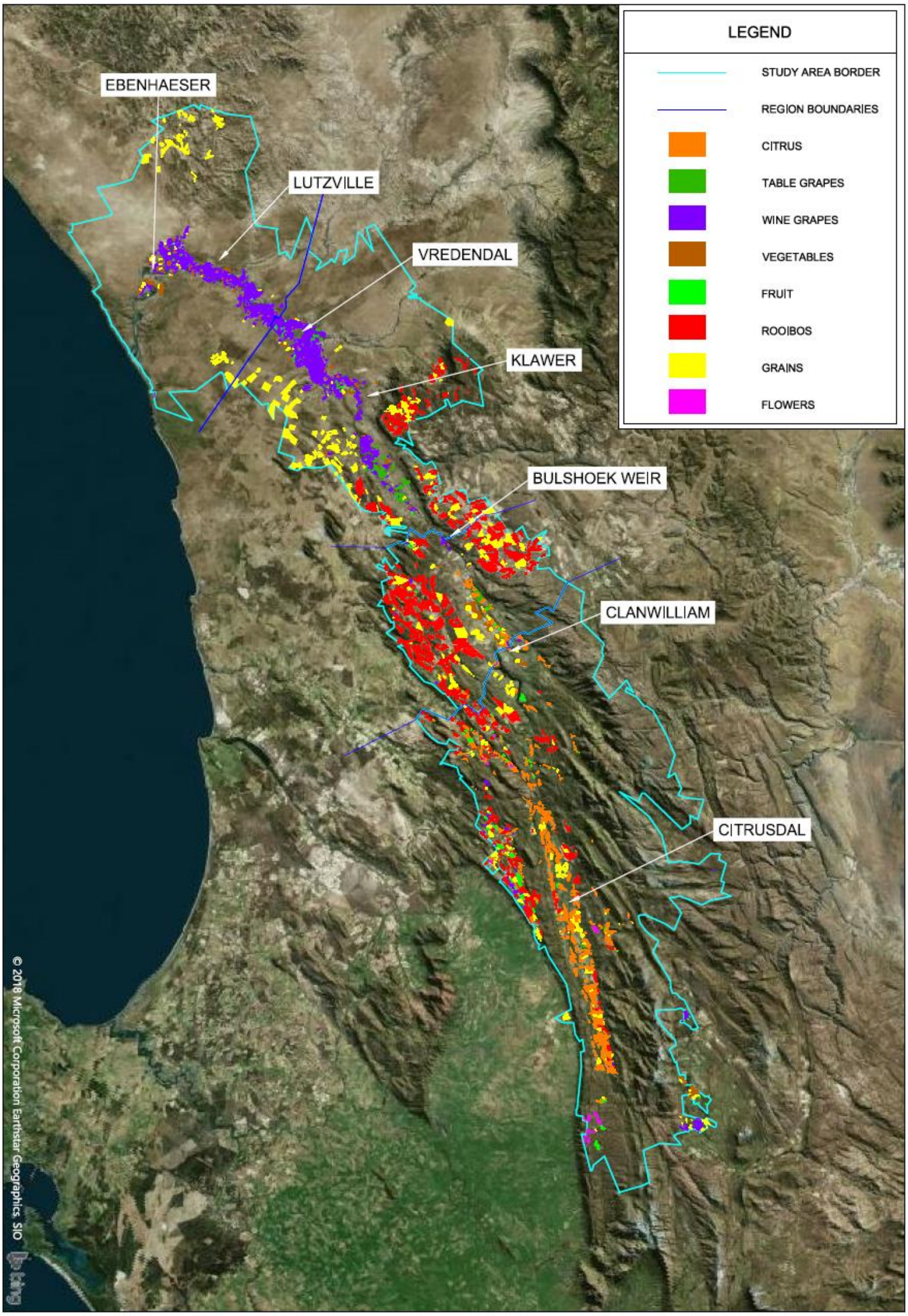


Figure 3.2 | Cape Farm Mapper Crop Census Data

Table 3.2 | Existing crop areas per region downstream of Clanwilliam Dam

Crop Type	Area (ha)			
	Region 2	Region 3	Region 4	Total (Downstream)
Irrigated				
Citrus	650	0	0	**650**
Table grapes	189	812	23	**1 024**
Wine grapes	228	6 189	4 784	**11 201**
Vegetables	500	373	597	**1 470**
Other fruit	50	145	5	**200**
Total	**1 616**	**7 519**	**5 409**	**14 545**

Table 3.3 | Crop irrigation quotas per region

Crop Type	Irrigation Quotas (m^3/ha)			
	Region 1	Region 2	Region 3	Region 4
Citrus	10,000	11,000	11,000	11,000
Table grapes	10,110	11,340	11,340	12,390
Wine grapes	8,500	9,500	9,500	9,500
Vegetables	8,213	9,281	9,281	9,281
Other fruit	9,000	9,900	9,900	9,900

Table 3.4 | Crop irrigation requirement areas downstream of Clanwilliam Dam

Crop Type	Irrigation Water Requirements (million m^3/a)			
	Region 2	Region 3	Region 4	Total (Downstream)
Citrus	7.15	0.00	0.00	**7.15**
Table grapes	2.14	9.21	0.28	**11.63**
Wine grapes	2.16	58.79	45.45	**106.40**
Vegetables	4.64	3.47	5.54	**13.64**
Other fruit	0.50	1.43	0.05	**1.98**
Total	**16.59**	**72.90**	**51.32**	**140.81**

Table 3.5 | Crop irrigation requirement areas upstream of Clanwilliam Dam

Crop Type	Area (ha)	Irrigation Requirements (million m³/a)	
	Region 1	Region 1	Total (All regions)
Citrus	6 757	67.57	**74.72**
Table grapes	4	0.04	**11.67**
Wine grapes	877	7.46	**113.86**
Vegetables	386	3.17	**16.82**
Other fruit	1 055	9.49	**11.47**
Total	**9 080**	**87.74**	**228.55**

3.3 Potential for Further Agricultural Development

While the potential for further agricultural development will be influenced by the: locality and extent of the potential agricultural areas as well as irrigable soils, as described below, priority area should also be based on locations closer to the targeted grouping to minimise travelling costs, access to existing infrastructure which will be upgraded or constructed, affordable pumping cost and is within the proximity to other available infrastructure such as roads, markets, etc.

3.3.1 Locality and Extent of the Agricultural Areas

In this section, land (properties) owned by government and privately-owned land were identified (**Figure 3.3**) within the study area, not considering height above rivers or canals or distance from rivers or canals. The land ownership details (name, address, contact details, etc.) have also been recorded for each property in the study area.

Table 3.6 summarises the property ownership for each region in the study area. The study area boundary and regions are as previously defined in the '*Feasibility Study for the Raising of Clanwilliam Dam'* (DWAF, 2008). The government owned properties do not include the urban/town areas such as Citrusdal, Vredendal, Klawer and Ebenhaeser, but only properties with possible development potential up to the above-mentioned town borders.

Table 3.6 | Property ownership per region

Study Area Region	Government (ha)	Private (ha)
Region 1: Upstream of Clanwilliam Dam (inclusive of the properties around the dam)	82 600	170 500
Region 2: Clanwilliam Dam to Bulshoek Weir (inclusive of the properties around the weir)	900	69 100
Region 3: Bulshoek Weir to Lutzville	40 800	91 800
Region 4: Klawer to Coast	2 200	130 900
Total	**126 500**	**462 300**

From **Table 3.6**, it is evident that only a small fraction of the study area is government-owned, around 22% with the other 78% being privately-owned land. Depending on the suitability of the government-owned land, the approach should be to first consider the development of new farms on these properties. For the expansion of existing farms, privately-owned land will likely be considered.

The locality of the government-owned properties in Region 1, in relation to existing irrigated agriculture and surface water sources, is another factor that must be considered. The majority of the 82 600 ha of government-owned properties are in the upper regions of the Cederberg Mountains consisting of steep slopes and likely to be significantly reduced when taking into account critical biodiversity areas and other potential environmental impacts. Thus, only a small area could be considered for the development of any new agricultural areas.

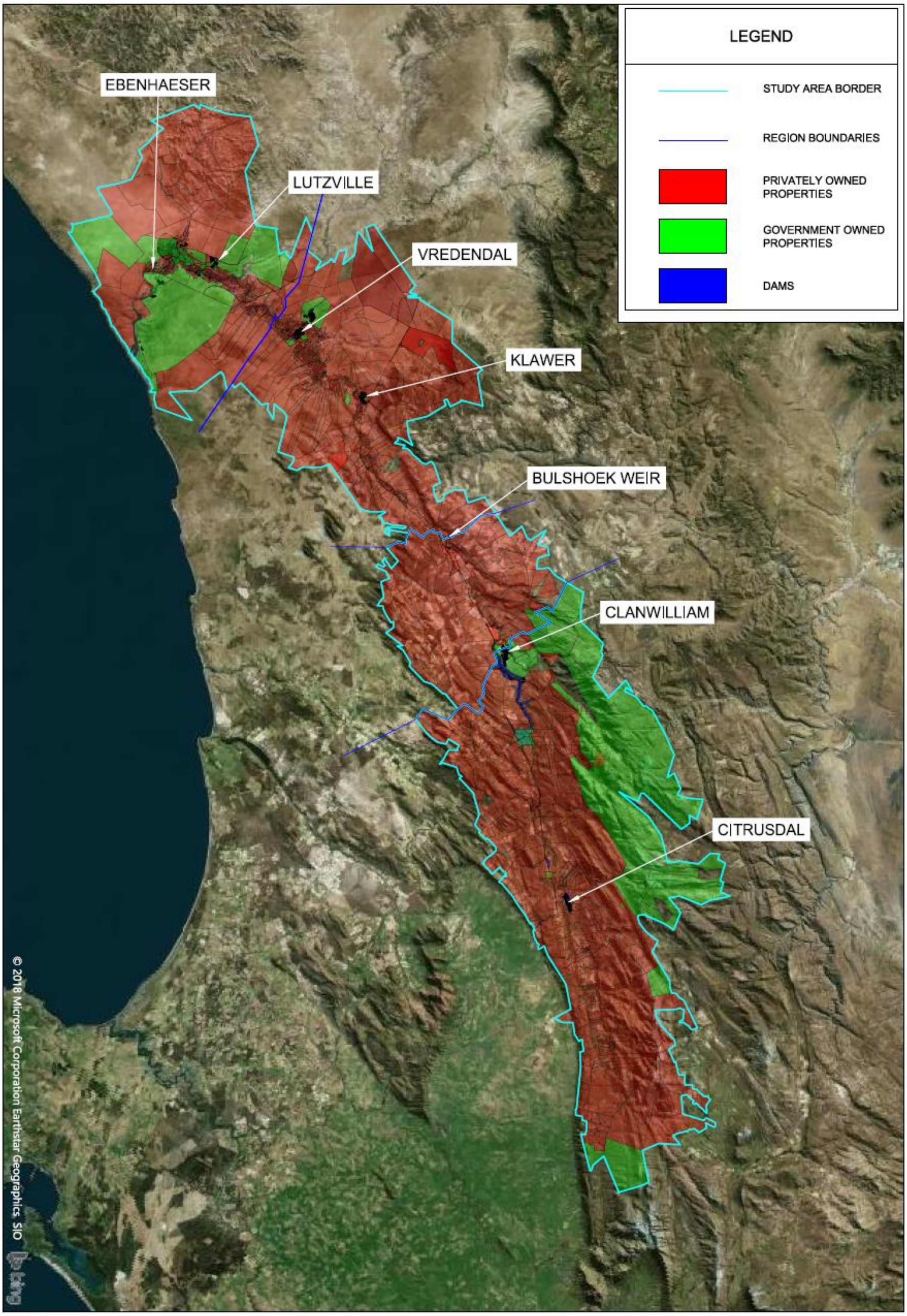


Figure 3.3 | Land ownership in the study area

3.4 Soil Suitability

The '*Soils, Water Requirements and Crops'* Report (DWAF, 2004), prepared as part of the Feasibility Study for the Raising of Clanwilliam Dam, included mapping of soils upstream of Bulshoek Weir to a lateral extent of about 60 m above the level of the river or existing canals.

Soils in the Olifants River Basin have a variety of naturally occurring soil properties that restrict the ability of plant roots to develop and absorb water and nutrients. These include physical and morphological (e.g. low clay content; cemented hardpans; surface crusting and hard-setting; dense and/or strongly structured subsoil clay layers; wetness; weathering rock and wind erosion) as well as chemical (e.g. acidity; free carbonates and alkalinity; and salinity) limitations.

An expert system approach was used to evaluate the potential of the different soil complexes in the production of annual and perennial crops. Five classes were used, as shown in **Table 3.7**.

Table 3.7 | Classes used to evaluate the potential of soils for different crop types

Potential	Recommendation for irrigated crop production	Percentage of maximum potential
Low	Not recommended	≤ 40%
Medium-low	Marginally recommended	> 40 - ≤ 50%
Medium	Conditionally recommended	> 50 - ≤ 60%
Medium-high	Recommended	> 60 - ≤ 80
High	Highly recommended	>80%

The total surface areas for the five potential suitability classes of soil types over the Olifants River Basin (Keerom to the Coast) for annual tuberous and non-tuberous crops and perennial crops, before and after amelioration of soil limitations are shown Table 3.8 and Table 3.9. Tuberous crops include crops such as potatoes, onions, sweet potatoes, and carrots; usually without hardpan amelioration. Non-tuberous crops include crops such as tomatoes, pumpkin, and beans; usually after hardpan amelioration. Perennial crops refer mainly to dry, wine and table grapes and citrus. The spatial distribution over the area from Keerom to Bulshoek Weir and Bulshoek Weir to the Coast is presented in **Table 3.8** and **Table 3.9** respectively.

Table 3.8 | Surface Area of the potential suitability of soil - Keerom to Bulshoek Weir

Potential class	Annual tuberous crops (ha)	Annual non-tuberous crops (ha)	Perennial crops	
			Before amelioration (ha)	After amelioration (ha)
≤ 40 %	11536	10774	18077	8099
> 40 - ≤ 50 %	7718	7303	9660	11063
> 50 - ≤ 60 %	476	7463	1196	8575
> 60 - ≤ 80 %	9930	4118	726	1922
> 80 %	0	0	0	0
Total area (ha)	**29 659**			

Table 3.9 | Surface Area of the potential suitability of soil - Bulshoek Weir to Coast

Potential class	Annual tuberous crops (ha)	Annual non-tuberous crops (ha)	Perennial crops	
			Before amelioration (ha)	After amelioration (ha)
≤ 40 %	83054	33457	86701	32540
> 40 - ≤ 50 %	812	5194	17418	1552
> 50 - ≤ 60 %	24264	21089	29118	2699
> 60 - ≤ 80 %	34464	82854	9356	105802
> 80 %	0	0	0	0
Total area (ha)	**142 594**			

The information in **Table 3.8** and **Table 3.9** are also displayed in the Potential Rating Soil Maps for the production of the various crops. An example of one of these maps, as recently updated, has been included below (**Figure 3.4)**.

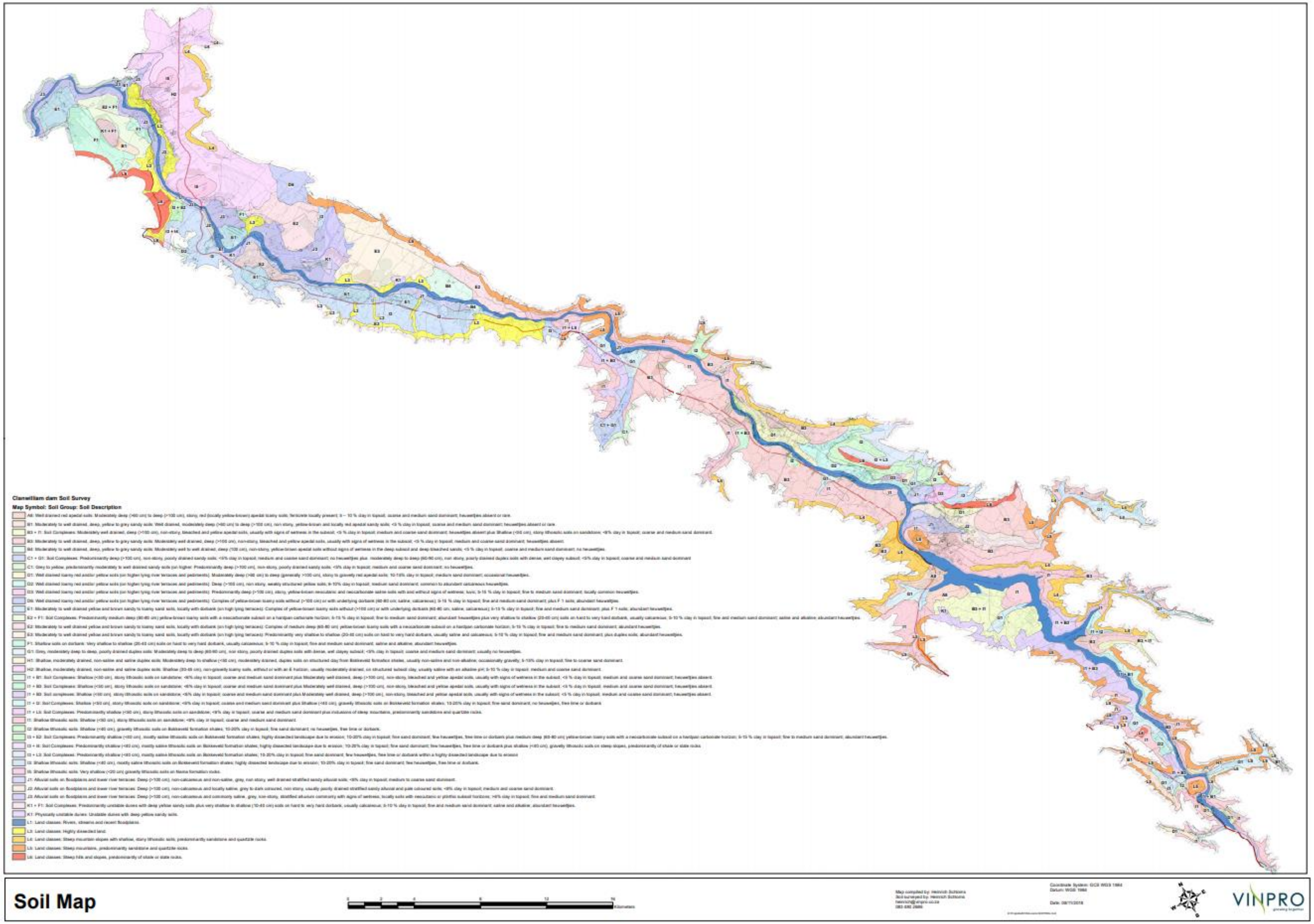


Figure 3.4 | Example of Potential Rating of soil map units

The potential irrigable areas previously identified will be reviewed, taking influencing factors into account. The findings from a soil survey and expert interpretation should be available before the future irrigation water requirements and associated infrastructure requirements are addressed. Due to advanced farming technology and management skills that exist in the developed sections of the study area, the inherent soil limitations do not pose any serious constraints on the irrigation development. It is rather factors such as relative position to water sources and environmental impacts that dictate further development.

3.4.1 Region 1 and 2 Soil Suitability

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 if 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 economically 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 potential irrigation areas do not yet reflect the impact of the Critical Biodiversity Areas and Ecological Support Areas or Protected Areas, and these areas are expected to significantly reduce once environmental sensitive areas are taken into account. It will also only be sensible to evaluate land ownership in more detail once specific irrigable areas have been identified.

3.4.2 Region 3 and 4 Soil Suitability

The soils in the surveyed area from Bulshoek Weir 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 of crops. 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 to produce perennial crops after amelioration of subsoil limitations, in particular hardpans, and if 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.

The potential irrigation areas do not yet reflect the impact of the Critical Biodiversity Areas and Ecological Support Areas or Protected Areas, and these areas are expected to reduce once environmental sensitive areas are taken into account. It will also only be sensible to evaluate land ownership in more detail once specific irrigable areas have been identified.

3.4.3 Increasing the extent of the soil survey

Considering that both the Clanwilliam WUA and LORWUA already have significant developments above the river and existing canals, it was decided to extend the soil survey to cover the lateral extent of 100 m above the level of the river or existing canals. The findings of the soil surveys will be provided in the Soil Survey Report.

3.5 Financial Viability of Crops and Recommended Farm Sizes

From the *Financial Viability of Irrigation Farming Sub-Report* (DWS, 2018), crop mixes and irrigation zones were identified. **Table 3.10** shows a summary of the identified crops per irrigation zone. The minimum viable commercial farm size was also investigated.

3.5.1 Selection of Crops

The following criteria were used for selecting crops to evaluate within this study were as follows:

- Crops which are well suited to the climate and soils enabling high yields and good quality to be produced; and
- Crops which are tried and tested in the area and already grown on a large scale commercially. Crops grown on a smaller scale with limited economic contribution to the region were therefore not selected.

Based on the above criteria the following crops were selected for this study:

1. Table grapes;
2. Citrus;
3. Raisins;
4. Wine grapes;
5. Tomatoes with brassica seed in rotation; and
6. Potatoes with wheat, in rotation.

Table Grapes

The bulk of South Africa's table grapes are exported. The Olifants River table grape producing area falls into a relatively early production window in the South African season, directly after the early areas, such as Limpopo and the Orange River. A shortage of water has resulted in limited expansion in the Olifants River area to date. As a result, there is still a relative shortage of table grapes during this production window, providing a good opportunity for future expansion in the Olifants River area.

Citrus

Citrus is the largest export fruit commodity in South Africa and the industry has performed well in recent years resulting in consistent growth in new plantings. Citrus volumes were down in the 2017 season, mainly due to drop-in orange volumes resulting from the drought in the Limpopo region and due to fruit drop in the Eastern Cape. Soft citrus and lemon volumes are set to grow considerably in the coming years because of new plantings and South Africa will need to grow its export markets for these crops.

Wine Grapes

Both the local and export markets play an important role in the South African wine industry. There is currently a shortage of bulk wine on a global level. It is anticipated that the South African price for bulk wine will therefore increase by up to 20%, providing some relief to growers.

Raisins

Global raisin production for 2017/2018 is also expected to decrease by 2% as modest gains in China are offset by lower output in Turkey, USA and Iran. Because of reduced supply, total stocks are expected to plunge 22% to 84,000 tons, an 8-year low. This also poses an opportunity for raisin exports from South Africa and indications from the South African Dried Fruit Association (SAD) are that the supply is expected to remain short in the world market for the foreseeable future.

Potatoes

The South African potato market is comprised of The National Fresh Produce Markets, processing, informal trade, retail and export, with the bulk of the volume sold in the local market. Slightly more than two thirds of the national crop are marketed in the formal market sector. South African production has increased by 35% in a decade from 2005 to 2015, to 248 million 10 kg bags. At the same time the number of producers has decreased, due to increased yields and an increase in the number of hectares per farmer.

Refer to **Table 3.10** for crop types recommended for each region.

Table 3.10 | Identified Irrigation Zones and Suitable Crops (DWS, 2018)

Zone	Location	Suitable Crops
1	Citrusdal	• Citrus (oranges & soft citrus)
2	From Clanwilliam Dam Wall to Bulshoek Weir (including Jan Dissels River)	• Citrus (oranges & soft citrus) • Table Grapes • Potatoes / wheat in rotation
3	Jakkalsvlei / Graafwater	• Potatoes • Grazing
4	From Bulshoek Weir to Trawal	• Table grapes • Raisins • Wine grapes • Tomatoes / brassica seed in rotation
5	From Trawal to the Coast	• Table grapes • Raisins • Wine grapes • Tomatoes / brassica seed in rotation

A summary of proposed crop water use requirements for each geographical area is shown below in **Table 3.11**. The table includes the irrigation efficiency factor for each crop type. It is recommended to make use of the most recent Validation & Verification (V&V) for the planning of bulk infrastructure options. (DWS, 2018). Finalised planning water requirements will be included in the report once available.

Table 3.11 | Summary of crop water use requirements per geographical area

Zone	Crop	Water use (m^3/ha/a)			Proposed volume (m^3/ha/a)
		Source	Efficiency factor	Volume	
1 – Citrusdal	Citrus	2004 Feasibility	90%	13 280	10 000
		V&V	90%	10 000	
		DOA	90%	14 310	
		DWS	90%	13 002	
2 – Clanwilliam	Citrus	2004 Feasibility	90%	14 100	11 000
		Jan Dissels study	90%	8000 (micro)	
		V&V	90%	11 000	
		DWS	90%	14 901	
	Table grapes	Jan Dissels study	90%	9000 (micro)	11 340
		V&V	90%	11 340	
		DWS	90%	12 417	
	Potatoes	2004 Feasibility	85%	5490	10 080
		DWS	80%	7440 / 10 811	
		V&V	80%	10 080	
3 – Jakkalsvlei / Graafwater	Potatoes	V&V	80%	10 080	10 080 Note that the value for Clanwilliam will also be used apply to the Jakkalsvlei / Graafwater area)
4 – Bulshoek to Trawal (quat E10K)	Table grapes	V&V	90%	11 340	11 340
	Wine grapes / raisins	V&V	90%	9500	9500
	Tomatoes	No data	-	-	It is recommended to use the V&V figure of 9281, which is the generic quota for vegetables

Zone	Crop	Water use (m^3/ha/a) Source	Efficiency factor	Volume	Proposed volume (m^3/ha/a)
	Vegetables (general)	V&V	80%	9281	9281
	Brassica	No data	-	-	Recommended to use Zone 5 figures of either 5030 or 2080, depending on season (as available from the DOA data)
5 – Klawer to Coast (quats E33G and E33H)	Table grapes	V&V	90%	12 390 (Vredendal)	12 390
		DOA	90%	4560 (Vredendal)	
			90%	5320 (Lutzville)	
		DWS	90%	12 128 (Klawer)	
			90%	11 959 (Lutzville)	
	Wine grapes / raisins	2004 feasibility	95%	9650 (Klawer)	9500
			95%	9080 (Lutzville)	
		V&V	90%	9500	
		DOA	90%	7110 (Lutzville)	
			90%	5960 (Vredendal)	
		DWS	90%	10 669 (Klawer)	
			90%	10 551 (Lutzville)	
	Tomatoes (processing)	2004 feasibility	95%	6930 (Klawer, Dec)	Recommended V&V value of 9281 for vegetables
			95%	6340 (Lutzville, Dec)	
	Tomatoes (table)	2004 feasibility	95%	8410 (Klawer, Dec)	
			95%	9340 (Klawer, Sep)	

Zone	Crop	Water use (m^3/ha/a)			Proposed volume (m^3/ha/a)
		Source	Efficiency factor	Volume	
			95%	7740 (Lutzville, Dec)	
			95%	8760 (Lutzville, Sep)	
	Tomatoes (unspecified)	DOA	80%	2830 (Vredendal, Mar)	
			80%	4710 (Vredendal, Jun)	
			80%	8800 (Vredendal, Sep)	
			80%	8180 (Vredendal, Nov)	
			80%	3700 (Lutzville, Mar)	
			80%	6110 (Lutzville, Jun)	
			80%	10 390 (Lutzville, Sep)	
			80%	9980 (Lutzville, Nov)	
		DWS	80%	11 276 (Lutzville, Sep)	
	Vegetables	V&V	80%	9281	9281
	Brassica	DOA	80%	4000 (Vredendal, Feb)	Recommended to use maximum volumes – either 5030 or 2080, depending on season
			80%	2080 (Vredendal, Apr)	
			80%	5030 (Lutzville, Feb)	
			80%	2660 (Lutzville, Apr)	

3.5.2 Water Use Values for Planning Purposes

The calculation of the aggregated water use requirements per crop is explained in this section. The aggregate crop water requirement for sub-area / zone is required for the evaluation of irrigation development options.

The extent of the main crops that are currently irrigated in the study area were identified. These crops are indicated in **Table 3.12** below. Note that Zone 3 was included with Zone 2 for calculation purposes.

Table 3.12 | Main irrigated crops grown in study area

Crop	Area (ha)			
	Zone 1	Zones 2 & 3	Zone 4	Zone 5
Citrus	6,757	650	0	0
Table Grapes	4	189	812	23
Wine Grapes	877	228	6,189	4,784
Vegetables	386	500	373	597
Fruit	1,055	50	145	5
Total	9,080	1,616	7,519	5,409

Source: GIS data obtained from Department of Agriculture

Further to the above the net crop water use requirements were calculated, by removing the irrigation efficiency factors (90% for permanent crops and 80% for annual crops). The net crop water use requirements are shown in **Table 3.13** for the identified crops.

Table 3.13 | Net crop water use requirements

Crop	Net crop water use (m^3/ha/a)			
	Zone 1	Zone 2 & 3	Zone 4	Zone 5
Citrus	9,000	9,900	9,900	9,900
Table Grapes	9,099	10,206	10,206	11,151
Wine Grapes	7,650	8,550	8,550	8,550
Vegetables	6,570	7,425	7,425	7,425
Fruit	8,100	8,910	8,910	8,910

The percentage (%) breakdown of identified crops that are planted in each zone was then calculated. Please refer to **Table 3.14** for the percentage breakdown of identified crops per zone.

Table 3.14 | Percentage breakdown of identified crops per zone

Crop	Area (ha)			
	Zone 1	Zone 2 & 3	Zone 4	Zone 5
Citrus	74.42	40.21	0.00	0.00
Table Grapes	0.05	11.68	10.80	0.42
Wine Grapes	9.66	14.08	82.31	88.45
Vegetables	4.26	30.93	4.97	11.03
Fruit	11.62	3.09	1.93	0.10

Lastly, the weighted average of the crop percentages per zone in **Table 3.14** and the net crop water use requirements in **Table 3.13** were used to calculate the aggregate crop water requirements. **Table 3.15** indicates the final aggregate crop water use requirements per zone, to be used for planning purposes.

Table 3.15 | Aggregate crop water use requirements

Zone	Aggregate water use (m^3/ha/a)
1	8,662
2 & 3	8,949
4	8,680
5	8,437

It was agreed that the extent of losses would be addressed for each option during the options analysis process. Losses have thus not been included in these water use requirement values.

3.6 Minimum Viable Farm Sizes

The minimum viable farm sizes resulting from the financial evaluations done for the *Financial Viability of Irrigation Farm Sub-Report* (DWS, 2018) are presented in **Table 3.16**, according to the identified commodities. The minimum viable farm size for an existing farm was calculated, as well as the minimum viable farm size for a new black-owned farm where the land was obtained at no cost.

Table 3.16 | Minimum Viable Farm Sizes (DWS, 2018)

Crop	Existing Commercial (ha)	New Black Owned (ha)
Citrus	22	90 (@IRR 8%)
Table Grapes	16	46
Wine Grapes	Not currently viable	Not currently viable
Raisins	68/12	26
Tomatoes/Brassica seed - commercial	27	41
Tomatoes/Brassica seed - Small scale production	6	6

In terms of the Black Producer Commercialisation Programme, of the Department of Agriculture, Forestry and Fisheries (DAFF), a Commercial Producer" is defined as a venture undertaken by an individual or business entity for the purpose of production and sale of agricultural products to make a profit. The annual turnover of commercial producers must exceed a minimum economic threshold (i.e. >R500 000) and be sufficient to support the producer and his family.

3.6.1 Financial Viability of Irrigation Farming

In general, the development of new irrigation farms seems to be problematic from a financial viability perspective. Given the reality of relatively profitable existing farming operations in the various regions of the study area, the major contributing factor to lower profit margins seem to be the expected relatively high capital cost of the development of new farms and the time taken for new plantings to come into full production.

It is therefore important to note that the expansion of existing irrigation farms will in general be financially more viable than the development of new irrigation farms. The main reasons for this are the cost effectiveness of the improved utilisation of infrastructure on existing farms relative to the costly nature of the development of new farms. For expansion of existing farms, citrus and table grapes currently appear to be profitable, followed by the other crops under certain circumstances.

Based on the financial evaluations, the following deductions have been made, which are to be considered when evaluating options:

1. Irrigation farming is capital intensive and costly due to, *inter-alia*, the following:
    - High-potential irrigation land is relatively scarce and is therefore expensive;

- The upgrading of medium-low and medium potential irrigation soil is a relatively expensive activity;
- The upgrading and development of bulk water infrastructure for irrigation is capital-intensive and is therefore costly,
- On-farm water infrastructure is also costly; and
- The establishment costs for new orchards/vineyards are high.

2. To produce a high income and offset the high capital- and other costs, high-value crops are produced, predominantly for export markets. These high-value crops however require a high level of technological and managerial inputs, making it difficult for new market entrants. For instance, the financial viability models for new black-owned farms and small-scale commercial farms is based on the yields that commercial growers achieve, but it cannot be assumed that all new black-owned farms will achieve these yields.

3.6.2 Economic Empowerment of Previously Disadvantaged Individuals

The previously mentioned financial viability study also investigated whether agricultural production could be profitable for smallholder (6ha farms) and commercial water users.

From a commercial perspective, the large-scale production of citrus and table grapes by previously disadvantaged individuals on new farms could be profitable in the study area if land is provided at no cost. A possibility exists to develop areas such as the lower Jan Dissels River and Zypherfontein to produce these crops at scale. Raisins, tomatoes and wheat could also be profitable if high yields are produced.

From a smallholder farming perspective, it was found that a 6ha agricultural unit in Ebenhaeser could potentially provide the farmer with an income of over R8 000 per month, if irrigation infrastructure and implements are covered by grants and the growers possess the inputs, skills and expertise to produce commercial-grade yields. It has been assumed that these farmers will only be liable for a very small portion of the total water levy. This finding could also be extrapolated to other areas that may be able to receive new water use allocations, e.g. municipal commonage schemes or other peri-urban or subsistence farming operations, should they similarly be exempt of paying full levies.

4 Environmentally Sensitive Areas

This section of the report provides a review of key environmental considerations for the proposed distribution options in the study area. This focuses on aspects of the natural environment which could potentially affect or be affected by the proposed distribution options. The analysis is indicative of the key environmental factors considered, with the aim of presenting the potential environmental constraints to be considered for the realisation of the project.

4.1 Western Cape Biodiversity Spatial Plan

The Western Cape Biodiversity Spatial Plan (2017) identifies Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs), per Municipality in the Western Cape, which require safeguarding to ensure the continued existence and functioning of species and ecosystems, including the delivery of ecosystem services, from a terrestrial and freshwater perspective. It also identifies Protected Areas (PAs) and Other Natural Areas (ONAs) in each Municipality.

4.1.1 Critical Biodiversity Areas and Ecological Support Areas

Critical Biodiversity Areas (CBAs) and Ecological Support Areas (ESAs) are terrestrial and freshwater areas that have been mapped as being important for conserving biodiversity patterns and ecological processes. More specifically, CBAs are areas that are required to meet biodiversity targets for species, ecosystems or ecological processes and infrastructure. According to the 2017 Western Cape Biodiversity Spatial Plan, CBAs are areas considered to be of high biodiversity and ecological value and therefore should be kept in a natural or near-natural state, with no further loss of habitat or species. Degraded areas should be rehabilitated to natural or near-natural condition and only low-impact, biodiversity-sensitive land uses are appropriate. The mapped CBAs have been categorised into those areas that are likely to be in a natural condition (CBA1) and those that are potentially degraded or represent secondary vegetation (CBA2).

ESAs are areas that are not considered essential for meeting biodiversity targets, however, they do play an important role in supporting the functioning of Protected Areas and/or CBAs. They create a vital link to the delivery of ecosystem services by supporting landscape connectivity, encompassing the ecological infrastructure from which ecosystem goods and services flow, and strengthening resilience to climate change. ESAs include features such as regional climate adaptation corridors, water source and recharge areas, riparian habitat surrounding rivers or wetlands, and endangered vegetation. Similarly, ESAs are also categorised into two categories, namely those that are still likely to be functional (i.e. in a natural, near-natural or moderately degraded condition) (ESA 1), and those that are severely degraded or have no natural cover remaining and therefore require restoration (ESA2). It is important to note that ESAs need to be maintained in at least a functional and often natural state, to support the purpose for which they were identified, but some limited habitat loss may be acceptable subject to an authorisation process.

Figure 4.1 shows the mapped terrestrial and aquatic CBA1 areas for the study area. There are very few areas mapped as CBA2 areas for the study area. The aquatic CBA areas cannot be identified in **Figure 4.1** because of the scale**.** The most prominent areas are near to Lamberts Bay and Elands Bay as shown by the white polygons in **Figure 4.2**. The ESA1 areas for the study area are shown in the **Figure 4.3**. There are no predominant ESA2 areas for the study area, as they are all small and at a very fine scale.

Figure 4.1 | Mapped Terrestrial and Aquatic Critical Biodiversity Areas 1

Figure 4.2 | Critical Biodiversity Areas 2

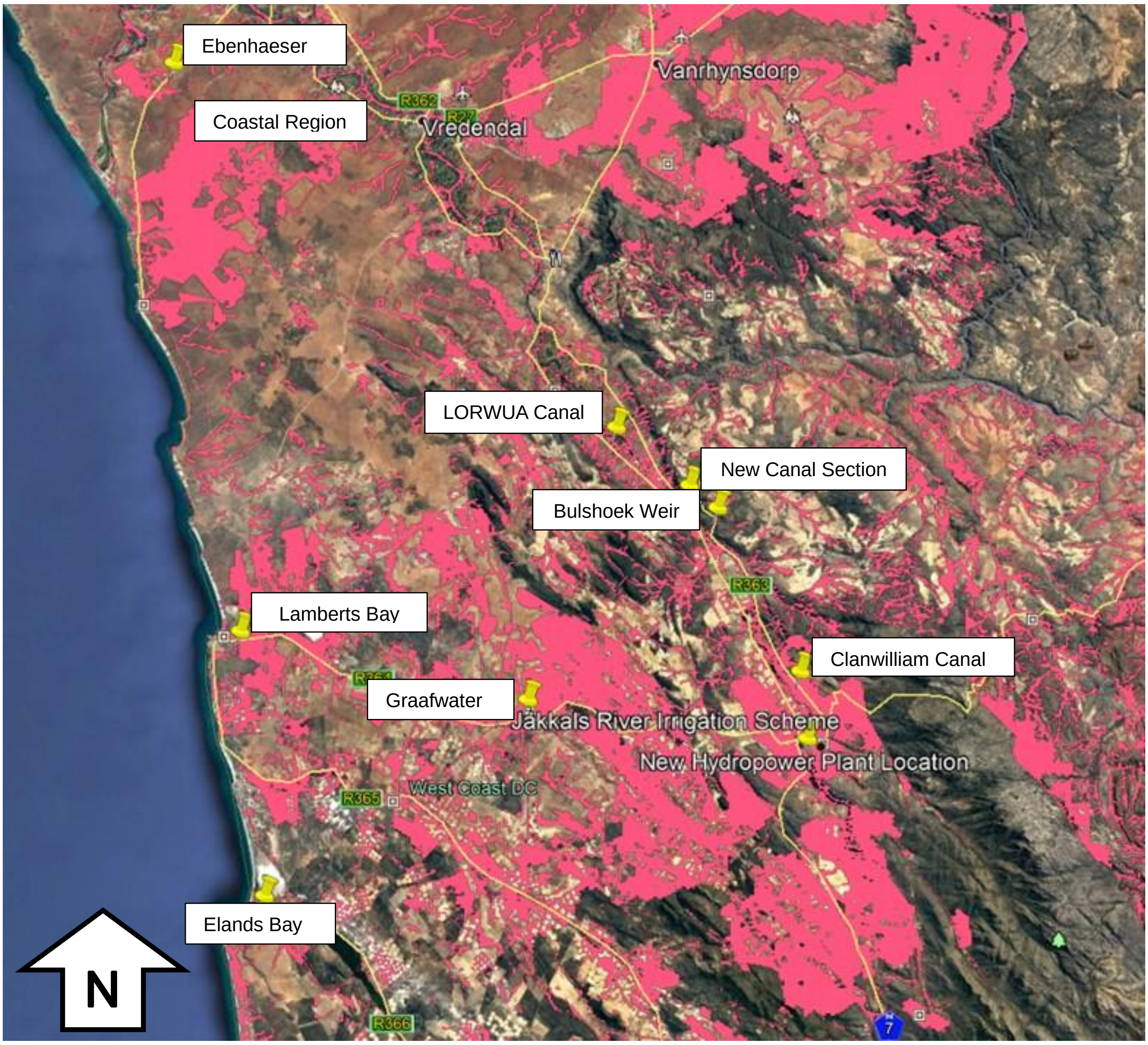


Figure 4.3 | Ecological Support Areas

4.1.2 Protected Areas

The Rondeberg Oord Private Nature Reserve is a private nature reserve located near the proposed Bulshoek Weir (**Figure 4.4**). It is a Protected Area that is recognised in terms of the National Environmental Management: Protected Areas Act (NEMPAA), Act 57 of 2003. In addition, the Ramskop Nature Reserve is located on the eastern bank of the Clanwilliam Dam. It is a local nature reserve that is also recognised in terms of the NEMPAA, Act 57 of 2003.

The Elandsbay State Forest is near to and north of Elands Bay (**Figure 4.5**). It is a nature reserve that is recognised in terms of the NEMPAA, Act 57 of 2003. Other nearby protected areas are the Steenboksfontein Private Nature Reserve and Aan de Klipheuvel, which is a contract nature reserve.

The Lutzville Conservation Area is a nature reserve that is located near the proposed coastal WODRIS irrigation area near Ebenhaeser (**Figure 4.6**) It is a Protected Area that is recognised in terms of the NEMPAA, Act 57 of 2003.

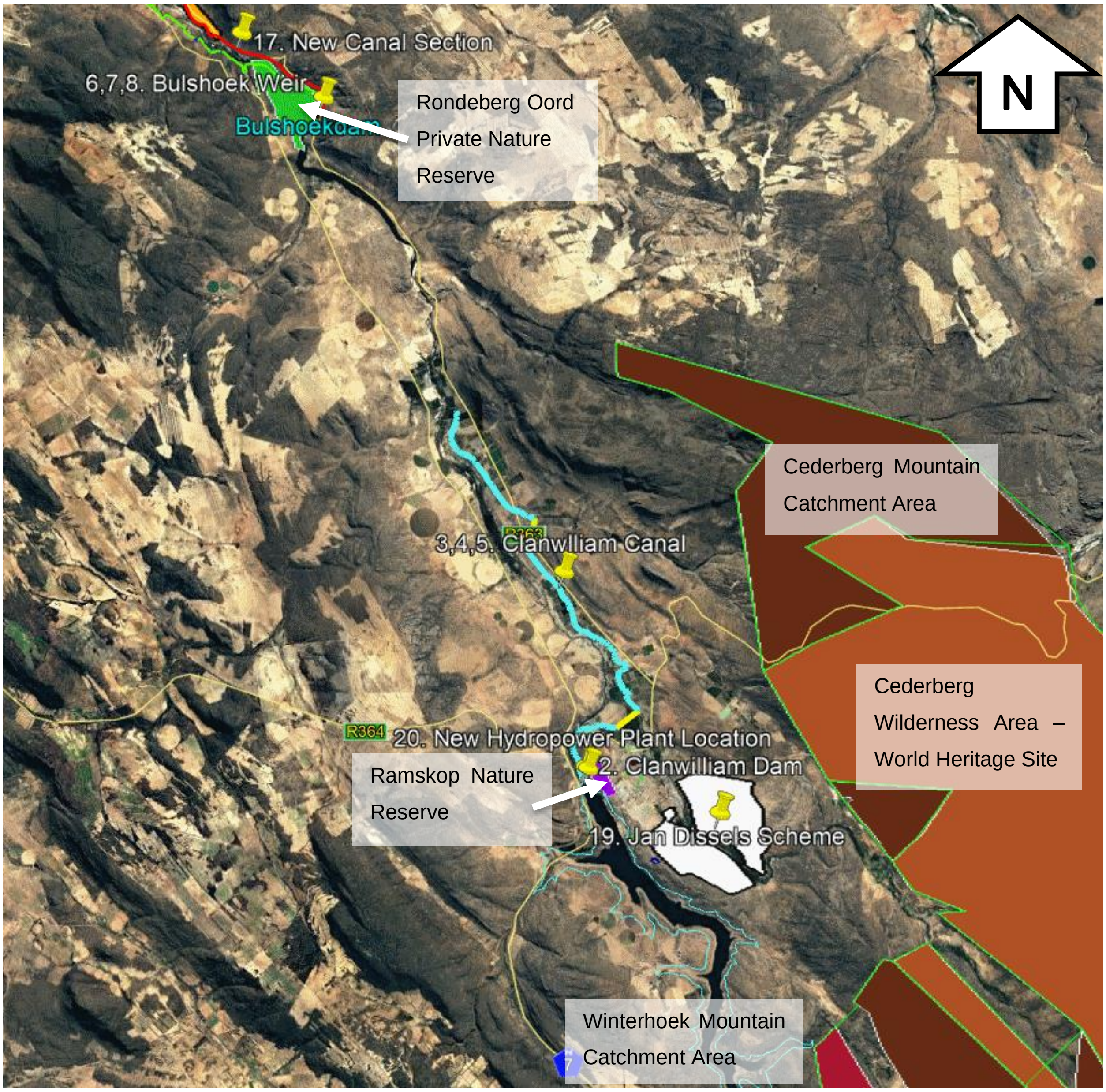


Figure 4.4 | Protected Areas 1

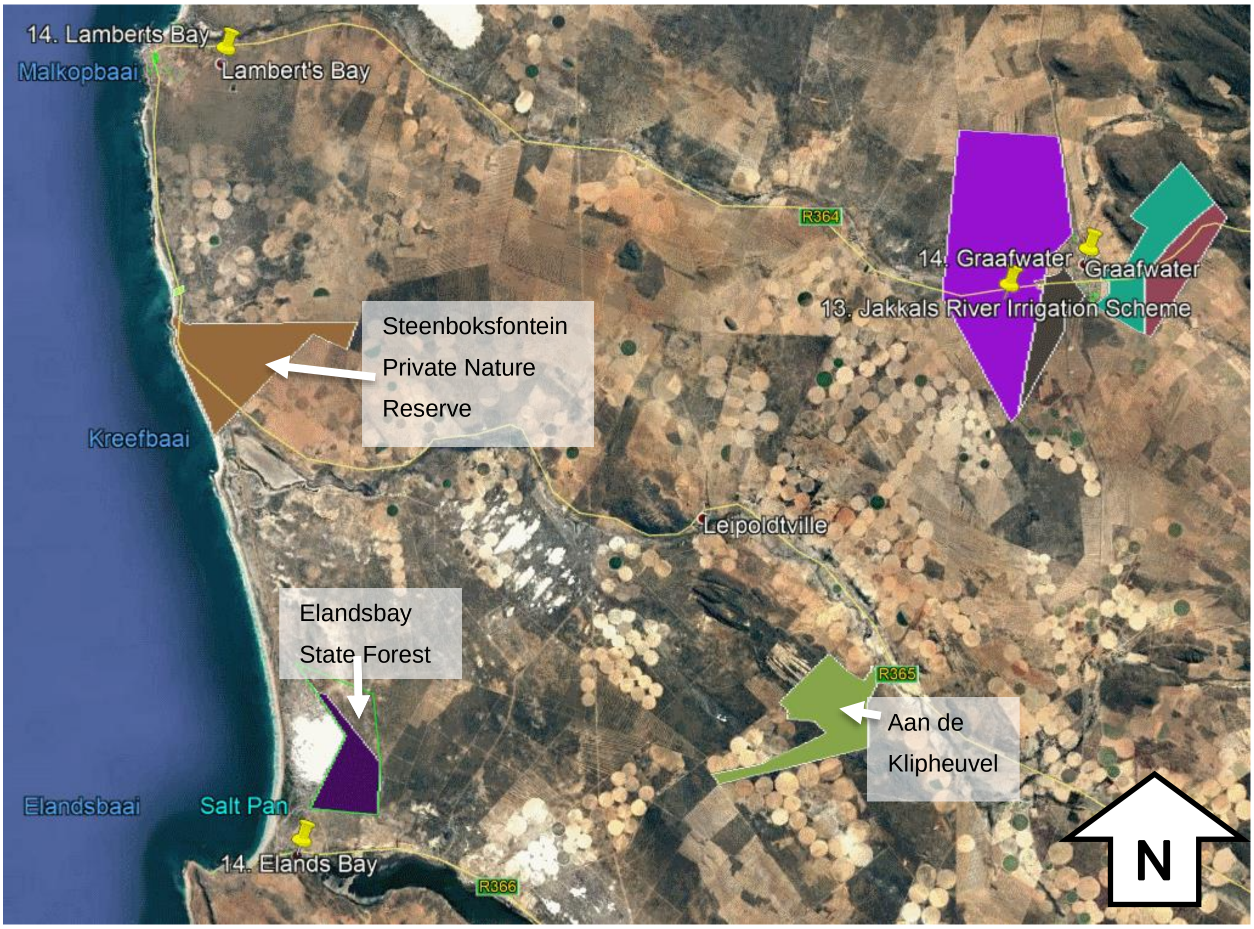


Figure 4.5 | Protected Areas 2

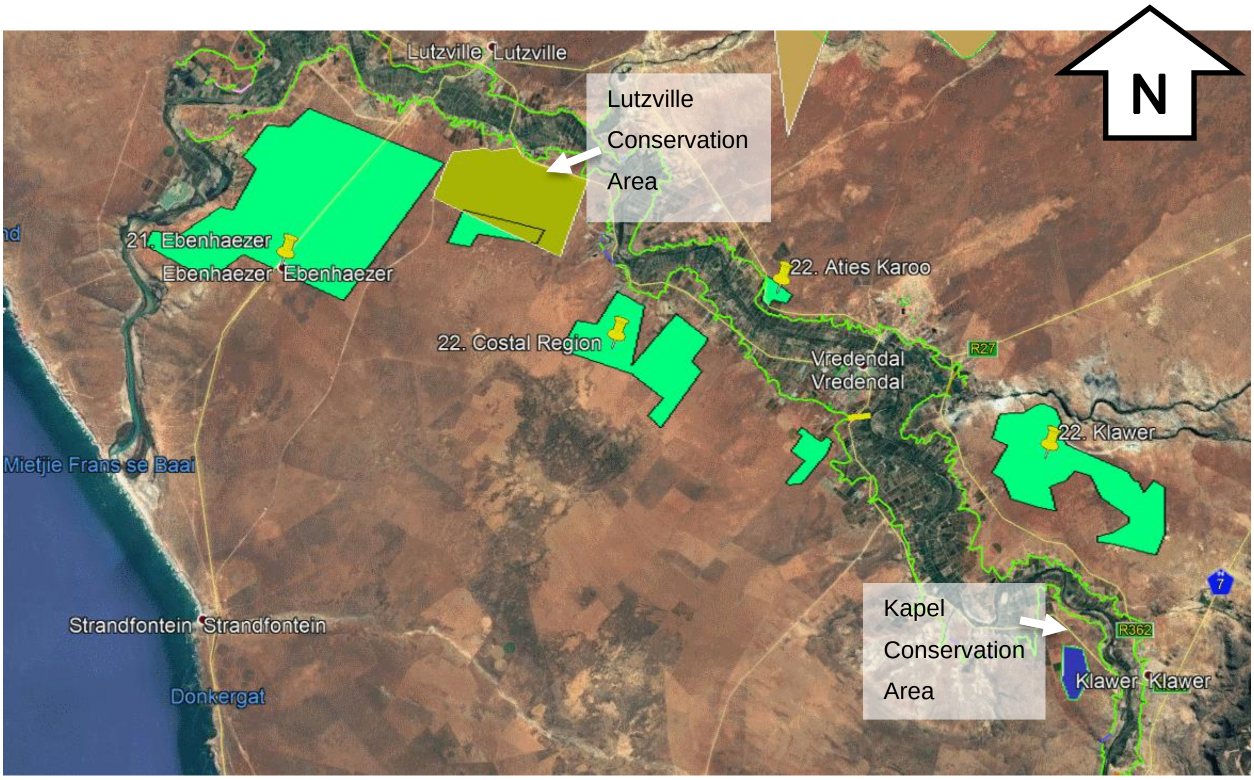


Figure 4.6 | Protected Areas 3

4.1.3 Other Natural Areas

Other Natural Areas (ONAs) are areas that have not been identified as a priority in the 2017 Western Cape Biodiversity Spatial Plan, but they retain most of their natural character and perform a range of biodiversity and ecological infrastructure functions. These areas are still an important part of the natural ecosystem and should be managed or utilised in a manner that minimises habitat and species loss and ensures ecosystem functionality. **Figure 4.7** below shows the ONAs mapped for the study area.

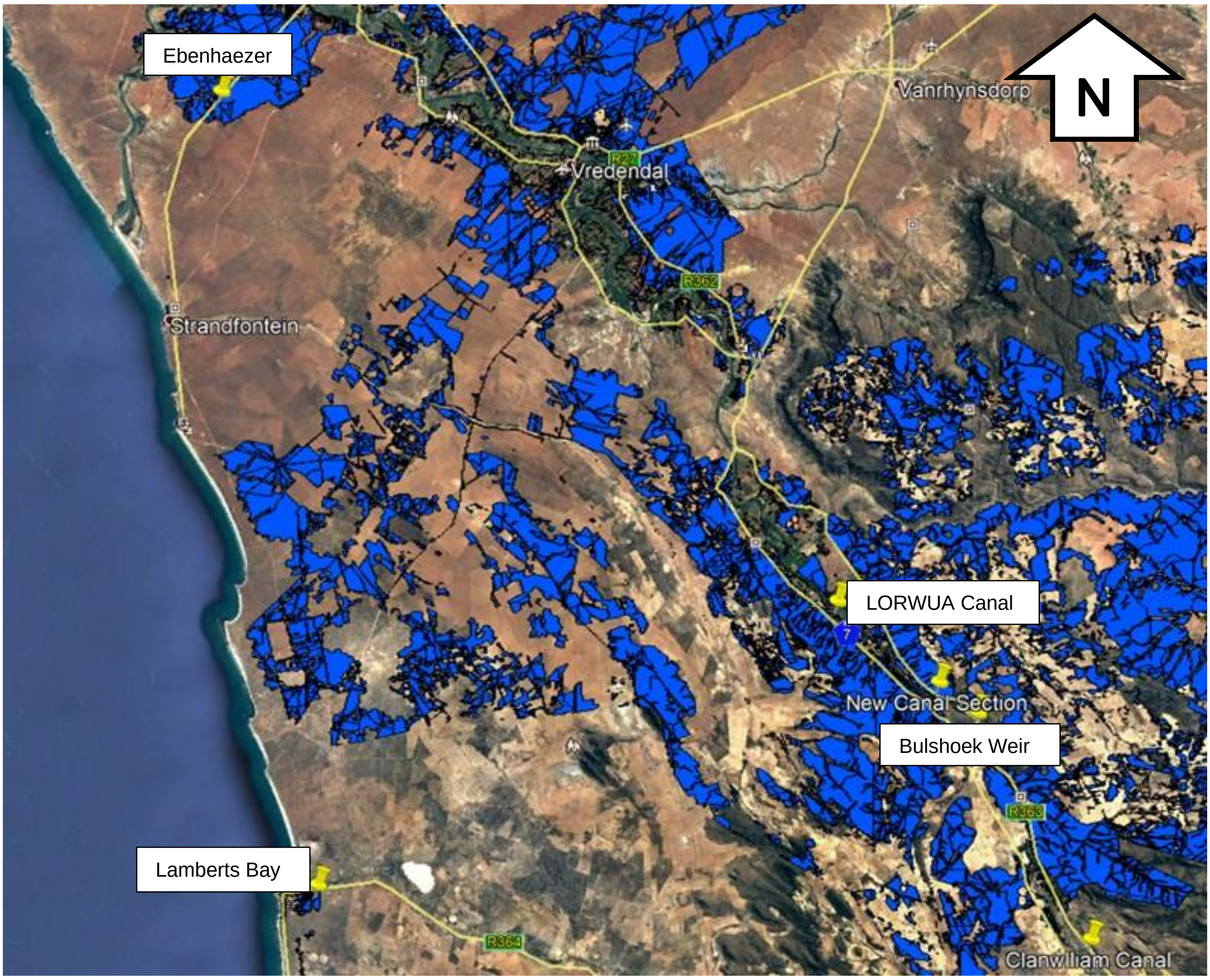


Figure 4.7 | Other Natural Areas

4.1.4 Natural Protected Area Expansion Strategy

National Protected Area Expansion Strategy (NPAES) as indicated in **Figure 4.8**, aims to achieve cost-effective protected area expansion for ecological sustainability and increased resilience to climate change. This is very important considering South Africa's protected area network falls short of sustaining biodiversity and ecological processes.

Two focus areas identified as part of the NPAES are located within the study area and surrounds. They are the Knersvlakte Hantam focus area and the Tankwa Cederberg Roggeveld focus area. The Knersvlakte Hantam focus area straddles the Western Cape and Northern Cape and is a Succulent Karoo priority area. It contains numerous irreplaceable quartz patches and provides opportunities to protect whole intact river reaches.

The Tankwa Cederberg Roggeveld focus area also straddles the Western Cape and the Northern Cape and is important from a freshwater biodiversity perspective. It includes a large portion of the Doring River, which plays a central economic role in sustaining the high levels of utilisation of the Olifants River and meeting the water requirements of the Olifants estuary. The Tankwa Cederberg Roggeveld focus area also presents opportunities for protecting several threatened river types and important fish sanctuary areas that harbour endemic and threatened freshwater fish.

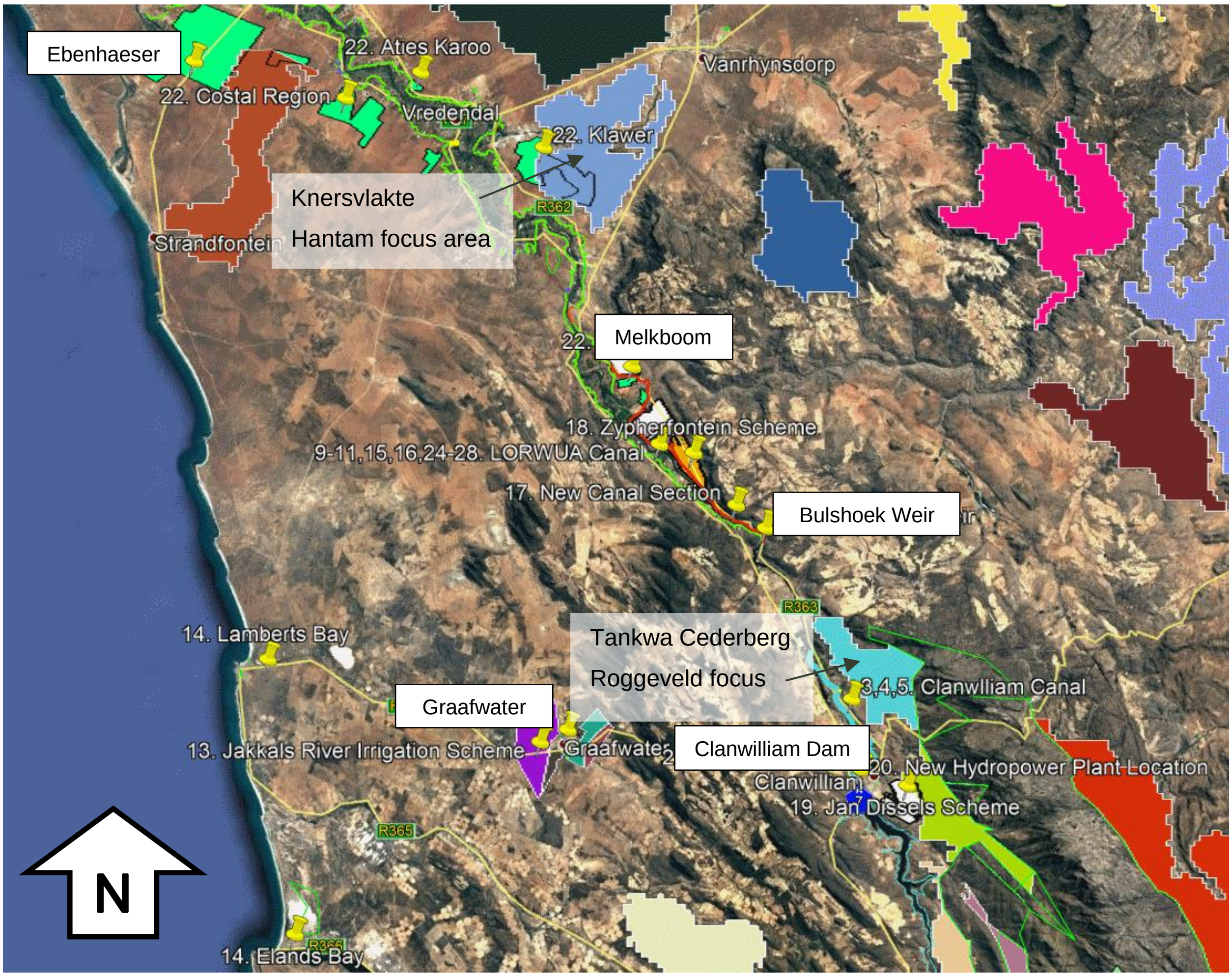


Figure 4.8 | National Protected Area Expansion Strategy Areas

4.2 Wetlands and National Freshwater Ecosystem Priority Area Rivers

The study area comprises numerous wetlands, drainage lines and rivers that are a National Freshwater Ecosystem Priority Area (NFEPA). The predominant watercourses and features are:

1. The estuarine wetland associated with the Verlorevlei River (Class C: Moderately Modified) and dam near Elands Bay.
2. The Olifants River (Class D: Largely Modified) and associated natural NFEPA wetland.
3. The Jan Dissels River (Class D: Largely Modified) and associated natural NFEPA wetland.
4. The estuarine wetland associated with the Jakkals River (Class C: Moderately Modified) near Lamberts Bay.
5. The estuarine wetland associated with the Olifants River near Ebenhaesar.

4.3 Threatened Ecosystems

Ecosystem threat status is indicative of the degree to which ecosystems are still intact or alternatively losing vital aspects of their structure, function and composition – on which their ability to provide ecosystem services depends. Ecosystems are categorized as Critically Endangered (CR), Endangered (EN), Vulnerable (VU) or Least Threatened (LT), based on the proportion of the ecosystem that remains in good ecological condition. Threatened ecosystems are an important factor to consider when identifying land for the various distribution options as they are listed in terms of the National Environmental Management: Biodiversity Act (NEM:BA), Act 10 of 2004. It is advised that any Vulnerable and/or Endangered vegetation is avoided as far as possible.

The study area contains the following threatened ecosystems:

1. Arid Estuarine Salt Marshes (LT)
2. Bokkeveld Sandstone Fynbos (VU) - threatened plant species associations
3. Cape Inland Salt Pans (LT)
4. Cape Lowland Freshwater Wetlands (LT)
5. Cederberg Sandstone Fynbos (VU) - threatened plant species associations
6. Citrusdal Shale Renosterveld (EN) - irreversible loss of natural habitat
7. Citrusdal Vygieveld (LT)
8. Doringrivier Quartzite Karoo (LT)
9. Fynbos Riparian Vegetation (LT)
10. Graafwater Sandstone Fynbos (LT)
11. Klawer Sandy Shrubland (VU) - irreversible loss of natural habitat
12. Knersvlakte Dolomite Vygieveld (LT)
13. Knersvlakte Quartz Vygieveld (LT)
14. Knersvlakte Shale Vygieveld (LT)
15. Kobee Succulent Shrubland (LT)
16. Lambert's Bay Strandveld (VU) - irreversible loss of natural habitat
17. Langebaan Dune Strandveld (LT)
18. Leipoldtville Sand Fynbos (EN) - irreversible loss of natural habitat
19. Namaqualand Riviere (LT)
20. Namaqualand Sand Fynbos (LT)
21. Namaqualand Spinescent Grassland (LT)
22. Namaqualand Strandveld (LT)
23. Nardouw Sandstone Fynbos (VU) - irreversible loss of natural habitat
24. North Hex Sandstone Fynbos (LT)

25. Northern Inland Shale Band Vegetation (LT)
26. Olifants Sandstone Fynbos (LT)
27. Vanrhynsdorp Gannabosveld (LT)
28. Vanrhynsdorp Shale Renosterveld (LT)

4.4 Stewardship Sites

Part of the Jan Dissels Scheme has been identified as the Augsberg stewardship site (CapeNature, 2017). This is shown by the pink area in **Figure 4.9** below. This stewardship site has a signed Biodiversity Agreement in place and is identified as approximately 1138.77 ha in size. The purpose of the Biodiversity Agreement is to conserve private conservation-worthy land.

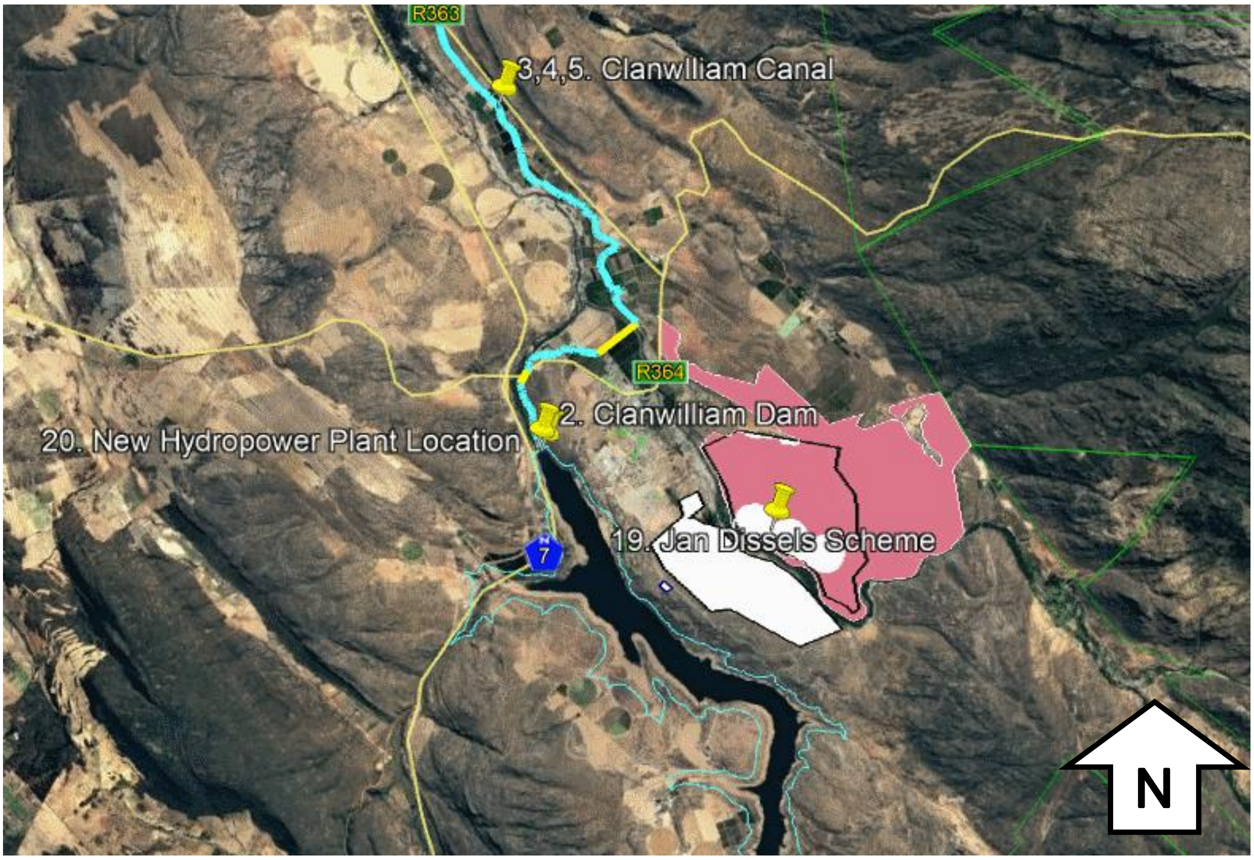


Figure 4.9 | Jan Dissels Stewardship Site

5 Water Quality Considerations and Constraints

5.1 Introduction

Water quality in the upper Olifants River, upstream of Clanwilliam Dam, is suitable for all uses. There is some evidence of elevated phosphate concentrations, which may be the result of agricultural activities and wastewater return flows in the Citrusdal area. The good quality water is stored in Clanwilliam Dam and Bulshoek Weir, from where it is distributed via a system of canals to irrigation farmers in the middle and lower Olifants River valley.

In the Olifants River downstream of Clanwilliam Dam and upstream of the Doring River confluence, the water quality remains suitable for agriculture and domestic water supplies although minor impacts of irrigation return flows and treated effluent discharges (elevated phosphate concentrations) are already evident. The Olifants River downstream of the Doring River confluence is progressively impacted by irrigation return flows resulting in a steady increase in salinity in a downstream direction. The result is that water in the lower Olifants River, upstream of the tidal effect zone, is poor and salinity exceeds the requirement for irrigation use.

This chapter provides an overview of water quality monitoring in the study area, and the water quality requirements of irrigation farmers. Water quality monitoring points are shown in **Figure 5.1**.

5.2 Water quality monitoring in the lower Olifants River

5.2.1 Department of Water and Sanitation

As part of the National Chemical Monitoring Programme (NCMP), the Department of Water and Sanitation has an extensive monitoring network in the Olifants River catchment that has been sampled at various frequencies for several years. The key monitoring points in the study area, for which data has been obtained, are presented in **Table 5.1**.

Table 5.1 | Key DWS water quality monitoring points used in this study

Point number	Description	n	First date	Last date	Flow Gauge	Latitude	Longitude
101895	E1H006 - Jan Dissels River at Clanwilliam Commonage Warmhoek - at Gauging Weir on Jan Dissels River	527	1/4/1978	11/4/2016	E1H006	-32.21156	18.93676
101903	E2H003 - Doring River at Melkboom on Doring River	724	5/13/1972	11/14/2017	E2H003	-31.86028	18.6875
101908	E3H001 - Troe-Troe River at Farm 256/Troe-Troe	13	7/21/1987	9/10/2013	E3H001	-31.62972	18.69472
186216	E3H004 - Olifants River at Lutzville (Formerly E2H016)	140	12/11/2002	5/23/2017	E3H004	-31.5653	18.3306
101900	E1R001Q01 - Bulshoek Weir on Olifants River: near Dam Wall	608	6/29/1972	3/16/2017	E1R001	-31.996	18.78645
101901	E1R002Q01 - Clanwilliam Dam on Olifants River: near Dam Wall	557	4/3/1968	8/3/2010	E1R002	-32.18472	18.875
101896	E1H007 - Bulshoek Weir on Left Bank Canal from Bulshoek Weir	349	3/10/1972	2/27/2018	E1H007	-31.99523	18.7866

Notes – Point number = Registered number on WMS, n = number of samples collected, First Date and Last Date = date the first sample was collected and date of the last sample date in the database when it was accessed.

Water samples are typically analysed for a number of constituents which include Calcium, Chloride, Dissolved Mineral Salts, Electrical conductivity, Fluoride, Potassium, Magnesium, Sodium, Ammonia, Nitrate-nitrogen, Nitrite-nitrogen, Ortho-phosphate, pH, Silicon, and Total Hardness. It also calculates a number of indices which include SAR, aSAR, Corrosivity index, Langelier index, Aggressiveness index, and Rayznar index.

5.2.2 Western Cape Department of Agriculture

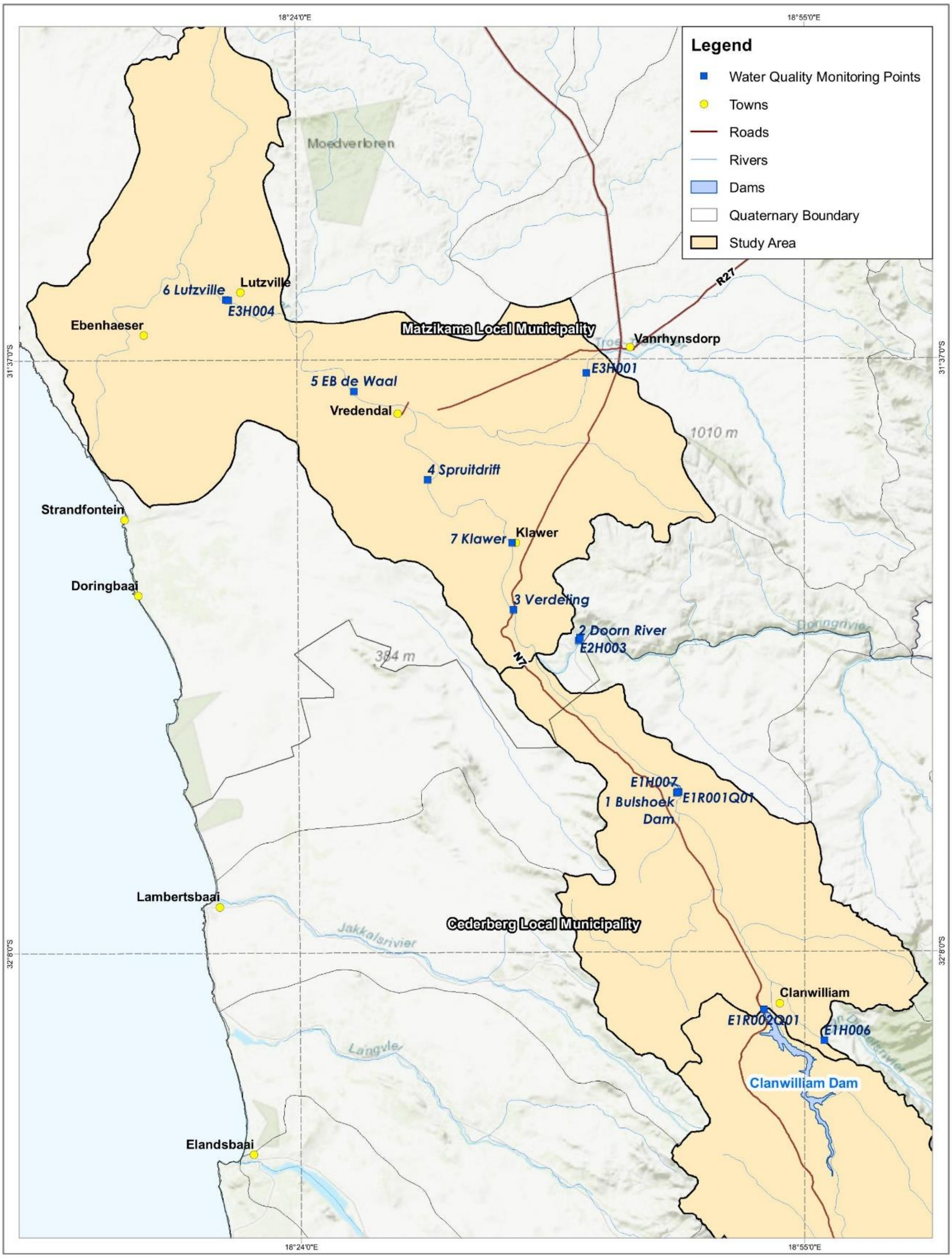
The Western Cape Department of Agriculture conducted intensive weekly monitoring of the lower Olifants River below Bulshoek Weir for a period of three years (hydrological years, September 2010 to October 2011, Sept 2011 to Oct 2012, and Sept 2012 to Oct 2013). Samples were collected at seven monitoring points (**Table 5.2**) and analysed for a number of constituents.

Table 5.2 | Western Cape Department of Agriculture monitoring points

Sampling point name	Longitude	Latitude
1 Bulshoek Weir	18.787245	-31.99595
2 Doring River	18.686265	-31.862627
3 Verdeling	18.619466	-31.835101
4 Spruitdrift	18.532857	-31.722385
5 EB de Waal	18.460242	-31.647809
6 Lutzville	18.327511	-31.564697
7 Klawer	18.618328	-31.77775

The samples were analysed for pH, Conductivity, TDS, Calcium, Magnesium, Potassium, Sodium, Chloride, Sulphate, Bicarbonate, Copper, Iron, Alkalinity, and Hardness. Indices that were calculated include SAR, Corrosivity index, Langelier index, Aggressiveness index, and Rayznar index.

This data set provided a very good indication of the changes in quality along the length of the lower Olifants River as well as the seasonal changes in quality. These changes are discussed below.



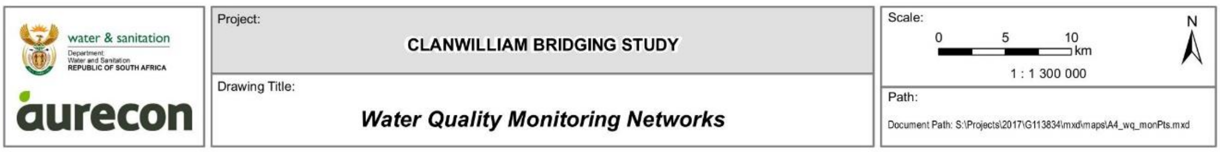


Figure 5.1 | Map showing the location of water quality monitoring points

5.3 Water quality requirements

Irrigation water supply is the key water use in the lower Olifants River followed by domestic water use. The generic water quality requirements of these two user sectors and their fitness for use categories (DWS, 2006) are summarised in **Table 5.3** and **Table 5.4.**

Table 5.3 | Generic water quality guidelines for Agricultural Use: Irrigation

VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Total Suspended Solids	mg/l	50	75	100	>100
CHEMICAL REQUIREMENTS					
Chloride	mg/l	100	137.5	175	>175
Electrical Conductivity	mS/m	40	90	270	>270
Fluoride	mg/l	2.0	8.5	15.0	>15.0
pH (upper)		8.4	8.4	8.4	>8.4
pH (lower)		6.5	6.5	6.5	<6.5
Sodium Absorption Ratio	mmol/l	2.0	8.5	15.0	>15.0
Sodium	mg/l	70.0	92.5	115.0	>115.0
Aluminium	mg/l	5.0	12.5	20.0	>20.0
Arsenic	mg/l	0.1	1.05	2.0	>2.0
Beryllium	mg/l	0.1	0.3	0.5	>0.5
Boron	mg/l	0.5	0.75	1.0	>1.0
Cadmium	mg/l	0.01	0.03	0.05	>0.05
Chromium VI	mg/l	0.1	0.56	1.0	>1.0
Cobalt	mg/l	0.05	2.75	5.0	>5.0
Copper	mg/l	0.2	2.6	5.0	>5.0
Iron	mg/l	5.0	12.5	20.0	>20.0
Lead	mg/l	0.2	1.1	2.0	>2.0
Lithium	mg/l	2.5	2.5	2.5	>2.5
Manganese	mg/l	0.02	5.1	10.0	>10.0
Molybdenum	mg/l	0.01	0.03	0.05	>0.05
Nickel	mg/l	0.2	1.1	2.0	>2.0
Selenium	mg/l	0.02	0.04	0.05	>0.05
Uranium	mg/l	0.01	0.06	0.1	>0.1
Vanadium	mg/l	0.1	0.56	1.0	>1.0
Zinc	mg/l	1.0	3.0	5.0	>5.0

VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
BIOLOGICAL					
Faecal coliforms	per 100ml	1	500	1000	>1000

Reference: South African Water Quality Guidelines, Volume 4, Agricultural Water Use - Irrigation (DWAF, 1996)

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site-specific conditions.

Table 5.4 | Generic water quality guidelines for Domestic Use

VARIABLE	UNITS	IDEAL	ACCEPTABLE	TOLERABLE	UNACCEPTABLE
PHYSICAL REQUIREMENTS					
Hardness	mg $CaCO_3$	200	300	600	>600
Turbidity	NTU	0.1	1	20	>20
CHEMICAL REQUIREMENTS					
Calcium	mg/l	80	150	300	>300
Chloride	mg/l	100	200	600	>600
Chlorine (upper)	mg/l	0.6	0.8	1.0	>1.0
Chlorine (lower)	mg/l	0.3	0.2	0.1	<0.1
Electrical Conductivity	mS/m	70	150	370	>370
Fluoride	mg/l	0.7	1.0	1.5	>1.5
Magnesium	mg/l	70	100	200	>200
Nitrate + Nitrite	mg N/l	6.0	10.0	20.0	>20.0
PH (upper)		9.5	10.0	10.5	>10.5
PH (lower)		5.0	4.5	4.0	<4.0
Potassium	mg/l	25	50	100	>100
Sodium	mg/l	100	200	400	>400
Sulphate	mg/l	200	400	600	>600
Total Dissolved Solids (TDS)	mg/l	450	1000	2400	>2400
Arsenic	mg/l	0.01	0.05	0.2	>0.2
Cadmium	mg/l	0	0.01	0.02	>0.02
Copper	mg/l	1.0	1.3	2.0	>2.0
Iron	mg/l	0.5	1.0	5.0	>5.0
Manganese	mg/l	0.1	0.4	4	>4
Zinc	mg/l	20	20	20	>20
BIOLOGICAL					
Total coliforms	per 100ml	0	10	100	>100
Faecal coliforms	per 100ml	0	1	10	>10

Reference: Quality of Domestic Water Supplies, Volume 1: Assessment Guide. (Water Research Commission, 1998).

* The 'Ideal' water quality is equated to the Target Water Quality Range (TWQR) provided in the Water Quality Guidelines.

** The above generic water quality guidelines are recommended for use in determining the present and desired water user category at a low confidence desktop and rapid approach.

*** The limits presented above do not take into account site-specific conditions.

Salinity

Salinity of water is measured by two common water quality criteria. The first, total dissolved solids (TDS), expressed in milligrams per litre (mg/l), is the total number of milligrams of salt that remains after a litre of water is evaporated. The higher the TDS, the higher the salinity. The second measurement of salinity is electrical conductivity (EC). The dissolved salts conduct electricity and therefore salt concentration is directly related to the EC reading.

In the WODRIS report the Provincial Department of Agriculture developed a site-specific classification for salinity (**Table 5.5**) that is more stringent than the SA Water Quality Guidelines for Irrigation Agriculture, to specify the water quality requirements for the Olifants irrigation area and to assess the fitness for use of the water.

Table 5.5 | Salinity ratings for irrigation in the Olifants River
(Provincial Government Western Cape, 2004). The values in brackets represent the generic SAWQG values for irrigation.

Salinity hazard	EC (mS/m)	TDS (mg/l)	Applicability
Low (Ideal*)	10 – 25 *(<40)*	64 – 160 *(<260)*	Can be used on most soils with little likelihood that soil salinity will develop. Some leaching is required but this occurs under normal irrigation practices except in soil of extremely low permeability.
Medium (Acceptable*)	25 – 75 *(40-90)*	160 – 480 *(260-585)*	Can be used for irrigation if a moderate amount of leaching occurs. Plants with moderate salt tolerance can be grown in most cases without special practices for salinity control.
High (Tolerable*)	75 – 225 *(90-270)*	480 – 1 440 *(585-1755)*	Not to be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good salt tolerance should be selected.
Very high (Unacceptable*)	≥ 225 *(>270)*	≥ 1 440 *(>1755)*	Not suitable for irrigation water under most conditions.

** The equivalent water use categories (Ideal, Acceptable, Tolerable, and Unacceptable) were added to the original table.*

Sodicity

Sodicity of water refers to the quantity of sodium in relation to calcium and magnesium in the water. Sodicity is measured as the function of the ratio of sodium to calcium and magnesium and is called the sodium adsorption ratio (SAR). Generally, sodic conditions are accompanied by high concentrations of salts. The SAR limits for irrigation water are listed in **Table 5.6** (PGWC, 2004).

Table 5.6 | Sodicity ratings for irrigation water

Sodicity hazard	SAR	Explanation
S1	0 – 10	**Low sodium water** can be used for irrigation on almost all soils with little danger of the development of harmful levels of exchangeable sodium.
S2	10 – 18	**Medium sodium water** will present an appreciable sodium hazard in fine textured soils having high cation exchange capacity, especially under low leaching conditions unless gypsum is applied.
S3	18 – 26	**High sodium water** may produce harmful levels of exchangeable sodium in most soils and will require special soil management – good drainage, high leaching and organic matter additions.
S4	> 26	**Very high sodium water** is unsatisfactory for irrigation purposes.

The Provincial Government Western Cape (2004) salinity and sodicity guidelines were therefore used to assess the fitness for use of the water in the study area for irrigation use.

5.4 Spatial and seasonal water quality trends

The focus of this assessment is on irrigation water supply because one of the many bulk conveyance options is to potentially use the Olifants River downstream of Bulshoek Weir as a conduit. Water can then be abstracted at points along the length of the river, where the quality is still fit for irrigation use. Total Dissolved Salts or its equivalent, Dissolved Mineral Salts, was used to assess the fitness for use for irrigation agriculture.

Water quality in Clanwilliam Dam (E1R002Q01) and in Bulshoek Weir (E1R001) is ideally suited for irrigation use (Figure 5.2). There is also very little change in salinity between Clanwilliam Dam and Bulshoek Weir. The salinity in the Doring River is also low, although higher than in Bulshoek Weir during the summer months. However, there is a large increase in salinity between Bulshoek Weir and the low water bridge at Lutzville (E3H004). The salinity increases to such a degree that the water in the lower reaches is unsuitable for irrigation at certain times of the year (**Figure 5.2**).

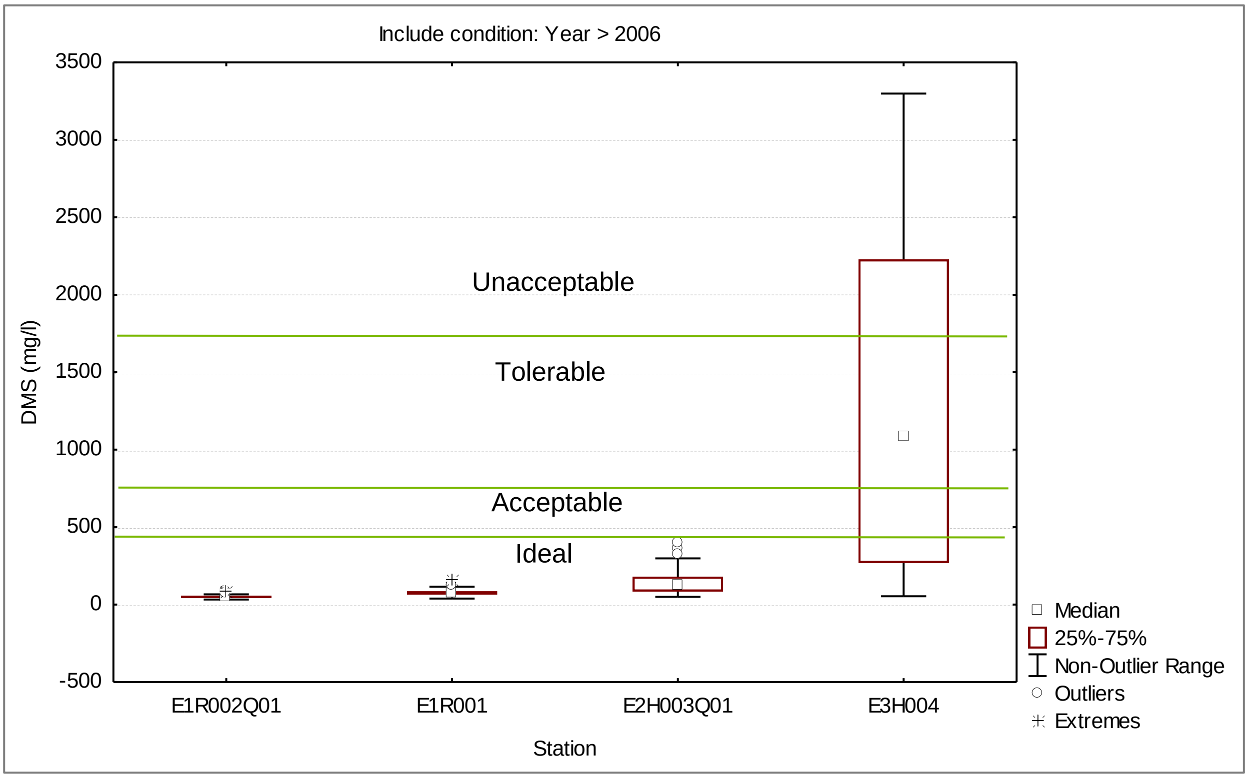


Figure 5.2 | TDS in the Lower Olifants River from 2006 to 2017/18

To assess the changes in salinity between Bulshoek Weir and Lutzville, the monitoring data that were collected by the Western Cape Department of Agriculture has been reviewed (**Figure 5.3**).

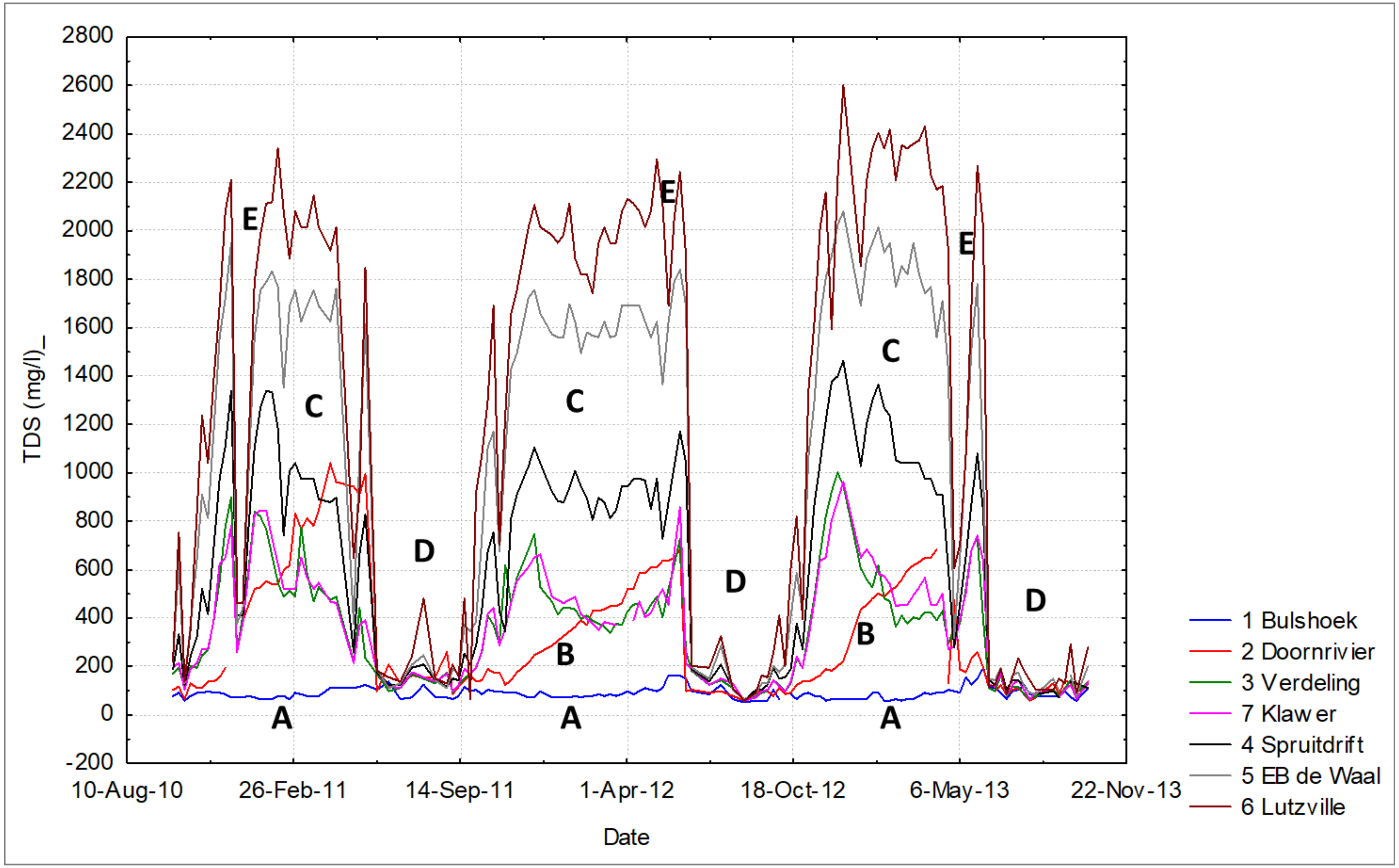


Figure 5.3 | Change in salinity along the Lower Olifants River - Bulshoek Weir to Lutzville

Several observations can be made from the data (**Figure 5.3**):

A. The salinity in Bulshoek Weir (blue line) was consistently low over the three hydrological years that were sampled.
B. Salinity in the Doring River (red line) was similar to the quality in Bulshoek Weir at the end of the wet winter season. It then increased steadily through the dry summer season, until the onset of the wet winter season that reset the salinity back to low concentrations. This was probably due to evaporation losses in summer, moderate irrigation return flows, and shallow groundwater inflows. The increase in salinity towards the end of summer did not seem to have a major impact on salinities at Verdeling and Klawer, probably due to very low flow in the Doring River.
C. During the dry summer season, when farmers are irrigating their crops, irrigation return flows increased the salinity in the Olifants River, and the increase was cumulative in a downstream direction. Between Bulshoek Weir and Verdeling there was, on average, about an 400% increase in salinity. There was almost no difference between the salinities at Verdeling and Klawer. Between Klawer and Spruitdrift there was a 72% increase in salinity, a 67% increase between Spruitdrift and EB de Waal, and about a 22% increase in salinity between EB de Waal and Lutzville. The biggest increase was therefore between Bulshoek Weir and Verdeling, downstream of the confluence with the Doring River.
D. With the onset of the wet winter season, salinities fell rapidly and remained moderate to low, up to the onset of the next dry season. The wet season flows reset salinity to background concentrations. With the onset of the dry season, salinities increased rapidly.
E. A decrease in salinity during a late or early wet season rainfall event is temporary and salinity levels return to high concentrations as soon as the pulse of good quality water leaves the system.

In an ideal situation, gauged flows would be available for the lower Olifants River, and this could be used to calculate salt loads at the sampling points, as well as the areal salt loads based on the irrigation area between the sampling points that would contribute to the return flow salt loads. However, flow gauging in the lower Olifants River at Bulshoek Weir, Lutzville and the Doring River is almost non-existent to support load calculations.

5.5 Temporal trends

The long-term DWS data were used to examine the temporal trends at the sampling points. Over the past 10 years there appears to be an increasing trend in salinity in both Clanwilliam Dam (E1R002Q01) (**Figure 5.4**) and Bulshoek Weir (E1R001) (**Figure 5.5**). However, the dissolved major salts (DMS) concentrations are still within the ideal range.

A concern is that the sampling frequency at Clanwilliam Dam and at Bulshoek Weir were severely curtailed after 2008 which may tend to skew the trend lines. The sampling for Clanwilliam Dam stopped in 2010. It is recommended that sampling in the lower Olifants River be restored and normalised.

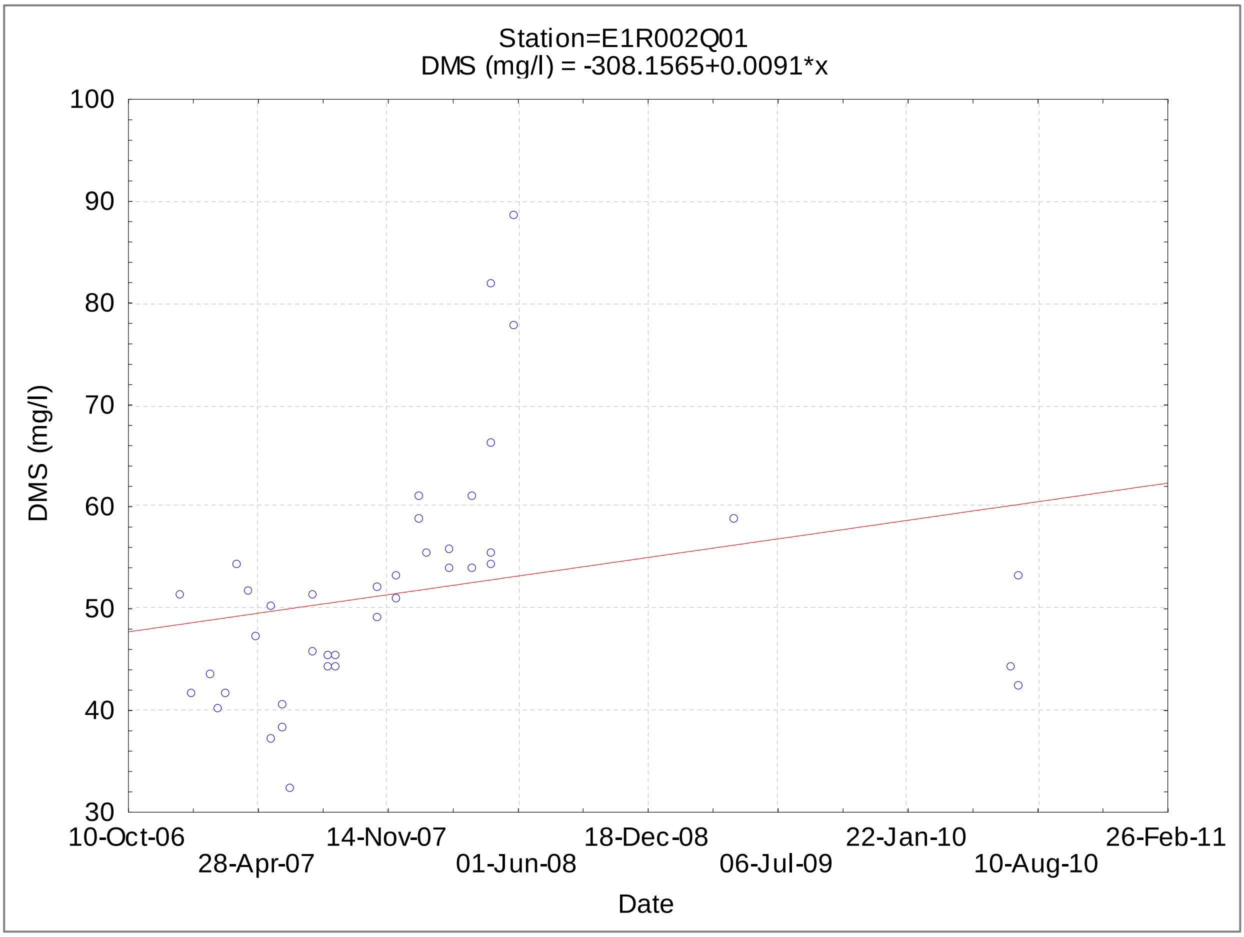


Figure 5.4 | TDS concentrations in Clanwilliam Dam from 2007 to 2010

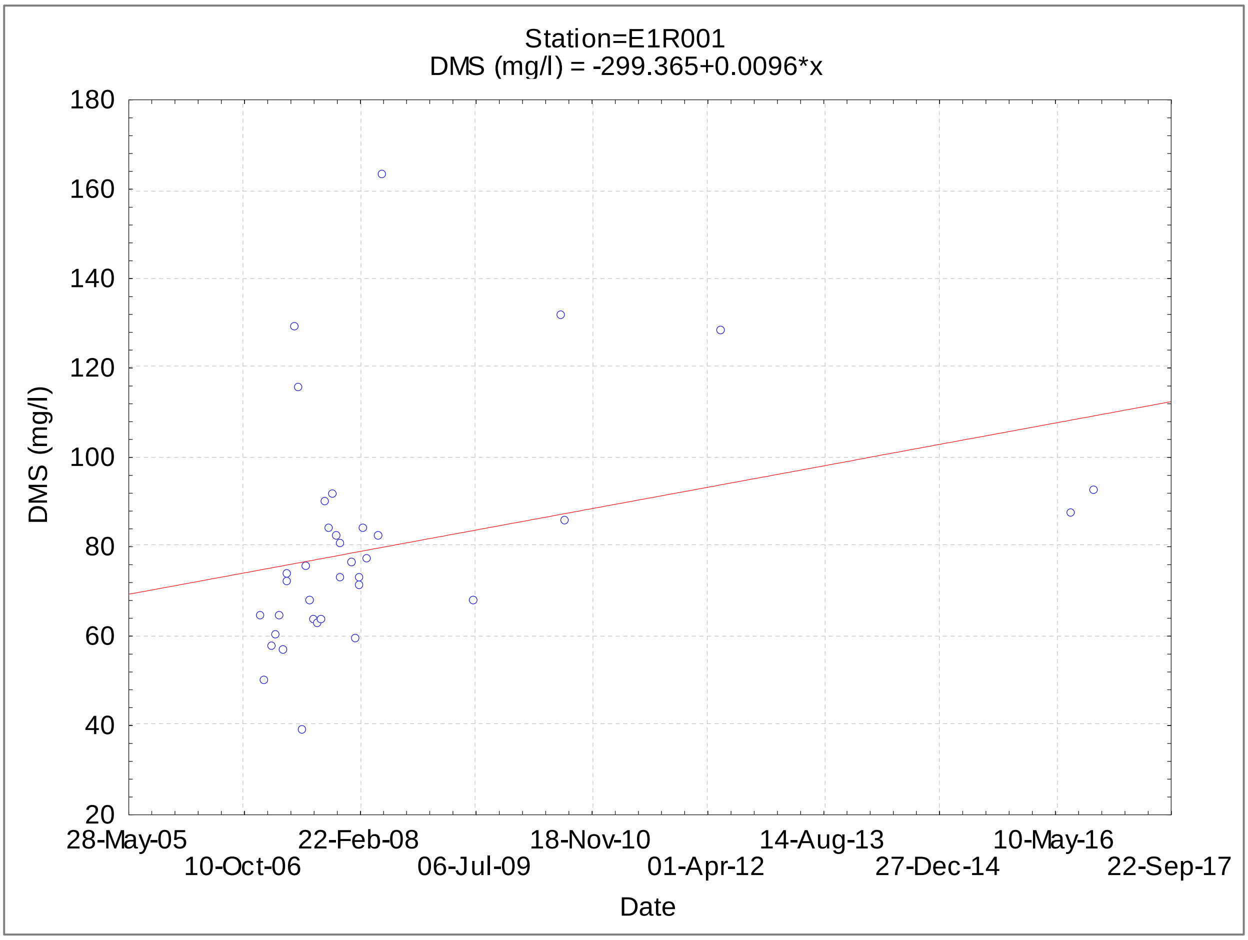


Figure 5.5 | TDS concentrations in Bulshoek Weir from 2007 to 2017

In the Doring River the long-term trend appears to be stable (**Figure 5.6**).

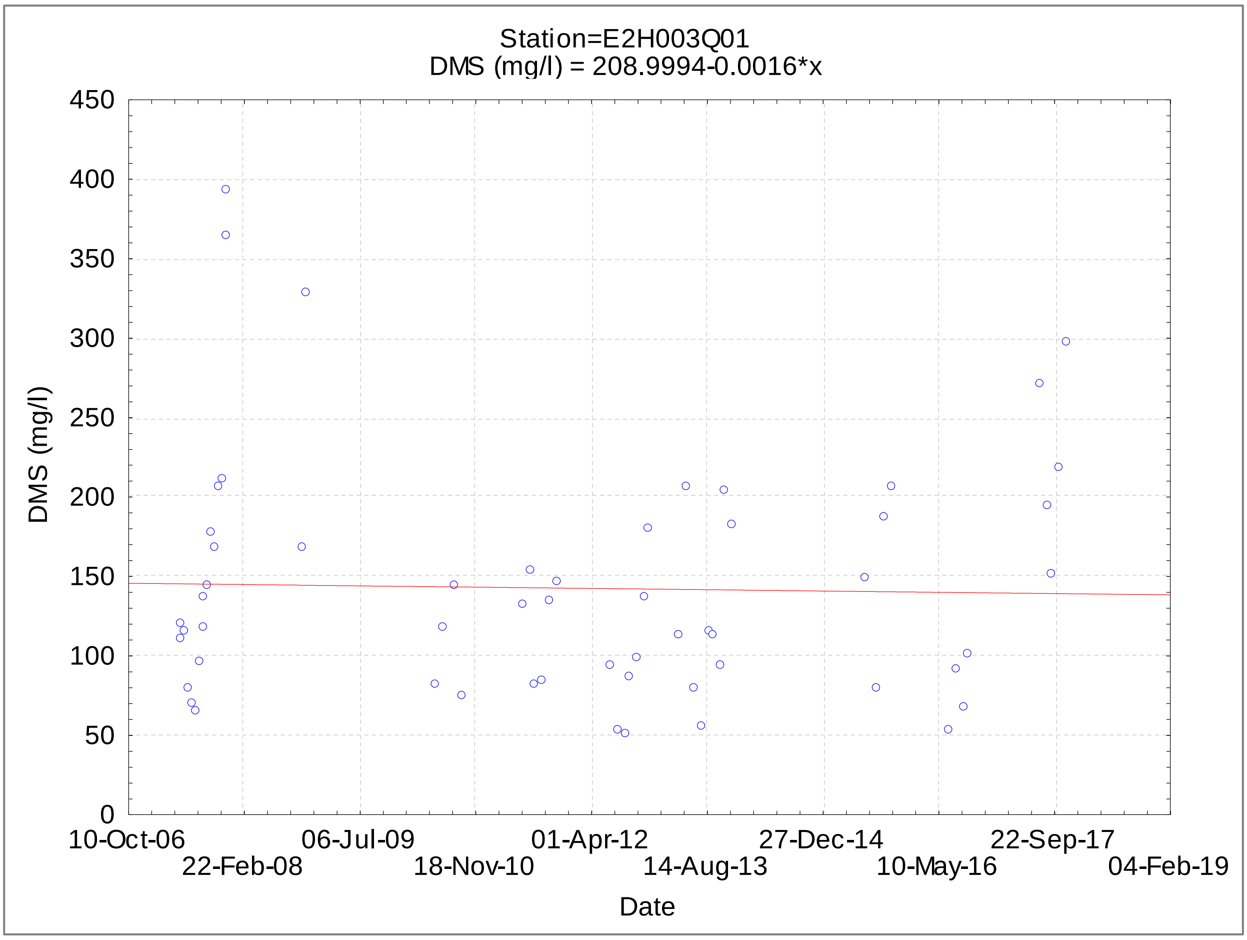


Figure 5.6 | TDS concentrations in the Doring River (before the confluence) from 2007 to 2017

The long-term trend in the Olifants River at Lutzville (E3H004) indicates an increasing trend (**Figure 5.7**). The upper limit for DMS for irrigation use (1440 mg/l from Table 5.5) is exceeded at least every year.

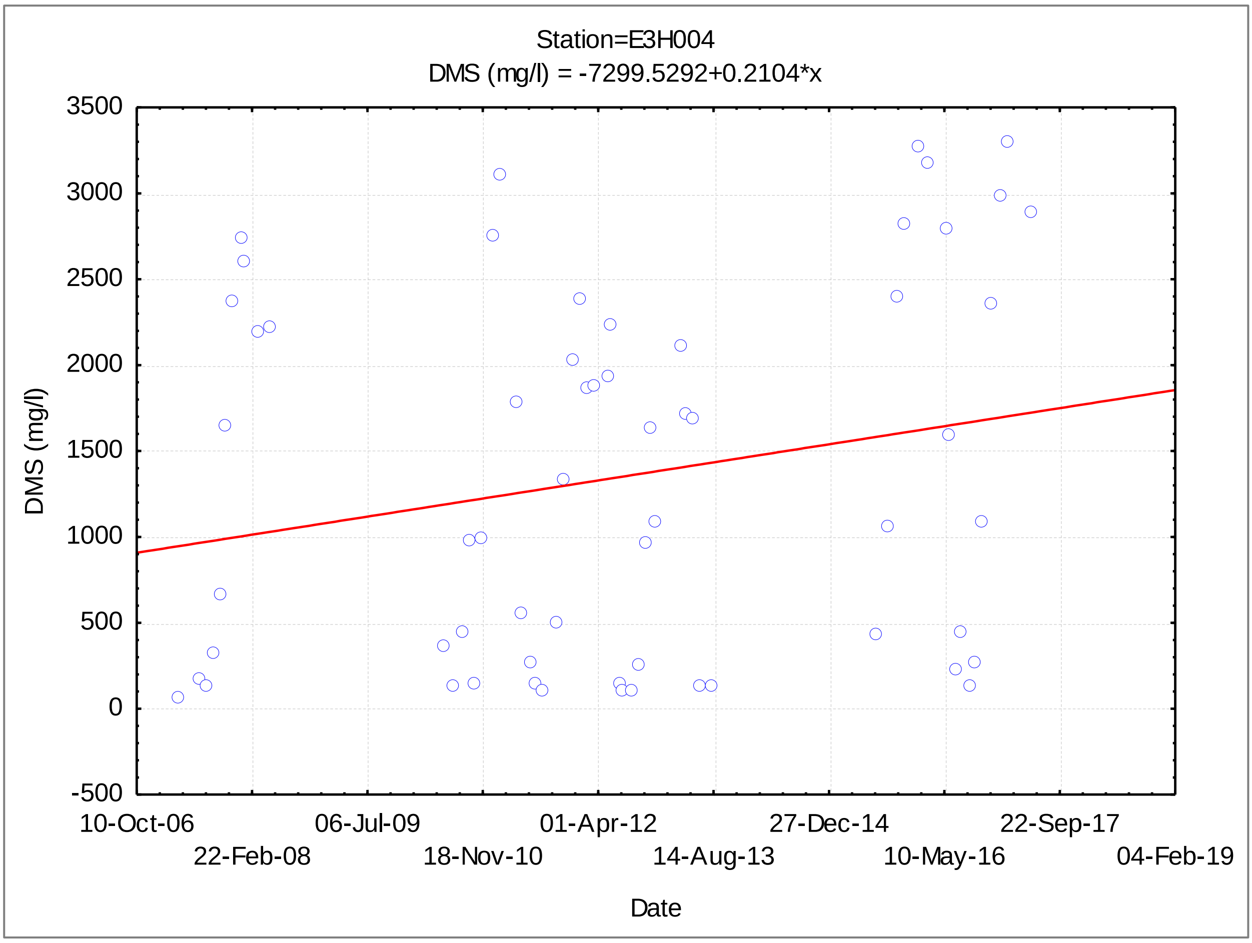


Figure 5.7 | TDS concentrations in the Olifants River at Lutzville from 2007 to 2017

5.6 Estimating salt export loads from irrigated areas

To estimate the impact of establishing new irrigation areas on the potential salt loads and concentrations in the Olifants River, the weekly water quality data collected by the Department of Agriculture over the 2010 – 2013 hydrological years were analysed. The calculations were focused on the dry summer seasons only as this was the period during which excessive salt concentrations were observed in the Olifants River below Bulshoek Weir. This is also the period during which the Olifants River could be considered as a conduit for irrigation water from Bulshoek Dam to users further downstream.

The salt loads and areal salt load contribution were calculated as follows:

1. At the time of sampling (2010 – 2013), river releases at Bulshoek Dam and gauged flows in the Doring River were estimated for the day a water sample was collected. No gauged flows were available for the gauging structure at Lutzville for the 2010 – 2013 sampling period.

2. For calculating salt loads an assumption was therefore made that the flow in the Olifants River downstream of the confluence of the Olifants River and the Doring River was the sum of the two flows. This flow was used to calculate the salt loads at the sampling sites from Verdeling to Lutzville. The salt load in kg/day was calculated by multiplying the salt concentration by the total flow for the day.
3. The mass of salt (kg/day) that entered the river between consecutive sampling points was calculated by subtracting the salt load at the upstream sampling point from the load at a particular sampling point.
4. The irrigation areas that would contribute return flows (with salts) to a particular sampling point were then estimated by adding together the irrigated areas within the river reaches. The contributing irrigated areas in the various section are given in **Table 5.7**.

Table 5.7 | Contributing irrigated areas

River reach	Irrigated area (ha)
Bulshoek to Doring River confluence	1170.15
Doring River confluence to Verdeling	1083.07
Verdeling to Klawer	213.56
Klawer to Spruitdrift	2207.21
Spruitdrift to EB de Waal	3819.78
EB de Waal to Lutzville	3916.32

5. The areal salt load (kg/ha/day) was then calculated by dividing the salt load by the irrigated area.
6. The median salt load per reach (kg/ha/day) was then calculated, as well as the range (interquartile range – 25th and 75th percentile values)

Table 5.8 | Salt load per reach

River reach	Areal salt load (kg/ha/day) (dry season)		
	Median	25th percentile	75th percentile
Bulshoek to Verdeling	11.54	8.94	18.75
Verdeling to Spruitdrift	14.30	9.73	19.22
Spruitdrift to EB de Waal	11.66	8.51	15.58
EB de Waal to Lutzville	6.37	3.20	8.50

7. The areal salt load can then be used to estimate, on average, the additional salt loads that could be added to the river in a particular river reach, from the added irrigation area. The change in salt concentration can then be estimated by assuming some flow in the river.

These estimates would only be valid for the dry season which is the critical period in terms of return flows to the lower Olifants River.

5.7 Water quality constraints and opportunities

If the Olifants River is being considered as a conduit for transporting irrigation water for abstraction further downstream, the following constraints would apply:

- During the summer months, high salinity irrigation return flows would probably increase the salinity to unacceptable levels for irrigation use. Fourie (1976) measured TDS in irrigation returns to the lower Olifants River and found that the concentrations typically varied between 3000 – 4000 mg/l. No recent measurements of TDS concentrations in the drainage water could be found. The biggest increase was between Bulshoek Dam and Verdeling, which is located downstream of the confluence with the Doring River. At Verdeling the water was, on average, still within an acceptable range, but further downstream, the salinity increased to a Tolerable range, and eventually an Unacceptable range for irrigation use.
- If new irrigation is established on soils with elevated salts, then additional water would be required to leach the salts from the soils. This would probably create additional salt loads to the lower Olifants River during the establishment of the fields (PGWC, 2004).

There may also be opportunities with respect to water quality:

- During the high flow winter months, salinity in the lower Olifants River is reset to concentrations similar to that in Clanwilliam Dam and Bulshoek Dam, or slightly higher, but still within the Ideal to Acceptable range for irrigation use. If off-channel storage can be created further downstream, low salinity water can be released during the winter season and abstracted further downstream with little impact on salinity in the river.

  It is recommended that only water of an Acceptable quality (**Table 5.5**) be abstracted from the river. This is to ensure that the quality in the off-channel storage dams is acceptable for irrigation with occasional incursions into a tolerable quality because of evaporation and local runoff.

  A duration diagram of TDS concentrations at sampling points during the months of June to September (wet season) was compiled (**Figure 5.8**). Note that in Figure 5.8 the TDS (Y axis) is a log scale. Water of an Acceptable quality can be abstracted at all the monitoring points for about 86% of the time, and quality of an Ideal quality for at least 50% of the time. Some pumping can be conducted at the end of the dry season (May) or the start of the dry season, in October (**Figure 5.9**). However, water quality of an Acceptable quality can only be abstracted at Spruitdrift for about 55% of the time, for 40% of the time at EB de Waal, and about 30% of the time Lutzville. The quality in the lower Olifants River in the two months bordering the wet season is at most of a marginal quality.

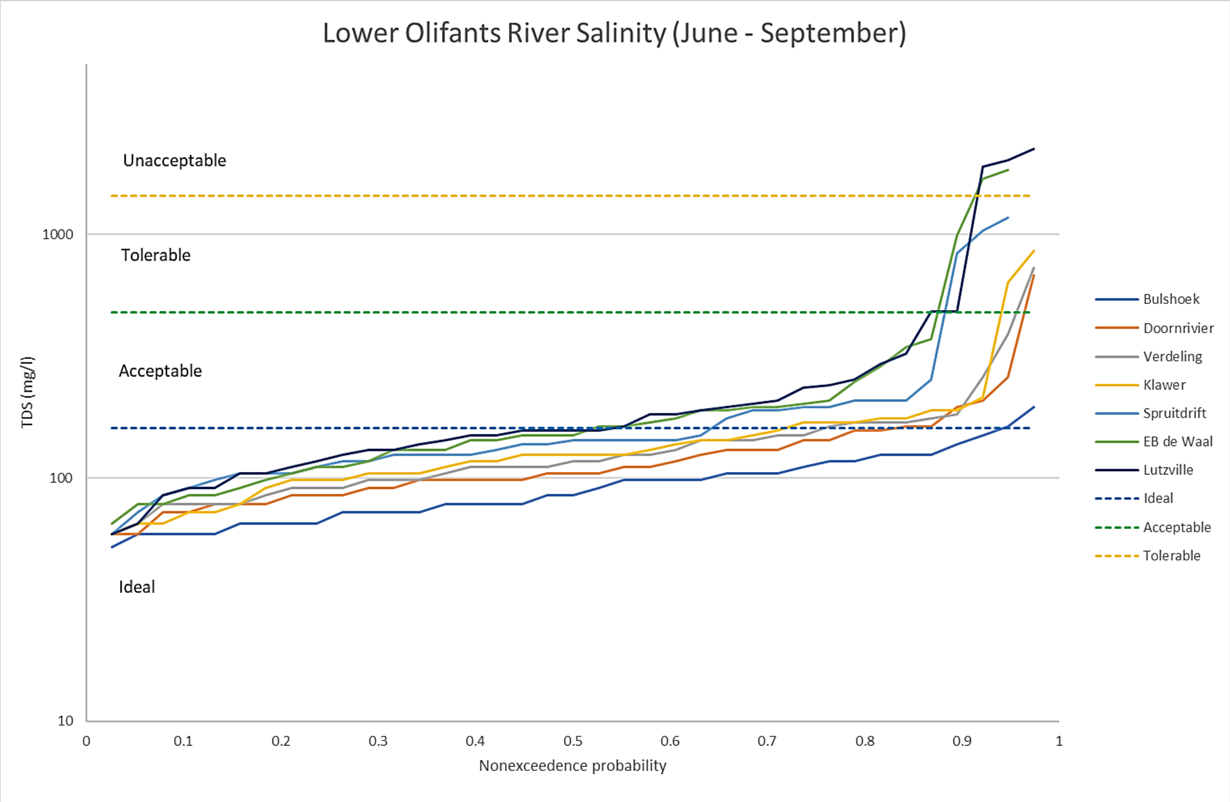


Figure 5.8 | TDS concentrations along the Lower Olifants River from June to September

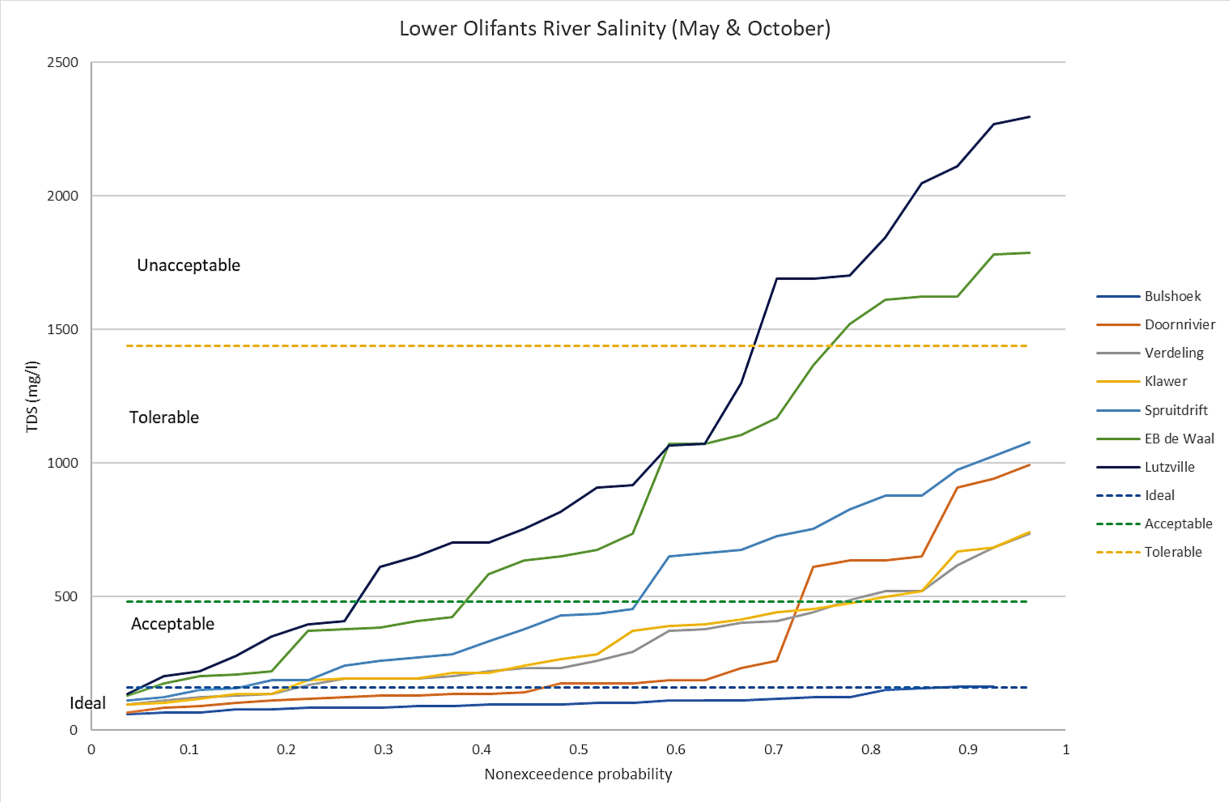


Figure 5.9 | TDS concentrations along the lower Olifants River in May and October

This would require farmers to monitor salinity in the lower Olifants River and to only transfer water when the salinity is in an Acceptable category (TDS < 480 mg/l or Electrical conductivity < 75 mS/m or <750 µS/cm[1]). During pumping the salinity levels in the off-channel storage dams should also be monitored to maintain the salt concentrations in an Acceptable category.

- Consideration should be given to limiting the discharge of high salinity irrigation drainage water into the lower Olifants River. Options such as creating “salt dams” have been identified during the WODRIS study (PGWC, 2004). Other options for controlling saline runoff from irrigated areas in South Africa have been documented in for example van Rensburg et al. (2011) and Moolman et al. (1999).

[1] Most handheld electrical conductivity meters record EC in µS/cm.

6 Distribution Options

A brainstorming session was held on 6 August 2018 to identify potential water distribution options and development areas. These options are shown on **Figure 6.1**.

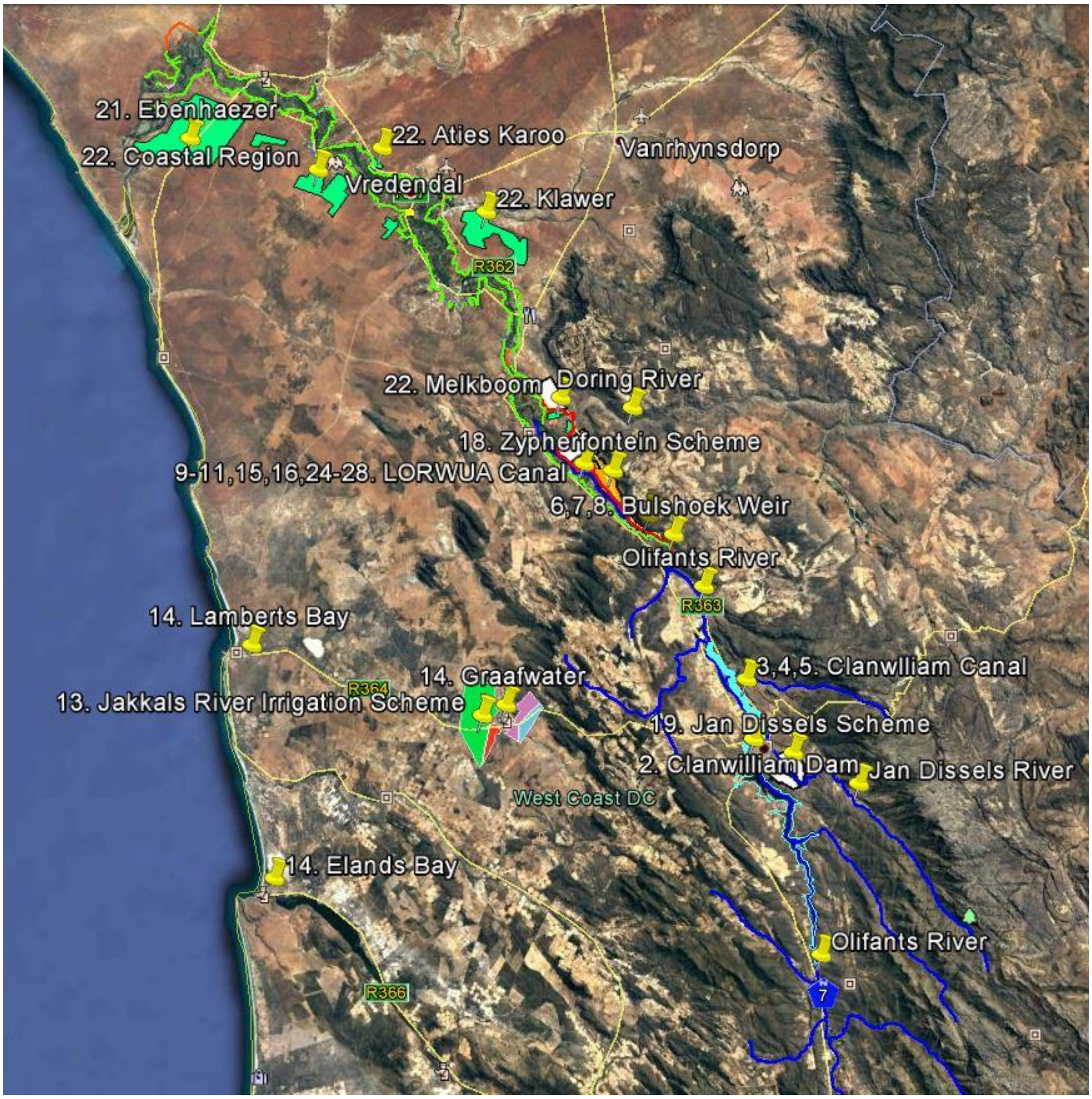


Figure 6.1 | Proposed distribution options and development areas

In all options, the use of additional irrigation may comprise:

- Expansion of irrigated areas on existing farms, or
- Establishment of new irrigation areas.

Allowance will also need to be made for plots of about 5ha size.

6.1 Identified Potential Options

6.1.1 Olifants River catchment upstream of Clanwilliam Dam

It has been decided that prospective irrigators may continue to apply for water use authorisations for the use of water for irrigation in the Olifants River valley upstream of the Clanwilliam Dam. Since there is very little scope for additional irrigation development upstream of Clanwilliam Dam without creating more on-farm balancing storage, water for new irrigation in this region would likely need be abstracted from the Olifants River in winter and stored in new/enlarged off-channel farm dams. This is expected to be an expensive option.

It is expected that, in most cases, farmers would have to pay for their share of the raising of the dam as well as for additional infrastructure cost for the development of new balancing dams.

Several dam sites (including a raised Clanwilliam Dam) were identified in the Olifants/Doring River Basin Study (DWAF, 1998), and were considered as possible storage dams to supply existing users and allow for possible future development. The dams considered were as follows:

- Grootfontein Dam. The dam site is situated on the Grootfontein farm, upstream of the confluence with the Olifants and Ratel Rivers.
- Keerom Dam. The dam site is situated on the Olifants river, upstream of the confluence with the Ratel River. The Dam was investigated as an alternative to the Grootfontein Dam. Based on the cost of the Keerom Dam, the Grootfontein Dam was recommended.
- Grootrivier Dam. The dam site is situated on the Groot River, downstream of the confluence with the Matjies River on the Elandsrit Farm.
- Melkboom Dam. Investigated to supply water to new irrigation development at Klawer and Aties Karoo, or to the so called coastal scheme. The dam site is situated upstream of the measuring and diversion weir, which is 1km upstream of the old Clanwilliam-Klawer Road.
- Rosendaal Dam. Considered as a storage dam to supply Citrusdal Irrigation Board. The dam site is situated at a bend on the Upper Olifants River, 27km directly north of Ceres.

At the start of the Clanwilliam Dam Raising Feasibility Study, in 2005, a Specialist Screening Workshop was held to discuss and critically evaluate the suite of development options in the Olifants and Doring River catchments and to compare these to the potential raising of Clanwilliam

Dam (DWAF Report No. P WMA 17/E10/00/0405). This included the potential Rosendaal, Visgat, Grootfontein and Keerom dams, which were screened out. The development of off-channel farm dams and groundwater schemes in this river reach was strongly supported.

This option will not be further evaluated in this study, but farmers will not be excluded from applying for water use authorisations as per the standard application process.

6.1.2 Abstraction directly from Clanwilliam Dam

Irrigators can pump water directly from the lake of the Clanwilliam Dam; however, abstraction points will be affected by the rise/fall of the water level. The Clanwilliam Water User Association (WUA) identified the total area west of Clanwilliam Dam (700 ha), located on the western side of the N7 highway near the bridge. The portion of the land near the dam, extending from the bridge to the old Total garage, has been expropriated for the dam raising.

6.1.3 Clanwilliam Canal

6.1.3.1 Using the full capacity of the Clanwilliam Canal

The Clanwilliam WUA is of the view that quotas only underutilised during a drought and that normal quotas are fully utilised. There are perceptions that the Clanwilliam Canal is currently underutilised and has some spare capacity (although the Clanwilliam WUA is not in agreement with this view). Water can be released down the canal to use its full capacity to improve the assurance of supply to existing users, or to extend the existing irrigated area.

There may be very limited spare capacity, which is currently limited additional freeboard. This option will evaluate development over-and-above the limited spare capacity in the canal.

The Clanwilliam WUA identified approximately 150 ha along the Clanwilliam canal (private land) for development. They have specifically identified potential new developments east of the upstream end of Bulshoek Weir (north-east of the Langkloof River).

6.1.3.2 Increase the capacity of the Clanwilliam Canal

The capacity of the Clanwilliam Canal could potentially be increased by e.g. widening the canal. The practicality of implementing this option would need to be considered, as it would likely mean closing the scheme during the construction period. As the canal is old and leakage is high, this would also provide efficiency savings, in addition to an increased supply.

6.1.3.3 Replace Clanwilliam Canal with a pipeline

An option to replace or upgrade the Clanwilliam Canal with a pipeline was proposed by the Clanwilliam WUA. The Clanwilliam WUA believes that farmers would be willing to contribute toward the construction of a pipeline from Clanwilliam Dam to Bulshoek Weir.

6.1.4 Jan Dissels Catchment

6.1.4.1 Jan Dissels Scheme supplied from Clanwilliam Dam

Water can be pumped from the Clanwilliam Dam to develop 800 to 1000 ha of irrigation land to the east of the Dam, south of Clanwilliam town, in the Jan Dissels River valley. An estimated 750 kW from the new hydropower plant to be installed on the left bank of the raised Clanwilliam Dam could potentially be made available for this development (no grid supply would be needed in such a case).

The land between the Clanwilliam Dam and the Jan Dissels River is municipal property, while the land on the opposite site of the river belongs to the province/agricultural school. This could possibly be a suitable area for smallholder plots, considering the proximity of the area to Clanwilliam town and existing markets.

There is a small existing privately-owned hydropower plant on the right bank at Clanwilliam Dam which supplies electricity to the town of Clanwilliam. With the raising of the Clanwilliam Dam, this supply will be discontinued, but provision has been made in the proposed new outlet works to supply a new, enlarged hydropower plant on the left bank. The capacity of the hydro-power plant can be enlarged, and conditions will be renegotiated. Pumping water to the Jan Dissels Scheme is a possible opportunity for usage of power to be generated by the new hydropower plant.

6.1.5 Options Located Outside the Olifants River Valley

Pumping water to these schemes from a new, enlarged hydropower plant at Clanwilliam Dam is a possible opportunity for usage of power to be generated by the new hydropower plant.

6.1.5.1 Jakkals River Irrigation Scheme

The Sandveld Investment and Development Company (SANID) proposed a project to develop an irrigation scheme along the Jakkals River to benefit historically disadvantaged farmers, with water supplied from Clanwilliam Dam. An investigation to pump water to a sizeable amount of land (approximately 800 ha) might be required for evaluation purposes. Ms Gabriel of DAFF recommended that alternatives to water supply from the Clanwilliam Dam be considered, such as rainwater harvesting, boreholes, etc.

6.1.5.2 Provision of water to coastal towns

A secondary objective of the postulated Jakkals River Irrigation Scheme was to supply the Cederberg Municipality, and potentially surrounding farmers, with domestic water for Graafwater, Lamberts Bay and Elands Bay, from Clanwilliam Dam. The provision of water to these coastal towns of an estimated 1.5 Mℓ/d should be compared to the option of drilling boreholes and/or desalinating water in these towns.

Many coastal towns in the Cape Province feel the pressure with water demands exceeding supply, especially during peak holiday seasons. An example is Lamberts Bay, a town about 280 kilometres from Cape Town - along the Cape West Coast, in Cederberg LM. To resolve this dilemma, the DWS and the Cederberg Municipality first considered two possibilities: provide additional boreholes; or install a 61-kilometre pipeline from the Clanwilliam Dam. Investigative studies, revealed the pipeline would not guarantee a sustainable water supply and test boreholes exposed overly excessive iron and manganese content in the water. The DWS and the town's municipality therefore decided to commission a new desalination plant adjacent to the town's existing water purification plant.

A 1700 m³/d reverse-osmosis (RO) seawater desalination plant, upgradeable to 5000 m³/d, has subsequently been built in Lamberts Bay. The plant should alleviate growing pressure on the region's water system and improve availability of high-quality water for the region's nearly 40,000 residents. This plant is however not operational yet.

6.1.6 Olifants River between Clanwilliam Dam and Bulshoek Weir

6.1.6.1 Abstraction from the Olifants River between Clanwilliam Dam and Bulshoek Weir

Users in the area between Clanwilliam Dam and Bulshoek Weir have the advantage of not being reliant on bulk water distribution infrastructure and only require limited, if any, balancing capacity. This portion of the river is already used to make releases from Clanwilliam Dam to convey irrigation water from the Dam to Bulshoek Weir and the downstream canals. Water can be pumped directly from the Olifants River for irrigation.

6.1.6.2 Transfer of lower Jan Dissels River scheduled allocations to the Olifants River

There is an opportunity for three water users in the lowest stretch of the Jan Dissels River to shift their abstractions to the Clanwilliam Canal or the Olifants River, thereby increasing low flows to improve the ecological status of the bottom stretch of the Jan Dissels River, which is currently very poor.

The possibility of transferring some of the irrigators at the beginning of the Clanwilliam Canal to abstract from the Olifants River to release some capacity for downstream users can also be investigated.

6.1.7 Abstraction Directly from the Bulshoek Weir

Irrigators may pump water directly from the lake of the Bulshoek Weir; however, abstraction points will be affected by the rise/fall of the water level. The current operating rule is that the level is kept at about 60% of capacity, to limit the leaks from the weir. This will further limit development opportunities.

6.1.8 Olifants River below Bulshoek Weir

6.1.8.1 Release water at Bulshoek Weir and pump directly from the river

An option is to release additional water down the Olifants River at the Bulshoek Weir, i.e. use the river as a conduit, and farmers can abstract water directly from the river. The extent of how far down the catchment, below the confluence with the Doring River, irrigation development can be considered (without significant conveyance infrastructure), will be influenced by water quality considerations. Development further down the catchment will require either additional canal or pipe conveyance infrastructure, or low-pressure desalination of water, which will evidently be expensive.

6.1.8.2 Release water downriver from Bulshoek Weir and pump into canal sections to use spare capacity in identified canal sections

Certain canal sections still have some spare capacity, even during the dry season, because of the way that the canal has been constructed. Water can be released from the Bulshoek Weir down the Olifants River and be pumped into these identified canal sections with spare capacity, to be used via existing canal infrastructure. Refer to **Figure 2.5** that indicates these canal sections.

Use of the spare capacity in canal sections can be used, either to expand current irrigation or potentially for new irrigation. A disadvantage below the confluence will be the poorer water quality, because of mixing in the Olifants River with the more saline Doring River water, compared to current water quality.

6.1.8.3 Release water downriver and pump to adjoining irrigation areas

Water can be released from the Bulshoek Weir down the Olifants River and be pumped either directly for irrigation, or to farm dams. The poorer quality water from the Doring River tributary will influence the extent to which water could be abstracted for irrigation below the confluence of the

Olifants and Doring rivers. Below the extent where abstracted river water could be used directly for irrigation, irrigation will get more expensive, due to the need to provide conveyance infrastructure (canal / pipeline) or alternatively to improve water quality through treatment/low-pressure desalination.

6.1.8.4 Zypherfontein Irrigation Scheme

The Zypherfontein Scheme provides an option for a large new development (approximately 2000 ha) downstream of Bulshoek Weir, but above the confluence with the Doring River to avoid poorer water quality. While additional irrigation development may be phased in over time, this provides an opportunity for a much faster uptake of water. The Lower Olifants River Water User Association (LORWUA) has indicated that it would strongly support such a scheme. 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 be advantages of scale, due to the size of the project.

The proposed Zypherfontein Scheme is located on private land, with the whole area belonging to two farmers. The land will likely need to be acquired in order for the project to be undertaken. Conveyance options to be considered are the following:

- Pumping from the Olifants River
- New canal system from Bulshoek Weir
- Increasing the capacity of a portion of the main canal section downstream of the Bulshoek Weir, with a branch and syphon crossing to the right bank, from where either a new pipeline or canal will convey water.

6.1.8.5 Irrigation areas identified in the Western Cape Olifants Doring River Irrigation Study

The irrigation areas identified in the Western Cape Olifants Doring River Irrigation Study (WODRIS) (PGWC, 2004) are summarised below, and are shown in **Figure 6.2**.

Melkboom irrigation area

Similar to the Zypherfontein Scheme proposal, the Melkboom option provides for a large new development downstream of the Bulshoek Weir on the right bank. The potential irrigation area of 514 ha is located just east of the Olifants/Doring Rivers' confluence and is divided by the Doring River and the gravel road, into two areas of 204 ha (western) and 310 ha (southern) respectively. Two water supply options could be considered, i.e.: (1) canal system or (2) pump water to several properties via a distribution network. The current owners are not farming.

Klawer irrigation area

The proposed Klawer irrigation area of 2 226 ha is the area located just north-west of Klawer between the National Road N7, the R362 regional road between Klawer and Vredendal, and south of the Biedouw River. Distribution of water will be by releasing more water through the canal from March to October, i.e. during the winter period, and/or via an enlarged LORGWS River canal, or pump water released from Bulshoek Weir from the lower Olifants River.

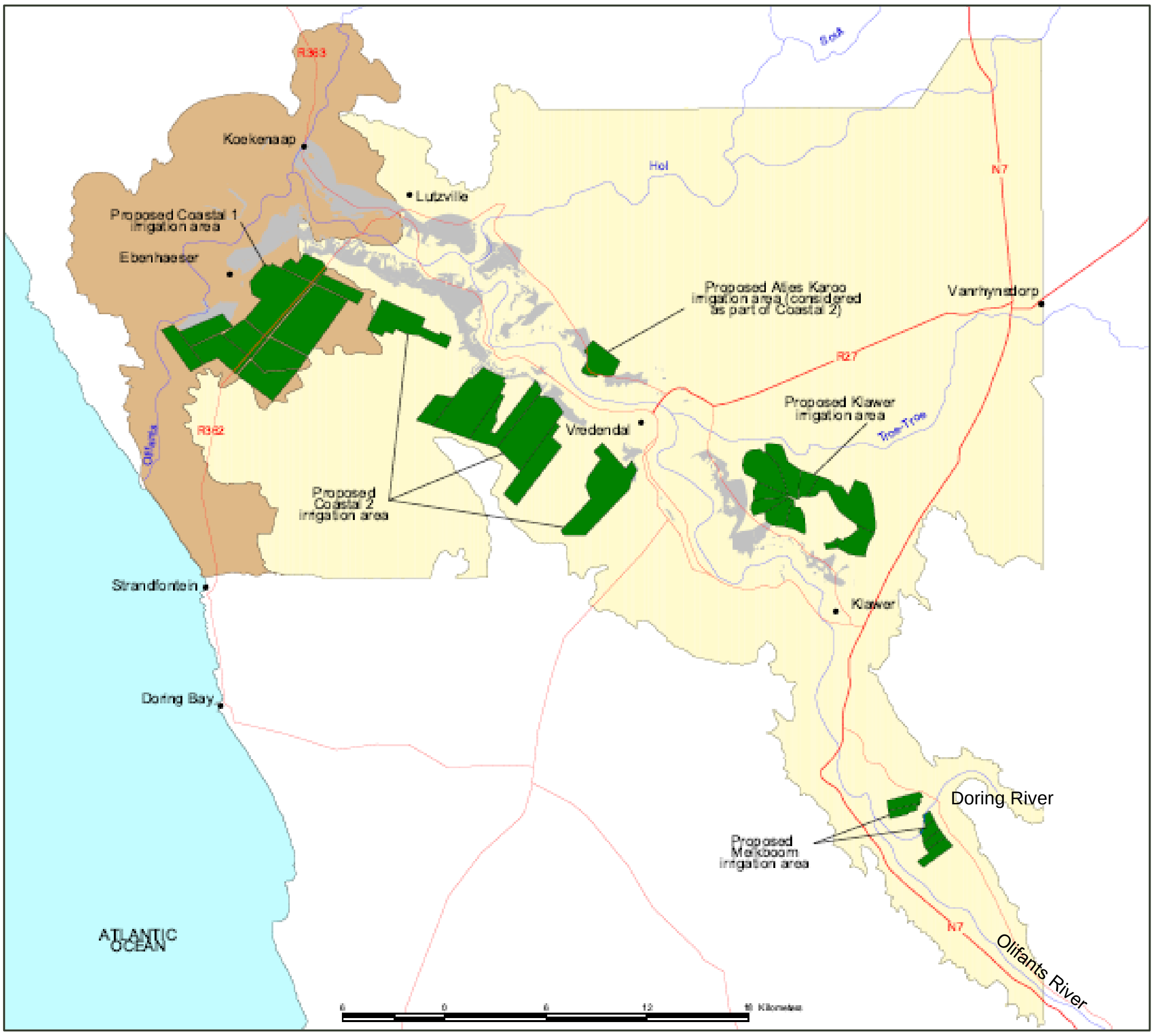


Figure 6.2 | Irrigation areas identified in the WODRIS (PGWC, 2004) study

Coastal Region irrigation area

The proposed Coastal Region irrigation area of 8 945 ha is the mildly undulating coastal plain west of the Olifants River to the Atlantic Coast, north of Doring Bay to as far as Ebenhaeser. It stretches from Ebenhaeser in the north-west to Tweelingkop south-west of Vredendal in the east. Distribution of water will be by releasing more water through the canal from March to October, i.e.

during the winter period, and/or via an enlarged LORGWS River canal, or pump water released from Bulshoek Weir from the lower Olifants River.

Aties Karoo irrigation area

The Aties Karoo area is the block of land bordered roughly by the National Road N7, the Hol/Vars Rivers, and the R27 regional road between Vredendal and Vanrhynsdorp. Based on the WODRIS botanical investigation (PGWC, 2003g), more than 90% of the proposed irrigation area was identified as a ‘red flag’ area. However, with the implementation of mitigation, 1 963 ha on the south-western fringe of the Aties Karoo have been identified

for development. Any envisaged irrigation development in this area would be subject to detail environmental impact assessments (EIAs). Distribution of water according to option 3.10, and/or an enlarged LORGWS canal, or supply pumped from the lower Olifants River.

6.1.8.6 Construct a new main canal section from the Bulshoek Weir on the Right Bank of the Olifants River

A distribution option is to construct a new main canal section from the Bulshoek Weir on the right bank of the Olifants River. The identified Zypherfontein area and possibly the Melkboom scheme offers a very large parcel of land to access, which may make the option of a canal for conveyance more attractive.

6.1.9 LORGWS (Bulshoek) Canal

6.1.9.1 Increase Abstraction from Existing Canals

There is currently no capacity to release additional water in the existing canal system during the dry season, with some spare capacity during winter months. Any construction work to be done on the canals, while water needs to continue flowing would be very expensive; due to the need to provide a bypass (dry periods are limited).

6.1.9.2 Increase Winter Use from Existing Canals

There is very little scope to release more water through the canals during the peak summer months. However, a distribution option that can be considered would be to put more water through the canals from March to October, i.e. the winter period. The planting of winter crops is currently a limitation, because the Clanwilliam Dam is empty at the start of the winter season.

This would require the introduction of alternative crop types that have a different water requirement, with peak demands at different times to those crops currently grown. However, this option may not be 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.

Alternatively, depending on the availability of land, water can be stored in small farm dams for irrigation in summer.

6.1.9.3 High volume low head lifting pump stations

On the LORWUA canals, the flow can potentially be increased by making use of high-volume low head lift pump stations, potentially in combination with the raising the canal side walls. Pump stations could be installed at intervals (possibly kilometres apart) along the canal, and the hydraulic grade line can be pulled down. This would allow additional flow to be release via the canal.

6.1.9.4 Replace all or sections of the LORGWS Canal with an increased capacity canal

The cost for lining the entire canal (precast concrete lining or in-situ cast concrete) is likely to be extremely high and would likely not be feasible. However, it may be worthwhile to investigate the costs of replacing certain portions of the canal on an annual basis.

6.1.9.5 Replace all or sections of the LORGWS Canal with a pipeline with an increased capacity

An alternative to replacing sections of the canal with a new lining would be to replace sections with a very large diameter pipeline. The practicality of implementing this option would need to be considered, as it would mean closing down the scheme, possibly for years.

6.1.9.6 Increase the capacity of the LORGWS canal and other betterments

This option involves increasing the capacity of the canal system by raising the canal or increasing its profile. If the canal had a larger carrying capacity, more water could be made available for irrigation downstream of the Bulshoek Weir, especially since the bulk of suitable irrigation areas is located very low down in the Olifants River catchment. The Feasibility Study (DWS, 2008) recommended that the canal profile should not be increased to increase its capacity.

It will be a significant challenge to undertake construction on the canal/s while water needs to flow. This would require a bypass during construction, which is very expensive. Another option is constructing new canal sections, depending on the availability and accessibility of land, and joining them into the existing canal. The issue of joining new canal sections to existing badly degraded concrete lining should be considered.

The need for required betterments for critical, degraded sections of the canal system is documented in the *Existing Infrastructure and Current Agricultural Development* Report of this study. These betterments could potentially increase certain sections of the canal to enable additional irrigation water to reach areas for new agricultural development.

6.1.9.7 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. Additional irrigation areas could potentially be supplied from a balancing dam. 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 Western Cape Provincial Department of Agriculture (WCDoA) is in support of further investigation of this option.

The LORWUA has suggested a storage dam near Klawer.

6.1.9.8 Additional farm dams along the canal

This option could increase the yield from the system, although it is not considered to have much potential, mainly because of limited land availability due to the small farm sizes. The LORWUA has advised that a few farmers had built dams up to 50 000 m^3 during the past 2 to 3 years

6.1.10 Ebenhaeser Scheme

In 1926, the Ebenhaezer families were moved from Lutzville to their current location, further down the Olifants River near the estuary, at the end of the canal system, farming an area of 257 hectares. The LORWUA operates and maintains the canal system up to the Ebenhaezer balancing dam. From there on, there is a canal to the Ebenhaezer community, which is operated and maintained by the community itself. The Ebenhaezer balancing dam, to alleviate erratic supply problems, was constructed in 2003 as an earth fill dam with a storage capacity of 140 000 m^3.

Available suitable land and bulk water supply for irrigation to the existing scheme is for now adequate and the current water supply is under-utilised. Ebenhaeser residents however claim that they are being disadvantaged in the way that the scheme is operated. 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, as well as the provision of better agricultural and community management. The planned project to supply water to the scheme under pressure has been significantly delayed due to a court challenge of the tender process.

The implications of the R350 million land claim that was awarded to the Ebenhaeser inhabitants, and whether it has any implications in terms of additional water requirements, needs to be unpacked.

6.2 Options screened out

The following were identified but are not regarded as options for new irrigation development.

6.2.1 Reducing losses in the LORGWS canal / refurbishment of the canal system

Undertaking of short-term and medium-term canal repairs is essential, as not doing so would negatively impact the functionality of the scheme. This option has the benefit of limiting losses from the canal. Improved WC/WDM, i.e. reducing losses, covering the canal, and other efficiency measures would limit losses and thus increase the supply from the canal. The overall condition of the canal is however so poor that a significant maintenance programme will take many years and will not improve the condition of the canal sufficiently in a short period of time, to be able to allow further development of irrigation from the canal, based on efficiency savings. This is therefore not regarded as an option.

6.2.2 Changes in crops

The LORWUA has suggested future crop changes as an option, e.g. instead of wine grapes shift to table grapes, increase the use of tunnels or shading, or grow nuts and vegetables. This is however regarded as a process driven by markets and is not regarded as a distribution option. An increase in the reliability of water supply to existing irrigators, once Clanwilliam Dam has been raised, may also influence the type of crops being grown, with especially citrus, that needs water year-round, being considered more frequently.

6.3 Approach and Methodology

To identify which irrigation land/distribution options should be evaluated, the following approach/methodology will be adopted:

1. Overlay all the GIS features on a map of the study area.
2. Eliminate the no-go areas, e.g. environmentally sensitive and ecological risk areas, areas where the slope is too steep, etc.
3. Identify all possible distribution options and irrigable areas that qualify for evaluation.
4. Apply a rule-based prioritisation (matrix) to the identified areas; *inter-alia* considering the following factors, to identify land parcels to consider for irrigation:
   - Land ownership (public land being preferable to private land), taking cognisance of lease agreements,
   - Proximity to Clanwilliam Dam and Bulshoek Weir,

- Proximity to existing infrastructure and the Olifants River, as well as elevation difference,
- Focus on disturbed areas (brownfields) first, i.e. potential for expansion of existing farms, and
- Soil and crop suitability (highly recommended to conditionally recommended).

5. Determine the total area that can be developed from the identified land parcels, according to study sub-areas, and compare this with the volume of available water.
6. Identify clusters of available land that can be developed as phased schemes, considering the range of options identified. Distinction can potentially be made further according to factors that have a significant influence on feasibility such as height above river/canal level.

Once a refined range of potential schemes have been identified to evaluate, the characteristics of such schemes will be unpacked, and bulk water distribution costs and potential impacts will be determined. The initial, more qualitative evaluation will reduce the options and will be followed with quantitative evaluations, possibly requiring some iteration as information comes to light, to zoom in on the “best” development options.

6.4 Other Considerations

6.4.1 Crop water requirements

An integral part of evaluating the distribution options involves establishing the crop water requirements in different regions. Although they have a scheduled quota of 12 200 m^3/ha/a, Mr R Nieuwoudt (DWS) estimated that the farmers in LORWUA’s area are currently applying 4000 to 6000 m^3/ha/a, thus irrigating a larger area than expected, and implying that they were using water only when needed.

When determining the irrigation water requirements of the identified potential irrigation land parcels, it is recommended that appropriate application rates be used for the likely crops to be planted.

It is a concern that the irrigation application rates have not been adequately addressed. Various sources could be contacted for additional information:

- The *Soils, Water Requirements and Crops* Report of the Clanwilliam Dam Raising Feasibility Study.
- The evaluation of "best practice" water usage by irrigation in the *Water Requirements and Availability* Report of the study to *Provide Support to Compulsory Licensing in the Jan Dissels River Catchment: Western Cape*.

- The Fruitlook initiative/system which provides energy values (stress pods, water applied, etc.) for crop areas. Mr M Wallace (Elsenburg) can be contacted for more information on Fruitlook.

6.4.2 Covering crops with netting

Covering crops with netting provides an advantage from a water requirements perspective, as it reduces evaporation and therefore also the crop water requirements. Mr A Conradie (WCDoA) estimated that crop areas covered by netting increased by 200% between 2013 and 2017.

6.4.3 Influence of groundwater quality

Poor groundwater quality has been noted at the fault intersecting the Doring River, which extends further south and intersects the Olifants River, as well as at Ebenhaeser. It will be necessary to produce a map indicating areas in which farmers would tend to over-irrigate due to water quality issues such as high salinity, thus impacting on the crop water requirements.

6.4.4 Farm sizes

Farm size are a factor when evaluating the development of agricultural areas. The global trend is to develop larger farms. The WCDoA is more in favour of large commercial sustainable farming operations, than smallholder farms which tend to function at subsistence level. DAFF have indicated that smallholder farms should form part of the mix of proposed farm sizes, for land reform. It would also be preferable for smallholder farms to be located closer to towns to save on housing and travelling costs. As part of this study, potential farm size was a variable in the economic evaluation of farm models, as documented in the *Viability of Irrigation Farming* Report. Farm sizes of 6 ha for smallholder farms were inter-alia investigated.

6.4.5 Political expectations

One of the challenges is the political expectations for the outcome of this study. Informed answers should be provided with respect to the technical and financial feasibility of the irrigation schemes which have political associations, e.g. the Jakkals River Irrigation Scheme and the Ebenhaeser Scheme.

6.4.6 Socio-economic considerations

It may be worth considering investigating the unemployment situation in the area, as well as the socio-economic impact of the 2017/18 drought on the area, as this would provide an understanding of the need for stable water supply. It would also provide motivation for infrastructure refurbishment and upgrade. Mr R Nieuwoudt (DWS) estimated that farmers received only 14% of their irrigation quota in the 2017/18 year, resulting in a harvest which is approximately 40% of normal production. Although agriculture was receiving drought relief, this was for livestock farming and not for irrigation farming.

6.4.7 Raising of the Clanwilliam Dam

It would be advantageous if the outcomes of this Post Feasibility Bridging Study coincide with the eventual raising of the Clanwilliam Dam, with a construction period of approximately five years. It may then be possible for the DWS construction team to move to also construct the distribution infrastructure once the dam raising has been completed.

7 Conclusions

1. The evaluation of the current agricultural development in the study area found that the existing irrigated areas totals 30 700 ha which is divided as follows:
    a. Region 1 (upstream of Clanwilliam Dam): 12 000 ha;
    b. Region 2 (Clanwilliam Dam to Bulshoek Weir): 2 900 ha; and
    c. Region 3 (Bulshoek Weir to Lutzville): 15 800 ha.
2. The current agricultural water requirement for the existing irrigation areas in the study sub-areas is 240 million m^3/a in total, which is divided as follows:
    a. Region 1 = 98.91 million m^3/a;
    b. Region 2 = 16.45 million m^3/a; and
    c. Region 3 = 125.07 million m^3/a.
3. Looking at further development, the land ownership within the study area is about 22% for government-owned land, and 78% for privately-owned land.
4. In terms of soil suitability, there is 0 ha of highly recommended soil potential areas (>80% maximum potential) from Keerom to the Coast for all crop types.
5. The recommended soil potential areas (> 60 - ≤ 80 maximum potential) from Keerom to Bulshoek are as follows:
    a. 9 930 ha for annual tuberous croups;
    b. 4 118 ha for annual non-tuberous crops; and
    c. 1 922 ha for perennial crops after amelioration (726 ha before amelioration).
6. The recommended soil potential areas from Bulshoek to the Coast the areas are as follows:
    a. 34 464 ha for annual tuberous croups;
    b. 82 854 ha for annual non-tuberous crops; and
    c. 105 802 ha for perennial crops after amelioration (9 356 ha before amelioration).

7. The following were identified as suitable crop mixes for this study:
    a. Table grapes;
    b. Citrus;
    c. Raisins;
    d. Wine grapes;
    e. Tomatoes with brassica seed in rotation; and
    f. Potatoes with wheat, in rotation.
8. In general, the development of new irrigation farms seems to be problematic from a financial viability perspective. The expansion of existing irrigation farms will in general be financially more viable than the development of new irrigation farms.
9. From a commercial perspective, the large-scale production of citrus and table grapes by previously disadvantaged individuals on new farms could be profitable in the study area if land is provided at no cost.
10. If the Olifants River is being considered as a conduit for transporting irrigation water for abstraction further downstream then water quality constraints would apply. During the summer months, high salinity irrigation return flows would probably increase the salinity to unacceptable levels for irrigation use.
11. If new irrigation is established on soils with elevated salts, then additional water would be required to leach the salts from the soils.
12. There are also opportunities with respect to water quality. During the high flow winter months, salinity in the lower Olifants River is reset to concentrations within the Ideal range for irrigation use.
13. Various distribution options were considered that will be investigated in further detail.

References

Creamer Media. 2017. *Western Cape: Multi-million rand maintenance plan underway to stem agriculture losses in Clanwilliam.* http://www.polity.org.za/article/western-cape-multi-million-rand-maintenance-plan-underway-to-stem-agriculture-losses-in-clanwilliam-2017-01-20. Accessed: 29 January 2018.

Department of Agriculture: Western Cape, South Africa. 2018. *CapeFarmMapper ver 2.0.6.7*. https://gis.elsenburg.com/apps/cfm/. Accessed: 26 March 2018.

Department of Water Affairs and Forestry, South Africa. 2002a. *Bulshoek Weir: Remedial Works Construction Complete Report*. Report No. 20/2/E100-04/C/1/4/2.

Department of Water Affairs and Forestry, South Africa. 2002b. *Bulshoek Weir: Operation and Maintenance Manual.*

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

Department of Water Affairs and Forestry, South Africa. 2008. *Bulshoek Weir: Report on Third Dam Safety Inspection Carried Out in terms of Government Notice R 1560 of 25 July 1986*. Report No. 20/2/E100-04/C/1/22.

Department of Water Affairs and Forestry, South Africa and Department for International Development, United Kingdom. 2007. *Inception Report*. Prepared by E van der Berg of Ninham Shand (Pty) Ltd, in association with Pegasys (Pty) Ltd and Informage, as part of the Support to Compulsory Licensing in the Jan Dissels river Catchment, Western Cape.

Department of Water Affairs and Forestry, South Africa and Department for International Development, United Kingdom. 2007. *Rapid II Reserve Determination Report.* Prepared by C Brown and R Magoba of Southern Waters Ecological Research and Consulting cc, as part of the Support to Compulsory Licensing in the Jan Dissels River Catchment, Western Cape.

Department of Water Affairs and Forestry, South Africa and Department for International Development, United Kingdom. 2007. *Groundwater Report.* Prepared by R Parsons of Parsons & Associates cc, as part of the Support to Compulsory Licensing in the Jan Dissels River Catchment, Western Cape.

Department of Water Affairs and Forestry, South Africa and Department for International Development, United Kingdom. 2007. *Opportunities for productive water use by emerging farmers Report*. Prepared by K von der Heyden and A Selby of Pegasys (Pty) Ltd, in association with Ninham Shand (Pty) Ltd and Informage, as part of the Support to Compulsory Licensing in the Jan Dissels River Catchment, Western Cape.

Department of Water Affairs and Forestry, South Africa and Department for International Development, United Kingdom. 2008. *A Framework for Water Allocation in the Jan Dissels River Catchment*. Prepared by A Selby of Pegasys, in association with Ninham Shand (Pty) Ltd and Informage, as part of the Support to Compulsory Licensing in the Jan Dissels River Catchment, Western Cape.

Department of Water and Sanitation, South Africa. 2016a. *Condition assessment audit of irrigation scheme infrastructure*. Prepared by LTE Consulting and PULA Strategic Resource Management. Document ID: WP0485WTE-Southern- Clanwilliam GWS.

Department of Water and Sanitation, South Africa. 2016b. *Bulshoek Weir: Operation and Maintenance Manual.*

Department of Water and Sanitation, South Africa. 2016c. *Condition assessment audit of irrigation scheme infrastructure*. Prepared by LTE Consulting and PULA Strategic Resource Management. Document ID: WP0485WTE-Southern- Olifants River van Rhynsdorp GWS.

Department of Water and Sanitation, South Africa. 2018. *Discussion Document: Crop Water Use Requirements.* Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam.

Department of Water and Sanitation, South Africa. 2018. *Financial Viability of Irrigation Farming Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam.

Fourie, JM. 1976. Mineralization of Western Cape Rivers: An investigation into the deteriorating water quality related to drainage from cultivated lands along selected catchments, with special reference to the Great Berg River. PhD Thesis, University of Stellenbosch.

IOL. 2015. *Relief for Clanwilliam farmers.* https://www.iol.co.za/news/south-africa/western-cape/relief-for-clanwilliam-farmers-1810878. Accessed: 16 May 2018.

Kriel, G. 2017. *Olifants River Valley farmers' irrigation woes*. https://www.farmersweekly.co.za/crops/field-crops/olifants-river-valley-farmers-irrigation-woes/. Accessed: 26 January 2018.

LORWUA. 2004. *Investigation into the rehabilitation of the canal downstream of Bulshoek Weir*. Prepared by Element Consulting Engineers. Project No. 03046.

Moolman, JH, de Clercq, WP, Wessels, WPJ, Meiri, A, and Moolman, CG. 1999. The Use Of Saline Water For Irrigation Of Grapevines And The Development Of Crop Salt Tolerance Indices. WRC Report No. 303/1/99. Water Research Commission.

Ndlendle, S. 2017. *Canal emergency repair saves water levels*. https://www.iol.co.za/news/south-africa/western-cape/canal-emergency-repair-saves-water-levels-7509419. Accessed: 26 January 2018.

Oosthuizen, C. and Brink, J. A. 2015. *Bulshoek Weir: Failure in slow motion or time bomb?* SANCOLD Conference, 1-3 September 2015, Cape Town, South Africa.

Roux, A. S. and Keuck, P. G. 2009. *Applying modern technology to solve water supply problems at Ebenhaeser in the Western Cape Province of South Africa*. 60th International Executive Council Meeting & 5th Asian Regional Conference, 6-11 December 2009, New Delhi, India.

van Rensburg, LD, de Clercq, WP, Barnard, JH and du Preez, CC. 2011. Salinity guidelines for irrigation: Case studies from Water Research Commission projects along the Lower Vaal, Riet, Berg and Breede Rivers Water SA, 37(5): 739 – 750.

Western Cape Government. 2017. *R4 million maintenance plan at Clanwilliam Dam canals stem water losses*. https://www.westerncape.gov.za/news/r-4-million-maintenance-plan-clanwilliam-dam-canals-stem-water-losses-1. Accessed: 26 January 2018.

http://www.veoliawatertechnologies.co.za/medias/news/2015-02-18,desalination-plant-is-constant-water-source.htm

Appendix A

Discussion Document: Crop Water Use Requirements

DEPARTMENT OF WATER AND SANITATION

Directorate: Options Analysis

Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam

DISCUSSION DOCUMENT: AGGREGATED CROP WATER USE REQUIREMENTS FOR PLANNING

October 2018

Prepared by: AgriFusion
2013/213207/07
1 Andringa Street
Stellenbosch
7600
South Africa

T +27 21 882 9922
E gerhard@agrifusion.co.za
W agrifusion.co.za

Contents

Tables

1 Introduction

As part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam, various crops have been identified that will be grown at scale in the study area. The crops per sub-region of the study area needed to be identified, not only to model the potential financial viability of these crops, but also to assist with identifying the water demand in specific areas which is in turn needed for the design options of the required bulk irrigation infrastructure.

The purpose of this paper is to investigate the water demands of the various crops identified, and to make a recommendation on the aggregated crop water requirement to be used for planning purposes in the various irrigation zones, for this study.

A desktop assessment was performed of the various information sources on the subject, and a study group meeting was held on Friday 28 October 2018 at Aurecon where representatives of the Department of Agriculture and Department of Water and Sanitation were present. The recommended crop water use figures as agreed upon by stakeholders are included in this document.

1.1 Identified crops and irrigation zones – Financial Viability of Irrigation Farming Sub-Report

Crop mixes and irrigation water requirements per irrigation zone were needed for the Financial Viability of Irrigation Farming Sub-Report. The identified irrigation zones and crop mixes were identified as follows.

Crops were chosen per specific sub-region of the study area, namely Citrusdal (Zone 1), from Clanwilliam Dam to the Bulshoek Weir (Zone 2) and from Bulshoek Weir to Ebenhaeser (Zone 3). Please refer to **Table 1-1** overleaf for a summary of the identified crops per irrigation zone for the purposes of the Financial Viability of Irrigation Farming Sub-Report.

Table 1.1 | Identified irrigation zones and suitable crops – Financial Viability of Irrigation Farming Sub-Report

Zone	Location	Quaternary Catchments	Suitable Crops
1	Citrusdal	E10D, E10E, E10F	• Citrus (oranges & soft citrus)
2	From Clanwilliam Dam Wall to Bulshoek Weir (including Jan Dissels River)	E10G, E10H, E10J	• Citrus (oranges & soft citrus) • Table Grapes • Potatoes / wheat in rotation
3	From Bulshoek Weir to Ebenhaeser (Trawal, Zypherfontein, Klawer, Vredendal, Melkboomsdrift, Lutzville, Koekenaap, Ebenhaeser)	E10K, E33G, E33H	• Table grapes – Trawal • Table grapes - Vredendal • Raisins • Wine grapes • Tomatoes / brassica seed in rotation

The criteria used for selecting crops to evaluate within this study were as follows:

- Crops which are well suited to the climate and soils enabling high yields and good quality to be produced; and
- Crops which are tried and tested in the area and already grown on a large scale commercially. Crops grown on a smaller scale with limited economic contribution to the region were therefore not selected.

1.2 Proposed Identification of Irrigation Zones for Design Options

In order to more accurately measure the water use requirements for the bulk irrigation infrastructure design options, more detail is needed on the identified irrigation zones. The Lower Olifants region could be split into two sub-regions, given that the water requirements are higher for Quaternary Catchment E33G and H than E10K. A further area, Jakkalsvlei, could also be added, given that this area will also be investigated.

It is proposed to use the irrigation zones set out in **Table 1-2** overleaf for calculating purposes.

Table 1.2 - Proposed irrigation zones and crop mixes for irrigation design options

Zone	Location	Quaternary Catchments	Suitable Crops
1	Citrusdal	E10D, E10E, E10F	• Citrus
2	From Clanwilliam Dam Wall to Bulshoek Weir (including Jan Dissels River)	E10G, E10H, E10J	• Citrus • Table Grapes • Potatoes / wheat in rotation
3	Jakkalsvlei / Graafwater	G30G, G30F	• Potatoes[2]
4	From Bulshoek Weir to Trawal	E10K	• Table grapes • Raisins • Wine grapes • Tomatoes / brassica seed in rotation
5	From Klawer to the Coast	E33G, E33H	• Table grapes • Raisins • Wine grapes • Tomatoes / brassica seed in rotation

[2] As obtained from Department of Agriculture's 2013 Crop Census as per Cape Farm Mapper and confirmed during study group meeting with relevant stakeholders

2 Information sources considered

This Chapter provides an overview of the information sources considered to determine crop water requirements. A comparative summary is available in **Table 3-1** at the end of Chapter 3.

2.1 Feasibility Study for the Raising of Clanwilliam Dam

The report *Soils, Water Requirements and Crops* (2007) (DWS Report No. DWAF Report No. P WMA 17/E10/00/1106) provides an analysis of crop water demands at a technical level, making use of the following sources:

- Olifants/Doring River Basin Study or ODRIS (Department of Water Affairs and Forestry, 1998);
- Western Cape Olifants Doring River Basin Study or WODRIS (Provincial Government of the Western Cape, 2003); and
- The results of the SAPWAT computer programme.

The report does not make a clear recommendation on the crop water quotas to be used. It mentions the general conclusion in the ODRIS that the net average irrigation demand for the Upper Olifants River is 8500 – 10 000 m^3/ha/a and for the Lower Olifants it is 10 000 – 12 000 m^3/ha/a.

Further to the above, the SAPWAT values as calculated by Van Heerden and Crosby (2002) is referenced in the document. Please refer to **Table 2-1** overleaf for a summary of the water use requirements.

Table 2.1 | Summary of total irrigation water requirement for selected crops in the Olifants River Basin according to SAPWAT

Crop	Planting date annual crops	Irrigation system	Irrigation system efficiency	Weather station	ET crop (mm/a)	Effective rain (mm/a)	Total irrigation requirement (mm/a)
Citrus		Drip	95%	Lutzville	1 187	133	1 366
				Klawer	1 288	169	1 466
				Augsburg	1 111	224	1 225
				Citrusdal	1 081	278	1 138
		Micro	90%	Lutzville	1 296	133	1 583
				Klawer	1 405	169	1 698
				Augsburg	1 209	224	1 410
				Citrusdal	1 181	278	1 328
Wine grapes		Drip	95%	Lutzville	813	136	908
				Klawer	878	174	965
				Augsburg	789	229	865
				Citrusdal	777	281	813
Potatoes	Feb	Centre pivot	85%	Lutzville	476	40	628
				Klawer	528	53	682
				Augsburg	431	49	549
				Citrusdal	455	34	599
Tomatoes – Processing	Dec	Drip	95%	Lutzville	521	14	634
				Klawer	560	12	693
				Augsburg	546	16	660
				Citrusdal	549	51	643
Tomatoes – Table	Dec	Drip	95%	Lutzville	640	35	774
				Klawer	702	32	841
				Augsburg	632	43	752
				Citrusdal	644	63	755
	Sep	Drip	95%	Lutzville	730	35	876
				Klawer	700	38	934
				Augsburg	755	47	895
				Citrusdal	723	134	801

Source: Department of Water Affairs and Forestry, 2004

2.2 Compulsory Licensing Study for the Jan Dissels River Catchment

As part of the above study, Mr J Lambrechts of the University of Stellenbosch calculated the estimated irrigation water requirements for identified crops in the Jan Dissels River catchment according to the SAPWAT2 computer programme (Department of Water Affairs and Forestry, 2008). The weather data at Augsburg was used for these calculations, and the crop water use requirements could therefore be extrapolated for the Clanwilliam area.

Note that these figures were found to be low, given that they were developed to be in line with international benchmarks for irrigation efficiency and that not all irrigators in South Africa could maintain these standards.

The recommended application rates for various crops are summarised in **Table 2-2** below.

Table 2.2 - Summary of recommended application rates for Jan Dissels River catchment according to SAPWAT2

Crop type	Irrigation system	Estimated Irrigation Water Requirement from SAPWAT (m^3/ha/a)
Citrus	Drip	7 000
	Micro	8 000
Table Grapes	Drip	8 000
	Micro	9 000
Vegetables - Tomatoes	Drip	6 500
Vegetables - Onions	Centre Pivot	7 000
Perennial Pastures	Sprinkler	15 000
Lucerne	Sprinkler	9 000

Source: Department of Water and Sanitation, 2008

Please refer to **Table 2-3** overleaf for the total calculated irrigation water requirement according to SAPWAT2, for various design parameters. Note that the results in **Table 2-2** were extrapolated from the data in **Table 2-3**.

Table 2.3 | Summary of recommended application rates for Jan Dissels River catchment according to SAPWAT2

Crop	Option	Planting Date	Cover Full growth (%)	Wetted Area (%)	System	System Efficiency (%)	Target yield	Distribution Uniformity	ET Crop	Effective rain	Total irrigation requirement	Catch-can Requirement
Citrus	Average	May	60	100	Basin	75	Normal	85	921	224	1258	1084
	Below ave	May	60	10	Drip	95	Controlled	85	608	224	586	676
	Average	May	60	10	Drip	95	Normal	85	683	224	711	804
	Average	May	60	10	Drip	95	Normal	85	683	224	845	804
	Average	May	90	20	Drip	95	Normal	85	1124	224	1228	1311
	Below ave	May	60	60	Micro	90	Controlled	85	692	224	706	769
	Average	May	60	60	Micro	90	Normal	85	759	224	840	893
	Average	May	90	100	Micro	90	Normal	85	1217	224	1420	1342
Vine-wine	Early/short	May	60	10	Drip	95	Controlled	85	465	188	466	517
	Medium	May	60	10	Drip	95	Normal	85	531	229	557	625
	Medium	May	60	10	Drip	95	Normal	85	483	229	513	568
	Early/short	May	60	60	Micro	90	Controlled	85	582	188	609	647
	Medium	May	60	60	Micro	90	Normal	85	605	229	669	712
Vine-table	Early-short	May	80	10	Drip	95	Normal	85	795	229	873	935
	Medium	May	80	10	Drip	95	Normal	85	811	229	894	954
	Medium	May	80	20	Drip	95	Normal	85	846	229	930	995
	Early-short	May	60	60	Micro	85	Normal	85	679	229	808	799
	Medium	May	80	60	Micro	85	Normal	85	873	229	1071	1027
	Early-short	May	80	80	Micro	85	Normal	85	905	229	1106	1065
	Early-short	May	80	80	Micro	95	Normal	90	905	229	929	1006
Tomato	Process	Dec	90	20	Drip	95	Controlled	90	547	16	624	608
	Process	Dec	90	20	Drip	95	Controlled	90	542	16	619	602
	Process	Dec	90	20	Drip	95	Normal	85	547	16	661	644
	Process	Dec	90	20	Drip	95	Normal	85	542	16	656	638
	Table	Sep	90	20	Drip	95	Controlled	90	754	47	830	838
	Table	Dec	90	20	Drip	95	Normal	85	633	43	752	745
	Table	Sep	90	20	Drip	95	Normal	85	756	47	897	889

Source: Department of Water Affairs and Forestry, 2008

2.3 Berg-Olifants Validation & Verification

Summary information on crop water demands per quaternary catchment was provided by the Department of Water and Sanitation (2018). These water quotas were used to determine crop water demands for existing lawful water uses in terms of the Validation & Verification (V&V) process. As such, the crop water use requirements are representative of irrigation water use efficiency for the Validation & Verification qualifying period (1996-1998). These figures were however still found to be relevant in determining current day crop water use requirements.

Please note that all irrigation methods were assumed to be micro irrigation for the purposes of the Validation & Verification process. An efficiency factor of 90% was therefore applied across all crops. Please see a summary of the V&V figures in **Table 2-4** overleaf.

In consultation with the Department of Water and Sanitation and Department of Agriculture, it was decided to make use of the V&V figures to calculate aggregate water demand per zone of the study area. It was however agreed to use an efficiency factor of 90% for permanent crops and 80% for annual crops. Please refer to **Table 2-5** overleaf for the V&V figures, adjusted to the correct crop factors (the crop factors for annual crops were changed from 90% to 80%).

Table 2.4 | Crop water use requirements per Quaternary Catchment as identified during the Validation & Verification Project (90% efficiency factor)

Quaternary Catchment	Irrigation board (IB)	IB quota	W/ Grapes	T/ Grapes	Citrus	Deciduous Fruit	Lucerne	Potatoes	Vegetables	Grazing	Average	Default
E10D	Citrusdal	12 200	8 500	10 110	10 000	9000	12000	7 050	7 300	12 000	9 495	10 500
E10E	Citrusdal	12 200	8 500	10 110	10 000	9000	12000	7 050	7 300	12 000	9 495	10 500
E10F	Citrusdal	12 200	8 500	10 110	10 000	9000	12000	7 050	7 300	12 000	9 495	10 500
E10G	Clanwilliam	12 200	9 500	11 340	11 000	9900	12000	8 960	8 250	11 700	10 331	12 200
E10H	Clanwilliam	12 200	9 500	11 340	11 000	9900	12000	8 960	8 250	11 700	10 331	12 200
E10J	Clanwilliam	12 200	9 500	11 340	11 000	9900	12000	8 960	8 250	11 700	10 331	12 200
E10K	Vredendal	12 200	9 500	11 340	11 000	9900	12000	8 960	8 250	11 700	10 331	12 200
E33G	Vredendal	12 200	9 500	12 390	11 000	9 900	13 200	7 250	8 250	13 200	10 586	12 200
E33H	Vredendal	12 200	9 500	12 390	11 000	9 900	13 200	7 250	8 250	13 200	10 586	12 200

Source: Validation & Verification figures obtained directly from DWS

Table 2.5 - Validation & Verification crop water use requirements – adjusted to agreed irrigation efficiency factors

Quaternary Catchment	Irrigation board (IB)	W/ Grapes (90%)	T/ Grapes (90%)	Citrus (90%)	Deciduous Fruit (90%)	Lucerne (80%)	Potatoes (80%)	Vegetables (80%)	Grazing (80%)	Average
E10D	Citrusdal	8 500	10 110	10 000	9000	13 500	7 931	8 213	13 500	11 078
E10E	Citrusdal	8 500	10 110	10 000	9000	13 500	7 931	8 213	13 500	11 078
E10F	Citrusdal	8 500	10 110	10 000	9000	13 500	7 931	8 213	13 500	11 078
E10G	Clanwilliam	9 500	11 340	11 000	9900	13 500	10 080	9 281	13 163	12 099
E10H	Clanwilliam	9 500	11 340	11 000	9900	13 500	10 080	9 281	13 163	12 099
E10J	Clanwilliam	9 500	11 340	11 000	9900	13 500	10 080	9 281	13 163	12 099
E10K	Vredendal	9 500	11 340	11 000	9900	13 500	10 080	9 281	13 163	12 099
E33G	Vredendal	9 500	12 390	11 000	9900	14 850	8 156	9 281	14 850	12 394
E33H	Vredendal	9 500	12 390	11 000	9900	14 850	8 156	9 281	14 850	12 394

Source: Validation & Verification figures obtained directly from DWS, adjusted to reflect agreed efficiency factors

2.4 Guideline of the Department of Agriculture

The publication *Estimated Irrigation Requirements of Crops in South Africa* is used as a guideline by the Department of Agriculture to determine crop water requirements for specific weather stations (Department of Agriculture and Water Supply, 1985).

The water use requirements of relevant crops for the available weather stations (Citrusdal, Lutzville and Vredendal) have been summarised in **Table 2-6** below. Note that these values have been adjusted with an efficiency factor of 90% for permanent crops (citrus, wine grapes and deciduous fruit), and an efficiency factor of 80% for cash crops (potatoes, lucerne, tomatoes, brassica).

Table 2.6 | Crop water use requirements as identified by the Department of Agriculture (1985)

Crops (all 25mm design applications)	Quotas (mm/a)		
	Citrusdal	Lutzville	Vredendal
Citrus	1,431	-	-
Wine	767	711	596
Table Grapes	604	532	456
Dec Fruit (L)	887	812	678
Potatoes (Mar-Jul)	420	536	429
Potatoes (Jan - May)	1,091	1,006	815
Potatoes (Nov - Mar)	1,608	1,339	1,119
Potatoes (Aug - Dec)	1,104	1,031	826
Potatoes (Jun - Oct)	454	583	444
Lucerne	2,280	2,146	1,751
Tomatoes (Jan - Jun)	628	-	-
Tomatoes (Jun - Nov)	-	611	471
Tomatoes (Mar - Aug)	-	370	283
Tomatoes (Nov-Apr)	-	998	818
Tomatoes (Sep - Feb)	1,221	1,039	880
Brassica (Mar-Jul)	279	-	-
Brassica (Dec - Mar)	898	-	-
Brassica (Apr-Aug)	-	266	208
Brassica (Feb-Jun)	-	503	400

Source: Department of Agriculture and Water Supply, 1985

2.5 Calculations by the Department of Water and Sanitation

The Department of Water and Sanitation in Clanwilliam calculated crop water use requirements making use of the application CROPWAT (2018), with effective rain data provided according to the Food and Agricultural Organisation of the United Nations. Note that the agreed irrigation system efficiency factors of 90% for permanent crops and 80% for cash crops have been applied in this calculation.

A summary of the crop water use requirements is indicated in **Table 2-7** below.

Table 2.7 – Crop water use requirements according to CROPWAT

Clanwilliam Dam conveyance study
Total Irrigation Water Requirements
(Derived from Cropwat software with effective rain according to FAO)

Station	Crop	Plant Date	Irr Sys	Irr Sys eff	ET crop (mm/a)	Eff Rain (mm/a)	Bulk Losses (%)	Total Irr Requirement (mm/a)
Citrusdal	Citrus		Drip	90%	1282.7	125	0%	1300.2
	Grapes - Table		Drip	90%	892.9	125	0%	867.1
	Grapes-Wine		Drip	90%	810.4	125	0%	775.4
	Potato	25-Sep	Centre Pivot	80%	832.8	3.4	0%	1037.6
	Potato	25-Jan	Centre Pivot	80%	564.6	32.2	0%	673.6
Clanwilliam	Citrus		Drip	90%	1389.6	53.9	0%	1490.1
	Grapes - Table		Drip	90%	1166	53.9	0%	1241.7
	Grapes-Wine		Drip	90%	1033.2	53.9	0%	1094.1
	Potato	25-Sep	Centre Pivot	80%	865.2	0.4	0%	1081.1
	Potato	25-Jan	Centre Pivot	80%	601	7.3	0%	744.0
Klawer	Citrus		Drip	90%	1334	37.5	0%	1444.7
	Grapes - Table		Drip	90%	1125.3	37.5	0%	1212.8
	Grapes-Wine		Drip	90%	994	37.5	0%	1066.9
	Potato	25-Sep	Centre Pivot	80%	822.7	0	0%	1028.4
	Potato	25-Jan	Centre Pivot	80%	585.7	12.1	0%	720.0
Lutzxville	Citrus		Drip	90%	1287.5	10.8	0%	1419.8
	Grapes - Table		Drip	90%	1086	10.8	0%	1195.9
	Grapes-Wine		Drip	90%	959.3	10.8	0%	1055.1
	Potato	25-Sep	Centre Pivot	80%	792.2	0	0%	990.3
	Potato	25-Jan	Centre Pivot	80%	561.6	2.2	0%	699.8
	Tomato	25-Sep	Drip	80%	902.1	0	0%	1127.6

Source: Department of Water and Sanitation, 2018 (calculated by CROPWAT)

2.6 Financial Viability of Irrigation Farming Sub-Report

The Financial Viability of Irrigation Farming Sub-Report of the current Post Feasibility Bridging Study makes use of crop water requirements as an input to the financial models for the identified crops. For this Sub-Report the SAPWAT figures of the 2007 feasibility study were used (with certain exceptions). The summary crop water use information is indicated in **Table 2-8** below. The footnotes to the table should be noted, also indicating situations where the SAPWAT figures were not used.

Table 2.8 | Crop water use requirement in Financial Viability Sub-Report

Crop	Irrigation water requirement per production area (m^3/ha/a)		
	Citrusdal	Clanwilliam	Trawal/Klawer[1]
Citrus fruit	11,380	12,250	-
Table grapes	-	9,000[4]	13,580
Wine grapes/Raisins	-	-	9,650
Potatoes with wheat in rotation[2]	4,997	-	-
Tomatoes[3]	-	-	6,930

Please see the following explanatory notes to the table above:

[1] - This is a combination of the Melkboom/Trawal and Klawer/Vredendal areas.

[2] - Centre pivot system (average water requirement of potatoes and wheat per production cycle).

[3] - Drip irrigation system (water requirement per production cycle).

[4] - No water requirement for table grapes in Clanwilliam was available from the previous study and this figure is therefore an estimate provided by a local farmer.

2.7 Other sources

Other sources that were considered but not found to be relevant include publications by the Water Research Commission (WRC) as provided by the Department of Agriculture, Forestry and Fisheries, and a study by Mr A.D. Nieuwoudt dated 1965. These studies could be further investigated if the need arises.

3 Proposed crop water use requirements

It was agreed to make use of the most recent V&V crop water use values for the planning of bulk irrigation infrastructure options. These figures have already been approved by the DWS and have recently been scrutinised by water users, technical advisors and DWS officials. If no V&V figures are available, information from other sources could be considered.

Please refer to **Table 3-1** overleaf for a summary of all the gross crop water requirement sources and their concomitant values for comparative purposes. The agreed requirements are indicated in the last column of **Table 3-1**.

Efficiency was not the most important factor in evaluating the crop water use figures, but rather a more conservative and realistic approach was followed to ensure that the water use figures are representative of all water users in the catchment. If irrigation efficiency needs to be brought into account, efficiency factors of 90% for permanent crops and 80% for cash crops have been agreed upon. Note however that the efficiency factors for the V&V figures are all set at a standard of 90% for all crops (based on the assumption that only micro irrigation was used during the qualifying period). On-farm losses due to storage dams should be noted but will not be factored in for calculation purposes.

Table 3.1 | Summary of gross crop water use requirements per geographical area

Zone	Crop	Water use (m^3/ha/a)			Proposed volume
		Source	**Efficiency factor**	**Volume**	
1 – Citrusdal	Citrus	2004 Feasibility	90%	13 280	10 000
		V&V	90%	10 000	
		DOA	90%	14 310	
		DWS	90%	13 002	
2 – Clanwilliam	Citrus	2004 Feasibility	90%	14 100	11 000
		Jan Dissels study	90%	8000 (micro)	
		V&V	90%	11 000	
		DWS	90%	14 901	
	Table grapes	Jan Dissels study	90%	9000 (micro)	11 340
		V&V	90%	11 340	
		DWS	90%	12 417	
	Potatoes	2004 Feasibility	85%	5490	10 080
		DWS	80%	7440 / 10 811	
		V&V	80%	10 080	
3 – Jakkalsvlei / Graafwater	Potatoes	V&V	80%	10 080	10 080 note that the value for Clanwilliam will also be used for the Jakkalsvlei / Graafwater area)

Zone	Crop	Water use (m^3/ha/a)			Proposed volume
		Source	Efficiency	Volume	
4 – Bulshoek to Trawal (E10K)	Table grapes	V&V	90%	11 340	11 340
	Wine grapes / raisins	V&V	90%	9500	9500
	Tomatoes	No data	-	-	It is recommended to use the V&V figure of 9281, which is the generic quota for vegetables
	Vegetables (general)	V&V	80%	9281	9281
	Brassica	No data	-	-	Recommended to use Zone 5 figures of either 5030 or 2080, depending on season (as available from the DOA data)

Zone	Crop	Water use (m^3/ha/a)			Proposed volume
		Source	Efficiency	Volume	
5 – Klawer to Coast (E33G and E33H)	Table grapes	V&V	90%	12 390 (Vredendal)	12 390
		DOA	90%	4560 (Vredendal)	
			90%	5320 (Lutzville)	
		DWS	90%	12 128 (Klawer)	
			90%	11 959 (Lutzville)	
	Wine grapes / raisins	2004 feasibility	95%	9650 (Klawer)	9500
			95%	9080 (Lutzville)	
		V&V	90%	9500	
		DOA	90%	7110 (Lutzville)	
			90%	5960 (Vredendal)	
		DWS	90%	10 669 (Klawer)	
			90%	10 551 (Lutzville)	
	Tomatoes (processing)	2004 feasibility	95%	6930 (Klawer, Dec)	Recommended V&V figure of 9281 for vegetables
			95%	6340 (Lutzville, Dec)	
	Tomatoes (table)	2004 feasibility	95%	8410 (Klawer, Dec)	
			95%	9340 (Klawer, Sep)	
			95%	7740 (Lutzville, Dec)	
			95%	8760 (Lutzville, Sep)	
	Tomatoes (unspecified)	DOA	80%	2830 (Vredendal, Mar)	
			80%	4710 (Vredendal, Jun)	
			80%	8800 (Vredendal, Sep)	
			80%	8180 (Vredendal, Nov)	
			80%	3700 (Lutzville, Mar)	
			80%	6110 (Lutzville, Jun)	
			80%	10 390 (Lutzville, Sep)	
			80%	9980 (Lutzville, Nov)	
		DWS	80%	11 276 (Lutzville, Sep)	
	Vegetables	V&V	80%	9281	9281
	Brassica	DOA	80%	4000 (Vredendal, Feb)	Recommended to use maximum volumes – either 5030 or 2080, depending on season
			80%	2080 (Vredendal, Apr)	
			80%	5030 (Lutzville, Feb)	
			80%	2660 (Lutzville, Apr)	

4 Water use values for planning purposes

In this section, the calculation of the aggregated water use requirements per crop is explained. The aggregate water use per crop is needed for bulk design infrastructure planning purposes.

The main irrigated crops that are currently grown in the study area were identified, together with their current extent in hectares. These crops are indicated in **Table 4-1** below. Note that Zone 3 was included with Zone 2 for calculation purposes.

Table 0.1 - Main irrigated crops grown in study area

Crop	Area (ha)			
	Zone 1	Zones 2 & 3	Zone 4	Zone 5
Citrus	6,757	650	0	0
Table Grapes	4	189	812	23
Wine Grapes	877	228	6,189	4,784
Vegetables	386	500	373	597
Fruit	1,055	50	145	5
Total	9,080	1,616	7,519	5,409

Source: GIS data obtained from Department of Agriculture

Further to the above the net crop water use requirements were calculated, by removing the irrigation efficiency factors (90% for permanent crops and 80% for annual crops). Please refer to **Table 4-2** for the nett crop water use requirements for the crops identified.

Table 0.2 - Nett crop water use requirements

Crop	Net crop water use (m^3/ha/a)			
	Zone 1	Zones 2 & 3	Zone 4	Zone 5
Citrus	9,000	9,900	9,900	9,900
Table Grapes	9,099	10,206	10,206	11,151
Wine Grapes	7,650	8,550	8,550	8,550
Vegetables	6,570	7,425	7,425	7,425
Fruit	8,100	8,910	8,910	8,910

The percentage (%) breakdown of identified crops that are planted in each zone was then calculated. Please refer to **Table 4-3** overleaf for the percentage breakdown of identified crops per zone.

Table 0.3 - Percentage breakdown of identified crops per zone

Crop	Area (ha)			
	Zone 1	Zone 2 & 3	Zone 4	Zone 5
Citrus	74.42	40.21	0.00	0.00
Table Grapes	0.05	11.68	10.80	0.42
Wine Grapes	9.66	14.08	82.31	88.45
Vegetables	4.26	30.93	4.97	11.03
Fruit	11.62	3.09	1.93	0.10

Lastly, the weighted average of the crop percentages in **Table 4-3** and the crop water use requirements in **Table 4-2** were calculated using Microsoft Excel. Please refer to **Table 4-4** for the final aggregate crop water use requirements.

Table 0.4 - Aggregate crop water use requirements

Zone	Aggregate water use (m^3/ha/a)
1	8,662
2 & 3	8,949
4	8,680
5	8,437

It was agreed that the extent of losses would be addressed for each option during the options analysis process, and not included as part of the planning crop water requirements.

5 Bibliography

Department of Agriculture and Water Supply. 1985. *Estimated Irrigation Requirements of Crops in South Africa.*

Department of Water Affairs and Forestry, South Africa. 1998. *Olifants/Doring River Basin Study: Soils and Irrigation Potential*. Report No PE 000/00/0498. BKS Engineering and Management. Pretoria. March 1998.

Department of Water Affairs and Forestry, South Africa. 2004. *Soils, Water Requirements and Crops*. Prepared by J J N Lambrechts, B H A Schloms and F Ellis of the University of Stellenbosch, as part of the Feasibility Study for the Raising of Clanwilliam Dam. DWAF Report No. P WMA 17/E10/00/1106.

Department of Water Affairs and Forestry, South Africa and Department for International Development, United Kingdom. 2008. *Water Requirements and Availability Report*. Prepared by A Sparks, K Hundley and G Howard of Ninham Shand (Pty) Ltd, in association with Pegasys (Pty) Ltd and Informage, as part of the Support to Compulsory Licensing in the Jan Dissels River Catchment, Western Cape.

Department of Water and Sanitation. 2018. *Summary of Validation & Verification Crop Water Use Requirements Per Quaternary Catchment (Microsoft Excel Spreadsheet).* Provided by e-mail.

Provincial Government Western Cape. 2001. Western Cape Olifants/Doring River Irrigation Study. Soils, and Irrigation Potential. Final Draft. Prepared by J J N Lambrechts, F Ellis, and B H A Schloms in association with ARCUS GIBB (Pty) Ltd. Cape Town. June 2003. PGWC Report No. 259/2004/10.

Aurecon South Africa (Pty) Ltd
1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com