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

Conceptual Design Sub-Report






July 2020

Department of Water and Sanitation
Directorate: Options Analysis

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

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DEPARTMENT OF WATER AND SANITATION

Directorate: Options Analysis

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

CONCEPTUAL DESIGN SUB-REPORT

July 2020

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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.

Report Index	Report Number	Report Title and Description of Content
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.
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

Introduction

This report describes the main features of the irrigation development schemes to be designed at feasibility level, and the revised suite of preferred irrigation development options. The report effectively serves as the 'Inception Report' for the feasibility design to follow.

Changes to Preliminary Preferred Options

It became evident that some of the identified preferred areas included areas that were too steep for irrigation farming. Vinpro thus calculated slopes for the preferred irrigation areas. Slopes steeper than 12% are considered too steep for irrigation, and the irrigation areas were thus modified accordingly.

In addition, the Melkboom irrigable area was enlarged to 505 ha, to include additional irrigable land identified. The Jan Dissels irrigable area was reduced by 55 ha to account for planned irrigation by the Augsburg Agricultural Gymnasium.

The potential for a Trawal Government Water Scheme was identified, comprising all, or a portion, of the proposed new irrigation development areas in the Trawal area, i.e. the Zypherfontein 1, Zypherfontein 2, Melkboom and Trawal irrigation areas.

The preferred irrigation areas and scheme water requirements were subsequently updated.

The total irrigation water requirement of the preferred schemes reduced, following the slope analysis, to the point where the total irrigation water requirement of the preferred options falls short of the 61.05 million m^3/a available for new irrigation. It therefore became necessary to identify further alternative scheme to make full use of the available additional water. It was deduced that the next augmentation option to consider, after consideration of the schemes that make use of spare flow capacities in existing canals, is the Klawer Phase 2 Scheme. Alternatively, the implementation of the Klawer Scheme, after the construction of the Right Bank Canal, can be considered, either development of the full area or a portion thereof.

Design-focussed Meetings and Site Visit

Four separate design-focussed meetings were held with land owners and water users in November 2019, and a field visit was undertaken in March 2020, to inspect potential abstraction sites, conveyance infrastructure routes and dam sites, for the three schemes to be designed. The two design teams were accompanied by geotechnical staff.

Supporting investigations

The geotechnical and materials evaluation will be undertaken as soon as the Covid-19 travel restrictions allow it.

A Light Detection and Ranging (LIDAR) topographical survey was undertaken by Southern Mapping for the Jan Dissels, Right Bank Canal and Ebenhaeser Schemes. The need for limited further surveying to be undertaken was identified. These include areas to support the design for the Right Bank canal and Ebenhaeser schemes.

Schemes for Feasibility Design

The following schemes were evaluated further, to prepare for feasibility design:

- **Jan Dissels Scheme**, pumping from Clanwilliam Dam. The scheme is very feasible from a cost perspective and offers a good opportunity for the inclusion of smallholder plots, given its proximity to Clanwilliam.

  A botanical survey was undertaken to confirm the extent of environmental sensitivity.

  Two sub-options were evaluated, namely either pumping directly from a floating intake on the lake of the raised Clanwilliam Dam or pumping from an outlet on the right bank of the dam wall. The comparative cost of the two sub-options is similar and both need to be evaluated further at feasibility level before a recommendation can be made. An access road may need to be constructed.

  The first sub-option, pumping from a floating intake, involves the construction of a 653 m long, 500 mm diameter rising main pipeline from the shore of the raised Clanwilliam Dam (above the 1:100 year floodline) to a small 11.6 Mℓ farm dam. The second sub-option, pumping from an outlet at the dam wall on the right bank, involves the construction of a 3 622 m long, 500 mm diameter rising main pipeline from the outlet at the dam to the small 11.6 Mℓ farm dam.

  An additional electrical supply must be planned for. A possibility is for the scheme to be (inter-alia) supplied from the future proposed hydro power plant, to be located on the left bank at the raised Clanwilliam Dam.

  The proposed irrigation area is located on State land, being used by the Cederberg Municipality and the Augsburg Agricultural Gymnasium. The Department of Water and Sanitation will be the owner of the scheme.

- **Right Bank Canal Scheme**, replacing the existing main left bank canal on the right bank of the Olifants River, including increased capacity to supply new downstream irrigation development and other future uses. This scheme is essential to ensure a secured future supply, given the high risk of disruption and shortfall in supply that the poor state of the existing canals, and especially the main (Trawal section) canal, poses to the lower Olifants River irrigators and other users, and to the prosperity of the region.

  The recommended Right Bank Canal Scheme is shown in **Figure E1**.

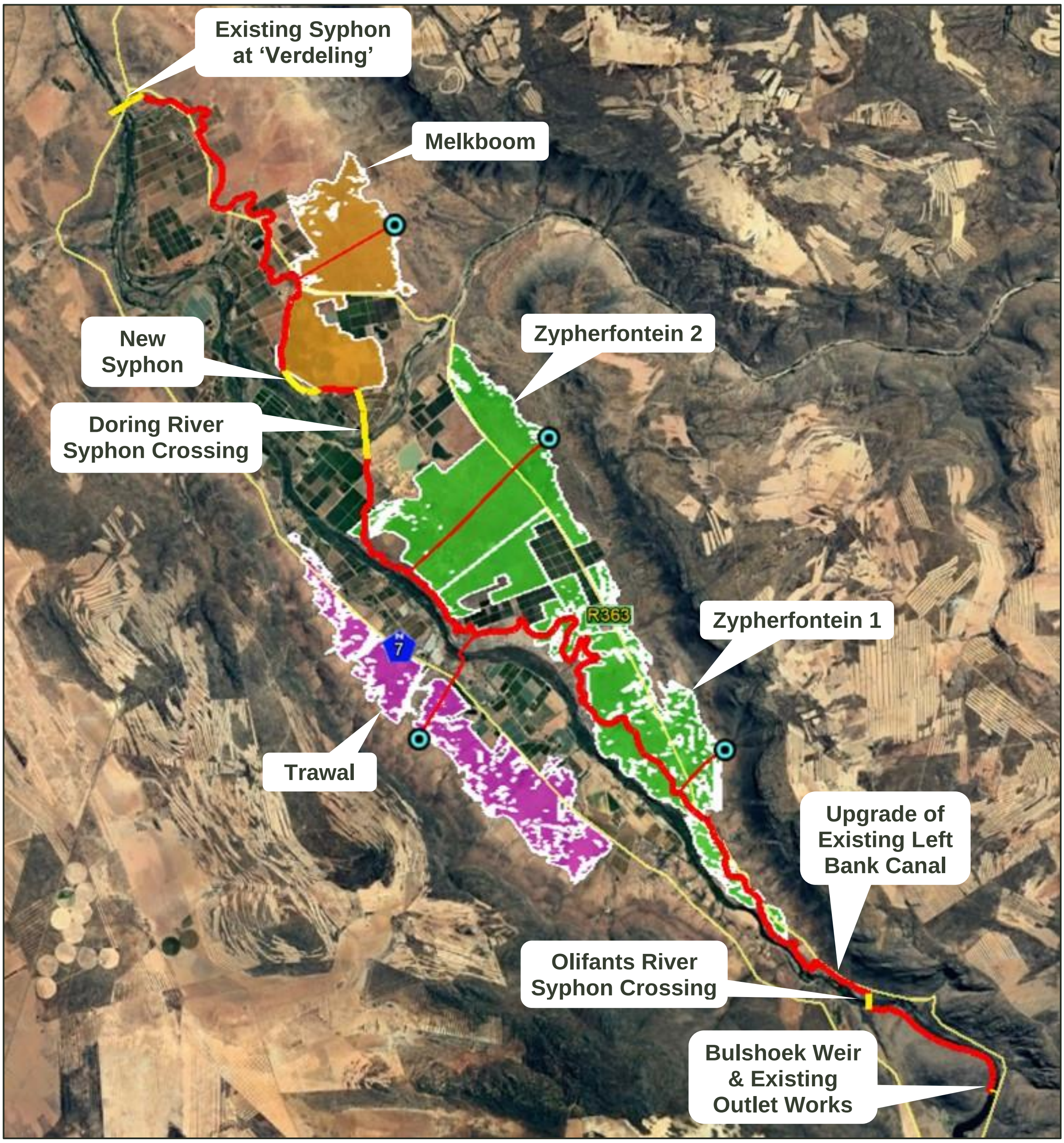

Figure E1: Layout of the Right Bank Canal Scheme

The scheme infrastructure is designed for a flow of 11.4 m/s throughout, providing for existing irrigators (current allocations plus increased assurance of supply), new irrigation from a raised Clanwilliam Dam and other future uses. The scheme uses the existing outlet works from the Bulshoek Weir and requires upgrading of the first three (3) km of the existing Left Bank Canal. It then crosses the Olifants River to connect into the new Right Bank Canal. The Right Bank Canal continues until it reaches the existing syphon at Verdeling, with a new 1.3 km syphon crossing plus a new 0.8 km syphon at the Doring River.

The proposed Right Bank Canal will supply the four significant potential irrigation areas in the Trawal region, namely the Zypherfontein 1 and 2, Trawal and Melkboom irrigation areas. The scheme is situated on privately-owned land.

- **Ebenhaeser Scheme**, making use of spare flow capacity in existing right bank and left bank distribution canal sections. The scheme will supply a combination of Ebenhaeser restitution farms and augment the Ebenhaeser community scheme. Augmentation of the water supply to prioritised restitution farms has a high priority from a social and political perspective, to ensure that such restitution farms can be successfully farmed, by increasing their currently inadequate water allocations. In addition, this scheme can augment supply to the existing historically disadvantaged community at Ebenhaeser. Five water requirement clusters were identified in consultation with community representatives. Six sub-options were identified and compared, and two sub-options were further evaluated.

  The volume of water that can be annually diverted from the various canal sections, and the associated balancing dam sizes required to gainfully use the diverted water for irrigation, were determined, as well as the associated sub-option costs. The combined scheme, diverting from the end of the Vredendal left bank canal section, as well as from the Retshof right bank canal section, was identified as the preferred sub-option.

  From the right bank Retshof diversion, water will be pumped via a 450 mm diameter, 888 m long rising main pipeline, to a 28 00 m^3 (28 Mℓ) small combined balancing dam. Water will also be diverted from the Vredendal canal to the combined small balancing dam, from the existing long weir. From the combined small balancing dam water will be pumped via a 700 mm diameter, 362 m long rising main pipeline, to a 2.302 million m^3 lined earthfill balancing dam. The dam will be situated South-West of and close to the Vredendal left bank canal diversion point, opposite the R363 road between Vredendal and Lutzville.

From the earthfill balancing dam, water will be pumped to a 10 450 m^3 (10.45 Mℓ) concrete balancing reservoir, via a 500 mm diameter, 2 160 m long rising main pipeline. From the concrete balancing reservoir, water will be gravitated to high points adjacent to the water requirement clusters, with adequate minimum pressure provided, via a 600/500/400 mm diameter, 17 300 m long gravity pipeline.

An additional volume of 150 000 m^3 has been included in the earthfill balancing dam capacity, for improved operation of the lower canal sections of the Lower Olifants River Government Water Scheme (LORGWS), as a betterment component, at the request of the Lower Olifants River Water User Association (LORWUA). This will be confirmed.

The diversion infrastructure, rising main pipelines, balancing dam and reservoir would be located on private land. Most of the gravity pipeline will be located on State land.

Reconnaissance-level evaluations

The evaluation of the following schemes was done at reconnaissance level:

- **Trawal Government Water Scheme**, comprising all or a portion of the proposed new irrigation development areas in the Trawal area.
- **Clanwilliam Scheme**, pumping from the lake of the raised Clanwilliam Dam.
- **Zandrug Scheme**, pumping from the Olifants River below the raised Clanwilliam Dam and upstream of Bulshoek Weir.
- **Bulshoek Scheme**, pumping from the lake of Bulshoek Weir.
- **Trawal Government Water Scheme (GWS)**, consisting of a GWS or co-operative for four new irrigation areas near Trawal.
- **Klawer Phase 1 Scheme**, using spare capacity in canal section/s to supply the first phase of the Klawer irrigation area close to Vredendal, on the right bank of the Olifants River, after passing through the right bank canal flows intended for the Ebenhaeser Scheme.
- **Klawer Phase 2 Scheme**, involving either raising and lining the Klawer right bank canal section, or replacing the Klawer canal section with a new canal section on the right bank, to irrigate the remainder of the Klawer irrigation area, or a portion thereof.
- **Klawer Scheme**, irrigating the full potential Klawer irrigation area, or a portion thereof, following the completion of the new Right Bank main canal.
- **Coastal 1 Scheme**, using spare capacity in canal section/s, located on the left bank of the Olifants River near Vredendal, after passing through the left bank canal flows intended for the Ebenhaeser Scheme, to irrigate a portion of the Coastal 1 irrigation area.

Comparison of Preferred Irrigation Schemes

Scheme features were documented for comparison as shown in **Table E1** for the post-Right Bank canal situation.

Table E1: Comparison of Preferred Schemes

Scheme	Irrigable Area (ha)	Incr. Req + Losses (Mm^3/a)*	Capital Cost Development (R million)	Total NPV Development Cost (R million)	URV (R/m^3)	Environ-mental impact	Opportunity for smallholders/ restitution
Jan Dissels	462	4.26	25.2	57.8	1.17	High	Yes
Clanwilliam	298	2.46	34.5	58.6	1.84	Medium	Yes
Transfer of lower Jan Dissels River irrigators	0	1.00	0.0	0.0	0.00	Low	-
Zandrug	1209	9.15	117.8	196.8	1.52	High	Partial
Bulshoek	266	2.25	25.9	44.4	1.56	Medium	No
Right Bank canal (including 4 Trawal irrigation areas)	2339	25.65	394.5	589.2	2.29	Medium	No
Klawer Phase 1 (flow-restricted)	412	5.09	77.1	108.5	2.25	Low	Yes
Klawer Phase 2 (partial development)	438	5.32	168.0	203.4	1.71	Low	Yes
Coastal 1 (flow-restricted)	89	1.21	41.6	51.5	4.92	Low	Yes
Ebenhaeser	361	4.65	291.4	327.6	7.75	Low	Yes
TOTALS	**5874**	**61.05**	**1 176.0**	**1 637.8**			

** In addition to existing allocations*

Phasing of Schemes

The phasing of the preferred schemes has been recommended, in three phases, namely Phases A, B and C. Alternate phasing has also been identified. A summary of the proposed phasing is shown in **Table E2**.

Table E2: Phasing of Preferred Schemes

Scheme	Zone	Incremental requirement + losses (Mm³/a)	Phase A	Phase B	Phase C
Jan Dissels		**4.26**	●	⊙	⊙
Clanwilliam		**2.46**	●	⊙	⊙
Transfer of lower Jan Dissels irrigators	2	**1.00**	●	⊙	⊙
Zandrug		**9.15**	●	⊙	⊙
Bulshoek		**2.25**	●	⊙	⊙
Right Bank canal & 4 Trawal irrigation areas	4	**25.65**		●	⊙
Klawer Phase 1		**5.09**	●		
Klawer Phase 2 partial development	5	**5.32**			●
Coastal 1 flow-restricted		**1.21**			●
Ebenhaeser		**4.65**	●		
Incremental Water Requirements + Losses		**61.05**	29.44	25.08	6.53
Water Loss %		**12.5%**	10.8%	12.4%	22.3%
Hectares of new irrigation		**5 874**	3 008	2 339	527

The options located closest to the Clanwilliam Dam, especially those options located upstream of the Bulshoek Weir, are the most attractive options, as water can be provided for irrigation at low cost with limited losses.

The preferred suite of schemes offers the unique opportunity to, start to address the most significant risk currently posed to the LORGWS, namely the very poor structural integrity of the canal system. This suite of options includes replacement of the main (Trawal) canal section with a new Right Bank Canal, from Bulshoek Weir up to ‘Verdeling’, where the canal splits. This betterment would also offer the opportunity to overcome the current restriction to flow in the main canal.

Several of the preferred schemes provide opportunities for the development of smallholder (assumed 7.5 ha) plots, being located reasonably close to towns. These options also provide the opportunity to support a restitution scheme or an existing HDI scheme (Ebenhaeser).

Should there be a need to identify and design a government water scheme at this stage, the four irrigation areas located in the Trawal area, namely Zypherfontein 1 and Zypherfontein 2, Trawal and Melkboom, (or portions thereof) should be considered, as these options contain large tracts of undeveloped land in private ownership.

Recommendations

The following recommendations are made:

1) Proceed with the geotechnical and materials investigation as soon as this is allowed in terms of the Covid-19 situation.
2) Proceed with the environmental assessment and, if necessary, undertake field clarifications as soon as this is allowed in terms of the Covid-19 situation.
3) The outstanding topographic survey for the Right Bank canal and Ebenhaeser Scheme, using Light Detection and Ranging (LIDAR) should be completed as soon as this is allowed in terms of the Covid-19 situation.
4) Proceed with the feasibility design of the following three schemes:
    a. Jan Dissels,
    b. Right Bank Canal, and
    c. Ebenhaeser.
5) Engage with land owners and LORWUA as required during the design phase.
6) The following additional feasibility design reports will be produced, using the scheme recommendations and layouts:
    a. Environmental Screening Sub-Report;
    b. Jan Dissels and Ebenhaeser Schemes Design Sub-Report; and
    c. Right Bank Canal Design Sub-Report.
7) The integrated Feasibility Design Report will be produced when the sub-reports have been approved.
8) Prepare a draft Terms of Reference to undertake an EIA process for the three schemes recommended for feasibility design above, to obtain environmental authorisation for their implementation.

Issues to address during feasibility design are the following:

- Describe the risk associated with the poor state of the existing canals and the further risk associated with an increase of the canal flows. This applies to the main left bank (Trawal) canal section as well as the main distribution canals on the left and right banks, downstream of Verdeling.
- The splitting of capital costs and net present values (NPVs) between new irrigation development and betterment costs (costs attributable to current irrigators) should be revisited, to ensure equity.

- Clarify the uncertainty regarding the cost of water from the LORGWS, following the raising of Clanwilliam Dam, so that the potential for a Trawal GWS can be assessed with more confidence.
- Although not currently part of the study, a risk analysis of the current distribution system versus an upgraded canal system would add significant value, including economic and social implications of system failures, and the likelihood of these occurring over an economic period (considering historic failures). In addition, the legal obligations on DWS to ensure that the infrastructure remains functional should be clarified.
- The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the critical biodiversity areas, following acceptance of the recommendations. Evaluation of schemes has confirmed that the ecological impact and environmental issues relating to new development significantly influence and limit the scope of development options. Dialogue around these issues has started and further discussion should take place between departments as soon as possible, to agree on the way forward.
- Obtain clarity from DEA&DP regarding the best means to comply with environmental legislation and receive authorisation for the proposed new irrigation development areas. The majority of these areas are privately owned and development will be via a joint-venture agreement.
- To obtain greater clarity on funding options, it is suggested that DWS provide a presentation to National Treasury to explain implementation approaches, and to request confirmation of National Treasury's view on this as well as any concerns and required procedures. For this purpose, it will be necessary to have information at hand regarding economic and job creation implications of new investment. It would further be valuable to also provide the risks for the economy and labour of potential canal failures if betterments are not undertaken, although this is not currently part of this study. These could potentially be determined as part of the Socio-Economic Impact Analysis task of this study.

Contents

Appendices

Figures

Tables

Acronyms

BA	Basic assessment
CA	Competent authority
CBA	Critical biodiversity area
CMA	Catchment management agency
Covid-19	Coronavirus disease 2019
DALRRD	Department of Agriculture, Land Reform and Rural Development
DEA&DP	Western Cape Provincial Department of Environmental Affairs and Development Planning
DEM	Digital elevation model
DTM	Digital terrain model
DWAF	(Previous) Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EA	Environmental authorisation
EC	Electrical conductivity
EIA	Environmental impact assessment
EMF	Environmental management framework
ESA	Ecological support area
ESRI	Environmental Systems Research Institute
GA	General authorisation
GIS	Geographical information system
GN	Government notice
GWS	Government water scheme
Ha	Hectare
HDI	Historically disadvantaged individual
HWC	Heritage Western Cape
kW	KiloWatt
LIDAR	Light detection and ranging
LORGWS	Lower Olifants River Government Water Scheme
LORWUA	Lower Olifants River Water User Association
MEC	Member of the Executive Council
mg/l	Milligram per liter
Mℓ	Megaliter

Mm^3/a	Million cubic meter per annum
mS/m	MilliSiemens per meter
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NEMPAA	National Environmental Management Protected Areas Act
NFEPA	National freshwater ecosystem priority area
NGL	Nominal ground level
NHRA	National Heritage Resource Act
NID	Notice of intent to develop
NPAES	National Protected Area Expansion Strategy
NPV	Net present value
NWRI	National Water Resources Infrastructure branch of DWS
NWA	National Water Act
PSC	Project Steering Committee
RM	Rising main pipeline
SAHRA	South African Heritage Resources Agency
SEA	Strategic environmental assessment
TDS	Total dissolved solids
uPVC	Unplasticised polyvinyl chloride
URV	Unit reference value
VAT	Value added tax
V&V	Verification and validation
WCDoA	Western Cape Provincial Department of Agriculture
WODRIS	Western Cape Olifants/Doring River Irrigation Study
WUA	Water user association
WUL	Water use licence

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 describes the main features of the irrigation development schemes to be designed at feasibility level, and the revised suite of preferred irrigation development options. The report effectively serves as the 'Inception Report' for the feasibility design to follow.

The report more specifically addresses the following:

a) Documentation of the required information for the irrigation development schemes to be designed at feasibility level, as updated with improved information. This includes a description of alternatives or sub-options that were considered and/or evaluated, as well as scheme layouts and features at a conceptual level. It also describes infrastructure components to be designed, operational aspects, preliminary environmental impacts and affected land and infrastructure.

b) Documentation of changes to other preferred irrigation development options that were re-evaluated and subsequently refined.

c) Documentation of the required information for the geotechnical and materials investigations, and environmental screening to proceed. Proposal of an updated suite and phasing of preferred irrigation development schemes.

This is the first of the feasibility design sub-reports. The following further feasibility design reports will be produced:

- Environmental Screening Sub-Report,
- Jan Dissels and Ebenhaeser Schemes Design Sub-Report,
- Right Bank Canal Design Sub-Report,
- Feasibility Design Report.

These design reports will be supported by the Topographical Survey Report and the Geotechnical and Soils Investigations Report/s.

1.3 Background to the Project

The Clanwilliam Dam is situated in the Olifants River near the town of Clanwilliam in the Olifants/Doorn River Catchment Management Area in the Western Cape. The dam requires remedial work for dam safety reasons, which offers the opportunity to increase the yield at the same time by raising the dam and enlarging the storage capacity. Water use in the region is predominantly for irrigated agriculture. The Clanwilliam Dam is shown in **Figure 1.1** and **Figure 1.2** shows the study area and provides an overview of the existing conveyance infrastructure discussed in this report.

Figure 1.1: Clanwilliam Dam
Photo courtesy of DWS

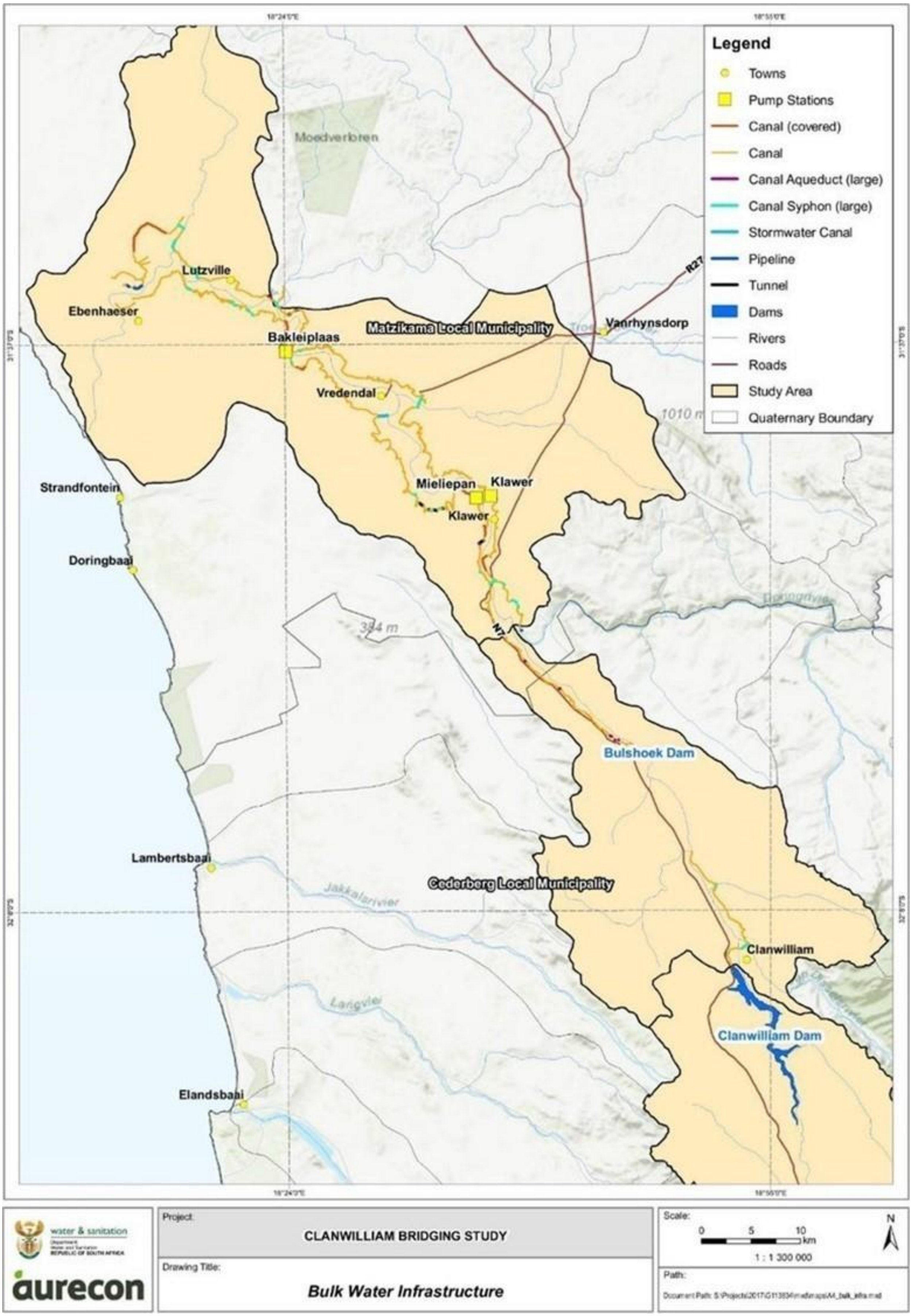

Figure 1.2: Study Area and Bulk Water Infrastructure

A feasibility study was completed in 2008, which concluded that the raising of Clanwilliam Dam, and further associated agricultural development, is economically viable and socially desirable. The feasibility study recommended the raising of the full supply level of the existing Clanwilliam Dam by 13 m, to augment the water supply to the existing scheduled irrigation area, towns and industrial use, as well as to provide additional water for new irrigation areas to establish historically-disadvantaged farmers, as well as supply other local water users.

The environmental authorisation for the raising of Clanwilliam Dam is effective from February 2010 and the project was approved by the then Minister of Water and Environmental Affairs as a Government Water Works in August 2010. The implementation of this project is currently in the construction stage, which commenced in October 2018, after a significant delay.

The Clanwilliam Dam Raising Feasibility Study Report titled '*Irrigation Development and Water Distribution Options'* provided reconnaissance-level information on the potential areas for new irrigation development and some water distribution options, but more detailed investigations are required.

The water distribution options and associated bulk water infrastructure have been determined at a higher (reconnaissance) level of confidence, the feasibility design and costing are now proceeding, and the project will be made implementation-ready.

1.4 Content of this Report

Chapter 1: Introduction (this Chapter): Introduces and provides background to the conceptual design of the preferred development options.

Chapter 2: Recommended Options: Summarises the previous findings and recommended options, the options to be designed in this study, and clarifies outstanding information required to proceed with the design.

Chapter 3: Supporting Investigations: Describes the status of the supporting topographical survey, geotechnical and materials investigations and environmental screening.

Chapter 4: Jan Dissels Scheme: Documents the further evaluation and refinement of the Jan Dissels Scheme and sub-options considered, the scheme layout and features at a conceptual level, infrastructure components to be designed and estimated costs.

Chapter 5: Right Bank Canal: Documents the further evaluation and refinement of the new Right Bank canal and sub-options considered, the scheme layout and features at a conceptual level, infrastructure components to be designed and estimated costs.

Chapter 6: Ebenhaeser Scheme: Describes the further evaluation and refinement of the Ebenhaeser Scheme and sub-options considered, the scheme layout and features at a conceptual level, infrastructure components to be designed and estimated costs.

Chapter 7: Reconnaissance-level Investigations: Documents the re-evaluation of other preferred irrigation development options, the scheme layouts and features at a conceptual level, infrastructure components and estimated costs.

Chapter 8: Comparison and Phasing of Preferred Irrigation Schemes: Summarises the updated proposed suite of preferred irrigation development schemes, and the potential phasing thereof.

Chapter 9: Conclusions: Summarises the findings as described in this report.

Chapter 10: Recommendations: Provides recommendations regarding the supporting investigations, irrigation schemes to evaluate further at feasibility level, and initiatives to support the implementation of the projects.

2 Recommended Options

This chapter summarises the previous findings and recommended irrigation development options, as well as further changes to options, and clarifies outstanding information required to proceed with the three options to be designed at feasibility level as part of this study.

2.1 Previously Recommended Options

The preferred development options, as described in the *Suitable Areas for Agricultural Development Report* of this study, are the following (option numbers are not consecutive, as a large amount of options were evaluated, from which the following options were selected):

- Option 1: **Jan Dissels**, pumping from Clanwilliam Dam;
- Option 2: **Clanwilliam**, pumping from Clanwilliam Dam;
- Option 3: **Transfer of Jan Dissels River Water Use Authorisations**;
- Option 4: **Zandrug**, pumping from Olifants River;
- Option 5: **Bulshoek**, pumping from Bulshoek Weir;
- Option 15: **Right Bank Canal**, replacing the existing main canal with increased capacity, supplying four new irrigation areas (Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom) and any increased downstream supply; and
- Options 20/21/22: **Use of spare capacity in Naauwkoes/ Vredendal canal sections**, supplying a combination of Ebenhaeser restitution farms and augmenting the Ebenhaeser community scheme, as well as either a scaled down Coastal 1 Scheme or alternatively a scaled down Klawer Scheme.

2.2 Preliminary Preferred Options Meetings with Land Owners

A series of meetings were held with farm owners of preferred irrigation development options in May 2019, to present the preliminary preferred irrigation development schemes, and to obtain information for clarification of the schemes from these land owners. An Information Document describing the background to the project and information on progress with the study was provided to stakeholders before the meetings.

The preferred development options are typically on several farms in private ownership. To proceed to feasibility design of these preferred options, the designers needed to understand whether they need to design for large schemes following expropriation of private land, or whether allowance should be made for some owners who want to enter into joint ventures with historically disadvantaged individual (HDI) farmers for new irrigation. The institutional models selected for implementation thus influences the approach to design. As these institutional models are unknown at this stage, it was proposed that the best way to limit this uncertainty was to meet with land owners, to try and get clarity on the way forward.

Four separate meetings were held with land owners (geographical clusters of preferred options) over a three-day period (14 to 16 May 2019), to get clarity and to limit later changes to options, that may significantly influence the feasibility design. These meetings also served the purpose of sensitising the land owners to the following project activities on their land, such as site reconnaissance, topographical surveys, environmental screening site visit and geotechnical surveys.

2.3 Changes to Preliminary Preferred Options

2.3.1 Slope analysis

During the meetings held with land owners of potential new irrigation areas, in May 2019, it became evident that some of the identified preferred areas included were too steep for irrigation farming. A big portion of the soil survey area lies on steep rocky mountain slopes which are not suitable for agriculture.

Vinpro undertook a soil survey as part of this study. Land parcels up to a lateral extent of 100 m above the level of the river or existing canals were evaluated within the identified project area, adding to previous soil surveys undertaken. The previous soil surveys undertaken (before this study) did not account for slope, i.e. did not eliminate areas that are located on slopes which are too steep for irrigation. It was therefore recommended that areas that are too steep (>12%), within the identified preferred irrigation areas, should be excluded.

The *Feasibility Study for the Raising of Clanwilliam Dam* inter-alia included a compilation of a soils map for the Olifants River Basin from Keerom, south of Citrusdal, to the coast. The lateral extent of the area covered was on average about 60 m above the level of the river or existing canals or an agreed horizontal distance away. The soils map was based on: i) the extensive reconnaissance soil survey of the Citrusdal valley from the Clanwilliam Dam south as far as Keerom (Lambrechts, et al., 1989); ii) the extensive, more detailed Western Cape

Olifants/Doring River Irrigation Study (WODRIS; Provincial Government Western Cape, 2003), iii) data from other soil studies; and iii) expert knowledge.

Vinpro thus compiled a digital elevation model (DEM) (created from 5 m contour data) for the preferred irrigation development areas, for areas not previously assessed for slope. A slope analysis using a DEM (created from 5 m contour data) and Environmental Systems Research Institute (ESRI) Spatial Analyst software was used to determine unsuitable land class area. The areas that fall within accepted slope ranges were identified for soil surveying. The task was completed in February 2019.

Three Slope classes were delineated as follows, as also illustrated in **Figure 2.1**.

- 0 – 6% **Green**
- 6 – 12% **Yellow**
- >12% **Red**

Slopes > 12% are considered too steep for irrigation.

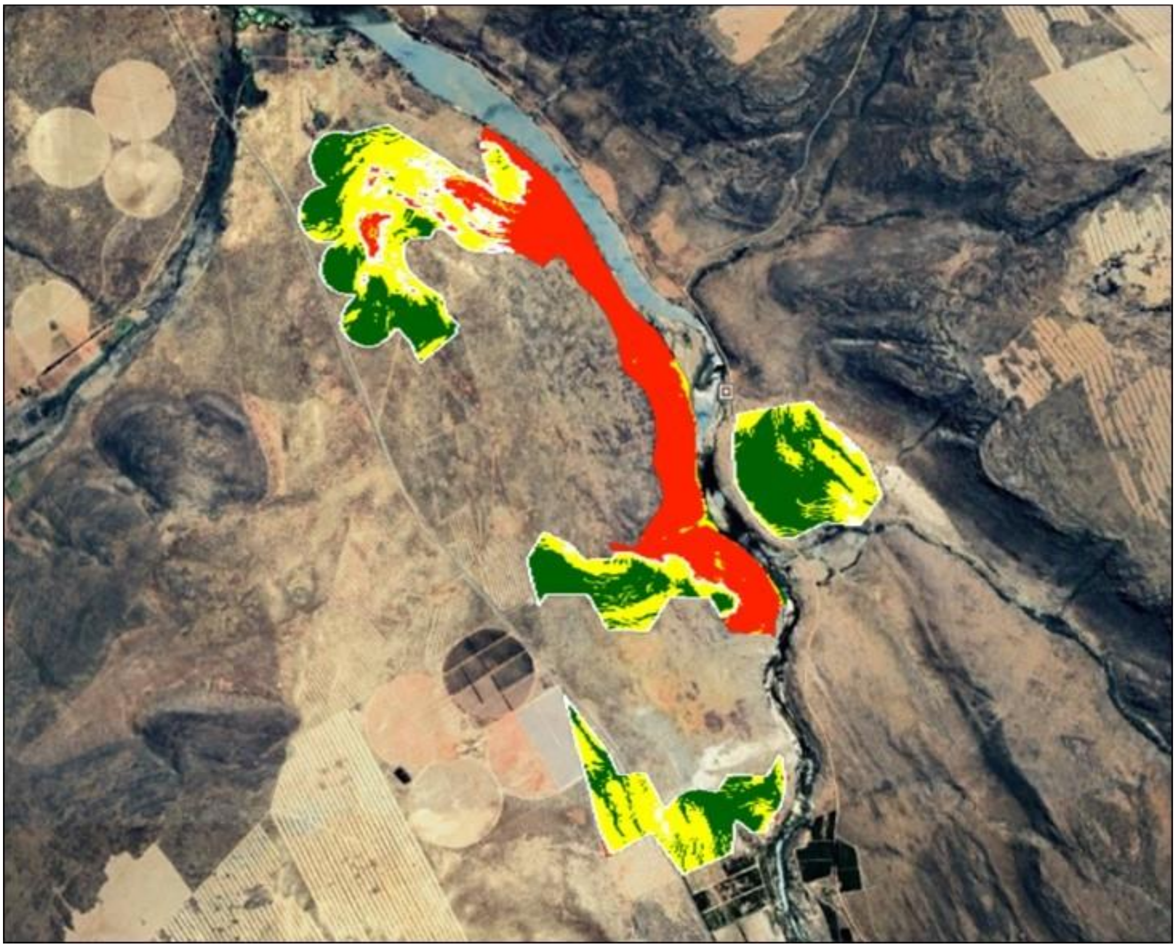

Figure 2.1: Example of slope analysis undertaken for the Bulshoek irrigation area

Changes to the irrigable areas of the Bulshoek (**Figure 2.1**) and Clanwilliam options were significant, while changes in the irrigable area of the other options were more limited.

2.3.2 Additional irrigable area identified

At the Project Steering Committee (PSC) meeting held on 11 March 2020, an area on the Melkboom farm (adjacent to the irrigation area of the Melkboom option) was identified as an area that should be added as a potential new irrigation area. The soil suitability of the area is good, but it appeared as if most of the land was already cultivated. It was pointed out (Mr Rassie Nieuwoudt, Chief Engineer, Water Resource Management – Berg/Olifants, DWS) that the existing irrigation is opportunistic irrigation from the Doring River when there are adequate flows of suitable quality.

An irrigable area of 204 ha was thus added to the Melkboom irrigation area, increasing the Melkboom irrigable area to 505 ha.

2.3.3 Change to Jan Dissels option area

The Augsburg Agricultural Gymnasium plans to start farming a portion of their land, as the income is needed to support the increasing number of learners that are applying for exemption of school fees, which is affecting the school's income. The school will install two small centre pivots (55 ha) for irrigation by the school, within the identified irrigation area. This reduced the irrigable area to 462 ha.

2.3.4 Updated Preferred Option Areas

During further analyses, isolated polygons of the preferred option areas of less than 1 ha were excluded. The option areas were accordingly updated, *inter-alia* taking into consideration the fragmented nature of some of the potential irrigation areas, due to the slope analysis.

The revised areas of the preferred options, as updated with the slope analysis, are as shown in **Figure 2.2** and **Table 2.1**.

The indicated water requirements include allowance for leaching, but exclude conveyance losses, or allowance for existing water allocations. The sizing of the options that are reliant on spare flow capacity in canal sections are not shown in the table, because the irrigable areas of these options are dependent on the remaining spare flow capacity in canal sections.

Figure 2.2: Location of preferred irrigation areas

Table 2.1: Revised Irrigable Areas of Preferred Options

#	Development Area	Revised irrigable area (ha)
1	Jan Dissels	462
2	Clanwilliam	298
4	Zandrug	1 209
5	Bulshoek	266
9	Zypherfontein 1	710
10	Trawal	510
11	Zypherfontein 2	614
12	Melkboom	505
20	Klawer (full area)	1 378
21	Coastal 1 (full area)	2 207
	TOTAL	**8 158**

2.3.5 Trawal Government Water Scheme

Concern was expressed about the large percentage of private land that formed part of the preferred irrigation development options. Only the Jan Dissels and Ebenhaeser options are located on Government-owned land, together only accounting for about 15% of the land to be developed for new irrigation.

The PSC decided that the study team should identify the most suitable area for a government water scheme or alternative institutional arrangement. This is an institutional option that does not affect the identification of the preferred irrigation options, but will affect the implementation of the schemes.

It was agreed that all, or a portion, of the proposed new irrigation development areas in the Trawal area are the most suitable for such an arrangement, i.e. the Zypherfontein 1, Zypherfontein 2, Melkboom and Trawal irrigation areas. These four potential irrigation areas are near each other. All the other preferred option areas are located on private land, and large portions of these properties are already farmed.

2.3.6 Revised new irrigation areas and water requirements

The revised irrigation areas and associated water requirements, following the slope analysis and with the enlarged Melkboom irrigation area, are shown in **Table 2.2**.

The water requirements for these irrigation options, *which exclude the options that use spare canal flow capacity*, total 44.77 million m^3/a, inclusive of losses. This leaves a shortfall of 16.28 million m^3/a, to make up the remainder of the 61.05 million m^3/a that is available for new irrigation.

Table 2.2: Revised new irrigation areas and water requirements

#	Scheme name	Irrigable Area (ha)	Water Requirement (Mm^3/a)	Total losses (Mm^3/a)	Current Farm Allocation (Mm^3/a)	Requirement + Losses (Mm^3/a)
Zone 2 - Clanwilliam Dam and Canal and Jan Dissels Catchment						
1	Jan Dissels	462	4.26	0.00	0.00	**4.26**
2	Clanwilliam	298	2.75	0.00	0.29	**2.46**
Zone 4 - Olifants River Below Bulshoek Weir to Trawal						
3	Transfer of lower JD irrigators		1.00			**1.00**
4	Zandrug	1 209	11.14	0.56	2.55	**9.15**
5	Bulshoek	266	2.46	0.12	0.33	**2.25**
Zone 4 - Olifants River Below Bulshoek Weir to Trawal						
15	Right Bank Canal and 4 Trawal options areas (Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom)	2 339	22.31	3.35	0	**25.65**

Although the irrigable areas of the Klawer and Coastal 1 options were also adjusted following the slope analysis, the spare flow capacities in the relevant existing canal sections that can be diverted for use, will determine the eventual areas that can be irrigated.

The water requirements of the options that rely on spare flow capacity in existing canal sections have not been included in **Table 2.2**, as the water requirements of these options are mainly determined by the additional flows that can be abstracted from existing canal sections.

2.3.7 Use of Spare Canal Capacity

Further detailed analysis of historical spare flow capacity (main distribution canals on the left bank and right bank) has confirmed that both the Left Bank and Right Bank canal sections have very limited spare flow capacity. The canal sections are shown in **Figure 2.3**.

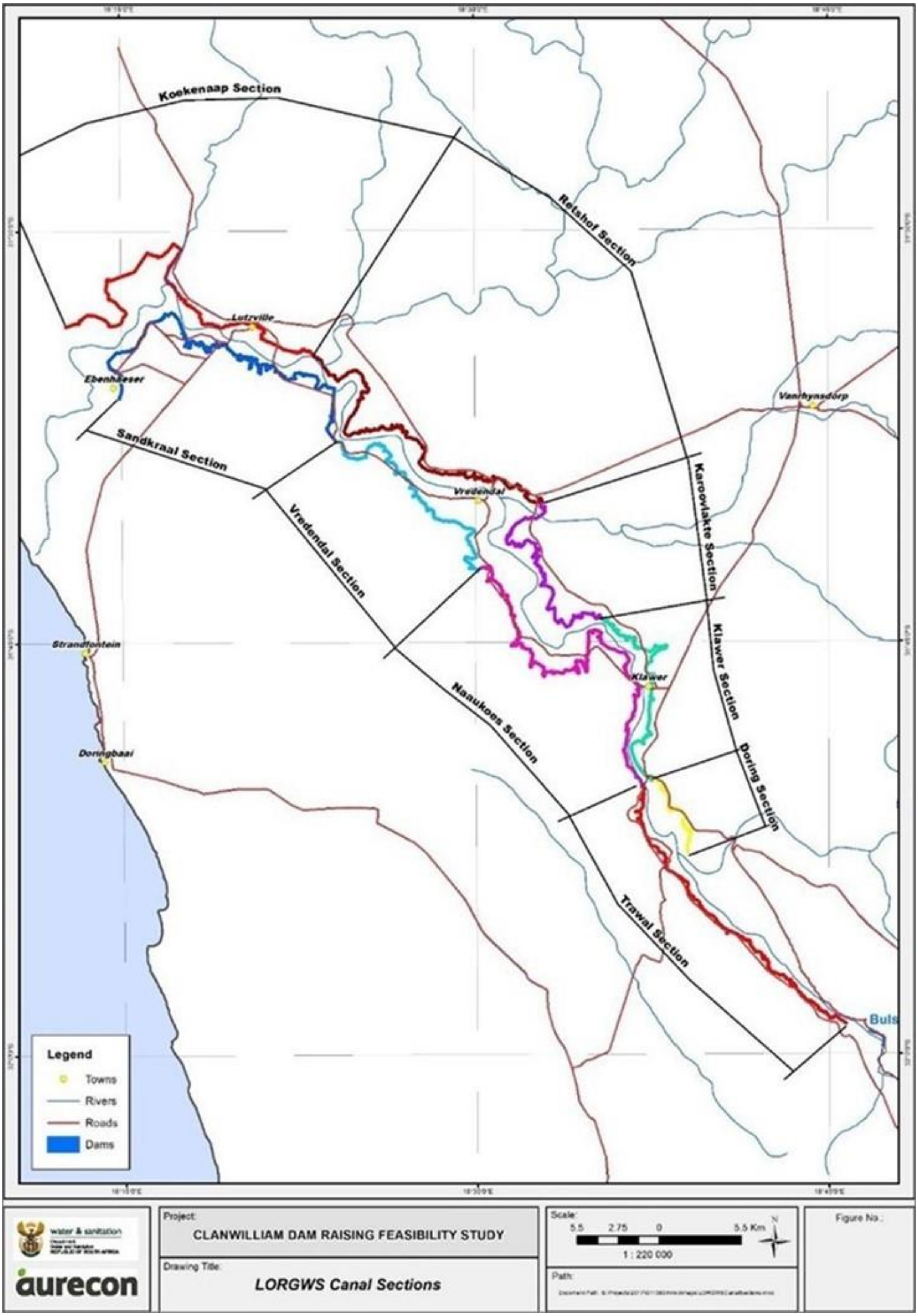

Figure 2.3: Canal sections

From the start of the right bank and left bank distribution canals, each existing canal section has more historical spare flow capacity than its downstream section, except for the Retshof / Koekenaap canal sections. The anomaly of the Koekenaap Canal section having more spare flow capacity than the Retshof canal section has been discussed with the Lower Olifants River Water User Association (LORWUA) (Mr Cliff Smith). This can potentially be explained in terms of a different crop mix being irrigated from the Koekenaap canal section.

The water requirement for the schemes that will make use of spare canal flow capacity is determined by the annual volume that can be diverted (having already accounted for canal losses) and stored in a balancing dam, minus evaporation.

Further evaluation of the **Ebenhaeser Scheme** sub-options is necessary. The Ebenhaeser representatives supported the sub-option with the highest water availability at the meeting held with them in November 2019. It was however agreed at the PSC meeting, held on 11 March 2020, that the scheme cost, and other factors, should also be considered in the selection of the preferred sub-option.

The sizing of the Coastal 1 and Klawer Phase 1 schemes are determined after providing for the flow to be passed through for the Ebenhaeser Scheme. This is based on the premise that the Ebenhaeser Scheme has a higher relative priority from a social and political perspective.

The **Coastal 1 Scheme** will not be viable as the spare flow capacity in the Vredendal canal section will be fully used by the Ebenhaeser Scheme (allowing 50% of the spare capacity for growth in use by existing irrigators as they get an increased assurance of supply when Clanwilliam Dam is raised). An alternative scaled-down Coastal 1 Scheme would be to use spare flow capacity in the Naaukoes (left bank) and/or Karoovlakte (right bank) canal sections, after passing through the flows intended for the Ebenhaeser Scheme. The previous conceptualised scheme (option 21) assumed the use of spare capacity in the Vredendal canal section. The Klawer Scheme, located on the right bank can however make better use of right bank spare flows.

An alternative scaled-down **Klawer Scheme** would use spare flow capacity in the Klawer canal section (right bank) (and/or Naaukoes (left bank) canal section), after passing through the flows intended for the Ebenhaeser Scheme. The previous conceptualised scheme (option 20) made use of spare capacity in the Naaukoes (left bank) canal section on the left bank. Spare flow capacity could alternatively be diverted from the Karoovlakte canal section, as the canal section is contiguous to the potential irrigation development, and the spare flow capacity is only very marginally smaller.

2.3.8 Need to identify additional preferred options

Following the reduction of irrigation areas, the irrigation water requirements of the preferred options also reduced, to the point where the total irrigation water requirement of the preferred options falls short of the 61.05 million m^3/a available for new irrigation. It became evident that the list of preferred options would need to be revisited, to ensure that the preferred options at least meet the available yield for new irrigation, and preferably even exceed it, so that alternate options are available, should it be required.

The next augmentation option to consider, after consideration of the schemes that make use of spare flow capacities in existing canals, is the Klawer Phase 2 Scheme. This scheme can be compared with the alternative of a Coastal 1 Phase 2 Scheme. Both these options would require the lining/raising or replacement of existing canal sections to increase the carrying flow capacity of these canals, following the construction of the new Right Bank main canal. For the Klawer Phase 2 option, this would entail raising / lining or replacing the full Klawer canal section. For the Coastal Phase 2 section this would entail the raising/lining or replacing the full Naaukoes canal section. The area that can be developed for any of these two schemes will likely be determined by the remaining volume to be allocated, and not by the size of the potential irrigation areas. Pumping heads for these schemes will also be very similar. Environmental impacts will also be very similar for the two potential options. These canal sections are very similar in maximum flow capacity (differing only by 1%), but the Naaukoes canal section is significantly longer than the Klawer canal section (40 km vs. 19 km). It is therefore evident that the Klawer Phase 2 Scheme will cost significantly less than the Coastal 1 Phase 2 Scheme. The Klawer Phase 2 option is therefore the preferred option to consider next.

Alternatively, the implementation of the Klawer Scheme, following the construction of the Right Bank Canal can be considered, either development of the full area or a portion thereof.

2.3.9 Reconnaissance-level evaluation

The following schemes will be evaluated further in this study, at reconnaissance level:

- **Clanwilliam Scheme**, pumping from the lake of the raised Clanwilliam Dam.
- **Zandrug Scheme**, pumping from the Olifants River below the raised Clanwilliam Dam and upstream of Bulshoek Weir.
- **Bulshoek Scheme**, pumping from the lake of Bulshoek Weir.
- **Trawal Government Water Scheme (GWS)**, consisting of a GWS or co-operative for four new irrigation areas near Trawal.

- **Klawer Phase 1 Scheme**, using spare capacity in canal section/s to develop the first phase of the Klawer irrigation area close to Vredendal, on the right bank of the Olifants River, after passing through the right bank canal flows intended for the Ebenhaeser Scheme.
- **Klawer Phase 2 Scheme**, involving either raising and lining the Klawer right bank canal section, or replacing the Klawer canal section with a new canal section on the right bank, to irrigate the remainder of the Klawer irrigation area, or a portion thereof.
- **Klawer Scheme**, irrigating the full potential Klawer irrigation area, or a portion thereof, following the completion of the new Right Bank main canal.
- **Coastal 1 Scheme**, using spare capacity in canal section/s, located on the left bank of the Olifants River near Vredendal, after passing through the left bank canal flows intended for the Ebenhaeser Scheme, to irrigate a portion of the Coastal 1 irrigation area.
- **Ebenhaeser Scheme**, using spare capacity in existing canal sections.

2.4 Design-focussed Meetings with Land Owners and Water Users

Four separate design-focussed meetings were held from 28 to 29 November 2019, specifically regarding the following irrigation schemes:

- Jan Dissels Scheme;
- Right Bank Canal; and
- Ebenhaeser Scheme.

Meetings were held with the following organisations:

- Jan Dissels Scheme: Cederberg Municipality, to introduce the scheme to Municipal representatives, gauge their reaction and obtain relevant information that may influence the design.
- Jan Dissels Scheme: Augsburg Agricultural Gymnasium, to introduce the scheme to representatives of the school and the Department of Education, gauge their reaction and obtain relevant information that may influence the design.
- Ebenhaeser Scheme: Ebenhaeser Community Property Association and Ebenhaeser Community Development Trust representatives to present sub-options, and to obtain feedback on their preferred sub-option and on water requirement clusters.
- LORWUA: Further progress with the Right Bank Canal and Ebenhaeser schemes were explained, and feedback was obtained on relevant information that may influence the design.

2.5 Schemes for Feasibility Design

The following schemes will be evaluated further in this study, to feasibility design level:

- **Jan Dissels Scheme**, pumping from Clanwilliam Dam. The scheme is located on State land, is very feasible from a cost perspective and offers a good opportunity for the inclusion of smallholder plots, given its proximity to Clanwilliam.
- **Right Bank Canal Scheme**, replacing the existing main canal with increased capacity on the right bank of the Olifants River, including capacity to supply new downstream irrigation development and other future uses. This scheme is essential to ensure a secured future supply, given the high risk of disruption and shortfall in supply that the poor state of the existing canals, and especially the main (Trawal section) canal, poses to the lower Olifants River irrigators and other users, and to the prosperity of the region.
- **Ebenhaeser Scheme**, making use of spare capacity in the existing canal sections, supplying a combination of Ebenhaeser restitution farms and augmenting the Ebenhaeser community scheme. Augmentation of the water supply to prioritised restitution farms has a high priority from a social and political perspective, to ensure that such restitution farms can be successfully farmed, by increasing their currently inadequate water allocations. In addition, this scheme can augment supply to the existing HDI community at Ebenhaeser.

2.6 Field visit

A field visit was undertaken on 16 and 17 March 2020, to inspect potential abstraction sites, conveyance infrastructure routes and balancing dam sites, for the three schemes to be designed. Sites that pose challenges for the Right Bank canal route were noted, including a steep cliff section, routing the canal past existing farm dams and the connection to the existing syphon at ‘Verdeling’, where flow would need to be reversed.

The two design teams were accompanied by geotechnical staff.

3 Supporting investigations

3.1 Geological and Geotechnical Evaluation

3.1.1 Methodology

The geological and geotechnical inputs into this Report were compiled on the back of a desk study of available information, and the brief reconnaissance visit to the various scheme elements, which was conducted during the period 16 to 17 March 2020.

To date no intrusive geotechnical investigations have been carried out.

Such intrusive investigations would be conducted for the favoured scheme layouts and would primarily include test pitting and a laboratory testing programme. A detailed geotechnical interpretive report covering all three schemes would then be prepared.

It is pertinent that the COVID lockdown has thus far prevented fieldwork. This will be reviewed once the lockdown regulations are lifted.

Available information consulted is as listed below, while other referenced publications are included in Section 11 References.

- 1:250 000 Geological Series. Sheet 3118 Calvinia. Council for Geoscience, 2001.
- 1:250 000 Geological Series. Sheet 3218 Clanwilliam. Geological Survey, 1973.

3.1.2 Regional geology

The 1:250 000 scale geological map 3118 Calvinia (Council for Geoscience, 2001) indicates that the area is underlain by rocks of the Cape Supergroup, with isolated remnants of the Gariep Supergroup (**Figure 3.1**). The principal rock types in the vicinity of the Right Bank Canal Scheme are horizontal to sub-horizontally dipping sandstone and quartzitic sandstone with minor conglomerate and siltstone. Sporadic outcrops of phyllite and greywacke dipping at 20° to 40° towards the south are visible in erosion gullies on side slopes of the existing canal along the proposed Retshof and Vredendal diversion of the Ebenhaeser Scheme.

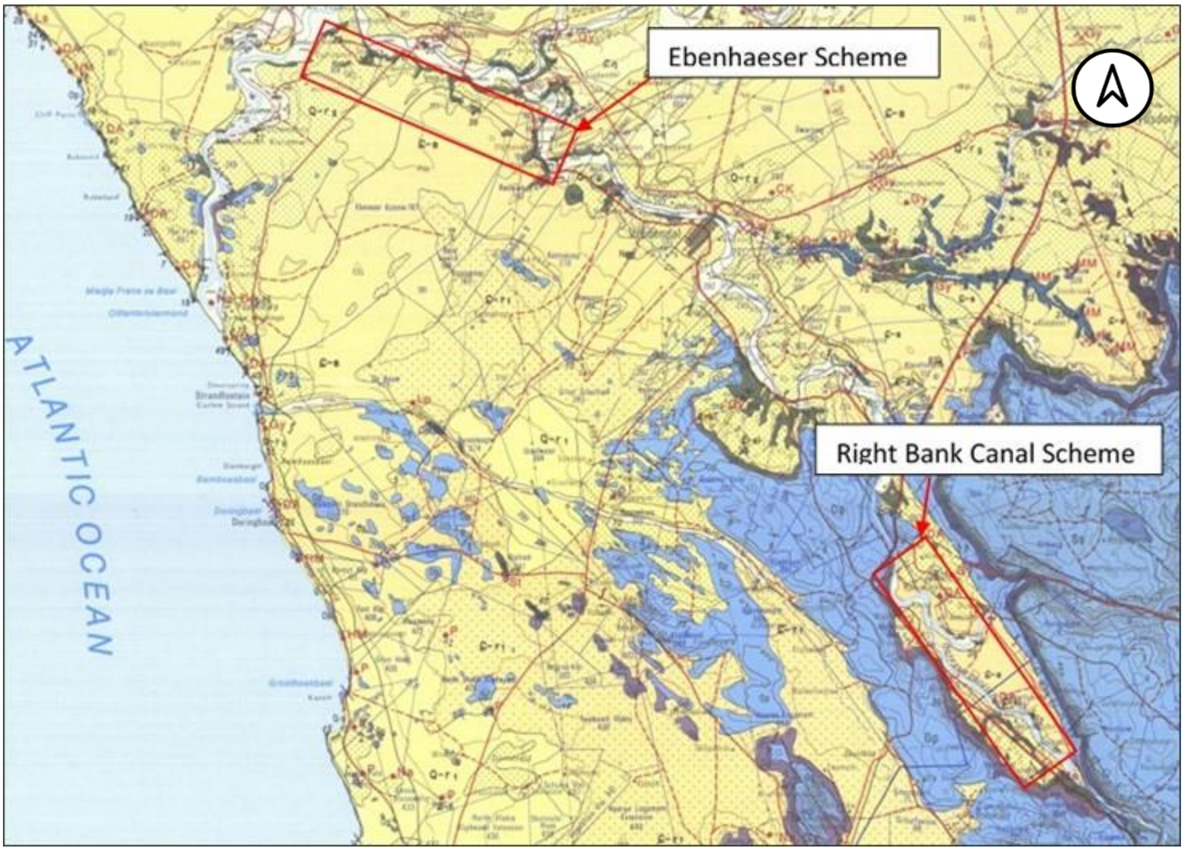

Figure 3.1: Regional geology, extract from the 1:250 000 scale geological map 3118 Calvinia (Council for Geoscience, 2001)

The weathered bedrock in the area is predominantly overlain by Cenozoic sediments of Tertiary and Quaternary age, which vary in thickness. The surface sands visible on the site comprise red aeolian sand and calcareous soil.

The boundary between the Cape Supergroup rocks and Quaternary sediments along the Right Bank Canal Scheme and further south west is marked by two major northwest trending faults that are secondary to the Cape Fold Belt, a fold and thrust belt of late Palaeozoic age. The Cape Fold Belt affected the sequence of sedimentary rock layers of the Cape Supergroup through faulting, folding and subsequent weathering, which has produced a rugged mountainous terrain characterised by a sequence of elevated ridges and peaks separated by broad linear valleys.

The area can be classified as desert climate to semi-arid climate with relatively low annual rainfall, which increases from north (Ebenhaeser) to south (Clanwilliam). The climate is characterised by fog and dew falls that supplement the low rainfall, and leads to high humidity and relatively cool night temperatures.

Mechanical disintegration is the dominant mode of rock weathering in areas of lower rainfall, whereas chemical decomposition dominates areas of higher rainfall. This is summarised via the widely used Weinert's climatic N-value (Weinert, 1980), where essentially mechanical disintegration occurs with N > 5 (more arid) and chemical decomposition where N < 5 (more humid). The N-value is calculated from climatic data as follows:

$$N = 12.Ej / Pa$$

where: Ej = evaporation during January

Pa = annual precipitation (adapted from Brink, 1983).

The Cape West Coast lies on the dry side of the country with a Weinert's climatic N value of between 7.5 and 20 (**Figure 3.2**). In this region of the country, residual soils are generally of limited thickness and disintegration is the dominant form of weathering.

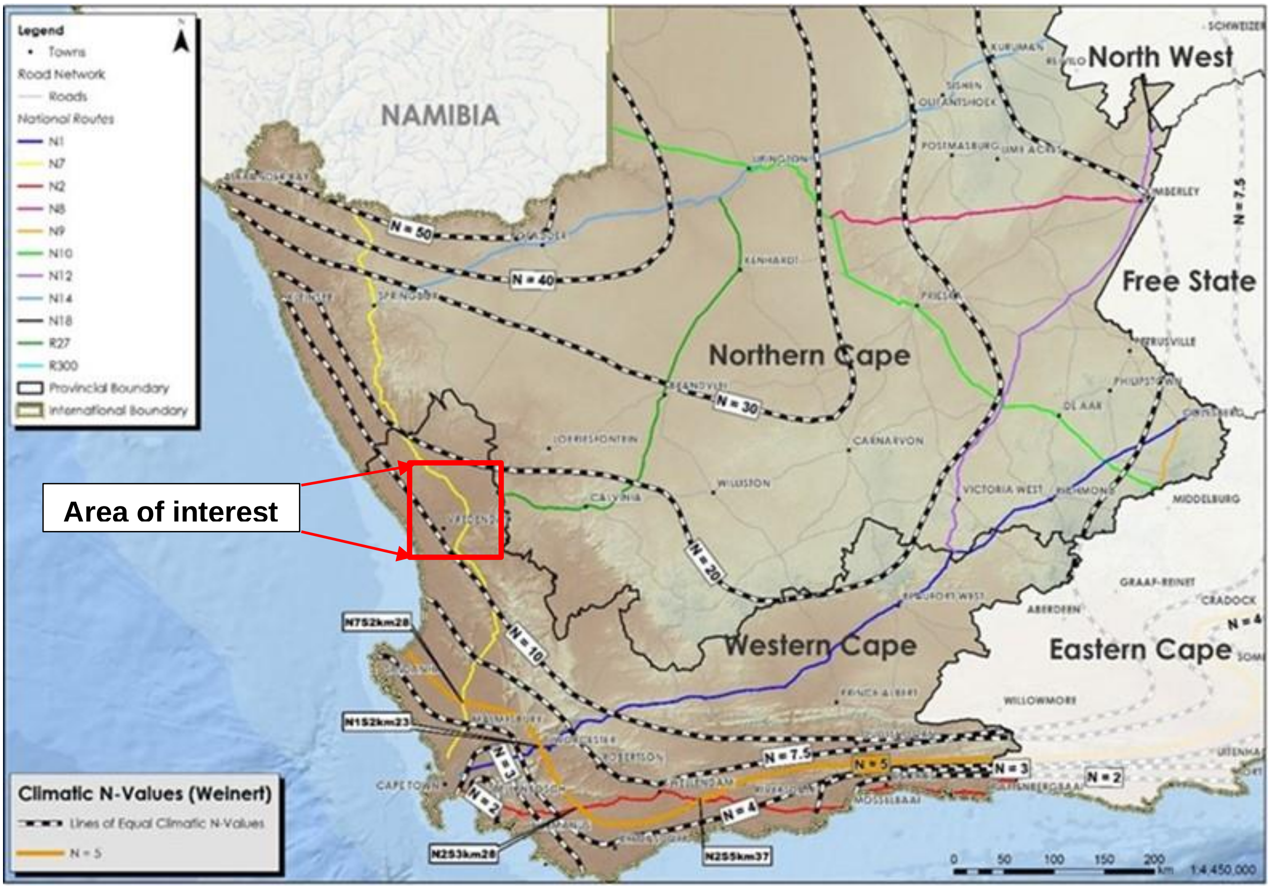

Figure 3.2: Climatic N-values for the affected area (modified after Weinert, 1980)

3.2 Environmental Assessment

The environmental assessment inputs into this Report were compiled on the back of a desk study of available information.

3.3 Topographical LiDar Survey

The topographical survey needed to be undertaken at an accuracy that can eventually be used for detailed design. An accurate survey will save considerable time during implementation. It was decided that the quickest and most practical approach would be to undertake a Light Detection and Ranging (LIDAR) survey.

Southern Mapping was contracted to produce a LIDAR survey of the areas as indicated in **Figure 3.3** to **Figure 3.5**. The survey mapping was provided in January 2020. The survey areas were defined to allow for flexibility with respect to the identified sub-options.

Figure 3.3: Survey area for the Jan Dissels Scheme

Accurate topographical information in the form of digital terrain modelling data, high quality ortho-photos and line mapping of salient features for the feasibility study were provided.

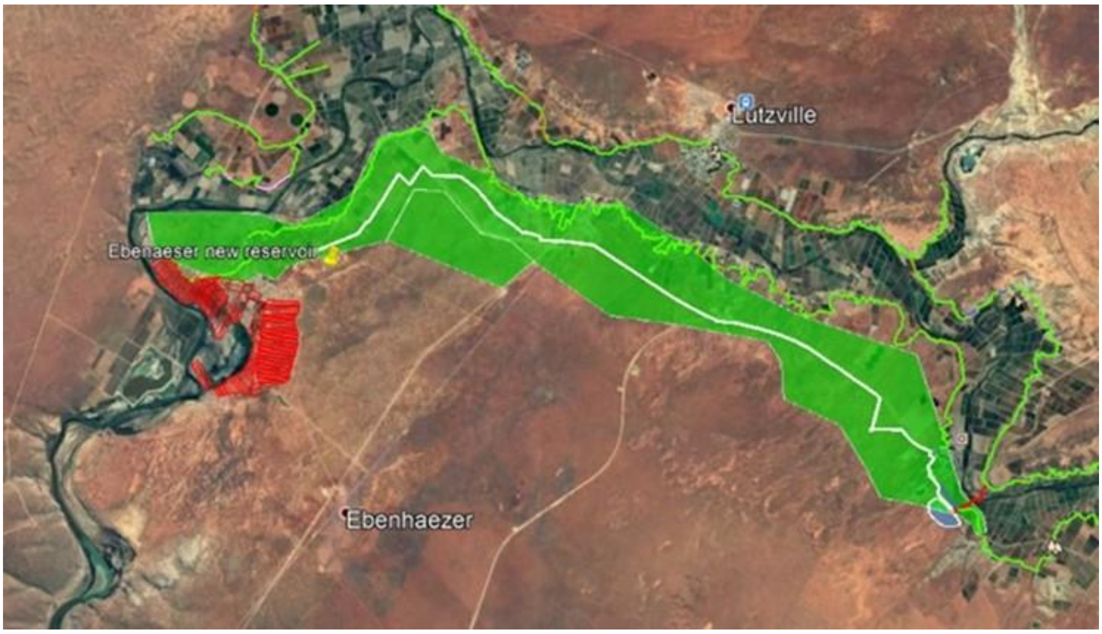

Figure 3.4: Survey area for the Ebenhaeser Scheme

Figure 3.5: Survey area for the Right Bank Canal and Trawal GWS

The following deliverables were submitted in electronic format:

- A digital terrain model (DTM) containing all the survey points (X, Y and Z co-ordinates); complete with descriptions of the acronyms used In ASCII and ESRI Grid format files;
- Digital ortho-photography Images files;
- A field book (*.fbk) and landXml (*.xml) data file in TDS format (compatible with AutoCad Civil 3D);
- Contours generated at 0.5m intervals;
- Line mapping (*.dwg or *.dxf} and *.shp file) containing the layout drawings of the site and showing 0.5 m contours, property boundaries, salient features, all services, survey controls, etc.; and
- The list of survey controls installed by the surveyor as part of the survey, with their coordinates and levels.

The Topographical Survey Report on the control survey undertaken includes the coordinated lists of the photo control stations established and employed, existing survey beacons and new survey beacons established.

The need for limited further surveying to be undertaken was identified. These include areas to support the design for the Right Bank canal and Ebenhaeser schemes. There are however 5 m contours available for these outstanding areas that can be used in the meantime. The option exists to extend the contract of Southern Mapping to undertake the additional surveying. They have provided a reasonable quote and the work can be completed within about a month, depending on the Covid-19 situation and associated travelling restrictions.

The survey can potentially be extended by the Departmental National Water Resources Infrastructure (NWRI): Survey Services (Southern Operations), contact person Mr Hein Lodewyk, by means of ground surveys, should it be necessary and if they are available.

4 Jan Dissels Scheme

This section describes the refined analyses undertaken for the Jan Dissels Scheme.

4.1 Introduction

An area of 716 ha west of Clanwilliam Dam, on the western side of the N7 highway, near the bridge, was originally identified as irrigable land.

The potential irrigable area, located south-east of Clanwilliam town in the Jan Dissels River valley was reduced to 148 ha due to environmental screening that was undertaken as part of the options analysis investigation. This option consisted of a smaller greenfield area as well as an area of existing irrigation, which has an existing scheduled water allocation. Most of the site is located within Critical Biodiversity Areas (CBAs), namely CBA1 areas. Ecological Support Areas (ESAs), namely ESA1 features, transect the site. The (initially conservative) environmental screening assumed that all CBA 1 areas would be screened out, as well as areas falling within the National Freshwater Protection Areas (NFEPA) wetlands demarcation area.

The area seemed very suitable for the development of smaller plots, given its proximity close to Clanwilliam town and existing markets. The land is owned by the State.

There was however concern that large areas that were initially identified as suitable to form part of the scheme (initially 593 ha) consists of severely degraded land, that is unlikely to ever be rehabilitated, given its location close to town and informal settlements.

With respect to the existing centre pivot irrigation on the identified land, the agricultural school plans to allow the existing lease contract with a farmer lapse in 2020 (180 ha).

A meeting was held with the Western Cape Provincial Department of Environmental Affairs and Development Planning (DEA&DP) to discuss the approval process for the full development of all options, as well as the challenges being experienced with the interpretation of the environmental sensitivity. It was agreed that the undertaking of a botanical survey is a sensible next step, to clarify the uncertainty regarding the ecological sensitivity.

Medium and high sensitivity areas are shown in the foreground in **Figure 4.1** (September 2019), while smoke from the municipal dump is seen in the background.

Figure 4.1: View of Jan Dissels Scheme area
Photo courtesy of N A Helme, 2019

Figure 4.2 shows the Jan Dissels Scheme irrigation area from the left bank of the Jan Dissels River (March 2020), with the areas irrigated by centre pivots visible.

Figure 4.2: Jan Dissels irrigation area

4.2 Refined Irrigable Land Analysis

4.2.1 Botanical Survey

A botanical survey was subsequently undertaken by Nick Helme to confirm the extent of environmental sensitivity. This survey involved:

- A site visit undertaken towards the end of September 2019, which is regarded as the optimal time for such a site visit, when flowers are blooming; and
- Compilation of a Botanical Report.

The content of the Botanical Report:

- Describes and places vegetation and fauna in the study area in a regional context;
- Identifies Species of Conservation Concern;
- Provides an overview and map of ecological conservation significance (sensitivity) showing No-Go areas and acceptable areas for development;
- Assesses and identifies likely ecological impacts of the proposed scheme; and
- Makes recommendations for minimising the botanical impacts of the proposed development alternatives, including suggesting possible development layout changes and management interventions.

The botanical survey made the following recommendations in terms of the area to be developed, as indicated in **Figure 4.3** and summarised below.

i) Low sensitivity areas (**Light Blue**): Develop these areas;
ii) Already irrigated zones: Keep these areas;
iii) High sensitivity areas (**Orange**): Do not develop and allow for a buffer of 50 m; and
iv) Medium sensitivity areas (the sections between low sensitivity and high sensitivity areas): Do not develop more than 30% of the land and develop adjacent to low sensitivity areas.

Figure 4.3: Jan Dissels Botanical Survey Recommendations

The Botanical Report, in addition, recommended providing ecological corridors of at least 200 m away from human settlements. This and the other recommendations made by the Botanist were accepted and applied to the proposed irrigation development. The remaining irrigable area of 591 ha is shown in **Figure 4.4**.

The resultant area was determined according to the following considerations:

- Omitting areas that are too steep for irrigation (>12°);
- Omitting land areas in use, such as the municipal dump, golf course and housing;
- Omitting NFEPA wetlands areas, except for the existing irrigated areas, where the irrigated area slightly overlaps with the NFEPA wetlands areas;
- Allowing 50 m buffers along the high sensitivity areas; and
- Some practical considerations, such as limiting impacts on roads.

Figure 4.4: Jan Dissels irrigable land (top 390 ha, bottom 201 ha)

It is possible that the proposed irrigation area could be reduced further by:

- Exposed sandstone areas that are unsuitable for irrigation;
- A small high-lying area that will require further pumping for water distribution; and
- Land needed for roads and other on-farm infrastructure.

4.3 Water Requirements

It has been assumed that only 80% of the area located on Municipal land (adjacent to Clanwilliam Dam) can be irrigated, given its irregular shape. It has been assumed that 90% of the area located on the opposite side of the Jan Dissels River, on land used by Augsburg Agricultural Gymnasium, can be irrigated.

The Augsburg Agricultural Gymnasium plans to start farming a portion of the land, as the income is needed to support the increasing number of learners that are applying for exemption of school fees, which is affecting the school's income. Following the meeting held with the school, it was established that the school will install two small centre pivots for irrigation by the school, within the identified irrigation area land. These are sponsored by the Western Cape Department of Agriculture (ref. Mr Albert van Zyl). The potential irrigable area amounts to 462 ha, if 90% of the school land is irrigable, minus the 55 ha for the school, and assuming that 80% of the municipal land is irrigable.

The water requirement for the assumed 462 ha of irrigable land is 4.26 million m^3/a. Conveyance losses will be minimal.

Various water licences are held by the school. This includes 27.4 ha (301 400 m^3/a) from the Jan Dissels River and 50 ha (350 000 m^3/a) from the Taaiboschkraal River, plus a scheduled allocation of 45 ha from the Clanwilliam Canal. Only the Jan Dissels River allocation is currently being used.

Apart from the 440 000 m^3/a allocation from the Jan Dissels River, the water allocation to the Cederberg Municipality from Clanwilliam Dam for municipal supply is 960 000 m^3/a and there is also an allocation for Caleta Cove.

There are existing goat farmers, referred to as the Masakhane Group, active in the area, as well as other HDI groups. The Masakhane Group already have a water allocation from the Jan Dissels River.

4.4 Sub-Options - Rising Main Pipeline

The high point that is suitable for a reservoir location, from where irrigation water can be gravitated to almost the entire area, is indicated by ‘Balancing dam’ in **Figure 4.5**. A rising main is required to supply water to the balancing dam from Clanwilliam Dam. Two routes for a rising main were identified:

- Rising Main (RM) Route 1, pumping from a floating inlet directly from a raised Clanwilliam Dam; and
- Rising Main Route 2, pumping from an outlet point provided below the raised dam wall, on the right bank.

The abstraction points of both options will be affected by the rise/fall of the water level in Clanwilliam Dam.

Figure 4.5: Location and Layout of Jan Dissels Scheme sub-options

A financial comparison (2020 prIces, excluding VAT) has been done to compare the capital cost, net present value (NPV) and unit reference value (URV) of the bulk water infrastructure of the two sub-options, as indicated in **Table 4.1**. This evaluation excludes the cost of access roads, distribution pipes and on-farm reservoirs.

Table 4.1: Comparative costing of sub-options

Sub-option	Capital cost (R million)	Total NPV cost (R million)	URV (R/m^3)
1. Rising main directly from dam wall	R 26.42	R 61.36	R 1.24
2. Rising main from floating intake	R 25.18	R 57.80	R 1.17

While both scheme sub-options have similar comparative capital costs (5% difference), sub-option 2 appears to be slightly more favourable, but would require an access road to be constructed. The advantage of sub-option 1 is that it will have a fixed outlet point at the raised

Clanwilliam Dam wall and not a floating inlet. It is therefore recommended that both sub-options are investigated further at feasibility level before a choice is made.

4.5 Scheme Overview and Components

For sub-option 1, water will be pumped directly from a floating intake in the lake of the raised Clanwilliam Dam. The abstraction point will be affected by the rise/fall of the water level, and allowance should be made to accommodate this. An access road must be constructed from the 'Ou Kaapse' Road or the township development located close by. The rising main pipeline route for this sub-option is shown in **Figure 4.6**.

Figure 4.6: Rising main pipeline route - sub-option 1

The sub-option (sub-option 1) involves the construction of a 653 m long, 500 mm diameter unplasticized polyvinyl chloride (uPVC) rising main pipeline from the 600 kW pump station located on the shore of the raised Clanwilliam Dam (above the 1:100 year floodline) to a small farm dam. The farm dam capacity was sized for a 12-hour design flow storage of 11 616 m^3. The pumping head from the dam to the reservoir is 114 m.

Sub-option 2 involves the construction of a 3 622 m long, 500 mm diameter uPVC rising main rising main pipeline, from the 654 kW pump station located at the outlet from the dam wall to the small 11.6 Mℓ farm dam. The pumping head from the dam to the reservoir is 124 m. About 600m of the pipeline will follow a steep slope.

Additional electrical supply must be planned for. The supply for Clanwilliam Town must be upgraded. A possibility is for the scheme to be (*inter-alia*) supplied from the future proposed hydro power plant, to be located on the left bank at the raised Clanwilliam Dam. Eskom should be liaised with.

4.6 Ownership and Operational Aspects

The Department of Water and Sanitation (DWS) will be the owner of the scheme. It is not yet evident who will operate the scheme, but it is likely that the DWS will operate it. It is a possibility that the DWS construction team could implement the scheme.

The Cederberg Municipality is the water authority and the water service provider. Management issues regarding water supply therefore need to be discussed with the municipality.

The scheme offers an opportunity as a 'low-hanging fruit'' option, as it can be implemented within a short period, to demonstrate benefits from the dam raising.

4.7 Geological and geotechnical appraisal

The area around the potential rising main routes, either pumping from a floating inlet directly from a raised Clanwilliam Dam or from an outlet at the dam wall, is underlain by quartzitic sandstone with thin shale and conglomerate lenses.

4.7.1 Balancing Dam / Reservoir

During the site visit, very hard rock quartzitic sandstone outcrops were observed at the proposed reservoir site, which is assumed to comprise a concrete reservoir. Blasting through hard rock will be required to ensure a level foundation in the bedrock. Alternatively, suitable material would be imported to create appropriate layerworks on which to found.

4.7.2 Raising Main Route 1

Very hard rock quartzitic sandstone outcrops were observed along the pipeline route. Should the pipeline be constructed above nominal ground level (NGL), extensive excavation (as for a buried pipeline / trench) would not be required. Shallow foundations would then be needed for the pipeline pedestals.

4.7.3 Access Road

There is an existing gravel road from the 'Ou Kaapse' Road to the site along the dam for the Sub-option 1 rising main route. It is uncertain whether this road would require upgrading; if so, quartzitic sandstone from the Cape Supergroup and possibly shale can be used as crushed stone for construction / base material. Should access be required along the entire length of the Sub-option 2 rising main route, a road would need to be constructed from the dam wall for approximately the first kilometre or so along the route, most of this distance against a steep hill. The rising main would be readily accessible for the remainder of the route.

4.8 Environmental Impacts

The sensitivity of the proposed irrigable areas for the Jan Dissels Scheme was assessed to guide design and planning work. Below is the description of the regulatory guidelines in terms of National Environmental Management Act (Act No. 107 of 1998) (NEMA), National Water Act (Act No. 36 of 1998) (NWA) and National Heritage Resource Act (Act No. 25 of 1999) (NHRA).

4.8.1 National Environmental Management Act (Act No. 107 of 1998)

With reference to the NEMA, certain activities may not commence without an Environmental Authorisation (EA) having been received from the relevant competent authority (CA). In terms of the 2014 Environmental Impact Assessment (EIA) regulations, as amended in 2017, pursuant to NEMA (Government Notice (GN) R982), certain activities that may have a detrimental impact on the environment (termed Listed Activities) require an EA from the CA. Development of irrigable land and the construction of pipelines and dams could potentially trigger NEMA Listing Notice 1 (GN R983), Listing Notice 2 (GN R983) and Listing Notice 3 (GN R985). . The Listed Activities are described in **Table 4.2** and must be reviewed when planning the agricultural developments in the Jan Dissels area.

Table 4.2: Summary of potential Listed Activities for the Jan Dissels Scheme

Activity No.	Activity Description
GN R983, as amended on 7 April 2017- Listing Notice 1 ***Authorisation required – Basic Assessment (BA)***	
9	The development of infrastructure exceeding 1 000 metres in length for the bulk transportation of water or storm water— (i) with an internal diameter of 0,36 metres or more; or (ii) with a peak throughput of 120 litres per second or more; excluding where— (a) such infrastructure is for bulk transportation of water or storm water or storm

Activity No.	Activity Description
	water drainage inside a road reserve or railway line reserve; or (b) where such development will occur within an urban area.
12	The development of— (i) dams or weirs, where the dam or weir, including infrastructure and water surface area, exceeds 100 square metres; or (ii) infrastructure (including borrow pits) or structures with a physical footprint of 100 square metres or more; where such development occurs— (a) within a watercourse; (b) in front of a development setback; or (c) if no development setback exists, within 32 metres of a watercourse, measured from the edge of a watercourse; — excluding— (aa) the development of infrastructure or structures within existing ports or harbours that will not increase the development footprint of the port or harbour; (bb) where such development activities are related to the development of a port or harbour, in which case activity 26 in Listing Notice 2 of 2014 applies; (cc) activities listed in activity 14 in Listing Notice 2 of 2014 or activity 14 in Listing Notice 3 of 2014, in which case that activity applies; (dd) where such development occurs within an urban area; (ee) where such development occurs within existing roads, road reserves or railway line reserves; or (ff) the development of temporary infrastructure or structures where such infrastructure or structures will be removed within 6 weeks of the commencement of development and where indigenous vegetation will not be cleared.
13	The development of facilities or infrastructure for the off-stream storage of water, including dams and reservoirs, with a combined capacity of 50 000 cubic metres or more, unless such storage falls within the ambit of activity 16 in Listing Notice 2 of 2014.
19	The infilling or depositing of any material of more than 10 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than [5] 10 cubic metres from – (i)] a watercourse; [(ii) the seashore; or (iii) the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or estuary, whichever distance is the greater—
24	The development of a road— (i) for which an environmental authorisation was obtained for the route determination in terms of activity 5 in Government Notice 387 of 2006 or activity 18 in Government Notice 545 of 2010; or (ii) with a reserve wider than 13,5 meters, or where no reserve exists where the road is wider than 8 metres; but excluding a road—

Activity No.	Activity Description
	(a) which is identified and included in activity 27 in Listing Notice 2 of 2014; (b) where the entire road falls within an urban area; or (c) which is 1 kilometre or shorter.
27	The clearance of an area of 1 hectare or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for— (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.
56	The widening of a road by more than 6 metres, or the lengthening of a road by more than 1 kilometre— (i) where the existing reserve is wider than 13,5 meters; or (ii) where no reserve exists, where the existing road is wider than 8 metres; excluding where widening or lengthening occur inside urban areas.
67	Phased activities for all activities— (i) listed in this Notice, which commenced on or after the effective date of this Notice or similarly listed in any of the previous NEMA notices, which commenced on or after the effective date of such previous NEMA Notices; excluding the following activities listed in this Notice- 17(i)(a-d); 17(ii)(a-d); 17(iii)(a-d); 17(iv)(a-d); 17(v)(a-d); 20; 21; 22; 24(i); 29; 30; 31; 32; 34; 54(i)(a-d); 54(ii)(a-d); 54(iii)(a-d); 54(iv)(a-d); 54(v)(a-d); 55; 61; 64; and 65; or (ii) listed as activities 5, 7, 8(ii), 11, 13, 16, 27(i) or 27(ii) in Listing Notice 2 of 2014

Activity No.	Activity Description
	or similarly listed in any of the previous NEMA notices, which commenced on or after the effective date of such previous NEMA Notices; where any phase of the activity was below a threshold but where a combination of the phases, including expansions or extensions, will exceed a specified threshold.
GN R984, as amended on 7 April 2017- Listing Notice 3 ***Authorisation required – Environmental Impact Assessment (EIA)***	
13	The physical alteration of virgin soil to agriculture, or afforestation for the purposes of commercial tree, timber or wood production of 100 hectares or more.
15	The clearance of an area of 20 hectares or more of indigenous vegetation, excluding where such clearance of indigenous vegetation is required for— (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.
16	The development of a dam where the highest part of the dam wall, as measured from the outside toe of the wall to the highest part of the wall, is 5 metres or higher or where the high-water mark of the dam covers an area of 10 hectares or more.
GN R985, as amended on 7 April 2017- Listing Notice 3 ***Authorisation required – Basic Assessment (BA)***	
2	The development of reservoirs, excluding dams, with a capacity of more than 250 cubic metres i. Western Cape i. A protected area identified in terms of the National Environmental Management Protected Areas Act (NEMPAA), excluding conservancies; ii. In areas containing indigenous vegetation; or iii. Inside urban areas: (aa) Areas zoned for use as public open space; or (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority or zoned for a conservation purpose.
4	The development of a road wider than 4 metres with a reserve less than 13,5 metres. i. Western Cape i. Areas zoned for use as public open space or equivalent zoning; ii. Areas outside urban areas; (aa) Areas containing indigenous vegetation; (bb) Areas on the estuary side of the development setback line or in an estuarine functional zone where no such setback line has been determined; or iii. Inside urban areas: (aa) Areas zoned for conservation use; or (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority.
12	The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance

Activity No.	Activity Description
	purposes undertaken in accordance with a maintenance management plan. Western Cape (i) within any critically endangered or endangered ecosystem listed in terms of section 52 of the National Environmental Management: Biodiversity Act (NEMBA) or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; (ii) within critical biodiversity areas identified in bioregional plans; (v) on land designated for protection or conservation purposes in an Environmental Management Framework adopted in the prescribed manner, or a Spatial Development Framework adopted by the Member of the Executive Council (MEC) or Minister.
14	The development of- (ii) infrastructure or structures with a physical footprint of 10 square metres or more; Where such development occurs- (c) within 32 metres of a watercourse, measured from the edge of a watercourse. Western Cape (ff) critical biodiversity areas or ecosystem service areas (gg) core areas of the biosphere reserve
18	The widening of a road by more than 4 metres, or the lengthening of a road by more than 1 kilometre. i. Western Cape i. Areas zoned for use as public open space or equivalent zoning; ii. All areas outside urban areas: (aa) Areas containing indigenous vegetation; (bb) Areas on the estuary side of the development setback line or in an estuarine functional zone where no such setback line has been determined; or iii. Inside urban areas: (aa) Areas zoned for conservation use; or (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority.
26	Phased activities for all activities— i. listed in this Notice and as it applies to a specific geographical area, which commenced on or after the effective date of this Notice; or ii. similarly listed in any of the previous NEMA notices, and as it applies to a specific geographical area, which commenced on or after the effective date of such previous NEMA Notices— where any phase of the activity was below a threshold but where a combination of the phases, including expansions or extensions, will exceed a specified threshold; — excluding the following activities listed in this Notice— 7; 8; 11; 13;

Activity No.	Activity Description
	20; 21; and 24. All the areas as identified for the specific activities listed in this Notice.

Most of the Jan Dissels development area is mapped as CBA 1, except for the exiting pivot irrigation cultivated fields. Small ESA 1 and ESA 2 corridors occur towards the north and south around the pivot irrigation fields and along the western portion of the development area below the Jan Dissels River. Approximately 170 ha of the north eastern section of the area is earmarked as a Protected Area expansion as part of the Tankwa Cedarberg Roggeveld (National Protected Area Expansion Strategy (NPAES)). Reasons for environmental sensitivity includes ecological processes, vegetation types, threatened vertebrate, water resource and wetland protection, upland-lowland interface and groundwater recharge. If the development of the proposed sites cannot be avoided, the activities would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity and location of protected species. It would be necessary for a freshwater specialist to delineate all wetlands, watercourses and floodlines. It should also be noted that, due to the sensitivity of the site, there might be a need for biodiversity offsets if residual impacts are significant.

Based on the information available for the proposed agricultural developments for the Jan Dissels Scheme, authorisation would have to be obtained for triggered Listed Activities in terms of the NEMA. The authorisation processes required would depend on the details of the proposed developments. A Basic Assessment would be required for activities such as the clearance of indigenous vegetation, pipelines, dams, reservoirs, working within or in close proximity to watercourses and development of new roads or widening of existing roads. There are however three (3) activities which would require an EIA and that would include the clearance of more than 20 ha of indigenous vegetation, the transformation of virgin soil to agriculture of 100 ha or more and the construction of a dam where the dam wall is higher than 5 m or the dam area exceeds 10 ha in extent.

Alternative options for, or prior to, environmental authorisation in terms of the NEMA is to undertake a Strategic Environmental Assessment (SEA) or an Environmental Management Framework (EMF) for all the irrigable areas of the Clanwilliam Bridging Study. Although not required by law in South Africa, a SEA can be an important tool to help project planners understand the cumulative impacts in a geographical area of different land uses. An EMF aims to integrate various environmental management instruments to assist a holistic decision-making process. An EMF process identifies and highlights the opportunities and constraints for development within defined control zones and sensitive areas within a specific region. There is currently an EMF developed for the Sandveld and Agter-Cederberg regions, which does not include the Jan Dissels development area.

4.8.2 National Heritage Resource Act (Act No. 25 of 1999)

Certain activities may not be initiated without prior approval/consent from the CA, which in this case would be Heritage Western Cape (HWC), if they have a potential to impact on the heritage or cultural features. This includes structures older than 60 years, landscapes and natural features of cultural significance, geological sites of scientific or cultural importance, archaeological and palaeontological sites, graves and burial grounds, sites of significance relating to slavery or movable objects, which are considered to be a national estate and need to be preserved or protected.

Section 38 (1) of the NHRA provides a list of the activities which should be authorised by HWC and is quoted below:

Section 38. (1): Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as-

> *(a) the construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300 m in length;*
>
> *(b) the construction of a bridge or similar structure exceeding 50 m in length;*
>
> *(c) any development or other activity which will change the character of a site—*
>
> > *(i) exceeding 5 000 m^2 in extent; or*
> >
> > *(ii) involving three or more existing erven or subdivisions thereof; or*
> >
> > *(iii) involving three or more erven or divisions thereof which have been consolidated within the past five years; or*
> >
> > *(iv) the costs of which will exceed a sum set in terms of regulations by the South African Heritage Resources Agency (SAHRA) or a provincial heritage resources authority;*
>
> *(d) the re-zoning of a site exceeding 10 000 m^2 in extent; or*
>
> *(e) any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority.*

Based on the information available for the proposed agricultural developments for the Jan Dissels scheme, authorisation would have to be obtained for Section 38 (a) and (c) activities in terms of the NHRA. The authorisation process would require the submission of a Notice of Intent to Develop (NID) to the HWC for determination of the need for further paleontological or archaeological specialist studies and impact assessments. Should further studies be required, an integrated Heritage Impact Assessment with specialist studies would have to be undertaken and submitted to HWC for authorisation.

4.8.3 National Water Act (Act No. 36 of 1998)

The National Water Act (Act No. 36 of 1998) (NWA) aims to regulate the use of water and/or activities which may potentially impact on water resources through the categorisation of water use activities, as described in Section 21 of the said Act:

(a) *Taking water from a water resource;*

(b) *Storing water;*

(c) *Impeding or diverting the flow of water in a watercourse;*

(d) *Engaging in a stream flow reduction activity contemplated in section 36;*

(e) *Engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);*

(f) *Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;*

(g) *Disposing of waste in a manner that may detrimentally affect a water resource;*

(h) *Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;*

(i) *Altering the bed, banks, course or characteristics of a watercourse;*

(j) *Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and*

(k) *Using water for recreational purposes*."

The regulated area of a watercourse is 100 m from the edge of a stream / river and 500 m from the edge of a wetland. Any activities taking place within this regulated area has the potential to impact on the quality or characteristics of that watercourse. For this reason, any activity taking place in this regulated area should be authorised in terms of a General Authorisation (GA) or a Water Use License (WUL) through the DWS, or any relevant Catchment Management Agency (CMA). For the Cederberg Municipality, the DWS is the CA for water use authorisations.

Based on the information available for the proposed agricultural developments for the Jan Dissels scheme, authorisation would have to be obtained for Section 21 (a), (b), (c) and (i) water uses in terms of the NWA. The authorisation process would require an integrated approach for the entire scheme and would include a freshwater impact assessment and risk assessment to be undertaken. It is likely that the integrated authorisation would require a full WUL and not a GA, but would be confirmed during a risk assessment process to be undertaken by the freshwater specialist. Activities which pose a low risk to the aquatic ecosystems would only require a GA, and medium and high-risk activities would require a WUL.

4.9 Affected Land and Infrastructure

4.9.1 Clanwilliam Dam

As it is expected that the DWS will be the owner of the scheme, no issues are foreseen with abstraction from the raised dam, as DWS is also the owner of Clanwilliam Dam.

4.9.2 Jan Dissels River Syphon

Ecological implications of the syphon through the Jan Dissels River should be considered.

4.9.3 Cederberg Municipality

The proposed irrigated area on the municipal land excludes areas that are currently being used for housing, agriculture, municipal services (rubbish dump) or recreation (golf course). Except for a small land parcel, the bulk of this irrigation area has been demarcated to fall below the 'Ou Kaapse' Road adjacent to the dam, and the service road adjacent to the Jan Dissels River. While some tracks fall within the area, impacts are expected to be very limited. Implications for Clanwilliam town and the nearby located Caleta Cove development, adjacent to Clanwilliam Dam, would need to be considered.

The area where the Masakhane Farmers are farming overlaps with the proposed irrigation area. It is therefore proposed that they be considered as beneficiaries of the scheme.

At the meeting held with the Cederberg Municipality on 27 November 2019 in Clanwilliam, to discuss implications of the planned scheme, the Municipality indicated that they view the irrigation development as a positive step. There are no concerns from a municipal spatial development framework (SDF) perspective.

Municipal spatial planning of the Cederberg Municipality must however be taken into consideration. The Municipal land is currently commonage land, not yet earmarked for development. There is a need for housing, and municipal officials have indicated that they would possibly reconsider the housing development plans, considering this to be new information. Officials further noted that the town is currently expanding into agricultural land. The Director for Community Service should be liaised with in this regard.

Security has been identified as an issue to consider, especially if people will not live on the land to be irrigated.

4.9.4 Augsburg Agricultural Gymnasium

A meeting was held with the Augsburg Agricultural Gymnasium on 28 November 2019 in Clanwilliam, to discuss implications of the planned scheme.

With respect to the existing centre pivot irrigation on the identified land, the school plans to let the existing lease contract with a farmer lapse (180 ha) and remove the existing centre pivots.

The school plans to start farming the land as additional income is needed to support the increasing number of learners that are applying for exemption of school fees, which is affecting the school's income. The school plans to install two small centre pivots to farm a portion of the area, totalling 55 ha, on a portion of the currently-irrigated area. Mr Albert van Zyl of the Western Cape Department of Agriculture (WCDoA) has arranged the centre pivots, and Mr Dirkie Mouton, head of a Clanwilliam WUA sub-committee, is also involved.

While some tracks fall within the area, further impacts are expected to be very limited.

5 Right Bank Canal

This section of the report provides an overview of the feasibility design of the proposed Right Bank Canal Scheme, which will be supplied from the existing Bulshoek Weir.

5.1 Introduction

Several major breaks have been experienced along the Bulshoek / Lower Olifants Canal due to ageing infrastructure. After more than 80 years of usage, the concrete lining of the existing canal has become frail and prone to damage, which results in canal breaks occurring frequently. The largest break happened in January 2015 with a repair cost of R11.5 million (2015 prices), and which cost the agriculture sector an estimated R100 million. The most recent canal failure on 30 December 2019 resulted in water loss of approximately 144 000 m^3 and a repair cost of R500 000 (**Figure 5.1**). LORWUA reported that it spends approximately R4.2 million per annum on normal maintenance with its own teams, and contracts out approximately R5.8 million per annum on more serious repairs.

Figure 5.1: Failure of the Lower Olifants Canal along the main (Trawal) section

It is evident that the poor state of the existing canals, especially the main (Trawal) section, poses a high risk of disruption and potential shortfall in water supply to the Lower Olifants River irrigators and other users, which includes towns in the area. Water is the driving force supporting the prosperity of the region. Therefore, the Right Bank Canal Scheme is being investigated as a means to ensure a secured future water supply to sustain existing development in the region, as well as to supply new irrigators. The Right Bank Canal Scheme is designed to replace the existing main canal with a new canal on the right bank of the Olifants River, which will have an increased capacity to also supply new downstream irrigation development and other future uses.

5.2 Water Requirements and Design Capacity

The existing canals supplying the LORGWS cannot currently provide the full allocations to irrigators because of the restrictive canal capacities. This constraint is in addition to the typical annual restrictions due to the current limiting storage of Clanwilliam Dam and sometimes drought conditions. Rebuilding the main canal with adequate flow capacity on the right bank will only solve this problem for existing irrigators up to ‘Verdeling’, where the canal splits. The situation will in the future incrementally be improved further, should more canal sections be replaced or improved.

The capacity of the Right Bank Canal should be designed considering the following aspects:

- Current flow capacity of the main canal, providing existing irrigators;
- An increased flow capacity for existing irrigators, to alleviate the bottleneck caused by the existing flow capacities of canal sections, taking a long-term view of incremental betterment/replacement of the existing canal sections;
- Future non-irrigation flows;
- Flow requirement for new irrigation downstream of Bulshoek Weir; and
- Adequate freeboard.

5.2.1 Current Bulshoek Main Canal flow capacity

According to the LORWUA, the current capacity of the main canal is 26 000 m^3/h (or 7.222 m^3/s).

The current irrigated area, which receives scheduled water allocations from the Clanwilliam Dam via the LORWUA canal system, is 9 517 ha. If irrigators obtain their full scheduled allocation of 12 200 m^3/ha/a, this equates to total scheduled water allocations of approximately 116 million m^3/a (average flow of 3.682 m^3/s). With an average peak factor of 2.13 (refer

Section 5.2.3), the canal is required to convey a peak flow of 7.842 m^3/s. This peak flow is slightly more than the current capacity of the canal as estimated by LORWUA.

5.2.2 Increased flow capacity for existing irrigators and other uses

An increased flow capacity for existing irrigators is required to alleviate the bottleneck caused by the existing restrictive flow capacities of canal sections, when taking a long-term view of incremental betterment/replacement of these existing canal sections. This will enable existing irrigators to increase the use of their current allocations, in line with the increased assurance of supply, following the raising of the Clanwilliam Dam. The benefit will initially only extend to 'Verdeling' once the Right Bank Canal has been constructed, but can be realised further downstream if the remainder of the canal sections are progressively improved.

Following the raising of Clanwilliam Dam, existing irrigators will have an increased assurance of supply. Up to 20.35 million m^3/a (25% of 81.4 million m^3/a) may be used by existing irrigators. This equates to an increased flow of 0.645 m^3/s, which is an 8.9% increase in current maximum flow. With the increased assurance of supply, it is expected that irrigation flows to existing irrigators will increase. Farmers may plant more permanent crops, and winter flows are also expected to increase. Such additional flows can be used by increasingly making use of spare canal capacity, which is already very limited, and then additionally as sections of canal infrastructure are upgraded.

The canal will be required to accommodate the peak flow during the summer months. An average peak factor (for January) for the irrigation development areas downstream of the Bulshoek Weir of 2.13 was applied to the average flow of 0.645 m^3/s to give a peak flow of 1.374 m^3/s for improving supply to existing irrigators. Adding the improved assurance of supply of 1.374 m^3/s to the existing canal capacity of 7.222 m^3/s means that a total flow of 8.596 m^3/s will be required to supply existing irrigators in future.

An increased canal flow capacity will also allow for future growth in water requirements from urban and municipal use and large industries, such as mines. An additional 1.1% increase in current maximum flow capacity of 0.079 m^3/s has been assumed to provide for this growth in water requirements.

These increased flow capacities required for improved assurance of supply to existing irrigators and other users is shown in **Table 5.1**.

Table 5.1: Water requirements for improved assurance of supply

Improved assurance of supply to existing irrigators	
Additional allocation for improved assurance of existing irrigators (million m^3/a)	20.35
Additional flow and losses for improved assurance of existing irrigators (m^3/s) [equivalent to 8.9% increase in existing canal capacity]	0.645
Average peak factor (January)	2.13
Increase of Peak flow (m^3/s)	**1.374**
1.1% increase for future non-irrigation flows (m^3/s)	**0.079**

5.2.3 Flow requirement for additional irrigation downstream of Bulshoek Weir

Current identified preferred new irrigation development schemes and their associated water requirements and losses are as shown in **Table 5.2**.

Table 5.2: Water requirements and losses of preferred development options

Sub-area	Water allocations (Mm^3/a)	Conveyance losses (Mm^3/a)	River losses (Mm^3/a)	Water allocations and losses (Mm^3/a)
Zone 2 - Olifants River Catchment upstream of and including Bulshoek Weir	17.95	0.00	0.64	18.59
Sub-total (above Bulshoek)	***17.95***	***0.00***	***0.64***	***18.59***
Zone 4 - Olifants River Below Bulshoek Weir to Trawal (post-Right Bank Canal)	22.31	2.02	1.62	25.95
Zone 5 - Olifants River from Klawer to Coast (post-Right Bank Canal)	13.59	2.26	0.68	16.51
Sub-total (Below Bulshoek)	***35.90***	***4.28***	***2.30***	***42.46***
Total	**53.84**	**4.27**	**2.94**	**61.05**

The total available water for additional allocation for new irrigation from a raised Clanwilliam Dam is 61.05 million m^3/a (75% of 81.4 million m^3/a). The preferred schemes below the Clanwilliam Dam were selected such that their combined water requirements plus losses equates to the total available water. However, what has become apparent is that irrigation is sometimes developed in soil that is marginal or not recommended for irrigation. While the total area (hectares) of the preferred irrigation areas are a good indication of the location and extent of new irrigation, it is likely that actual development will differ to some extent.

New irrigation development areas below the Bulshoek Weir (i.e. Zone 4 and Zone 5) require a total allowance of 42.46 million m^3/a.

The design capacity of the new proposed Right Bank Canal should be sufficient to convey the potential water allocation, as well as account for canal conveyance losses. Furthermore, the design flow of the new canal should allow for peak flows. A peak factor of 2.17 and 2.09 was used for Zone 4 and Zone 5 respectively. These peak factors were determined by a planning sub-committee, consisting of DWS, WCDoA, Aurecon and Agrifusion, who derived the crop water requirements for each zone/sub-area. The design flow component for additional irrigation is calculated as shown in **Table 5.3** as **2.723 m^3/s**.

Table 5.3: Design flows for additional irrigation

Sub-Area	Water allocation (Mm^3/a)	Canal losses (Mm^3/a)	Water allocation & losses (Mm^3/a)	Ave flow (m^3/s)	Peak factor (Jan)	Peak / design flow (m^3/s)
Zone 4	22.31	2.02	24.33	0.771	2.17	1.674
Zone 5	13.58	2.26	15.83	0.502	2.09	1.049
Total	**35.89**	**4.27**	**40.16**	**1.273**		**2.723**

5.2.4 Total design flow

The total peak design flow for the proposed Right Bank Canal at the outlet of the Bulshoek Weir is calculated as **11.40 m^3/s**, as shown in **Table 5.4**. The various components of the Right Bank Canal scheme will thus be sized for this design flow.

Table 5.4: Right Bank Canal peak design flows

Flow component	Flow (m^3/s)
Current irrigation	7.222
Improved assurance of supply to existing irrigators	1.374
Future non-irrigation flows	0.079
Additional irrigation	2.723
Total peak design capacity	**11.398**

5.3 Scheme Overview and Components

An initial reconnaissance assessment of alternatives for supplying water from Bulshoek Weir considered several options, including options for refurbishing the existing canal and to construct a new canal on the right bank from Bulshoek Weir to 'Verdeling'. The proposed scheme would be required to serve the identified new irrigation areas of Trawal, Zypherfontein 1 and 2, and Melkboom as shown in **Figure 5.2**. The red line on the map indicates the very early indicative location of a new Right Bank Canal route.

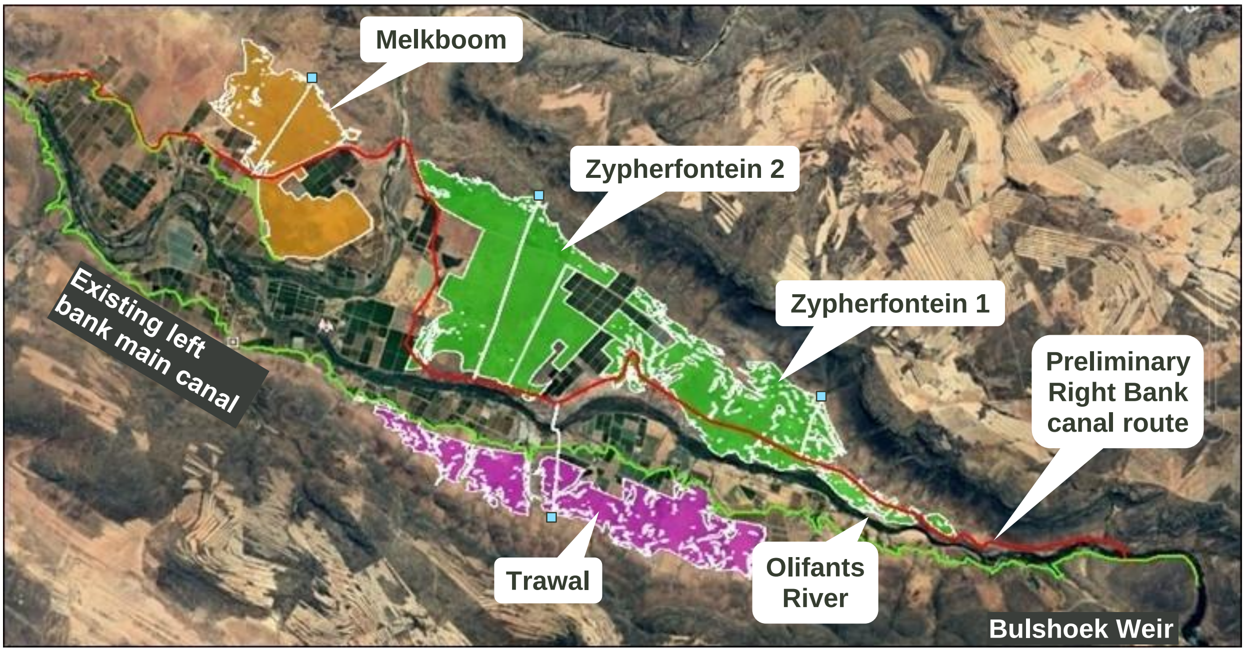

Figure 5.2: New irrigation schemes between Bulshoek Dam and Verdeling Syphon

This preliminary desktop appraisal of the route for the proposed Right Bank Canal was done before the topographical survey was conducted and was thus based on available 5 m contour information. The following challenging sections of the canal were noted:

- A number of reaches of the proposed canal would be located where the topography is steep, and rock may be present, which would significantly increase the cost of the proposed canal.
- There are a few problematic sections of the proposed canal route which would require the relocation of portions of the R363 road on the right bank of the Olifants River.
- The structural strength of the existing syphon crossing may be problematic.
- It was proposed, in the short-term to medium-term, that the existing canal on the left bank continue to supply the existing and proposed additional left bank irrigation areas upstream of 'Verdeling' at Trawal, as it is more economical to do so than serve such irrigators from the proposed Right Bank Canal. In the long-term the complete phasing out of the left bank main canal may be a possibility.

The proposed Right Bank Canal Scheme involves construction of the following components to convey water from the Bulshoek Weir to the existing syphon at Verdeling:

- Intake works to the canal system, i.e. outlet works at the Bulshoek Dam,
- Right bank canal from the Bulshoek Weir to the right bank (current) outlet of the existing syphon at Verdeling,
- Siphons along the canal route, and
- Modifications to the existing syphon at Verdeling.

The scheme is located on strata of the Table Mountain Group. In the vicinity of Bulshoek Weir this bedrock is visible, but further in a downstream direction as the river valley widens, the rocks are covered by various Quaternary-age transported soils comprising predominantly sand soils.

Following the preliminary reconnaissance assessment, an initial desktop analysis of the canal route was conducted to confirm and identify challenging sections. Possible sub-options for each of the canal components were also considered in this desktop evaluation and were investigated further during a site visit. **Figure 5.3**, along with the descriptions (IDs) in **Table** 5.5, shows the various sub-options for the components of the Right Bank Canal Scheme.

Table 5.5: Right Bank Canal Scheme sub-options

ID	Sub-Option
Outlet Works (Section 5.4.1)	
O1	Existing outlet works
O2	Convert disused buttress gate to new outlet works structure
Canal (Section 5.4.2)	
C1	New Right Bank Canal
C2	Existing Left Bank Canal
Syphon 1 (Section 5.4.3)	
S1A	Syphon at the Bulshoek Weir
S1B	Syphon installed 3 km downstream of the Bulshoek Weir
Syphon 2 (Section 5.4.4)	
S2A	Short syphon with canal between existing dams
S2B	1.3 km long syphon
S2C	2.2 km long syphon
S2B+S2D	1.3 km long syphon + 700 km long canal reach + 800 km long syphon
Existing Syphon (Section 5.4.5)	
E1	Existing syphon at Verdeling

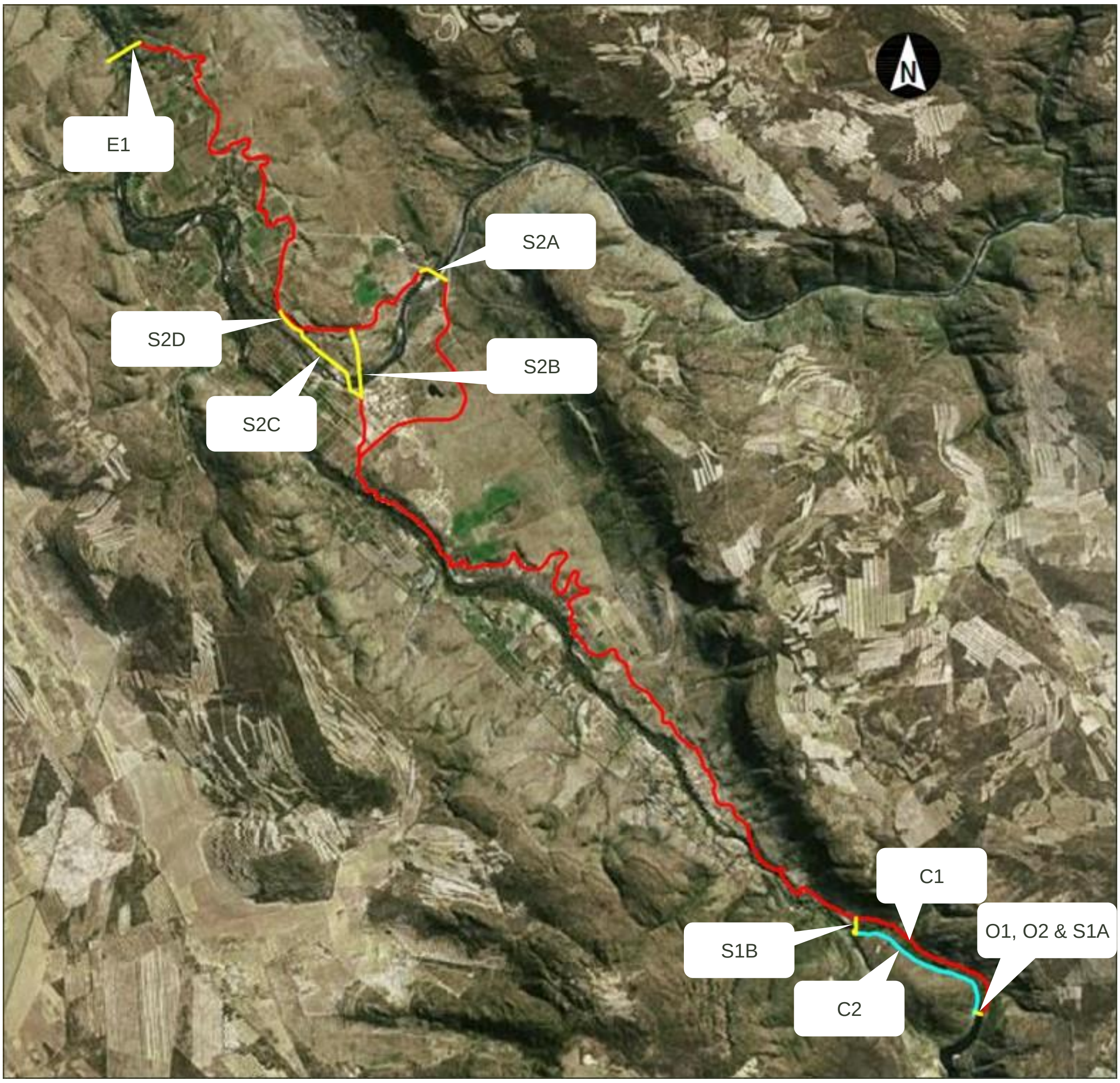

Figure 5.3: Right Bank Canal Scheme components

5.4 Sub-Options

5.4.1 Outlet Works

The Bulshoek Weir (**Figure 5.4**) was constructed in 1924. No details of the actual founding conditions were recorded at the time. The weir has a history of leakage through the rock foundation. A new mass concrete apron was constructed in 2003 – 2005 and detailed records of the exposed bedrock were captured then. Due to its age and the condition of the weir, it would be risky to blast in the vicinity of the weir to construct a new outlet to serve the proposed Right Bank Canal.

Figure 5.4: Concrete masonry Bulshoek Weir

5.4.1.1 Existing Outlet Works Structure

The sluices used to control the flow into the existing main canal appear to be in good condition. It is unlikely to be feasible to increase the level in the canal immediately downstream of the outlet works for the following reasons:

- The level of the outlet works to the canal provides access to storage in Bulshoek Weir. This is necessary to balance releases from Clanwilliam Dam, and to utilise runoff from the Jan Dissels River and other tributaries downstream of Clanwilliam Dam.
- The level of the intake works to the canal is dictated by the existing outlets of this historical structure and it is very unlikely that these levels can be changed.

The existing outlet works (**Figure 5.5**) has five sluice gates, each estimated to be 1.5 m wide and 2 m high. The total width of the outlet works is approximately 17.5 m. The LORWUA stated that the maximum capacity of the canal is 26 000 m^3/h (i.e. 7.222 m^3/s). Assuming an orifice opening height of 0.284 m with all five sluice gates open and a difference in water level height of 3.6 m (upstream water level at dam full supply level and downstream water level at full canal depth including freeboard), the existing outlet structure will have a flow of 11.5 m^3/s. Based on this calculation, it appears that the existing outlet structure does not need to be modified to release the peak design flow of 11.4 m^3/s into the proposed Right Bank Canal.

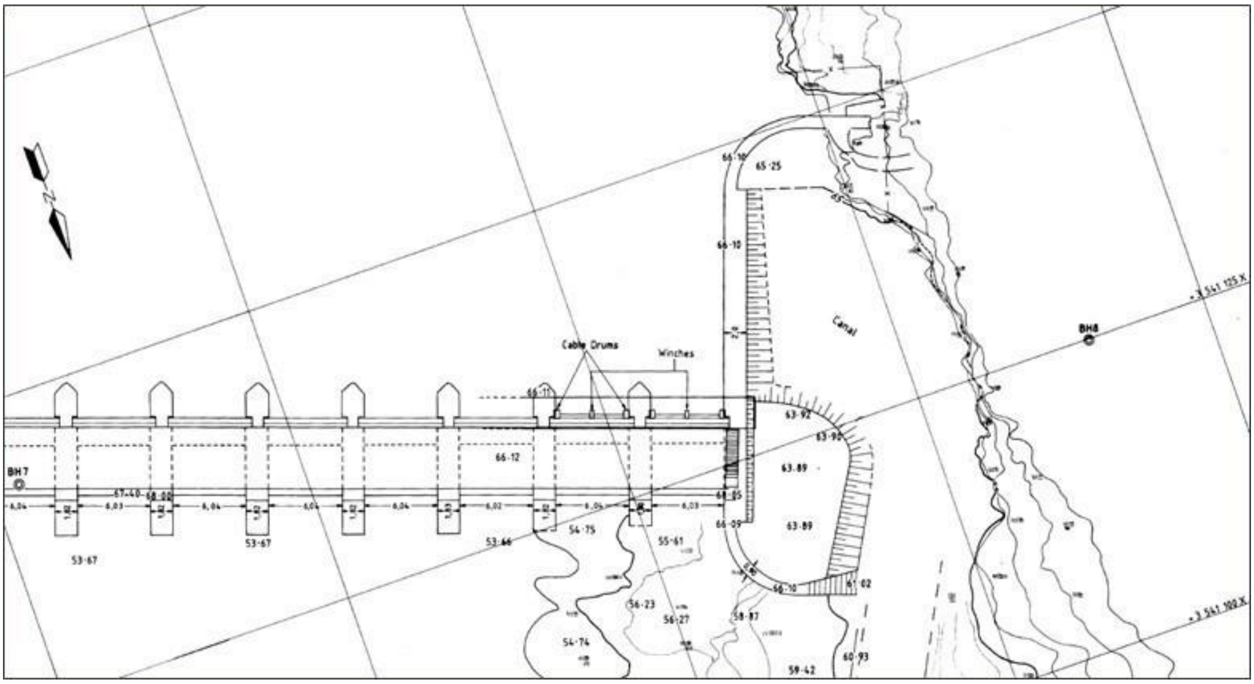

Figure 5.5: Existing outlet structure

5.4.1.2 Converting Disused Spillway Gate to New Outlet Works Structure

It was noted during the site visit that the spillway gate on the right bank of Bulshoek Weir is no longer in use (see **Figure 5.6**). An option for an alternative outlet structure to the Right Bank Canal would be to convert this disused spillway gate by constructing a wet well and intake pipe from the gate. This option would eliminate the need for a new syphon to cross from the left bank to the right bank of the Olifants River. A coffer dam or steel caisson would be required on the upstream side of the weir during construction. The structural integrity of Bulshoek Weir would need to be investigated.

Figure 5.6: Last buttress gate at the Bulshoek Weir no longer in use

It is known that the spillway section of the weir is founded on predominantly slightly to moderately weathered, thickly bedded, close to medium jointed, brown to white, hard rock quartzitic sandstone. Should the envisaged new outlet works structure be founded at the same depths as the Bulshoek Weir then there would be no concerns in terms of bearing capacity. At the same time, it must be acknowledged that the new apron was constructed to counter significant erosion damage to the founding rock mass, where interbedded weak strata were eroded away. Remedial foundation grouting of the Bulshoek Weir foundation, planned to happen in conjunction with apron construction, was not carried out. There is therefore a possibility that founding conditions for a new outlet works structure might be compromised at depth as a result of lateral erosion via weaker interbeds.

Should this option be favoured it would be essential that further geotechnical investigations are conducted for detailed design purposes. Such investigations must include exploratory rotary core drilling to confirm conditions at depth.

The rock mass condition visible at crest level of the weir consist of highly weathered quartzitic sandstone and is assumed to be representative of rock to be excavated for the founding of the new outlet works structure. Cognisance must be taken of the risks of blasting in such close proximity to the existing structure; both in terms of the structure itself, but also the impact on the founding rock mass in terms of creating and / or opening of fractures. In addition to the risks posed by blasting, the integrity of the existing structure may be compromised by forces imposed by construction of the proposed outlet works.

If it is found to be a practically feasible option, conversion of the last spillway gate to a suitable outlet structure for the new Right Bank Canal is roughly estimated to cost R 25 million (comparative cost).

It is important to note that the Bulshoek Weir is a national monument. For the betterment works project previously undertaken on the dam structure, it was a requirement that the aesthetics of the Bulshoek Weir not be affected. It is assumed that a similar restriction on any construction works to convert the gate into an outlet structure would be enforced.

5.4.2 Canal

5.4.2.1 New Right Bank Canal (C1)

One of the sub-options for the proposed canal route is to follow a route which starts immediately downstream of the Bulshoek Weir on the right bank of the Olifants River. This means that either a syphon is required from the existing outlet structure to cross the Olifants River (discussed in **Section 5.4.3.1**) or the outlet must be transferred to the Right Bank (discussed in **Section 5.4.1.2**). An initial desktop study of the contours from the topographical survey, confirmed later by the site visit, indicated that there is a steep cliff section for approximately the first 3 km of the proposed route. During the site visit, hard rock was also observed along this steep cliff section, as can be seen from **Figure 5.7**.

Figure 5.7: Steep cliff section along the proposed Right Bank Canal (C1) route

Geological distinction can be made between the initial 3 km section of the new canal from the Bulshoek Weir, and the canal beyond that point. The initial 3 km portion is characterised by shallow bedrock often seen as scattered outcrop on the surface. This includes a section where the possible canal alignment follows the existing R363 gravel road, and includes a section where this road, and therefore the new canal, is aligned along a cliff edge.

The shallow quartzitic sandstone bedrock indicates that canal excavation will require blasting. The blasted faces will further expose a blocky rock mass, as defined by sub-horizontal bedding planes and sub-horizontal joints, and consideration of the stability of the blasted faces will be required.

In addition to blasting, the steep cliff section may pose further construction challenges to the proposed canal. It may require a rectangular cross-sectional shape to accommodate the design flows without having too large a cut excavation. In some sections, the proposed canal route also conflicts with the old N7 / R363 road alignment, which would result in access problems.

A rectangular cross-section with a base width of 5.5 m and wall height of 2.33 m (refer to **Figure** 5.8) is proposed to convey the required flow of 11.4 m^3/s for the first 3 km of the new Right Bank Canal. Construction of this section is expected to cost in the order of R 170 million (comparative cost).

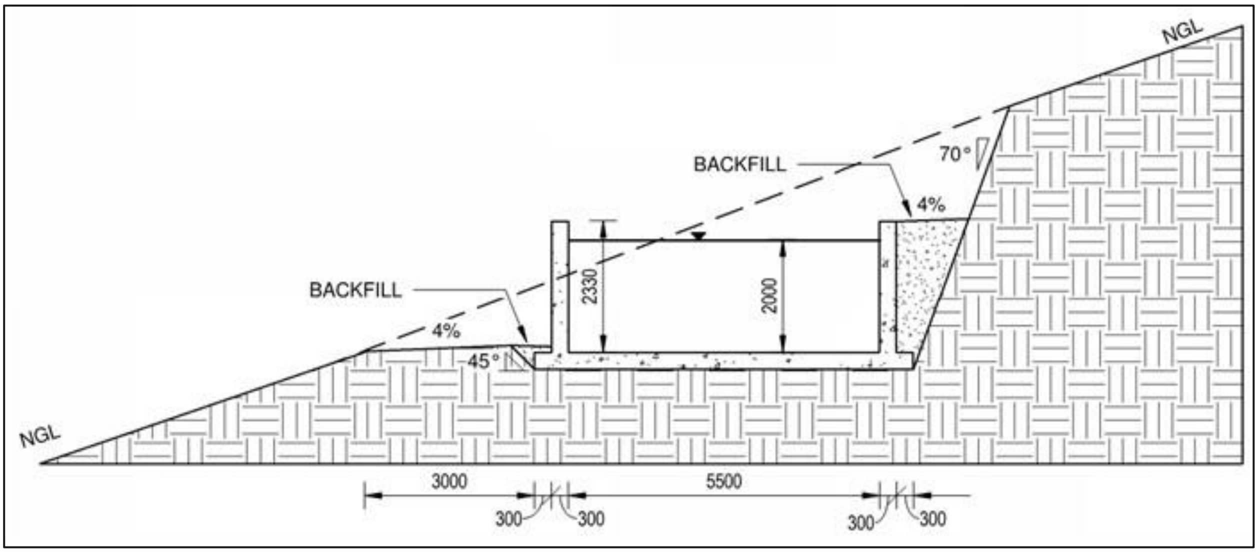

Figure 5.8: Typical rectangular canal cross-section

For the canal route from 3 km (after the steep cliff section) up to the syphon at Verdeling, a trapezoidal cross-section with varying dimensions and side slopes is proposed to convey the design flow (refer to **Figure 5.9** and **Table 5.6**).

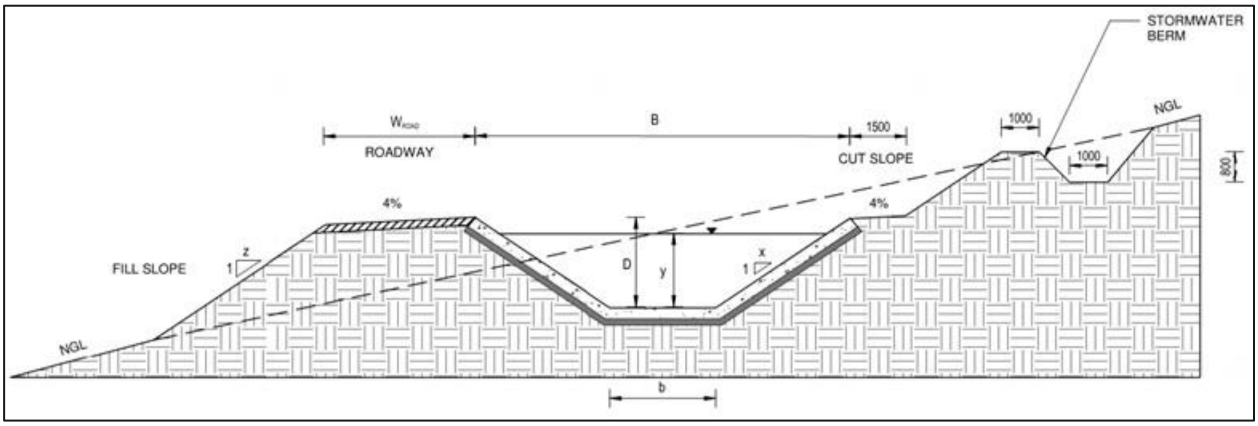

Figure 5.9: Trapezoidal canal cross-section (Types T1, T2 and T3)

Geological conditions along this section (from 3 km to Verdeling) are expected to be more variable. Generally, the landscape is characterised by more gently-sloping topography. Geological profiles are expected to predominantly comprise sandy soils, which may vary to comprise gravelly sands in places. Occasional rocky areas might also be encountered.

In terms of excavation conditions, 'soft excavation' can be assumed to dominate within the typical 2.3 m canal depths, but where the occasional rocky areas are encountered allowance should be made for blasting. Cut slopes in such sandy soils would not be stable if cut steeper than say 30°. If space constraints dictate steeper slopes, stabilisation measures will be required, such as shoring of temporary excavations, benching, or other support measures.

Table 5.6: Canal sections - design parameters

Parameter	Symbol (refer to Figure 5.8 and Figure 5.9)	Type R1	Type T1	Type T2	Type T3
Canal Shape		Rectangular	Trapezoidal	Trapezoidal	Trapezoidal
Canal Slope		1:5000	1:5000	1:5000	1:5000
Bottom width (m)	b	5.5	2.8	4.0	5.0
Side slope (1H:xV)	x		1.5	1	0.5
Top width (m)	B	5.5	8.64	7.72	6.82
Flow depth (m)	y	1.996	1.945	1.855	1.824
Flow velocity (m/s)		1.039	1.025	1.050	1.057
Froude number		0.235	0.288	0.282	0.269
Freeboard (m)		0.330	0.423	0.404	0.396
Total depth (m)	D	2.330	2.370	2.260	2.220
Roadway width (m)	W_{ROAD}	> 3.0 (no road)	4.0	4.0	1.5 (no road)
Cut Slope	z	2.75 / 1.0*			
Fill Slope	z	1.0			

** Dependent on geotechnical findings*

The comparative construction cost of the second canal reach (upstream of Syphon 2), with a length of 18.6 km, will be approximately R 467 million. The comparative construction cost of the third canal reach (downstream of Syphon 2 and upstream of Verdeling syphon), with a length of 8.9 km, will be approximately R 191 million. This brings the total estimated comparative capital cost of the canal for sub-option C1 to R 828 million.

5.4.2.2 Existing Left Bank Canal (C2)

Due to the construction difficulties associated with the steep cliff along the initial section of the proposed Right Bank Canal route, the sub-option of upgrading the existing Left Bank Canal for approximately the first 3 km was considered. The current horizontal alignment of the existing canal would be followed (**Figure 5.10**). It would however need to be upgraded to ensure that it can accommodate the increased capacity required for the additional irrigation and other users. The canal would maintain its trapezoidal cross-section, but would be widened for the additional flow, and its lining must be rehabilitated to reduce the likelihood of future canal breaks.

The canal with increased capacity will have a 4 m base width, 2.26 m depth and side slopes of 1:1. A lining thickness of 150 mm is proposed. Further, the existing Parshall flume in the left bank canal will be replaced by a new Crump weir. The canal alignment will be optimised to allow for a sufficient straight reach of canal upstream and downstream of the new Crump weir.

The slopes adjacent to the left bank canal are generally characterised by scattered outcrop of hard rock quartzitic sandstone. It can be assumed that excavations to widen the left bank canal will therefore require blasting, i.e. ‘hard excavation’. A key consideration for blasting adjacent to the already-weak left bank canal is the risk of damaging these canals. Great care will have to be exercised in blasting close to this canal. As with blasting for the new right bank canal, consideration would also have to be given to the stability of these blasted rock faces.

Figure 5.10: Existing Left Bank Canal section (C2)

The existing access road can be used during construction, but it may need to be upgraded to provide future access. To enable upgrading of the canal it will be necessary to pump water from the Olifants River into the existing canal downstream of the 3 km section to be upgraded. The historical weekly flows (average from 2006/07 to 2015/16) in the main section of the existing canal are shown in **Figure 5.11** (starting in the first week of October). Based on the assumption that the construction for the upgrade of the left bank canal would take place only during the winter months, i.e. the low-flow period, then a flow of approximately 12 000 m^3/h (3.33 m^3/s) would need to be pumped temporarily from the Olifants River to the canal. This flow would need to be lifted by 20 m, over a distance of 75 m.

It is estimated that upgrading of the canal could be completed during the 20-week low-flow period; however, there is a potential risk of delays during construction resulting in higher costs related to temporary over-pumping. Based on the assumption that upgrading of the Left Bank Canal will occur over two low-flow seasons, the temporary over-pumping capital costs would be approximately R34 million, with an estimated R15 million operating cost. The operating cost was calculated based on the use of a diesel generator. Alternative electrical power supply sources will need to be investigated for the temporary pumping. The comparative capital construction cost of the upgraded left bank canal (including demolition of the existing canal) is estimated at approximately R 108 million. Adding the remainder of the main right bank canal downstream of Syphon 1B (R 658 million), the total comparative capital cost of sub-option C2 amounts to R 815 million.

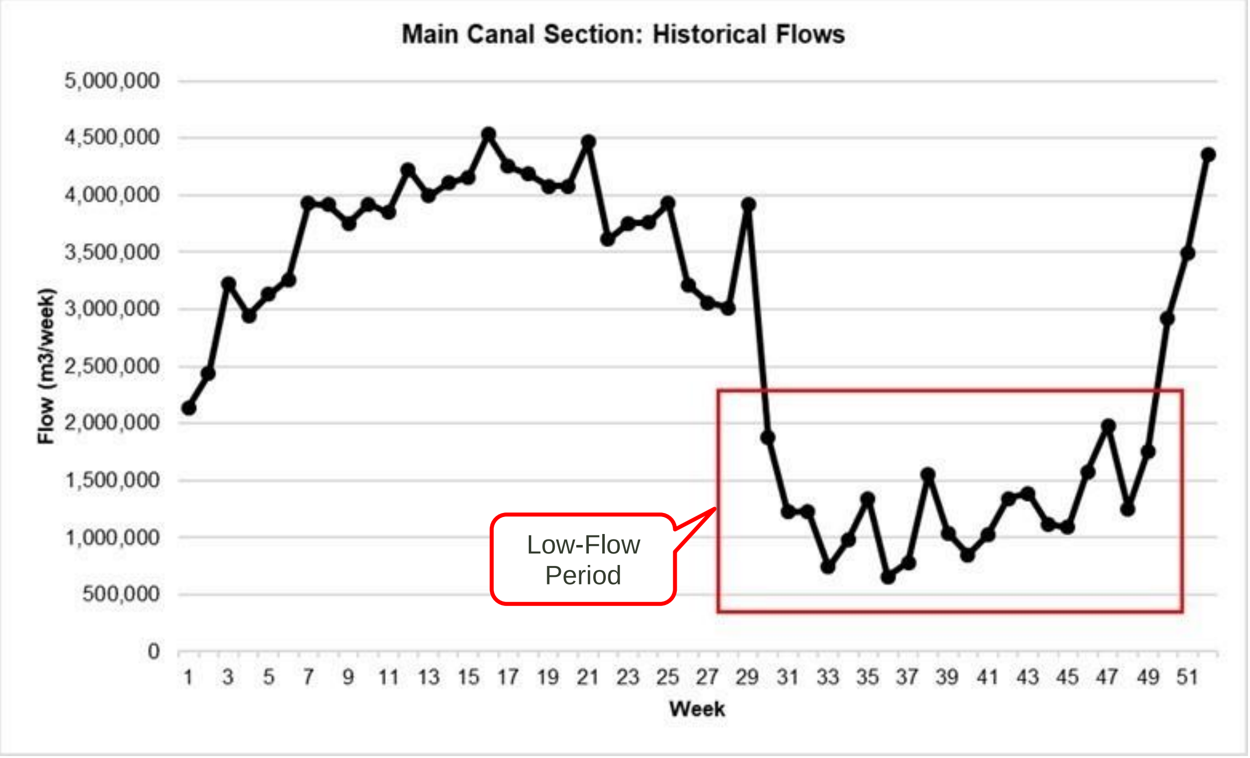

Figure 5.11: Main canal section – historical weekly flows

5.4.3 Syphon 1

A new river crossing (syphon) is required over the Olifants River if the existing outlet structure at the Bulshoek Weir is used for the proposed scheme. The crossing (syphon) will be located at the Bulshoek Weir if the canal route follows the right bank of the Olifants River for its entire length. An alternative crossing will be located approximately 3 km further downstream if the existing Left Bank Canal is upgraded, i.e. after the steep cliff section on the right bank of the Olifants River. Either above-ground or below-ground installations can be considered for the river crossing (syphon).

5.4.3.1 Syphon at the Bulshoek Weir (S1A)

Close to the Bulshoek Weir, the river is characterised by extensive shallow bedrock. An above-ground concrete encasement can be constructed to cross the Olifants River (refer **Figure 5.12**). This would be preferable to installing the syphon below ground as any blasting near the existing Bulshoek Weir should be avoided. There would not be significant environmental impact due to the proximity downstream of the existing dam. In addition, the stilling basin created by the above-ground concrete casing would not negatively impact the hydraulics of the existing weir's spillway.

A nominal pipe diameter of 2 400 mm is required to convey the flow of 11.4 m^3/s, which would result in a headloss of 0.87 m. The estimated comparative construction cost of the syphon, including encasement is R 11 million.

Figure 5.12: Syphon S1A at Bulshoek Weir

An offtake structure from the existing Left Bank Canal is needed to convey the flow through the syphon. Such a structure is shown in **Figure 5.13** below. The comparative capital cost of the intake (including demolition of relevant portion of canal) is estimated at a total of R 6 million. An outlet structure is proposed on the opposite bank to convey the flow into the canal. This structure is shown in **Figure 5.14**. This structure's comparative capital cost is estimated at R 3 million, which brings the total cost of Syphon 1A to R 20 million.

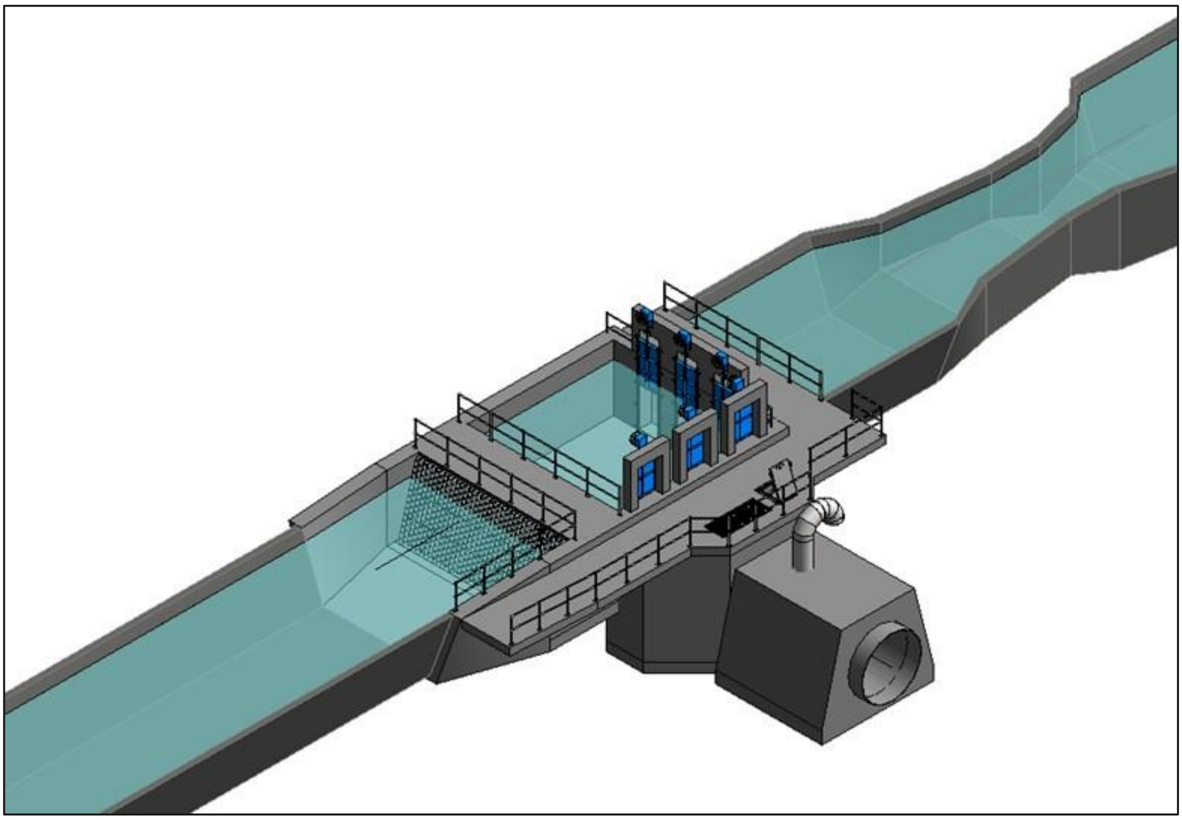

Figure 5.13: Syphon S1A inlet at Bulshoek Weir – upstream of existing Parshall Flume

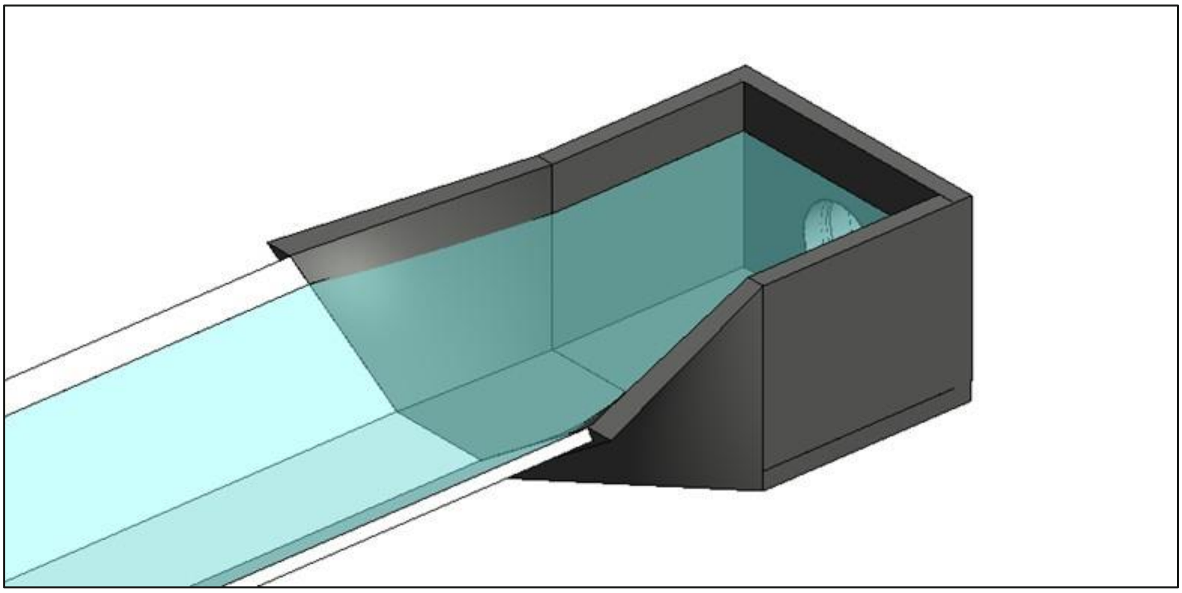

Figure 5.14: Typical syphon S1A outlet

5.4.3.2 Syphon Installed 3 km Downstream of the Bulshoek Weir (S1B)

An alternative to the syphon at Bulshoek Weir (S1A) would be to install the syphon 3 km downstream of the Bulshoek Weir (at coordinates X = -22 360.943, Y = -3 539 913.126). Conditions of the river at this location are less certain (**Figure 5.15**). The cursory reconnaissance noted the perennial pool which suggest a relatively deep river bed, bounded on the upstream side by dense bush, which suggests shallow bed conditions that allowed establishment of the trees. It is assumed that this boundary is aligned with the major fault shown on the geological map.

The syphon crossing would presumably favour the area of the shallow river bed, i.e. through the heavily bushed area, but at this stage it is not known if the conditions comprise shallow bedrock, or thick alluvial deposits. These conditions would have to be confirmed as they would fundamentally influence the decision whether the river crossing comprises below- or above-ground options, or even a pipe bridge.

For this sub-option, with a length of 580 m, several syphon types were considered:

(1) Single DN2400 steel pipe below the river,
(2) Single DN2400 steel pipe with a steel truss bridge,
(3) 5 DN1200 parallel concrete pressure pipes.

A cost comparison of the three syphon options is provided in **Table 5.7** below, which shows that the Single DN2400 steel pipe with a steel truss bridge has the lowest comparative construction cost at R 14 million.

Practically, a pipe bridge is considered as a preferred alternative to a below-ground pipe jack to cross the river, as river crossings of this nature tend to have complications due to the geotechnical and underwater working conditions. Continuous dewatering would be required to keep the pipe jacking dry. A steel truss pipe bridge would also have a lower environmental impact than the below-ground option. The pipe bridge would need buttresses and piers across its length to support the weight of the syphon.

A nominal pipe diameter of 2 400 mm is required to convey the flow of 11.4 m^3/s, which would result in a headloss of 0.87 m.

Table 5.7: Cost comparison of syphon S1B options

Option	Cost
Single DN2400 steel pipe below the river	R 16 million
Single DN2400 steel pipe with Pipe Bridge	R 14 million
5 DN1200 parallel concrete pressure pipes	R 41 million

Figure 5.15: Syphon S1B installed 3 km downstream of the Bulshoek Weir

A syphon crossing at this location would require construction of a new offtake structure from the existing left bank canal. Blasting within shallow bedrock is to be expected and consideration of associated risks to the fragile left bank canal would be required. Similar inlet and outlet structures as shown in **Figure 5.13** and **Figure 5.14** will be used (with comparative costs of R 6 million and R 3 million respectively), bringing the total comparative cost of Syphon 1B to R 23 million.

5.4.4 Syphon 2

An additional syphon is proposed at approximately chainage 23 km of the canal route (coordinates X = -31 545.113 m, Y = -3 531 065.467 m), where the conveyance infrastructure crosses the non-perennial Doring River (**Figure 5.16**).

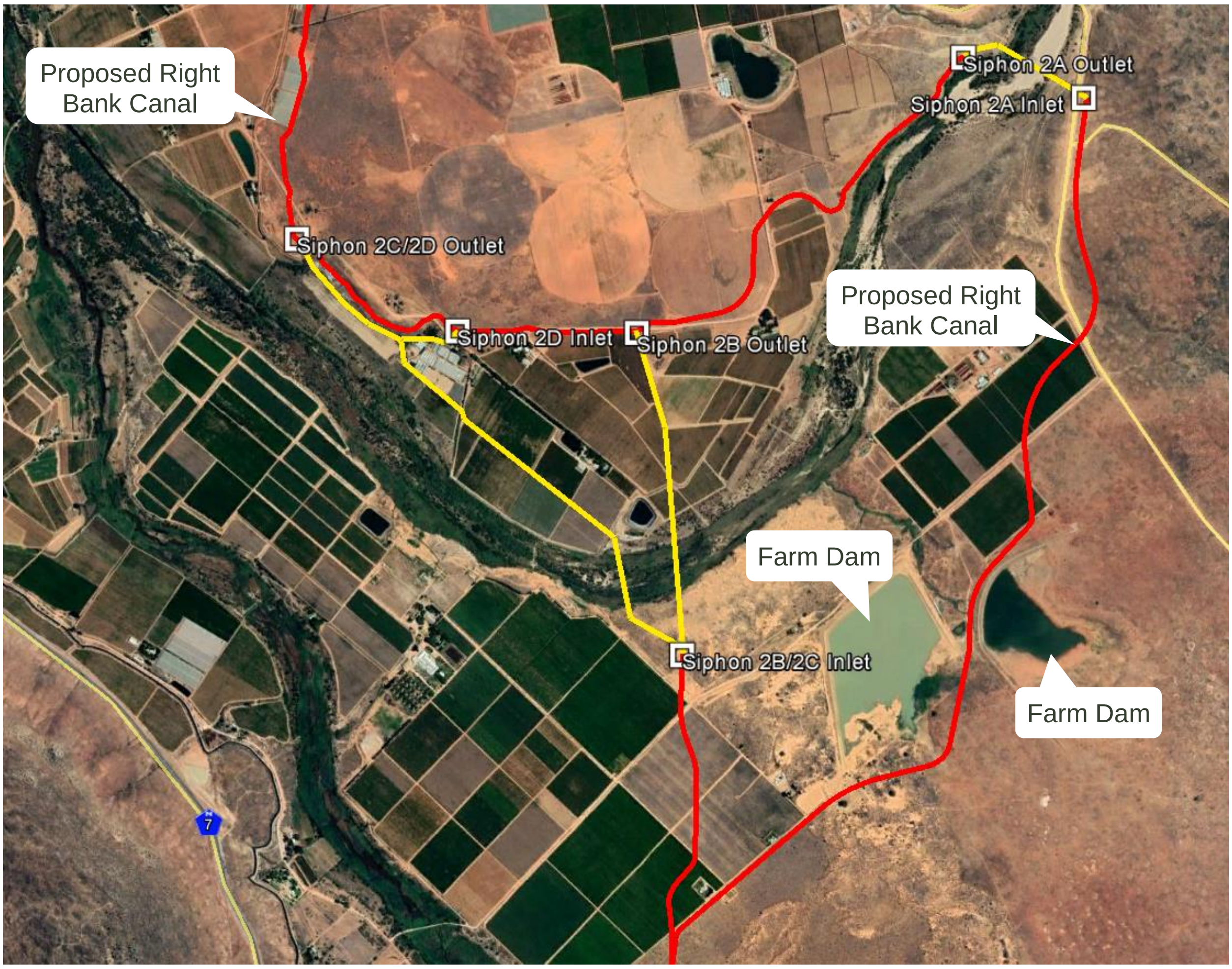

Figure 5.16: Sub-options for second syphon crossing

There are several options for a syphon crossing of the Doring River. At this stage geological conditions at the various options are uncertain. Thick sand deposits appear common, but there are areas where shallow rock might be expected, in particular on the respective river banks. For example, a syphon near the R363 road bridge is likely to encounter rocky conditions on the river banks, and although the river bed comprises sand, the thickness of these alluvial deposits is not known at this stage. Confirmation of the geological conditions would be fundamental in determining the optimum location for the river crossing.

The inlet structure that will be used in all cases is shown in **Figure 5.17**. The geological conditions at the respective syphon inlet and outlet structures would also need confirmation and would have implications in terms of foundation design. The preliminary comparative cost of this structure is R 6 million. The same outlet as shown in **Figure 5.14** will be used in all cases. The comparative cost of the outlet structure is R 3 million.

Different types of siphons were considered as described in sections **5.4.4.1** to **5.4.4.3**.

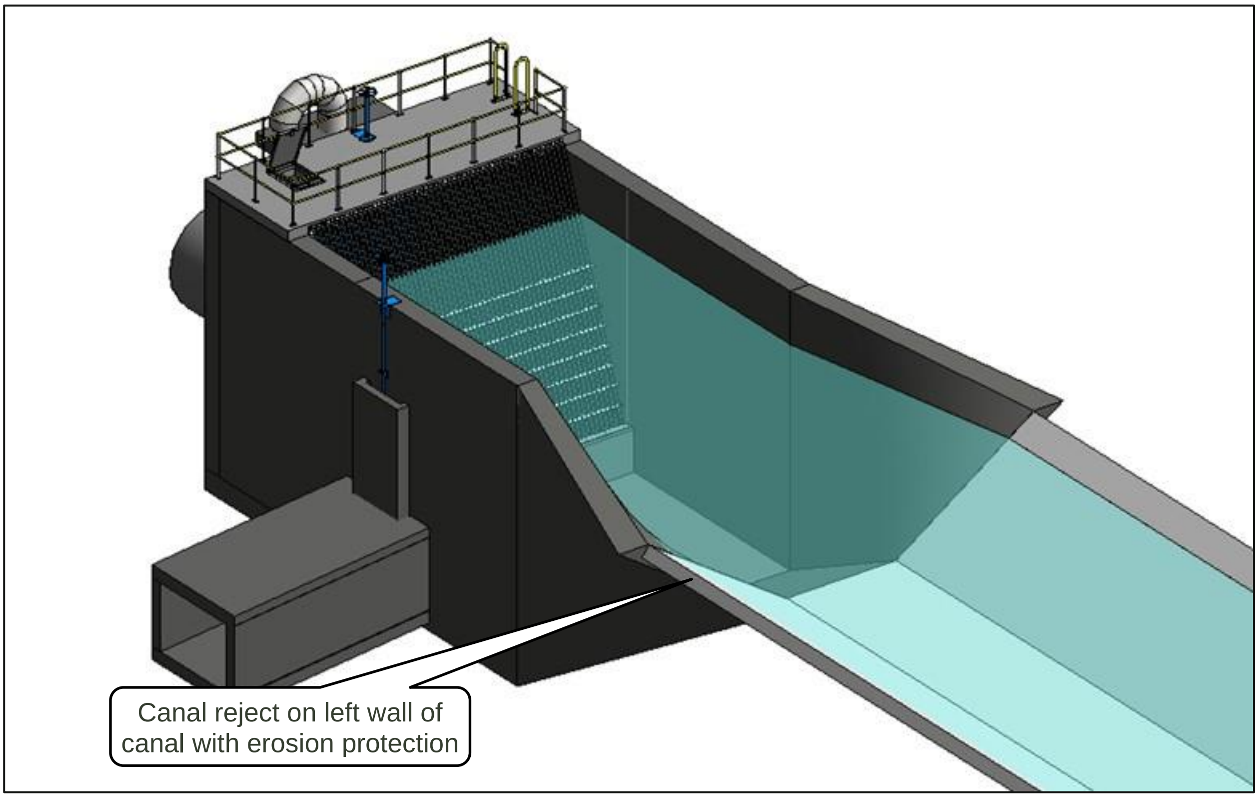

Figure 5.17: Typical syphon 2 inlet

5.4.4.1 A 580 m Syphon with Deep Cut Canal between Existing Dams (S2A)

Initially a short syphon was investigated to cross the Doring River further up the valley near the old N7 road crossing. This sub-option would require the canal to traverse between two existing farm dams. The disadvantage to this canal route is that the canal could potentially be damaged in the event of a dam flooding. On the site visit it was noted by Mr J Matthee of LORWUA that the existing farm dams were illegally built, and that the landowner was intending to sell his property. Even if the property was sold and the farm dams were demolished, the ground conditions along the canal would be relatively wet.

For this sub-option, with a length of 580 m, several syphon types were considered:

(1) Single DN2400 steel pipe,
(2) Two DN1800 parallel steel pipes,
(3) 2.3 m x 2.6 m in-situ concrete culvert,
(4) 6 DN1200 parallel concrete pressure pipes.

A cost comparison of the four syphon options is provided in **Table 5.8** below, which shows that the 2.3 m x 2.6 m in-situ concrete culvert has the lowest comparative construction cost at R 25 million. Two extra sections of canal need to be constructed, when compared to sub-option

S2C (4.8 km and 3.4 km respectively). The first part of the extra canal will have very deep cut sections (in the order of 10 m) to avoid the existing farm dams. Geotechnical factors that would come into play would include the geological profile at the potential cutting location, with implications including excavatability (particularly if rock is present), as well as the stability of such high cut slopes. This is expensive earthworks and brings the comparative cost of these canal sections to R 331 million. After including the inlet and outlet, the total comparative cost for sub-option S2A is R 365 million.

Table 5.8: Cost comparison of syphon S2A options

Option	Cost
Single DN2400 steel pipe	R 33 million
Two DN1800 parallel steel pipes	R 47 million
2.3 m x 2.6 m in-situ concrete culvert	R 25 million
6 DN1200 parallel concrete pressure pipes	R 65 million

5.4.4.2 A 1.3 km Long Syphon (S2B)

The second alternative is to start the syphon crossing before the farm dams, further downstream in the Doring River valley, for a syphon length of 1 277 m. Several syphon options were considered:

(1) Single DN2400 steel pipe,
(2) Two DN1800 parallel steel pipes,
(3) 2.3 m x 2.6 m in-situ concrete culvert,
(4) 7 DN1200 parallel concrete pressure pipes.

A cost comparison of the four syphon options is provided in Table 5.9 below, which shows that the 2.3 m x 2.6 m in-situ concrete culvert has the lowest comparative construction cost at R 56 million. A 1.5 km long extra section of canal needs to be constructed (compared to sub-option S2C), costing R 49 million. After including the inlet and outlet, the total comparative cost for sub-option S2C is R 114 million.

Table 5.9: Cost comparison of syphon S2B options

Option	Cost
Single DN2400 steel pipe	R 60 million
Two DN1800 parallel steel pipes	R 85 million
2.3 m X 2.6 m in-situ concrete culvert	R 56 million
7 DN1200 parallel concrete pressure pipes	R 134 million

5.4.4.3 A 2.2 km Long Syphon (S2C)

An alternative to the syphon routes discussed above is to start the syphon crossing before the farm dams, at the same location as alternative S2B, but the outlet would be further along the route to avoid a steep section of canal. The syphon length would then be 2 307 m. Several syphon options were considered:

(1) Single DN2400 steel pipe,
(2) Two DN1800 parallel steel pipes,
(3) 2.3 m x 2.6 m in-situ concrete culvert,
(4) 7 DN1200 parallel concrete pressure pipes.

A cost comparison of the four syphon options is provided in **Table 5.10** below. The single DN2400 steel pipe and the 2.3 m x 2.6 m in-situ concrete culvert have the lowest comparative construction cost of R 99 million and R 101 million respectively. The advantages and disadvantages of these two options need to be considered to choose the most cost-effective option. No extra canal needs to be constructed. After including the inlet and outlet, the comparative cost for sub-option S2C is R 108 million.

Table 5.10: Cost comparison of syphon S2C options

Option	Cost
Single DN2400 steel pipe	R 99 million
Two DN1800 parallel steel pipes	R 142 million
2.3 m x 2.6 m in-situ concrete culvert	R 101 million
7No. DN1200 parallel concrete pressure pipes	R 216 million

5.4.4.4 1.3 km and 0.8 km Long Siphons (S2B+S2D)

Due to DWS' maintenance concerns and inspection requirements, an option to construct an additional syphon after sub-option 2B's syphon was investigated, in order to reduce the stretch of continuous syphon. This additional syphon length (S2D) is 836 m. Several syphon options were considered for syphon S2D:

(1) Single DN2400 steel pipe,
(2) Two DN1800 parallel steel pipes,
(3) 2.3 m x 2.6 m in-situ concrete culvert,
(4) 6 DN1200 parallel concrete pressure pipes.

A cost comparison of the syphon options is shown in **Table 5.11** below. The single DN2400 steel pipe and the 2.3 m x 2.6 m in-situ concrete culvert have the lowest comparative construction cost of R 32 million and R 37 million respectively. The advantages and disadvantages of these two options need to be considered to choose the most cost-effective option. Syphon S2B's preferred option must also be considered to ensure ease of construction.

Given the use of a culvert at syphon S2B, a similar culvert at syphon S2D makes sense, and is thus the preferred option (with a comparative cost of R 37 million).

A short reach of trapezoidal canal needs to be constructed to link these two siphons. This has a comparative cost of R 16 million. After including two inlets and two outlets, the comparative cost for sub-option S2B+S2D is R 127 million.

Table 5.11: Cost comparison of syphon S2D options

Option	Cost
Single DN2400 steel pipe	R 32 million
Two DN1800 parallel steel pipes	R 45 million
2.3 m x 2.6 m in-situ concrete culvert	R 37 million
6 DN1200 parallel concrete pressure pipes	R 53 million

5.4.5 Existing Syphon at Verdeling

There is an existing syphon at Verdeling across the Olifants River, adjacent to the N7 national road, which connects and allows water to flow from the existing left bank canal to the existing right bank canal. It is a 2 m diameter steel pipe, 650 m long, with a differential head of 0.6 m with its current flow.

With the implementation of the proposed Right Bank Canal scheme, it will be necessary to allow reverse flow from the right bank to the left bank canal. The reverse design flow through the syphon was calculated using the same approach described in **Section 5.2** above. The calculation of the required reverse flow of **3.708 m^3/s** is shown in **Table 5.12**. For this design flow, the existing syphon will have a differential head of 0.5 m.

Table 5.12: Syphon at Verdeling reverse design flow

Flow component	Flow (m^3/s)	Comment
Current irrigation	2.706	Max. current capacity of Naaukoes section is 9740 m^3/h (Source: LORWUA)
Improved assurance of supply to existing irrigators	0.687	Assumed additional allocation for improved assurance of supply is distributed in a 50%/50% split for both sides of the existing canal system. Peak factor of 2.13.
Future non-irrigation flows	0.030	1.1% allowance
Additional irrigation	0.345	Ebenhaeser (full scheme flow requirement), Coastal 1 water requirements and losses
Total	**3.708**	

To reverse the flow in the existing syphon, the existing head loss and the reverse head loss need to be overcome by lifting the water level in the intake chamber of the syphon. To do this, a new inlet chamber will be built on top of the existing canal. This chamber will include a trash rack and vertical sluice gates to fully control the flow in the downstream system. The raised water level is 2.4 m above the existing level. **Figure 5.18** shows this concept. The alterations to the right bank syphon inlet would cost approximately R 9 million (comparative cost).

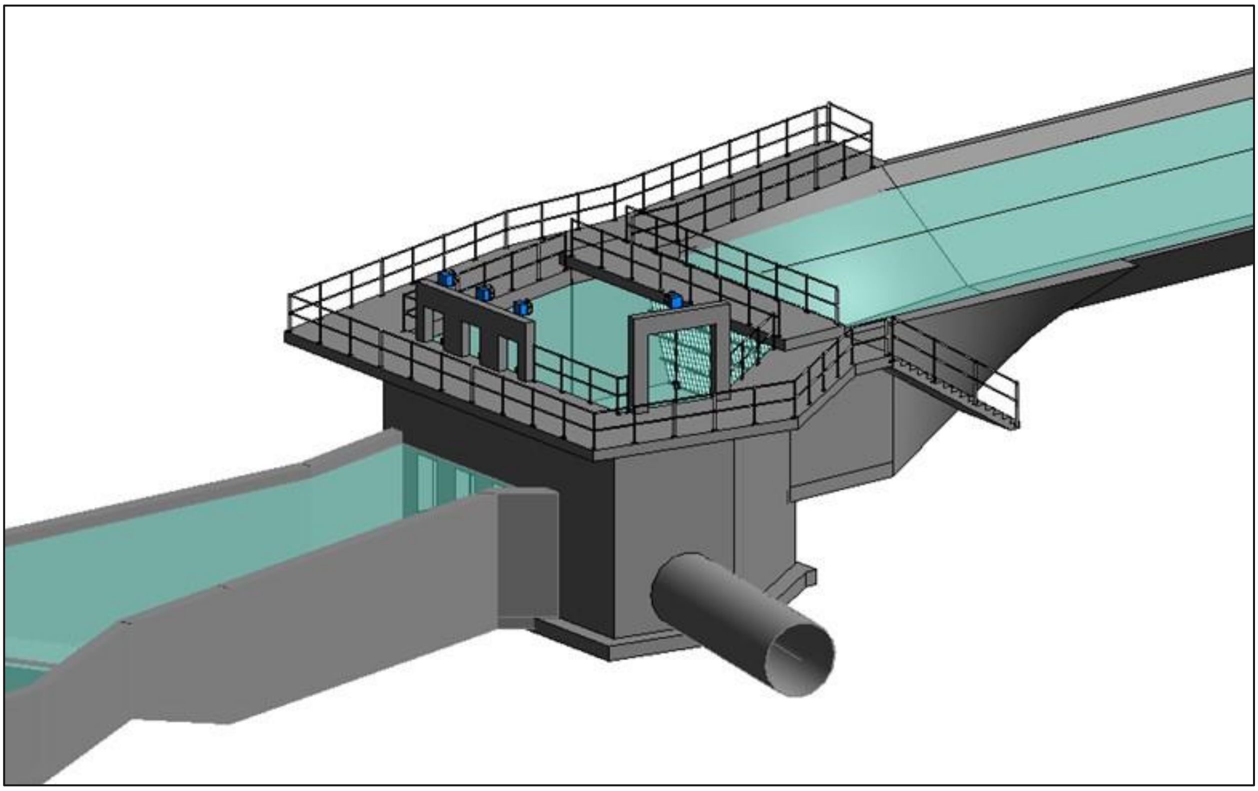

Figure 5.18: Raised syphon intake structure at Verdeling

5.5 Comparison of Sub-Options

The various sub-options were compared for each of the canal components discussed above as shown in **Table 5.13**. The comparative capital costs, constructability issues, and environmental and social impacts were considered.

Table 5.13: Comparison of sub-options

ID	Sub-Option	Cost	Practical Considerations	Environmental Impact	Social Impact
Intake Works (Section 5.4.1)					
O1	Existing outlet structure	No Cost – use as is	• Based on initial information, the existing outlet is sufficient for the increased flow	• No Impact. **This sub-option is preferred above the conversion of the disused buttress gate on the right bank.**	• None.
O2	Convert disused buttress gate to new structure	R 25 million	• Coffer dam/steel caisson on upstream side during construction. • Drill and grout in bars to existing structure. • Consolidation grouting. • The Bulshoek Weir is listed as a National Monument – there can be no visible modifications to the dam. • Blasting risks in close proximity to the existing structure – impact on structure itself, and impact on the founding rock mass in terms of creating and/or opening of fractures.	• NWA, Act 36 of 1998: Section 21(a), (b), (i). – Freshwater Impact Assessment – DWS risk assessment – Water Use License (WUL) application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. – EA for work undertaken within an active stream and potential impact on the aquatic environment. • NHRA, Act 25 of 1999: – Section 34 – altering of structures older than 60 years. • Dam safety regulations, 2012 – Apply for alteration of an existing dam with the Dam Safety Office (DSO) (as part of the Department of Water and Sanitation). – This requires the services of an Approved Professional Person (APP). – The APP will be responsible for the design work as well as application for a licence to construct from the DSO. – After completion of all construction work, the APP must submit a completion report, completion drawings and a completion certificate stating that the work has been completed according to his/her specifications.	• The Bulshoek Weir is listed as a National Monument.
Canal (Section 5.4.2)					
C1	New Right Bank Canal	R 828 million	• Blast through hard rock – conservation of stability of blasted faces required. • Large cut sections.	• NWA, Act 36 of 1998: Section 21(c) & (i). – Freshwater Impact Assessment – DWS risk assessment – WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended.	• Negotiate servitude with landowner. • Existing canal system can remain operational

ID	Sub-Option	Cost	Practical Considerations	Environmental Impact	Social Impact
			• Restricted access during construction. • Steep slopes along cliff.	− EA for work undertaken within close proximity to a river, riparian zone and associated wetlands and the removal of indigenous terrestrial vegetation. − Freshwater and Botanical impact assessment • NHRA, Act 25 of 1999: Section 38 (a) & (c) – construction of a canal of more than 300 m and changing the characteristics of a site: − Heritage Impact Assessment − Authorisation from Heritage Western Cape (HWC).	throughout construction duration.
C2	Existing Left Bank Canal (first 3 km) connecting to New Right Bank Canal	R 815 million	• Use existing access road. • Excavation mostly done. • Exercise caution when blasting adjacent to the already-week left bank canal. • Remove existing canal lining. • Widen for increased capacity. • Build new main canal to modern standards. • Temporary pumping to downstream section of existing main canal.	• NWA, Act 36 of 1998: Section 21(c) & (i). − Freshwater Impact Assessment − DWS risk assessment − WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. − EA for expansion work undertaken within close proximity to a river, riparian zone and associated wetlands. • NHRA, Act 25 of 1999: − Section 34 – altering of structures older than 60 years. • With regards to the temporary pumping: − There will be no impact on the river abstraction volumes compared to the existing scheme; − There will be no physical alterations to the river bank as no permanent structure will be installed; − If a diesel generator is used, it will need to be contained in a bunded area to prevent spillage of hydrocarbons in the river. **This sub-option is preferred above the construction of a new outlet to the canal on the right bank and replaces the steep cliff section of the right bank canal.**	• None.
Syphon 1 (Section 5.4.3)					
S1A	Syphon at the Bulshoek Weir	R 20 million	• Tying into existing canal structure. • Consider impacts of blasting – reduce where possible.	• NWA, Act 36 of 1998: Section 21(b), (c) & (i). − Freshwater Impact Assessment − DWS risk assessment − WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. − EA for work undertaken within an active river and riparian	• None.

ID	Sub-Option	Cost	Practical Considerations	Environmental Impact	Social Impact
				zone. • NHRA, Act 25 of 1999: Section 38 (c) – changing the characteristics of a site should structures exceed 5000 m²: – Heritage Impact Assessment – Authorisation from HWC.	
S1B	Syphon installed 3 km downstream of the Bulshoek Weir	R 23 million	• Tying into existing structure. • Steep slopes. • Possible ridge piers in river • Possible concrete encasement under river	• NWA, Act 36 of 1998: Section 21 (b), (c) & (i). – Freshwater Impact Assessment – DWS risk assessment – WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. – EA for work undertaken within an active river and riparian zone. • NHRA, Act 25 of 1999: Section 38 (a) & (c) – construction of pipe exceeding 300 m in length and changing the characteristics of a site should surface structures exceed 5000 m²: – Heritage Impact Assessment – Authorisation from HWC. **This sub-option is preferred above the syphon below the Bulshoek weir and construction of new canal on the right bank along the steep cliff section (3 km).**	• Negotiate servitude with landowner.
Syphon 2 (Section 5.4.4)					
S2A	548 m long syphon with canal between existing dams	R 365 million	• Construction through non-perennial river. Construction during dry winter periods. • Limited working space between existing farm dams. • Long extra sections of canal (8.2 km). • Canal needs to traverse steep sections downstream of syphon. • Very deep canal cut sections to avoid dams	• NWA, Act 36 of 1998: Section 21 (b), (c) & (i). – Freshwater Impact Assessment – DWS risk assessment – WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. – EA for work undertaken within a stream and riparian zone and removal of indigenous terrestrial vegetation. – Freshwater and Botanical impact assessments • NHRA, Act 25 of 1999: Section 38 (a) – construction of pipe exceeding 300 m in length: – Heritage Impact Assessment – Authorisation from HWC.	• Negotiate servitude with landowner. Landowner intends to sell property. • Illegally built dams. • Disruption of farm infrastructure.

ID	Sub-Option	Cost	Practical Considerations	Environmental Impact	Social Impact
			(>10 m) • Substantial earthworks, especially in cut. There is no way to balance cut/fill locally. • Excavatability concerns and stability of high cut slopes.		
S2B	1.3 km long syphon	R 114 million	• Construction through non-perennial river. • Construct half a section of the syphon at a time. • Extra portions of canal needed (1.5 km). • Canal through steep hill downstream of syphon – substantial earthworks.	• NWA, Act 36 of 1998: Section 21 (b), (c) & (i). − Freshwater Impact Assessment − DWS risk assessment − WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. − EA for work undertaken within a stream and riparian zone and removal of indigenous terrestrial vegetation. − Freshwater and Botanical impact assessments • NHRA, Act 25 of 1999: Section 38 (a) – construction of pipe exceeding 300m in length: − Heritage Impact Assessment − Authorisation from HWC. **This sub-option is preferred above the short syphon with canal between existing dams and the 2.2 km long syphon. The shorter distance of pipeline installation, indigenous vegetation disturbance and construction through the Doring River where there is existing agricultural disturbance might cause less of an impact on the natural environment.**	• Negotiate servitude with landowner/s. • Disruption of farm infrastructure.
S2C	2.2 km long syphon	R 108 million	• Construction through non-perennial river. • Construct half a section of the syphon at a time. • No canal through steep sections. • More head loss due to longer syphon. • No extra portions of	• NWA, Act 36 of 1998: Section 21 (b), (c) & (i). − Freshwater Impact Assessment − DWS risk assessment − WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. − EA for work undertaken within a stream and riparian zone and removal of indigenous terrestrial vegetation. − Freshwater and Botanical impact assessments • NHRA, Act 25 of 1999: Section 38 (a) – construction of pipe exceeding 300 m in length:	• Negotiate servitude with landowner/s. • Disruption of farm infrastructure.

ID	Sub-Option	Cost	Practical Considerations	Environmental Impact	Social Impact
			canal needed.	– Heritage Impact Assessment – Authorisation from HWC.	
S2B+S2D	1.3 km long syphon plus additional 0.8 km long syphon	R 127 million	• Construction through non-perennial river. • Construct half a section of the syphon at a time. • Syphon through steep hill downstream of syphon	• NWA, Act 36 of 1998: Section 21 (b), (c) & (i). – Freshwater Impact Assessment – DWS risk assessment – WUL application • NEMA, Act 107 of 1998: 2014 EIA Regulations, as amended. – EA for work undertaken within a stream and riparian zone and removal of indigenous terrestrial vegetation. – Freshwater and Botanical impact assessments • NHRA, Act 25 of 1999: Section 38 (a) – construction of pipe exceeding 300 m in length: – Heritage Impact Assessment – Authorisation from HWC. **This sub-option will have similar environmental impact as sub-option S2B and is thus preferred above the short syphon with canal between existing dams (S2A) and the 2.2 km long syphon (S2C).**	• Negotiate servitude with landowner/s. • Disruption of farm infrastructure.
Existing Syphon (Section 5.4.5)					
E1	Existing syphon at Verdeling	R 9 million	• Modifications to existing right bank syphon inlet. • Temporary pumping to existing right bank canals.	• NHRA, Act 25 of 1999: – Section 34 – altering of structures older than 60 years.	• None.

Various permutations of the sub-options can be compared to determine which results in the most suitable overall Right Bank Canal. The possible permutations and total comparative cost of each are provided in **Table 5.14**.

Table 5.14: Permutations of sub-options and costing

#	O1	O2	C1	C2	S1A	S1B	S2A	S2B	S2C	S2B + S2D	E1	Cost (R million)
Cost per sub-option	R 0 m	R 25 m	R 828 m	R 815 m	R 20 m	R 23 m	R 365 m	R 114 m	R 108 m	R 127 m	R 9 m	
1	X		X		X		X				X	R 1222 m
2	X			X		X	X				X	R 1212 m
3		X	X				X				X	R 1227 m
4	X		X		X			X			X	R 971 m
5	X			X		X		X			X	R 961 m
6		X	X					X			X	R 976 m
7	X		X		X				X		X	R 965 m
8	X			X		X			X		X	R 955 m
9		X	X						X		X	R 970 m
10	**X**			**X**		**X**				**X**	**X**	**R 974 m**

Permutations no. 4 to 10 have similar overall comparative costs (less than 5% difference). Other factors, besides cost, therefore need to be considered to select the preferred option. The preferred sub-options in **Table 5.13** indicates that Permutation no. 10 is recommended as the combination of sub-options for the Right Bank Canal scheme to be designed further at feasibility level.

Reasons for preferring Permutation no. 10 include:

- Using the left bank existing outlet is preferred over building a new outlet on the right bank of the Bulshoek Weir;
- Upgrading a 3 km reach of the existing left bank canal is preferred over constructing a new canal on difficult, steep slopes in an existing national road servitude on the right bank. This will also have a lower environmental impact;

- For the syphon crossing at the Doring River, syphon S2B+S2D is preferred over siphons S2B and S2C because of difficult, steep sandy slopes on the right bank of the Doring River.
- Syphon S2B+S2D will allow for easier maintenance and inspection compared to syphon S2C;
- Using syphon S2B+S2D will ensure consistent canal cross-sections (trapezoidal) and syphon types (rectangular concrete culvert);
- Syphon S2B+S2D will have a similar environmental impact as the syphon S2B sub-option.

This permutation has a comparative capital cost of R 974 million. The feasibility design of the proposed Right Bank Canal scheme will be described in the *Right Bank Canal Design Sub-Report* of this study.

5.6 Scheme Features

The recommended Right Bank Canal Scheme is shown in **Figure 5.19**. The scheme infrastructure is designed for a flow of 11.4 m^3/s throughout. The scheme uses the existing outlet works from the Bulshoek Weir and requires upgrading of the first three km of the existing Left Bank Canal, where it then crosses the Olifants River to connect into the new Right Bank Canal. The Right Bank Canal continues until it reaches the existing syphon at Verdeling, with a new 1.3 km syphon crossing plus a new 0.8 km syphon at the Doring River.

This Right Bank Canal will supply the existing scheme downstream of Verdeling and the four significant potential irrigation areas in the Trawal region.

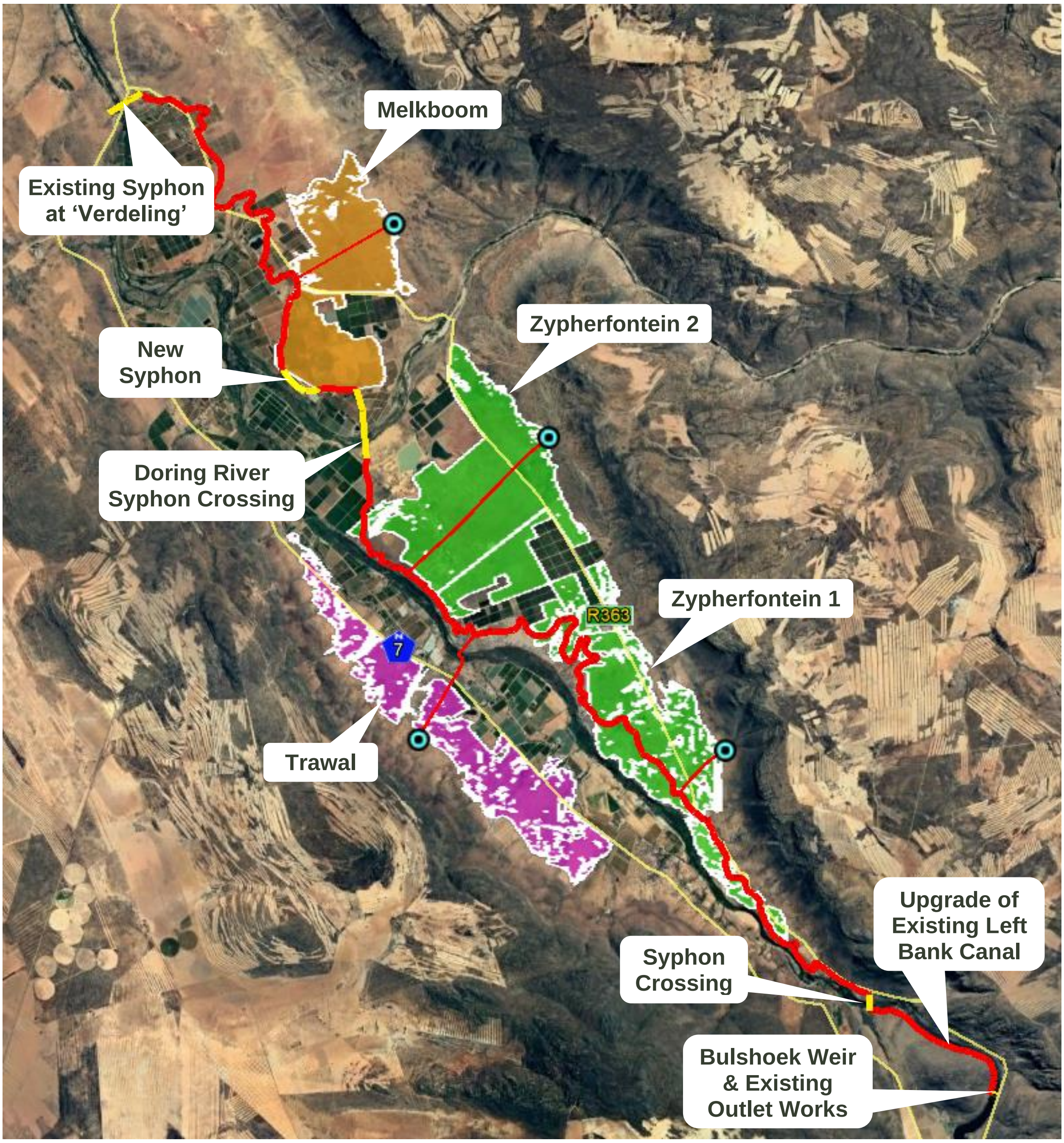

Figure 5.19: Layout of the recommended Right Bank Canal Scheme

5.7 Scheme Design and Costing

Several permutations were considered, and options evaluated to supply the four significant potential irrigation areas in the Trawal region, i.e. the so-called Zypherfontein 1 and 2, Trawal and Melkboom irrigation areas. Two of the conveyance options that were evaluated, instead of the Right Bank Canal Scheme, are the following:

- *Trawal Scheme supplied from river* (previously referred to as Option 10). This scheme entails flows released at Bulshoek Weir and pumped from the Olifants River: Water released from Bulshoek Weir down the Olifants River and pumped from the river to the scheme on the left bank, above the Doring River confluence. The irrigable area is 510 ha.
- *Small right bank canal supplying three areas* (previously referred to as Option 14b). This scheme includes supply to the Zypherfontein 1, Zypherfontein 2 and Melkboom irrigation areas. Water will be released from Bulshoek Weir via an 8 km section of the raised and lined existing main canal, then pumped and conveyed via a pipeline and a syphon crossing the Olifants River to the right bank, to a new small high-level canal supplying the three irrigation areas under gravity. The total irrigable area is 1 829 ha.

Should a new Right Bank main canal not be constructed, these would have been the preferred schemes to supply these irrigation areas, as documented in the *Suitable Areas for Agricultural Development Report* of this study. The attributable development cost of the four Trawal schemes is thus the combined cost of these two potential irrigation schemes. The water requirements of these potential schemes were updated, the design of these schemes revisited, and the costs updated to 2020 costs.

The water requirements of Options 10 and 14b are as shown in **Table 5.15**.

Table 5.15: Water requirements for Options 10 and 14b

Option/s	10	14b	10 + 14b
Water requirement (million m^3/a)	4.87	17.46	22.31

The comparative capital cost (2020 prices, excluding VAT) of the potential schemes are shown in **Table 5.16**. The development costs for comparison with the total scheme development of the Right Bank Canal has been assumed to be equal to the development costs of (Option 10 + Option14b), as shown in **Table 5.16**.

Table 5.16: Comparative Development Capital Costs in million Rand

Conveyance Option	Pump stations	Pipelines & syphon	Farm dams	Raising/lining of 8km main canal (betterment portion)	High-level small canal	Purchase of land	Prof. design & support	Total Capital Cost
Option 10	39.51	16.16	1.59	0	0	13.16	14.45	**84.87**
Option 14b	113.53	67.70	25.83	49.53	122.70	53.15	55.84	**488.29**
Options 10+14b	**153.04**	**83.86**	**27.42**	**49.53**	**122.70**	**66.32**	**70.29**	**573.16**

The water requirements of the Right Bank Canal Scheme, which includes pumped supply from the new canal to the individual farm dams of the four irrigation areas (**Figure 5.19**), were updated, the reconnaissance-level design of the scheme revisited, and the costs updated to 2020 costs. The comparative capital cost (2020 prices, excluding VAT) of the Right Bank Canal Scheme is shown in **Table 5.17**.

Table 5.17: Right Bank Canal Scheme Comparative Capital Costs in million Rand

Development Costing	Pump stations	Pipelines & syphon	Farm dams	New RB main canal (all inclusive)	Purchase of land	Prof. design & support	Total Cost
Right Bank Canal	99.24	105.45	26.99	974.00	69.65	200.28	**1 475.61**

The cost values for these options are given in **Table 5.18**. The betterment costs are the difference between the development costs (option 10 + option 14b) and the cost of the Right Bank Canal Scheme.

Table 5.18: Cost Values in R/m³ at 8% discount rate

Cost Item	Development costs - options 10 & 14b	Right Bank canal + 4 schemes	Betterment costs
Total comparative capital cost (R million)	573.16	1 475.61	902.45
Total NPV Cost (R million)	782.28	1 500.98	718.70
Unit Reference Value (R/m³)	**3.05**		

While the total Right Bank Canal Scheme will have a comparative capital cost of R 1 475.6 million, an amount of R 573.2 million is attributable to development capital costs of the four irrigation areas.

5.8 Construction Materials

For this Right Bank Canal Scheme, consideration would have to be given to various construction materials.

Concrete elements would require suitable coarse and fine aggregate. The hard rock quarry used for construction of Bulshoek Weir lies within the basin and would present practical problems if considered for re-opening. One of the issues would be that the left bank forms the Rondeberg Oord Private Nature Reserve, and a new quarry in the vicinity would be an unlikely option. In theory, it is expected that potential hard rock quarry sites could be identified in the vicinity of the North Bank Canal routing, specifically on the eastern bank of the Olifants River, but whether this would be desirable or economically viable for the relatively small volumes is questionable. A hard rock quarry will be established for the raising of Clanwilliam Dam, and this might be another potential source of aggregate to consider, alternatively other commercial sources might be considered.

Local sources of sand for concrete manufacture are likely to be identified in the area.

5.9 Operational Aspects

Once the proposed Right Bank Canal has been completed, it is proposed that the existing main canal (Trawal canal section), on the left bank of the Olifants River, continues to supply the existing irrigators and proposed additional irrigators on the left bank of the Olifants River, between Bulshoek Weir and Verdeling, as an interim measure.

In the short- to medium-term, the Right Bank Canal would then supply all current irrigation supplied via the existing main canal, except for the current irrigators located on the left bank of the Olifants River, between Bulshoek Weir and Verdeling. All new irrigation (from additional allocations following the raising of Clanwilliam Dam) that is not taken up upstream of and including Bulshoek Weir will be supplied via the Right Bank Canal, except for additional irrigation to be located on the left bank of the Olifants River, between Bulshoek Weir and Verdeling.

In the long-term, the Right Bank Canal would supply all existing irrigation currently supplied via the existing main canal, as well as all new irrigation (following the raising of Clanwilliam Dam) that is not taken up upstream of and including Bulshoek Weir.

5.10 Affected Land and Infrastructure

5.10.1 Bulshoek Weir

It is expected that the DWS will be the owner of the scheme and that it will be operated by the LORWUA. Thus, no issues are foreseen with additional water supply from the Bulshoek Weir.

5.10.2 Existing Left Bank Canal

Upgrading of the existing Left Bank Canal (3 km) will require the use of the existing access road during construction.

5.10.3 R363 Road

The proposed Right Bank Canal will cross the existing R363 Road at various sections and it will be located next to the road in some sections. The R363 Road belongs to the Western Cape Department of Transport and Public Works. Approval will be required from the provincial roads department for the road crossings and possible construction works in the road reserve.

5.10.4 Farm Owners

The horizontal alignment for the proposed Right Bank Canal runs through private property owned by farmers. Acquisition of land for the canal will need to be negotiated with these landowners.

5.10.5 Existing Syphon at Verdeling

No issues are expected with obtaining permission from the DWS and the LORWUA for modifications required on the existing syphon at Verdeling to allow flow in the syphon to be reversed.

6 Ebenhaeser Scheme

This section provides an overview of the design of the proposed Ebenhaeser Scheme.

6.1 Ebenhaeser Community Property

The existing Ebenhaeser Community Project is located approximately 12 km from Lutzville. Ebenhaeser is scheduled under LORWUA for 257 ha of water use entitlements, which needs to be distributed to 153 plots (1.68 each) plus a commercial farmer with 8.6 ha. The water is delivered to an existing balancing dam at the end of the canal system. A pumped scheme to deliver the water under pressure is currently being constructed. It is proposed (and there is already a planned layout of plots) that the area on this land will be expanded by at least 170 hectares. Some of this will replace land that cannot be rehabilitated and for which water is already scheduled. There is also other land that could be irrigated in the vicinity.

6.2 Ebenhaeser Land Claim

The successful land claim lodged by the Ebenhaeser Community has resulted in thirteen farm parcels being handed over to Ebenhaeser Community Project Association during March 2019; with further farms to be handed over in future (44 farms are part of the longer-term restitution deliberations). The water allocations to these farms are currently inadequate. For example, there is a 14 ha farm with no water allocation, and a 62 ha farm with a 13 ha allocation.

The community has noted that in 1925 the government promised the people from Ebenhaeser access to 500 morgen (about 400 hectares) of irrigation water, which has to date not been honoured. The expectation from the Ebenhaeser community is therefore that they receive priority.

6.3 Spare Capacity in canal sections

Historical weekly flows (2006/07 to 2018/19) for the canal sections were obtained from LORWUA, which includes allowance for canal losses. Both the left bank and right bank canal sections have some spare capacity, due to the seasonal pattern of flow releases to irrigators, although this is very limited to non-existent during the summer months. The spare flow capacity per week was calculated for each canal section, by comparing the historical flows in canal sections with the maximum flow capacity of each canal section.

Maximum weekly flow capacities, as provided by LORWUA, are shown in **Table 6.1**.

Table 6.1: Maximum flow capacities in canal sections

Canal section	Capacity (m^3/h)	Capacity (m^3/s)
Sandkraal	2 794	0.776
Vredendal	6 516	1.810
Naauwkoes	9 740	2.706
Koekenaap	4 100	1.139
Retshof	5 313	1.476
Karoovlakte	8 895	2.471
Klawer	9,635	2.676
Doring River	920	0.256
Trawal (Main)	26 007	7.224

It was established that additional flows can be released from Bulshoek Weir during weeks when there is spare flow capacity in the canal sections, to be diverted at identified diversion points for storage and use. This is shown for the Vredendal canal section, as an example, in **Table 6.2**, where week 1 is the first week in October of each historical year. Years in which there were more severe water restrictions because of droughts are less useful, and cannot be used for planning, as they give the impression of significant spare capacity, which is not the case. This applies for the immediate years following the last year (2015/16) shown in **Table 6.2**.

From the table, it is evident that there were many weeks without flow. This is normally an indication of ‘dry weeks’ without flow, to undertake maintenance of the canals. In a few cases this is due to canal breakage or possibly other maintenance problems, although this is often only a portion of a week. A week during the summer peak season (November to March), where a canal section seems to have significant spare capacity, is an indication that the data should be treated with caution. During the evaluation of canal spare capacity for the sub-options (described in the following sub-section), adjustments were made to some weekly spare capacity flow values. To consider the diversion of flows, a peak period, where there would likely be a continuous shortfall in irrigation supply, needs to be identified.

Table 6.2: Example of historical canal flows and spare flow capacity in the Vredendal canal section

VREDENDAL CANAL SECTION: HISTORICAL FLOWS										
Week	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
1	555,363	572,333	560,871	565,880	622,904	728,393	546,683	342,036	519,102	431,934
2	641,210	569,417	620,325	722,196	701,204	809,271	692,969	404,420	611,664	451,620
3	814,563	677,444	773,982	856,004	709,034	1,051,110	872,937	632,684	677,052	536,892
4	871,101	820,760	883,953	917,245	771,728	688,649	811,364	667,724	715,392	543,204
5	891,513	911,966	897,480	964,386	925,992	938,210	909,981	766,976	762,606	556,332
6	906,809	923,967	988,254	934,241	1,006,493	999,000	1,028,147	731,835	719,652	604,380
7	1,010,975	937,076	1,328,300	786,348	1,150,767	1,168,190	1,052,231	1,107,439	657,624	604,752
8	1,007,276	1,015,274	1,124,847	950,781	1,123,740	997,245	1,255,042	1,030,307	817,302	606,864
9	1,002,780	1,010,637	1,201,770	973,350	1,129,410	1,047,708	1,107,756	1,083,578	838,554	610,485
10	1,091,475	1,075,329	1,273,995	1,079,406	1,179,428	1,139,684	1,015,254	1,036,868	873,012	655,308
11	1,175,784	1,092,110	1,334,124	1,132,299	578,016	1,150,362	1,055,835	1,070,078	903,936	679,764
12	1,146,555	1,146,235	1,409,273	1,358,967	244,895	1,355,688	1,277,583	1,256,278	910,992	690,102
13	1,084,091	1,067,148	1,339,875	1,163,444	1,065,299	1,112,981	1,146,231	1,140,453	893,886	638,448
14	1,130,990	1,085,630	1,325,214	1,107,594	1,202,256	1,147,527	1,063,773	1,128,317	902,826	691,818
15	1,159,812	1,130,355	1,360,962	1,187,622	1,217,660	1,160,352	1,101,911	1,161,959	407,310	754,686
16	1,147,195	1,151,510	1,398,352	1,191,389	1,352,583	1,378,025	1,287,868	1,237,124	500,286	690,408
17	1,122,728	1,380,249	1,352,592	1,326,659	1,184,031	1,192,347	1,143,666	1,142,951	569,448	710,736
18	1,124,267	1,171,112	1,373,166	1,206,536	1,163,025	1,181,817	1,149,188	1,146,393	596,430	683,652
19	1,080,905	1,160,730	1,372,383	1,034,681	1,113,183	1,135,310	1,198,274	1,121,688	956,202	620,958
20	1,030,469	1,162,160	1,355,697	1,166,400	1,258,123	1,332,399	1,156,626	1,092,812	882,180	647,286
21	979,656	1,074,438	1,496,759	1,312,139	1,081,202	1,094,594	1,275,592	1,276,947	881,130	599,658
22	960,053	1,038,623	1,360,962	1,123,983	1,054,715	1,061,924	1,055,147	1,104,989	810,114	0
23	948,794	936,671	1,323,999	1,153,062	1,029,591	1,043,888	1,035,153	1,076,544	781,770	522,264
24	920,201	1,149,448	1,262,844	1,114,412	1,217,066	975,645	1,029,861	1,057,050	790,434	504,036
25	963,553	885,560	537,116	432,944	996,125	1,160,838	1,156,861	1,162,083	768,330	561,264
26	885,465	923,117	1,160,460	594,405	943,583	859,653	953,397	972,905	758,694	49,266
27	806,180	308,490	1,131,057	644,045	969,543	788,454	907,349	916,313	690,396	596,646
28	834,246	889,475	985,986	1,106,163	954,396	762,318	795,960	907,916	672,336	44,616
29	823,825	876,191	1,366,700	1,166,994	1,133,198	852,701	882,388	1,168,314	704,352	535,830
30	691,281	765,530	1,149,120	1,032,561	0	703,310	0	0	608,028	0
31	667,022	0	1,120,068	910,562	0	0	0	0	532,314	381,720
32	0	0	909,306	0	848,651	0	836,285	925,466	0	0
33	10,917	751,883	167,090	0	0	664,187	0	0	36,822	0
34	658,841	42,838	0	950,130	24,324	0	36,950	48,346	284,898	0
35	0	0	870,480	0	822,623	42,039	924,804	894,456	0	0
36	0	777,519	0	0	0	654,426	0	0	36,822	24,300
37	697,559	0	0	872,073	0	0	0	0	284,898	324,552
38	6,068	33,241	1,121,518	0	713,651	0	708,357	713,313	0	0
39	0	733,253	719,388	28,852	0	854,901	0	0	36,822	48,444
40	588,263	0	527,580	776,669	0	0	0	50,944	284,898	495,636
41	529,592	0	0	0	728,933	0	767,246	810,162	0	0
42	10,477	410,882	137,511	0	796,608	787,725	0	22,316	44,394	56,622
43	0	0	692,199	869,430	781,812	20,588	27,036	0	512,886	594,030
44	741,636	0	787,590	0	0	0	878,526	804,762	0	0
45	523,058	690,201	0	0	0	940,572	0	0	49,794	54,372
46	13,264	609,444	75,946	1,060,790	1,015,457	0	0	0	572,658	663,288
47	0	12,459	1,053,243	1,027,781	842,346	33,494	938,064	883,643	0	0
48	786,578	0	946,647	0	0	949,091	0	0	56,550	53,466
49	848,529	853,592	0	0	0	919,188	0	0	845,208	831,822
50	834,584	666,887	0	1,150,754	1,177,551	932,742	873,504	1,102,788	0	800,058
51	924,048	808,110	1,279,314	1,210,937	1,175,364	1,101,060	920,984	1,103,814	58,116	808,134
52	1,170,447	994,934	1,374,867	1,185,989	1,332,896	1,387,187	1,091,958	1,269,059	833,964	846,486
53										845,970
Total Mm^3	37.820	36.294	46.833	40.350	39.339	40.305	37.969	37.574	26.652	22.652

SPARE FLOW CAPACITY										
Week	06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16
1	539,325	522,356	533,817	528,809	471,785	366,296	548,006	752,652	575,586	662,754
2	453,479	525,272	474,363	372,492	393,485	285,417	401,720	690,269	483,024	643,068
3	280,125	417,245	320,706	238,684	385,655	43,578	221,751	462,004	417,636	557,796
4	223,587	273,929	210,735	177,443	322,961	406,040	283,325	426,965	379,296	551,484
5	203,175	182,723	197,208	130,302	168,696	156,479	184,707	327,713	332,082	538,356
6	187,880	170,721	106,434	160,448	88,196	95,688	66,542	362,853	375,036	490,308
7	83,714	157,613	0	308,340	0	0	42,458	0	437,064	489,936
8	87,413	79,414	0	143,907	0	97,443	0	64,382	277,386	487,824
9	91,908	84,051	0	121,338	0	46,980	0	11,111	256,134	484,203
10	3,213	19,359	0	15,282	0	0	79,434	57,821	221,676	439,380
11	0	2,579	0	0	516,672	0	38,853	24,611	190,752	414,924
12	0	0	0	0	849,793	0	0	0	183,696	404,586
13	10,598	27,540	0	0	29,390	0	0	0	200,802	456,240
14	0	9,059	0	0	0	0	30,915	0	191,862	402,870
15	0	0	0	0	0	0	0	0	687,378	340,002
16	0	0	0	0	0	0	0	0	594,402	404,280
17	0	0	0	0	0	0	0	0	525,240	383,952
18	0	0	0	0	0	0	0	0	498,258	411,036
19	13,784	0	0	60,008	0	0	0	0	138,486	473,730
20	64,220	0	0	0	0	0	0	1,877	212,508	447,402
21	115,032	20,250	0	0	13,487	95	0	0	213,558	495,030
22	134,636	56,066	0	0	39,974	32,765	39,542	0	284,574	0
23	145,895	158,018	0	0	65,097	50,801	59,535	18,144	312,918	572,424
24	174,488	0	0	0	0	119,043	64,827	37,638	304,254	590,652
25	131,135	209,129	557,572	661,744	98,564	0	0	0	326,358	533,424
26	209,223	171,572	0	500,283	151,106	235,035	141,291	121,784	335,994	0
27	288,509	786,198	0	450,644	125,145	306,234	187,340	178,376	404,292	498,042
28	260,442	205,214	108,702	0	140,292	332,370	298,728	186,773	422,352	0
29	270,863	218,498	0	0	0	241,988	212,300	0	390,336	558,858
30	403,407	329,158	0	62,127	0	391,379	0	0	486,660	0
31	427,667	0	0	184,127	0	0	0	0	562,374	712,968
32	0	0	185,382	0	246,038	0	258,404	169,223	0	0
33	0	342,806	927,599	0	0	430,502	0	0	0	0
34	435,848	0	0	144,558	0	0	0	0	809,790	0
35	0	0	224,208	0	272,066	0	169,884	200,232	0	0
36	0	317,169	0	0	0	440,262	0	0	0	0
37	397,130	0	0	222,615	0	0	0	0	809,790	770,136
38	0	0	0	0	381,038	0	386,331	381,375	0	0
39	0	361,436	375,300	0	0	239,787	0	0	0	0
40	506,426	0	567,108	318,020	0	0	0	0	809,790	599,052
41	565,097	0	0	0	365,756	0	327,443	284,526	0	0
42	0	683,806	957,177	0	298,080	306,963	0	0	0	0
43	0	0	402,489	225,258	312,876	0	0	0	581,802	500,658
44	353,052	0	307,098	0	0	0	216,162	289,926	0	0
45	571,631	404,487	0	0	0	154,116	0	0	0	0
46	0	485,244	0	33,899	79,232	0	0	0	522,030	431,400
47	0	0	41,445	66,907	252,342	0	156,624	211,046	0	0
48	308,111	0	148,041	0	0	145,598	0	0	0	0
49	246,159	241,097	0	0	0	175,500	0	0	249,480	262,866
50	260,105	427,802	0	0	0	161,946	221,184	0	0	294,630
51	170,640	286,578	0	0	0	0	173,705	0	0	286,554
52	0	99,754	0	0	0	0	2,730	0	260,724	248,202
53										248,718
Total Mm^3	8.618	8.276	6.645	5.127	6.068	5.262	4.814	5.261	15.265	17.088

Following the raising of Clanwilliam Dam, existing irrigators will receive an increased assurance of supply. Up to 20.3 million m^3/a (25% of 84.4 million m^3/a) may be used by existing irrigators. This equates to an increased flow of 0.644 m^3/s, which is an 8.9% increase in current maximum flow. Such additional flows can be used by increasingly making use of spare canal capacity, which is already very limited, and then incrementally increased as further canal sections are upgraded. Until the additional canal sections have been upgraded though, calculations will be done with the proposed new Right Bank Canal in place, and with the capacities of the current downstream canal sections.

To allow for the likely increase in flows to existing irrigators *before* most of the canal infrastructure has been upgraded, and to limit the risk of shortfall in supply of the Ebenhaeser Scheme, it has been assumed that a maximum of 50% of current annual spare canal capacity may be abstracted for the Ebenhaeser Scheme. The calculation of spare capacity in canal sections will further not be based on average spare canal capacity, but will apply to a non-drought year where flows are high, i.e. potentially for a year that has the smallest spare capacity, to further limit the risk of a shortfall in supply to the Ebenhaeser Scheme.

Canal losses are a significant factor, and the following losses have been used in the calculations (source for existing canal losses was LORWUA):

- Current main canal (Trawal Section): 20%;
- Current left bank canal sections (Naaukoes, Vredendal and Sandkraal): 35%;
- Current right bank canal sections (Klawer, Karoovlakte, Retshof and Koekenaap): 20%; and,
- New right bank canal: 10%.

6.4 Canal abstraction rate and balancing dam sizing

An evaluation tool was developed in Excel to determine the abstaction volumes and abstraction patterns for the various identified sub-options.

The determination of the Ebenhaeser abstraction volume and patterns take into account:

- Weekly spare canal capacity (m^3/week), for the canal section being evaluated, over the selected evaluation year. For the left bank canal sections, 2012/13 was used for the evaluation and 2010/11 was used for the right bank canal sections, as weeks that best represent future conditions when the canals may experience increased flows. Dry weeks for canal maintenance have also been identified as weeks with no spare capacity.
- It has been assumed that the maximum annual diversion volume is 50% of annual spare capacity in a canal section, to allow for increased flows to existing irrigators once they have

an increased assurance of supply. It is expected that the patterns of usage of existing irrigators may slightly change as they plant more permanent crops and incraese winter use.

- The maximum annual flow that can be diverted from a canal section/s to a balancing dam, in excess of flows released to existing irrigators, minus evaporation losses from the dam, is the utilisable water volume. Canal losses are considered when calculating diversion flows.
- The distribution of the Ebenhaeser annual water requirement is done according to the monthly distribution of weighed monthly crop water requirements for sub-area 5, as determined in this study, from which a weekly water requirement is determined. The peak months are from November to March.
- Weekly distribution of evaporation is from S Class Pan.
- A relationship of dam storage to height for an off-channel balancing dam has been developed for initial assessments. Refined dam costs for specific dam sites have been calculated for the final sub-options considered.

A calculation is done to determine the minimum off-channel dam capacity (live storage) to store surplus canal flows and then use the stored water during the peak irrigation period (critical period), so that the dam just empties. An additional dead storage volume of 5% is added to determine the full supply volume of the dam.

Scheme irrigation is done in weekly cycles. Constant flows are typically released for 6-hourly periods, and released volumes have been calculated per week. Because the canal flows are released at a constant weekly rate, the abstraction rate from the canal should not exceed the release rate, as it will influence other irrigators. The maximum expected weekly flow that can be abstracted (over 7 full days) will then determine the maximum diversion flow rate from a canal section per week.

6.5 Identification of Sub-Options

Six sub-options were identified, namely:

- Divert from the end of Vredendal canal section, left bank canal;
- Divert from Retshof canal section, right bank canal;
- Combined scheme, diverting from end of Vredendal canal section, left bank canal and from Retshof canal section, right bank canal;
- Divert from Sandkraal canal section, left bank canal;
- Divert from Koekenaap canal section, right bank canal; and
- Combined scheme, diverting from Sandkraal canal section, left bank canal and from Koekenaap canal section, right bank canal.

These canal abstraction points are shown in **Figure 6.1**.

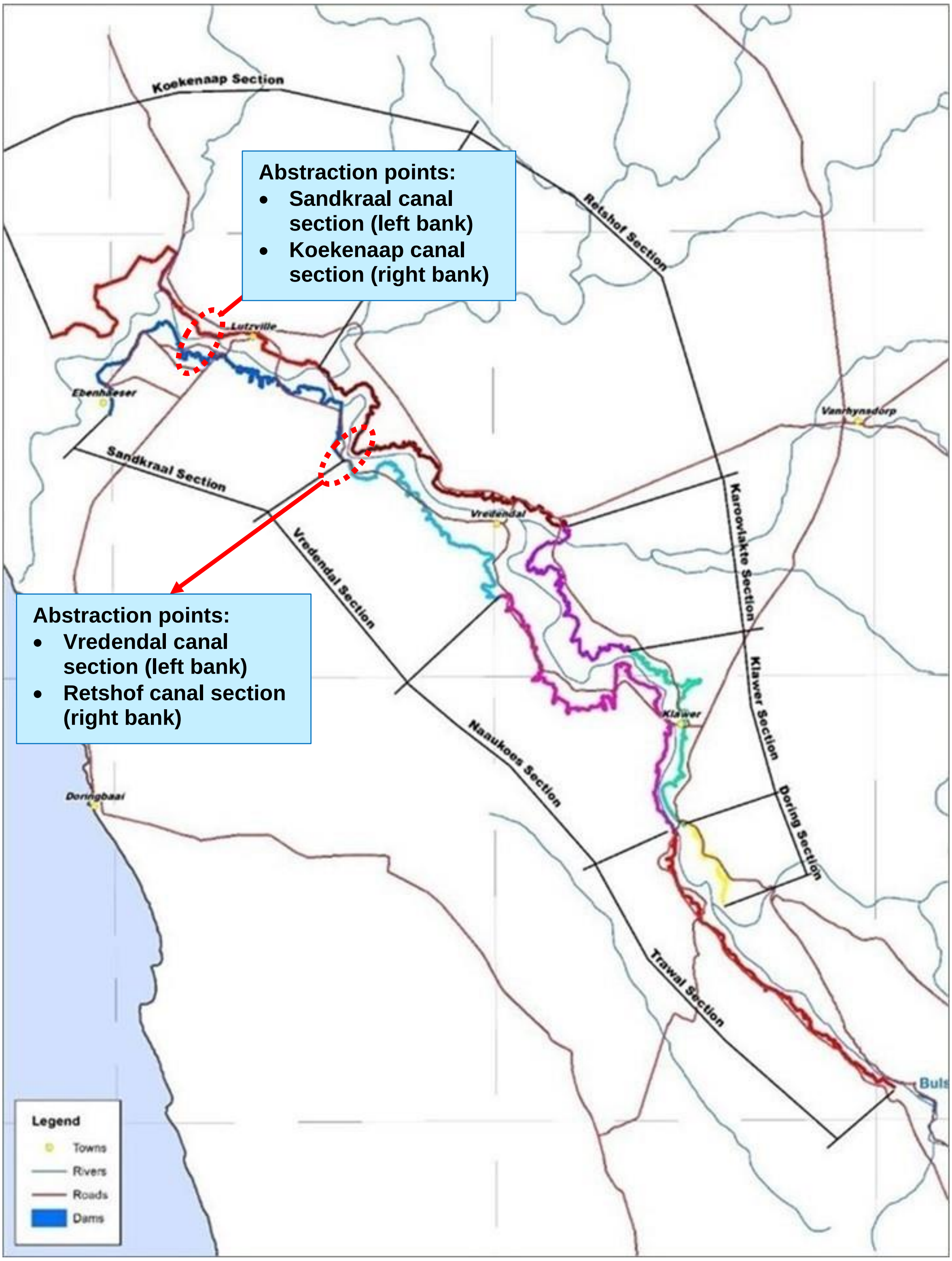

Figure 6.1: Potential abstraction points from existing canals for Ebenhaeser Scheme

An explanation of the use of the Excel Tool for evaluating the use of canal spare capacity, which was specifically developed for this purpose, has been included in **Appendix A**.

An evaluation of the six sub-options, with the Excel Tool for evaluating the use of spare canal capacity, yielded results as indicated in **Table 6.3**. The 'Water Requirement' is the usable volume after water has been diverted and stored in a balancing dam. The 'Balancing Dam capacity' is the minimum volume of storage required to store diverted flows, to be able to just meet irrigation water requirements. To determine the balancing dam capacity is an iterative exercise.

Table 6.3: Water requirements and balancing dam capacities

#	Sub-option	Water requirement (million m^3/a)	Balancing Dam capacity (million m^3)
1	Divert from end of Vredendal canal section, left bank canal	1.892	1.273
2	Divert from Retshof canal section, right bank canal	1.701	0.893
3	Combined scheme, diverting from end of Vredendal canal section, left bank canal and from Retshof canal section, right bank canal	3.650	2.152
4	Divert from Sandkraal canal section, left bank canal	0.849	0.588
5	Divert from Koekenaap canal section, right bank canal	2.085	0.861
6	Combined scheme, diverting from Sandkraal canal section, left bank canal and from Koekenaap canal section, right bank canal	2.968	1.454

At the 27 November 2019 meeting held with representatives of the Ebenhaeser Community Property Association and the Ebenhaeser Community Development Trust at Vaalkrans, representatives expressed support for Sub-option 3, the combined scheme diverting from the Vredendal and Retshof canal sections, as it provided the largest annual volume for irrigation. At that point, this sub-option was identified for design. At the PSC meeting 11 held on 11 March 2020, it was agreed that the relative scheme costs (along with other factors) should also be considered in selecting the sub-option to design.

From an evaluation of the findings as shown in **Table 6.3**, the following conclusions are drawn:

- Diverting only from left bank canal sections, sub-options 1 and 4, provide limited diversion volumes.
- It is not worthwhile considering the two right bank diversions, sub-options 2 and 5 on their own. Should water be pumped from the right bank diversion points, it would be conveyed past the potential left bank diversion points, and it makes sense to combine the diverted volumes.
- The following two sub-options will thus be further evaluated:
  - Sub-option 3: Combined scheme, diverting from the end of Vredendal canal section, left bank canal and from Retshof canal section, right bank canal,
  - Sub-option 6: Combined scheme, diverting from the Sandkraal canal section, left bank canal and from the Koekenaap canal section, right bank canal.

6.6 Water requirements

Five water requirement clusters (**Figure 6.2**) to augment the supply to restitution farms have been identified in consultation with community representatives. It has been assumed that the restitution farms, to be commercially farmed, will use 80% of the scheme's supply volume in four clusters (Clusters 1 to 4), at an aggregate water requirement of 12 000 m^3/ha/a, to match that of surrounding commercial farms. The remaining 20%, will be used for expansion of the Ebenhaeser Community Project irrigation area with smallholder plots (Cluster 5), at an aggregate water requirement of 8 437 m^3/ha/a. Significantly more land is available for irrigation, should water feasibly be conveyed to the area, both for restitution farms and expansion of community smallholder plots.

A leaching requirement of 20% has been added to the estimated water requirement to leach salts from greenfield soils for the first 5 years after establishment. As it is unknown to what extent this will apply for the restitution farms, this approach has not been adjusted. After 5 years, it has been assumed that a leaching requirement of 3% will be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

Water requirements and losses for the two sub-options are as shown in **Table 6.4**.

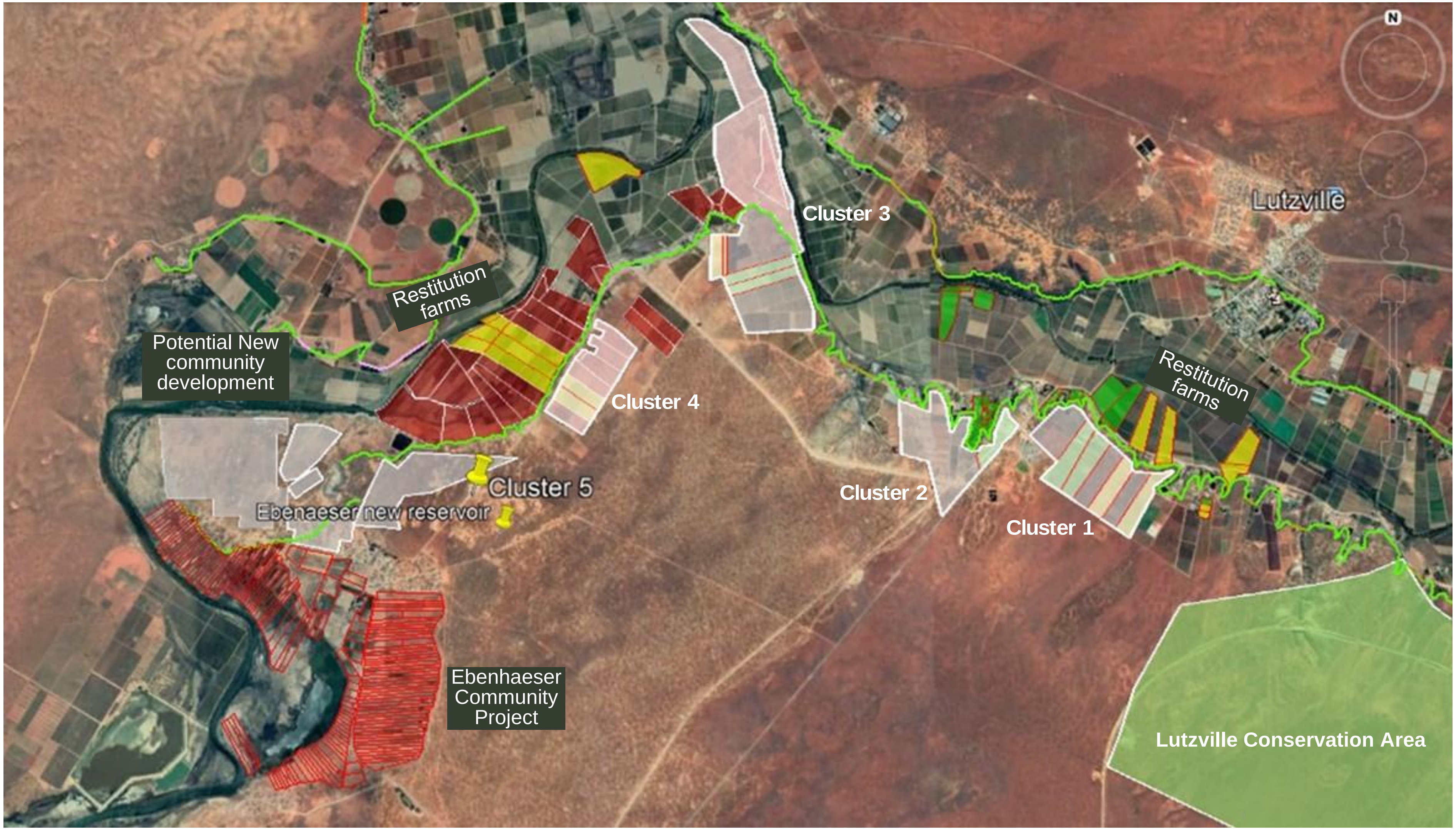

Figure 6.2: Ebenhaeser water requirement clusters

Table 6.4: Water requirements and losses of sub-options

#	Sub-option	Irrigable Area (ha)	Water Requirement (Mm^3/a)*	Total losses (Mm^3/a)	Requirement + Losses (Mm^3/a)
3	Vredendal-Retshof diversions	361	3.650	1.01	**4.66**
6	Sandkraal-Koekenaap diversions	293	2.968	0.75	**3.72**

** After accounting for conveyance losses and balancing dam evaporation*

The design of the two sub-options will be done to convey water to the edge (high point) of the water requirement clusters.

The losses are comprised of river losses from Clanwilliam Dam to Bulshoek Weir, and canal losses up to where the water is abstracted. Losses have been calculated for the situation after implementation of the Right Bank canal, as a combination of losses in the Right Bank canal (10%) and the relevant section where abstraction takes place. For left bank abstraction a combined loss factor of 20% has been used, and for right bank abstraction a combined loss factor of 15% has been used. Losses in the new Right Bank canal are assumed to be 10% of flow volume.

6.7 Scheme Overview and Components

Abstraction structures will be required at the canal off-takes, and small combined balancing capacity (12 hours) at the left bank canal off-take points. Canal flows will be diverted during weeks with surplus canal flow. From a right bank off-take, water will be pumped to the small combined balancing dam/reservoir at the left bank abstraction point, and water from the left bank canal will be diverted to the small combined balancing reservoir. From the small balancing reservoir/dam, water will be pumped to a lined earthfill balancing dam.

Two alternatives have been identified for sub-option 3 - Vredendal-Retshof diversion, namely:

a) Sub-option 3a, with the balancing dam located close to the left bank diversion point at a lower relevant level, at a site more suited to construct an earthfill dam. From the balancing dam, water will be pumped to a concrete balancing reservoir, from where water will gravitate to the edge of the water requirement clusters.
b) Sub-option 3b, with the balancing dam located higher up the hill, from where water will gravitate to the edge of the water requirement clusters.

Should sub-option 3 Vredendal-Retshof be the preferred sub-option, LORWUA has requested that balancing storage of 150 000 m^3 be added to the storage volume of the balancing dam, to be used for stabilising the operation of the lower sections of the right and left bank canals. This would mainly be a betterment cost.

For sub-option 3a, water will be pumped from the balancing dam to a concrete reservoir and gravitated to irrigators. For sub-option 3b, water will be gravitated from the balancing dam to irrigators. For sub-option 3b, water needs to be pumped twice, while water needs to be pumped three times for sub-option 3a.

Figure 6.3 and **Figure 6.4** show the layout and bulk water infrastructure components for sub-options 3a and 3b of the Vredendal-Retshof diversion respectively.

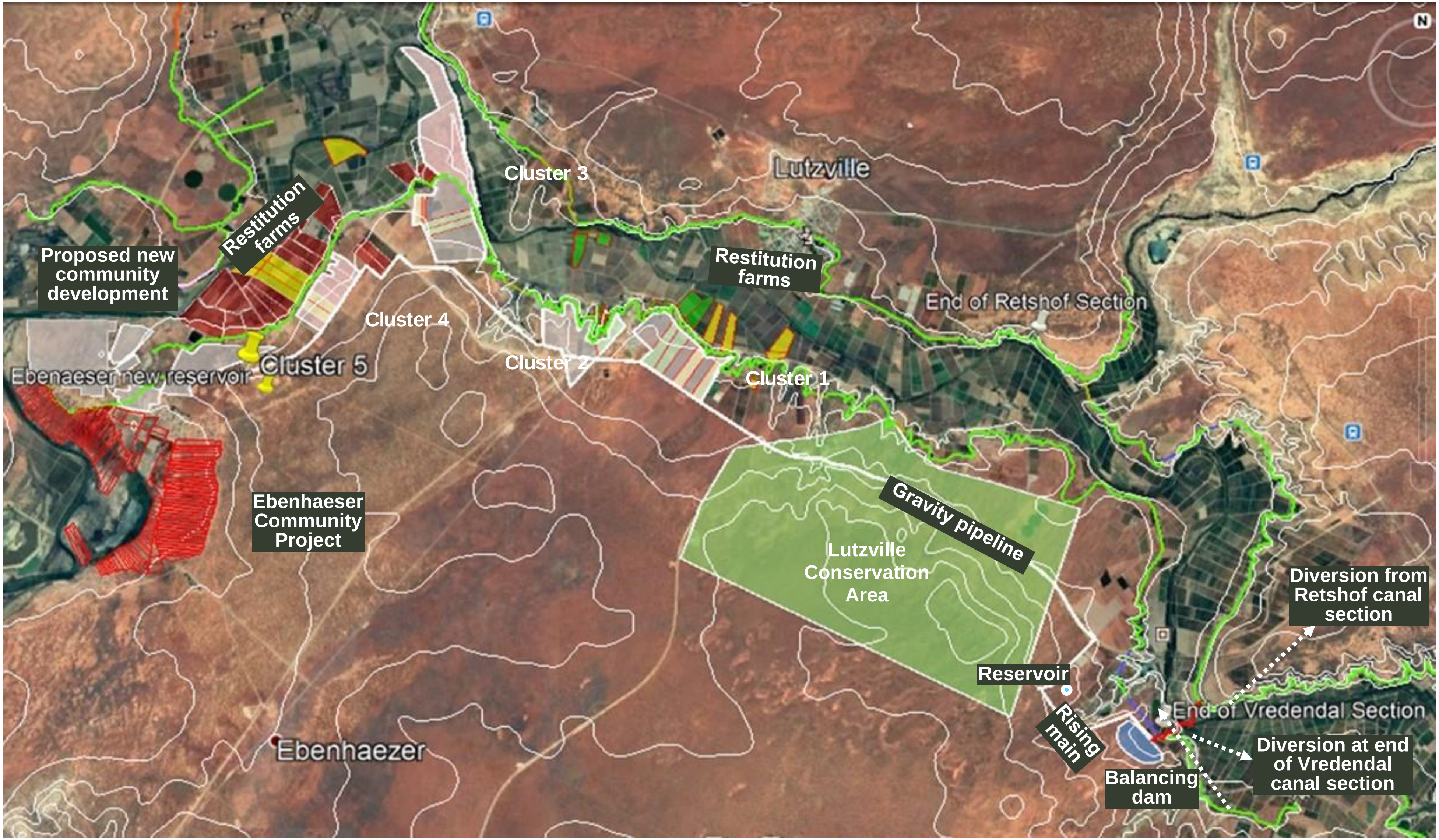

Figure 6.3: Layout of sub-option Vredendal-Retshof 3a

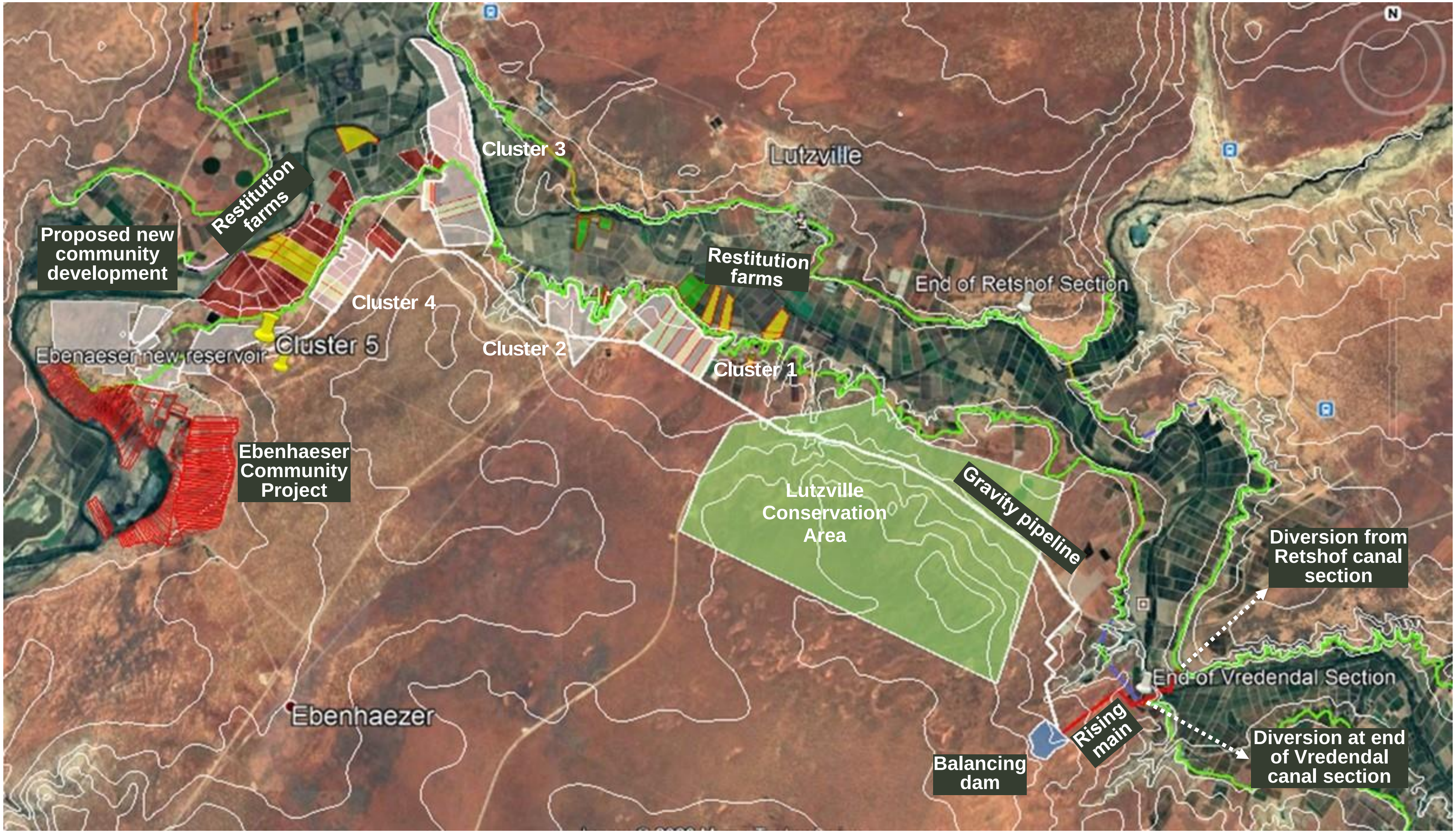

Figure 6.4: Layout of sub-option Vredendal-Retshof 3b

Two alternatives have been identified for sub-option 6 - Sandkraal-Koekenaap diversion, namely:

a) Sub-option 6a, with the balancing dam located close to the left bank diversion point at a lower relevant level. From the balancing dam, water will be pumped to a concrete balancing reservoir, from where water will gravitate to the edge of the water requirement clusters.
b) Sub-option 6b, with the balancing dam located higher up the hill, from where water will gravitate to the edge of the water requirement clusters.

For sub-option 6a, water will be pumped from the balancing dam to a concrete reservoir and gravitated to irrigators. For sub-option 6b, water will be gravitated from the balancing dam to irrigators. For sub-option 6b, water needs to be pumped twice, while water needs to be pumped three times for sub-option 6a.

Figure 6.5 and **Figure 6.6** show the layout and bulk water infrastructure components for sub-options 6a and 6b of the Sandkraal-Koekenaap diversion respectively.

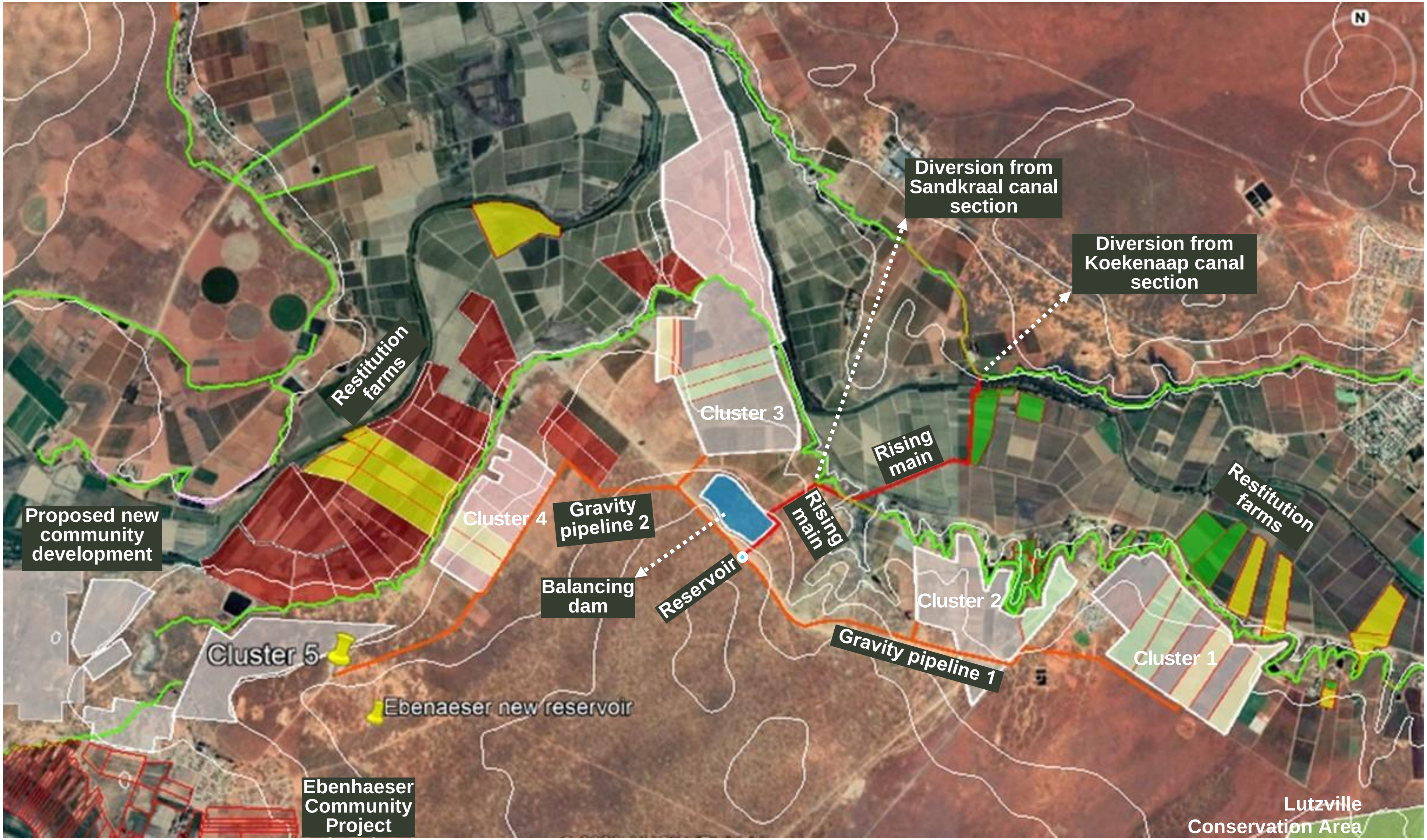

Figure 6.5: Layout of sub-option Sandkraal-Koekenaap 6a

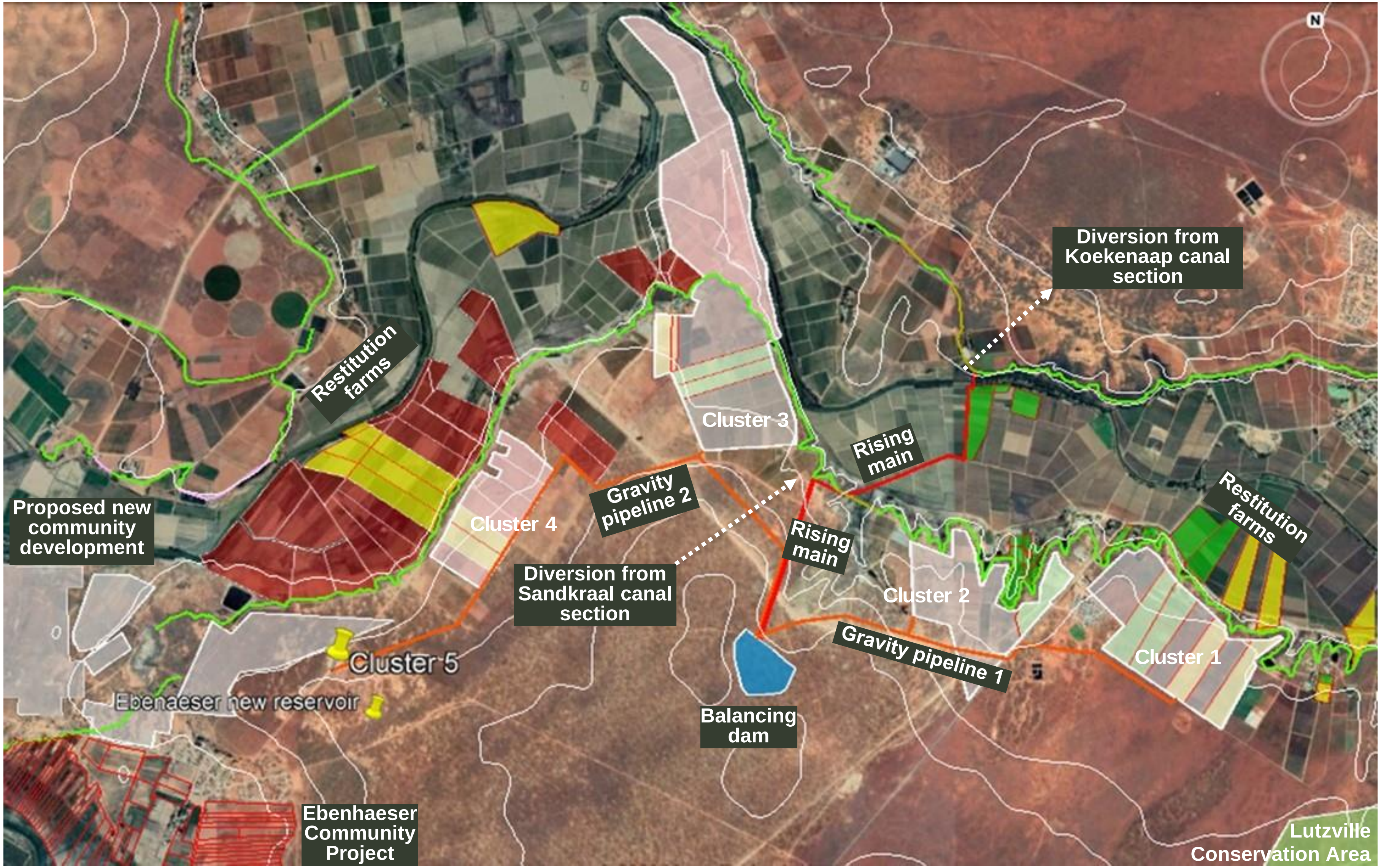

Figure 6.6: Layout of sub-option Sandkraal-Koekenaap 6b

6.8 Design and costing comparison

The comparative capital costs (2020 prices, excluding VAT) of the sub-options are shown in **Table 6.5**. The cost values for these options are given in **Table 6.6**.

Table 6.5: Sub-option Comparative Capital Costs in million Rand

Sub-option	Balancing dams	Pump stations	Pipelines & syphon	Reservoir	Purchase of land	Prof. design & support	Total Cost
3a Vredendal-Retshof lower dam	116.24	26.79	73.87	33.61	0.79	40.13	**291.42**
3b Vredendal-Retshof upper dam	160.26	35.66	86.71	-	0.67	45.22	**328.55**
6a Sandkraal-Koekenaap lower dam	103.80	23.00	22.20	29.24	0.79	29.79	**208.81**
6b Sandkraal-Koekenaap upper dam	79.05	23.16	29.76	-	0.67	21.18	**153.83**

Table 6.6: Sub-option Cost Values in R/m³ at 8% discount rate

Cost Item	3a Vredendal-Retshof lower dam	3b Vredendal-Retshof upper dam	6a Sandkraal-Koekenaap lower dam	6b Sandkraal-Koekenaap upper dam
Total comparative capital cost (R million)	291.42	328.55	208.81	153.81
Annual operating cost (R million/annum)	4.16	6.00	3.58	3.56
Total NPV Cost (R million)	327.57	387.91	243.53	194.40
Unit Reference Value (R/m³)	**7.75**	**9.17**	**7.08**	**5.65**

6.9 Comparison of sub-options

It is slightly less costly to site the balancing dam as low as possible, and then pump to a reservoir, from where water is gravitated to irrigators. This is because the design flow from the canal diversions to the balancing dam (combined diversion peak week flow) is much higher than the design flow from the balancing dam to the concrete reservoir (peak irrigation use week flow). The availability of more suitable balancing dam sites, and hence lower estimated costs, however has the biggest influence on the scheme cost.

Sub-option 3a is the more feasible of the two Vredendal-Retshof sub-options, mainly because of its less expensive balancing dam.

Sub-option 6b is the more feasible of the two Sandkraal-Koekenaap sub-options, mainly because of its less expensive balancing dam.

A comparison of sub-option 3a Vredendal-Retshof and sub-option 6a Sandkraal-Koekenaap is shown in **Table 6.7**.

Table 6.7: Comparison of sub-options 3a and 6b

Aspect	Comparison
Annual volume available for irrigation	The available volume for irrigation is 3.650 million m^3/a from the Vredendal-Retshof sub-option and 2.968 million m^3/a from the Sandkraal-Koekenaap sub-option. The Vredendal-Retshof sub-option can provide 23% more volume than the Sandkraal-Koekenaap sub-option can provide.
Scheme Cost	The Vredendal-Retshof sub-option is significantly more expensive, with the lifetime NPV cost of the scheme being comparatively 69% higher, capital cost 89% higher and URV 37% higher.
Risk of shortfall	As the abstraction points for the Sandkraal-Koekenaap sub-option are located further down-canal from Bulshoek Weir, in smaller canal sections, this scheme presents a comparatively higher risk of additional flows for Ebenhaeser not reaching the diversion points, due to increased requirements from existing irrigators, once they receive an improved assurance of supply.
Improved lower scheme operation	Sub-option 3 Vredendal-Retshof creates an opportunity to cost-effectively provide for additional balancing storage of 150 000 m^3 (mainly a betterment cost), to be used to stabilise the operation of the lower sections of the right and left bank canals.
Infrastructure located on private land	More of the bulk water infrastructure of the Sub-option 3 Vredendal-Retshof will be located on private land than the Sandkraal-Koekenaap sub-option.

The Vredendal-Retshof sub-option 3a (lower dam) is recommended for design, because of the following reasons:

- The volume available for irrigation is 23% higher than the volume available from the Sandkraal-Koekenaap diversion option, and the sub-option is strongly supported by the Ebenhaeser representatives,
- The scheme provides a lower risk of shortfall in supply. For the Sandkraal-Koekenaap sub-option, additional flow for the scheme would need to be routed via two additional existing canal sections (Sandkraal canal section on the left bank and Koekenaap canal section on the right bank) to diversion points, in comparison with the Vredendal-Retshof sub-option,

- In the longer-term canal sections will be incrementally improved or replaced to ensure the continued sustainability of the Lower Olifants River Government Scheme (LORGWS). Five canal sections (Naaukoes and Vredendal on the left bank and Klawer, Karoovlakte and Retshof) would need to be replaced to change the Vredendal-Retshof scheme from a scheme reliant on spare capacity to a normalised supply situation, where the design of new canal sections accounts for the additional irrigation flows, and reduces the risk of a shortfall in supply. This would be sooner than a normalised supply situation for the Sandkraal-Koekenaap can be achieved, as this would require the improvement or replacement of two additional canal sections (Sandkraal on the left bank and Koekenaap on the right bank).
- Environmental impacts are fairly similar, although the gravity pipeline of the Vredendal-Retshof sub-option would traverse the Lutzville Conservation Area, but the gravity pipeline will mainly follow a route within the Sishen-Saldanha railway reserve, so this is not expected to present much of a problem.
- The Vredendal-Retshof sub-option provides an opportunity to more cost-effectively provide for additional balancing storage betterment of 150 000 m^3 for operational purposes, to improve the operation of the lower left bank and right bank canal sections. These sections (Sandkraal and Koekenaap canal sections) are located far from Bulshoek Weir and water released from Bulshoek Weir takes a very long time (almost two days) to reach these irrigators.
- The scheme is comparatively more expensive, but the other benefits, especially the reduced risk of a shortfall in supply, are considered to carry more weight than the comparative cost difference.

6.10 Recommended scheme features

6.10.1 Design flows

The design water requirements for the rising mains and the gravity pipeline for the Vredendal-Retshof sub-option 3a (lower dam) is as shown in **Table 6.8** and **Table 6.9** respectively.

Table 6.8: Ebenhaeser Scheme Rising Main design flows

Rising Main	Design flow (m^3/s)
Rising Main 1: Retshof to LB small balancing reservoir	0.270*
Rising Main 2: LB small balancing reservoir to lower balancing dam	0.648
Rising Main 3: Lower balancing dam to concrete reservoir	0.242

** Recommend increasing this flow value for feasibility design*

The design flows of the rising mains up to the balancing dam have been based on calculated historical diversion flows for representative years. The actual spare flow capacity in future years will vary.

A potential change that is recommended for the feasibility-level design of the scheme, is to increase the design flow of Rising Main 1 slightly, from 0.270 m^3/s to 0.292 m^3/s, which equates to 45% of the design flow of Rising Main 2, which is the relative percentage of the Retshof canal maximum flow capacity compared to the combined maximum flow capacities of the Vredendal and Retshof canal sections.

Table 6.9: Ebenhaeser Scheme Gravity Pipeline design flows

Gravity pipeline	Design flow (m^3/s)
Section 1: Reservoir to Cluster 1	0.242
Section 2: Cluster 1 to Cluster 2	0.195
Section 3: Cluster 2 to Cluster 3	0.168
Section 4: Cluster 3 to Cluster 4	0.106
Section 5: Cluster 4 to Cluster 5	0.048

6.10.2 Operational betterment balancing storage and cost

An additional volume of 150 000 m^3 has been included in the balancing dam capacity, for improved operation of the lower canal sections of the LORGWS, as a betterment component, at the request of LORWUA. This would increase the required size of the balancing dam from 2.152 million m^3 to 2.302 million m^3. This betterment cost was not included in the scheme cost indicated in **Table 6.5** and **Table 6.6**.

For the estimate of the betterment cost, it has been assumed that all the operational balancing flows would be diverted from the left bank Vredendal canal section, at the scheme diversion location. The size of the balancing dam would increase from 2.152 million m^3 to 2.302 million m^3.

The additional betterment capital cost is R 13.3 million and the betterment NPV cost is R 13.9 million.

6.10.3 Scheme features

The proposed diversion point in the left bank Vredendal canal section is in a cutting upstream of a long weir (**Figure 6.7**), just before a tunnel.

Figure 6.7: Vredendal canal abstraction point

The diversion point in the right bank Retshof canal section is in the middle of a long bend, as shown in **Figure 6.8**, with the Sishen-Saldanha railway line visible in the background. Diversion structures are needed at both diversion points. From the Retshof diversion, water will be pumped by a 92 kW pump station at a pumping head of 45 m, via a 450 mm diameter, 888 m long rising main pipeline, to a 28 Mℓ small combined balancing dam that will provide 12 hours of storage. Water will also be diverted from the Vredendal canal to the combined small balancing dam, from behind the existing long weir, that will provide increased head.

Figure 6.8: Abstraction point from the Retshof canal section

Figure 6.9 shows the view from the abstraction point at the Retshof canal towards the Vredendal canal on the other side of the valley. The balancing dam site is on the ridge behind the Vredendal canal.

Figure 6.9: View from Retshof canal abstraction point towards Vredendal canal

From the combined small balancing dam, water will be pumped by a 441 kW pump station at a pumping head of 33 m, via a 700 mm diameter, 362 m long rising main pipeline, to a 2.302 million m^3 lined earthfill balancing dam (**Figure 6.10**), to be situated South-West of and close to the Vredendal left bank canal diversion point, opposite the R363 road between Vredendal and Lutzville.

Figure 6.10: Balancing dam site

From the balancing dam, water will be pumped to a 10.45 Mℓ concrete balancing reservoir, at a pumping head of 110 m, via a 500 mm diameter, 2 160 m long rising main pipeline,

From the balancing dam, water will be gravitated to high points adjacent to the water requirement clusters, with adequate minimum pressure provided, via a 600/500/400 mm diameter, 17 300 m long gravity pipeline.

6.11 Geological and geotechnical aspects

According to the 1:250 000 scale geological map 3118 Calvinia (Council for Geoscience, 2001), graphitic and sericitic schist, phyllite, greywacke, quartzite, impure dolomite, limestone and marble (Nat) from the Aties Formation, Gariep Supergroup are present along various sections of the pipeline routes. The area is covered predominantly by Quaternary-age calcareous soil (Q-r2) towards the north western portion along the pipeline route, and red aeolian sand (Ç-s) towards the centre and north east.

6.11.1 Rising Main 1 - Retshof Diversion

Medium to hard rock phyllite outcrops, dipping at an angle of 40° to the southwest (**Figure 6.11**), and minor greywacke in places were observed during the site visit. Blasting through hard rock will be required, if the pipeline is to be constructed below NGL, i.e. buried. The blasted faces will further expose the disturbed / seamy rock mass, as defined by the dipping strata and consideration of the stability of the blasted faces will be required.

Figure 6.11: Exposed phyllite dipping at 40° towards the South-East

Due to unfavourable physical and mechanical properties of phyllite, that include low strengths and platy mineral alignment, this rock type is not considered to be acceptable to be used as construction material.

6.11.2 Rising Main 2 - Vredendal Diversion

The south-western portion along the route is underlain by red aeolian sand, which is known to be potentially collapsible / dispersive, and the pipeline may therefore be influenced by differential settlement. The pinholed structure observed in the aeolian sand during the site visit is characteristic of dispersive soils, which under certain conditions deflocculate, and are rapidly eroded and carried away by waterflow. Although there was no evidence of a shallow water table during the site visit, the geotechnical investigation will have to include testing to confirm the potential dispersivity of the aeolian sands.

6.11.3 Balancing Dam, Rising Main 3 and Concrete Reservoir

The proposed sites for the balancing dam, Rising Main 3 and the concrete reservoir are underlain by red aeolian sand (**Figure 6.12**) that are known to be potentially collapsible / dispersive, and may therefore cause differential settlement of these structures. The pinholed structure observed in the aeolian sand during the site visit is characteristic of dispersive soils, which under certain conditions deflocculate and are rapidly eroded and carried away by waterflow.

Soil profiles in this area are expected to predominantly comprise very loose to loose sandy soils. In terms of excavation conditions, 'soft excavation' can be assumed to dominate within the pipeline depths, but where the occasional rocky areas are encountered, allowance should be made for blasting. Cut slopes in such sandy soils would not be stable if cut steeper than say 30° and, if space constraints dictate steeper slopes, stabilisation measures will be required, such as shoring of temporary excavations, benching, or other support measures.

Figure 6.12: Red aeolian sand in the vicinity of the balancing dam

For the balancing dam specifically, it is assumed at this stage that the basin will be fully lined. The sandy soil profile is likely highly pervious, and the assumption of a lined basin is considered prudent. It is noted, however, that a series of adjacent dams are apparently unlined. The performance of these unlined structures is however not known. At this stage it is assumed that materials to construct the embankment will be sourced from within the basin. The geotechnical investigations must include appropriate testing of these materials to determine their properties, including compaction characteristics and shear strengths, as well as potential dispersivity. Permeability testing must also be carried out.

6.11.4 Ebenhaeser Gravity Pipeline

The same red, very loose to loose, pinholed, aeolian sand as described above is found along most of the gravity pipeline route. The sidewalls of trenches in sand will likely be unstable even for shallow depths, and battering or shoring of trench sidewalls and other excavations will be necessary.

According to the geology map, graphitic and sericitic schist, phyllite, greywacke, quartzite, impure dolomite, limestone and marble are present along various sections of the pipeline route. The exact rock types will be confirmed during geotechnical investigations. Hardpan calcrete is evident in the north western portion of the route.

The weathered rock and hardpan calcrete are likely to classify as intermediate or hard rock excavation and allowance should be made for blasting.

6.12 Environmental Impacts

The sensitivity of the proposed irrigable areas for the Ebenhaeser scheme was assessed to guide design and planning work. Below is the description of the regulatory guidelines in terms of NEMA (Act No. 107 of 1998), NWA (Act No. 36 of 1998) and the NHRA (Act No. 25 of 1999).

6.12.1 National Environmental Management Act (Act No. 107 of 1998)

With reference to the NEMA, certain activities may not commence without an EA having been received from the relevant CA. In terms of the 2014 EIA regulations, as amended in 2017, pursuant to NEMA (GN R982), certain activities that may have a detrimental impact on the environment (termed Listed Activities) require an EA from the CA. Development of irrigable land and the construction of pipelines and dams could potentially trigger NEMA Listing Notices 1 (GN R983), 2 (GN R983) and 3 (GN R985) and therefore require subsequent authorisation from the CA.

The Listed Activities are described in **Table 6.10** below and must be reviewed when planning the agricultural developments in the Ebenhaeser area.

Table 6.10: Summary of Listed Activities which could potentially be triggered for the Ebenhaeser Scheme

Activity No.	Activity Description
GN R983, as amended on 7 April 2017- Listing Notice 1 ***Authorisation required – Basic Assessment***	
9	The development of infrastructure exceeding 1 000 metres in length for the bulk transportation of water or storm water— (i) with an internal diameter of 0,36 metres or more; or (ii) with a peak throughput of 120 litres per second or more; excluding where— (a) such infrastructure is for bulk transportation of water or storm water or storm water drainage inside a road reserve or railway line reserve; or (b) where such development will occur within an urban area.
12	The development of— (i) dams or weirs, where the dam or weir, including infrastructure and water surface area, exceeds 100 square metres; or (ii) infrastructure (including borrow pits) or structures with a physical footprint of 100 square metres or more; where such development occurs— (a) within a watercourse; (b) in front of a development setback; or (c) if no development setback exists, within 32 metres of a watercourse, measured from the edge of a watercourse; — excluding— (aa) the development of infrastructure or structures within existing ports or harbours that will not increase the development footprint of the port or harbour; (bb) where such development activities are related to the development of a port or harbour, in which case activity 26 in Listing Notice 2 of 2014 applies; (cc) activities listed in activity 14 in Listing Notice 2 of 2014 or activity 14 in Listing Notice 3 of 2014, in which case that activity applies; (dd) where such development occurs within an urban area; (ee) where such development occurs within existing roads, road reserves or railway line reserves; or (ff) the development of temporary infrastructure or structures where such infrastructure or structures will be removed within 6 weeks of the commencement of development and where indigenous vegetation will not be cleared.
13	The development of facilities or infrastructure for the off-stream storage of water, including dams and reservoirs, with a combined capacity of 50 000 cubic metres or more, unless such storage falls within the ambit of activity 16 in Listing Notice 2 of 2014.
19	The infilling or depositing of any material of more than 10 cubic metres into, or the dredging, excavation, removal or moving of soil, sand, shells, shell grit, pebbles or rock of more than [5] 10 cubic metres from – (i)] a watercourse;

Activity No.	Activity Description
	[(ii) the seashore; or (iii) the littoral active zone, an estuary or a distance of 100 metres inland of the high-water mark of the sea or estuary, whichever distance is the greater.
24	The development of a road— (i) for which an environmental authorisation was obtained for the route determination in terms of activity 5 in Government Notice 387 of 2006 or activity 18 in Government Notice 545 of 2010; or (ii) with a reserve wider than 13,5 meters, or where no reserve exists where the road is wider than 8 metres; but excluding a road— (a) which is identified and included in activity 27 in Listing Notice 2 of 2014; (b) where the entire road falls within an urban area; or (c) which is 1 kilometre or shorter.
27	The clearance of an area of 1 hectares or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for— (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.
56	The widening of a road by more than 6 metres, or the lengthening of a road by more than 1 kilometre— (i) where the existing reserve is wider than 13,5 meters; or (ii) where no reserve exists, where the existing road is wider than 8 metres; excluding where widening or lengthening occur inside urban areas.
67	Phased activities for all activities— (i) listed in this Notice, which commenced on or after the effective date of this Notice or similarly listed in any of the previous NEMA notices, which commenced on or after the effective date of such previous NEMA Notices; excluding the following activities listed in this Notice- 17(i)(a-d); 17(ii)(a-d); 17(iii)(a-d); 17(iv)(a-d); 17(v)(a-d); 20; 21; 22; 24(i); 29; 30; 31; 32; 34;

Activity No.	Activity Description
	54(i)(a-d); 54(ii)(a-d); 54(iii)(a-d); 54(iv)(a-d); 54(v)(a-d); 55; 61; 64; and 65; or (ii) listed as activities 5, 7, 8(ii), 11, 13, 16, 27(i) or 27(ii) in Listing Notice 2 of 2014 or similarly listed in any of the previous NEMA notices, which commenced on or after the effective date of such previous NEMA Notices; where any phase of the activity was below a threshold but where a combination of the phases, including expansions or extensions, will exceed a specified threshold.
GN R984, as amended on 7 April 2017- Listing Notice 3 ***Authorisation required – Environmental Impact Assessment***	
13	The physical alteration of virgin soil to agriculture, or afforestation for the purposes of commercial tree, timber or wood production of 100 hectares or more.
15	The clearance of an area of 20 hectares or more of indigenous vegetation, excluding where such clearance of indigenous vegetation is required for— (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.
16	The development of a dam where the highest part of the dam wall, as measured from the outside toe of the wall to the highest part of the wall, is 5 metres or higher or where the high-water mark of the dam covers an area of 10 hectares or more.
GN R985, as amended on 7 April 2017- Listing Notice 3 ***Authorisation required – Basic Assessment***	
2	The development of reservoirs, excluding dams, with a capacity of more than 250 cubic metres i. Western Cape i. A protected area identified in terms of NEMPAA, excluding conservancies; ii. In areas containing indigenous vegetation; or iii. Inside urban areas: (aa) Areas zoned for use as public open space; or (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority or zoned for a conservation purpose.
4	The development of a road wider than 4 metres with a reserve less than 13,5 metres. i. Western Cape i. Areas zoned for use as public open space or equivalent zoning; ii. Areas outside urban areas;

Activity No.	Activity Description
	(aa) Areas containing indigenous vegetation; (bb) Areas on the estuary side of the development setback line or in an estuarine functional zone where no such setback line has been determined; or iii. Inside urban areas: (aa) Areas zoned for conservation use; or (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority.
12	The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. Western Cape (i) within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; (ii) within critical biodiversity areas identified in bioregional plans; (v) on land designated for protection or conservation purposes in an Environmental Management Framework adopted in the prescribed manner, or a Spatial Development Framework adopted by the MEC or Minister.
14	The development of- (ii) infrastructure or structures with a physical footprint of 10 square metres or more; Where such development occurs- (c) within 32 metres of a watercourse, measured from the edge of a watercourse. Western Cape (ff) critical biodiversity areas or ecosystem service areas (gg) core areas of the biosphere reserve
18	The widening of a road by more than 4 metres, or the lengthening of a road by more than 1 kilometre. i. Western Cape i. Areas zoned for use as public open space or equivalent zoning; ii. All areas outside urban areas: (aa) Areas containing indigenous vegetation; (bb) Areas on the estuary side of the development setback line or in an estuarine functional zone where no such setback line has been determined; or iii. Inside urban areas: (aa) Areas zoned for conservation use; or (bb) Areas designated for conservation use in Spatial Development Frameworks adopted by the competent authority.
26	Phased activities for all activities— i. listed in this Notice and as it applies to a specific geographical area, which commenced on or after the effective date of this Notice; or ii. similarly listed in any of the previous NEMA notices, and as it applies to a specific geographical area, which commenced on or after the effective date of such

Activity No.	Activity Description
	previous NEMA Notices— where any phase of the activity was below a threshold but where a combination of the phases, including expansions or extensions, will exceed a specified threshold; — excluding the following activities listed in this Notice— 7; 8; 11; 13; 20; 21; and 24. All the areas as identified for the specific activities listed in this Notice.

Small areas in the northern parts of the Ebenhaeser Scheme options are mapped as CBA 1. Small ESA 1 and ESA 2 corridors occur along the pipeline route and watercourses in the area. Reasons for environmental sensitivity include ecological processes, vegetation types, threatened vertebrate, water resource and wetland protection, and upland-lowland interface. Should the development of the proposed sites be initiated, the activities would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity and location of protected species. It would be necessary for a freshwater specialist to delineate all wetlands, watercourses and floodlines.

Based on the information available for the proposed agricultural developments for the Ebenhaeser Scheme, authorisation would have to be obtained for triggered Listed Activities in terms of the NEMA. The authorisation processes required would depend on the details of the proposed developments. A Basic Assessment would be required for activities such as the clearance of indigenous vegetation, pipelines, dams, reservoirs, working within, or in close proximity to watercourses, and development of new roads or widening of existing roads. There are however three (3) activities which would require an EIA and that would include the clearance of more than 20 ha of indigenous vegetation, the transformation of virgin soil to agriculture of 100 ha or more and the construction of a dam where the dam wall is higher than 5 m or the dam area exceeds 10 ha in extent. It is also important to note that a section of the pipeline would be constructed through the Lutzville Conservation Area, which forms part of the Knersvlakte Nature Reserve Complex and is managed by CapeNature. For construction through this nature reserve, authorisation should be obtained from the Management Authority, which is CapeNature in this case. Depending on the exact route and micro-siting sensitivities through this protected area, construction through this section might prove to be a challenge, but would have to be assessed in consultation with CapeNature.

Alternative options for, or prior to, environmental authorisation in terms of the NEMA is to undertake a SEA or an EMF for all the irrigable areas. Although not required by law in South Africa, a SEA can be an important tool to help project planners understand the cumulative impacts in a geographical area of different land uses. An EMF aims to integrate various environmental management instruments to assist a holistic decision-making process. An EMF process identifies and highlights the opportunities and constraints for development within defined control zones and sensitive areas within a specific region. There is currently an EMF developed for the Sandveld and Agter-Cederberg regions, which does not include the Ebenhaeser development area.

6.12.2 National Heritage Resource Act (Act No. 25 of 1999)

With regards to NHRA, certain activities may not be initiated without any prior approval/consent from the CA, which in this case would be HWC if they have a potential to impact on the heritage or cultural features (structures older than 60 years, landscapes and natural features of cultural significance, geological sites of scientific or cultural importance, archaeological and palaeontological sites, graves and burial grounds, sites of significance relating to slavery or movable objects) considered to be a national estate and need to be preserved or protected.

Section 38 (1) of the NHRA provides a list of the activities which should be authorised by HWC and is quoted below:

Section 38. (1): Subject to the provisions of subsections (7), (8) and (9), any person who intends to undertake a development categorised as-

- *(a) the construction of a road, wall, powerline, pipeline, canal or other similar form of linear development or barrier exceeding 300m in length;*
- *(b) the construction of a bridge or similar structure exceeding 50m in length;*
- *(c) any development or other activity which will change the character of a site—*
  - *(i) exceeding 5 000 m^2 in extent; or*
  - *(ii) involving three or more existing erven or subdivisions thereof; or*
  - *(iii) involving three or more erven or divisions thereof which have been consolidated within the past five years; or*
  - *(iv) the costs of which will exceed a sum set in terms of regulations by SAHRA or a provincial heritage resources authority;*
- *(d) the re-zoning of a site exceeding 10 000m^2 in extent; or*
- *(e) any other category of development provided for in regulations by SAHRA or a provincial heritage resources authority.*

Based on the information available for the proposed agricultural developments for the Ebenhaeser Scheme, authorisation would have to be obtained for Section 38 (a) and (c) activities in terms of the NHRA. The authorisation process would require the submission of a NID to the HWC for determination of the need for further paleontological or archaeological specialist studies and impacts assessments. Should further studies be required, an integrated Heritage Impact Assessment with specialist studies would have to be undertaken and submitted to HWC for authorisation.

6.12.3 National Water Act (Act No. 36 of 1998)

The NWA (Act No. 36 of 1998), aims to regulate the use of water and/or activities which may potentially impact on water resources through the categorisation of water use activities as described in Section 21 of the said Act:

(a) Taking water from a water resource;
(b) Storing water;
(c) Impeding or diverting the flow of water in a watercourse;
(d) Engaging in a stream flow reduction activity contemplated in section 36;
(e) Engaging in a controlled activity identified as such in section 37(1) or declared under section 38(1);
(f) Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;
(g) Disposing of waste in a manner that may detrimentally affect a water resource;
(h) Disposing in any manner of water which contains waste from, or which has been heated in, any industrial or power generation process;
(i) Altering the bed, banks, course or characteristics of a watercourse;
(j) Removing, discharging or disposing of water found underground if it is necessary for the efficient continuation of an activity or for the safety of people; and
(k) Using water for recreational purposes."

The regulated area of a watercourse is 100 m from the edge of a stream / river and 500 m from the edge of a wetland. Any activities taking place within this regulated area has the potential to impact on the quality or characteristics of that watercourse. For this reason, any activity taking place in this regulated area should be authorised in terms of a GA or a WUL through the DWS, or any relevant CMA. For the Matzikama Municipality, the DWS is the CA for water use authorisations.

Based on the information available for the proposed agricultural developments for the Ebenhaeser scheme, authorisation would have to be obtained for Section 21 (a), (b), (c) and (i) water uses in terms of the NWA. The authorisation process would require an integrated approach for the entire scheme and would include a freshwater impact assessment and risk assessment to be undertaken. It is likely that the integrated authorisation would require a full

WUL and not a GA but would be confirmed during a risk assessment process to be undertaken by the freshwater specialist. Activities which pose a low risk to the aquatic ecosystems would only require a GA, and medium and high-risk activities would require a WUL.

6.13 Operational Aspects

During weeks that there is identified spare flow capacity in the Vredendal and Retshof canal sections, and when the balancing dam is not full, additional flows will be released from Bulshoek Weir, equal to the spare weekly capacity in the Vredendal and Retshof canal sections respectively, plus estimated canal losses. This may entail requesting weekly requirements for Ebenhaeser according to a pre-planned annual schedule, and monitoring whether planned diversion volumes are being met.

Water will be pumped to the balancing dam from the canal diversion points, with diversion ceasing should the dam be full. Diversion rates from the canal off-take points should be equal to the canal flow release rates. The dam should be full just before the start of the irrigation peak season, likely in early November. At the end of the peak season, the dam will be empty - having been drawn down over a period of 4.5 to 5 months.

It has not yet been clarified with LORWUA how the balancing storage portion of the scheme should be operated. Should it not be possible to gravitate water to the right bank Retshof canal from the balancing dam, a separate small balancing storage dam along the Retshof canal may be needed. The balancing storage added onto the Ebenhaeser scheme balancing storage will reduce. This should be clarified during the feasibility design.

From the balancing dam, water will be pumped to the reservoir, and gravitated for irrigation as needed. It is recommended that the scheme be operated by LORWUA, as the operational releases need to be carefully integrated with releases for existing irrigators. For weeks when the requested irrigation demands from irrigators (plus estimated canal losses) exceed the canal capacities, the same rule will apply to current and future irrigators, including the beneficiaries of this scheme.

There is some concern of the effect of the additional head on the integrity of the existing canals, as flows will increase in canal sections on average once this scheme has been implemented.

6.14 Affected Land and Infrastructure

Figure 6.13 shows the remaining 'FALA' State land (blue and pink areas) of the Department of Agriculture, Land Reform and Rural Development (DALRRD) located near the existing Ebenhaeser Community Scheme. The diversion infrastructure, rising main pipelines, balancing dam and reservoir would be located on private land, which either needs to be acquired or servitudes need to be registered. Most of the gravity pipeline route will be located on State land. **Figure 6.14** shows the main bulk infrastructure components that will be located on private land.

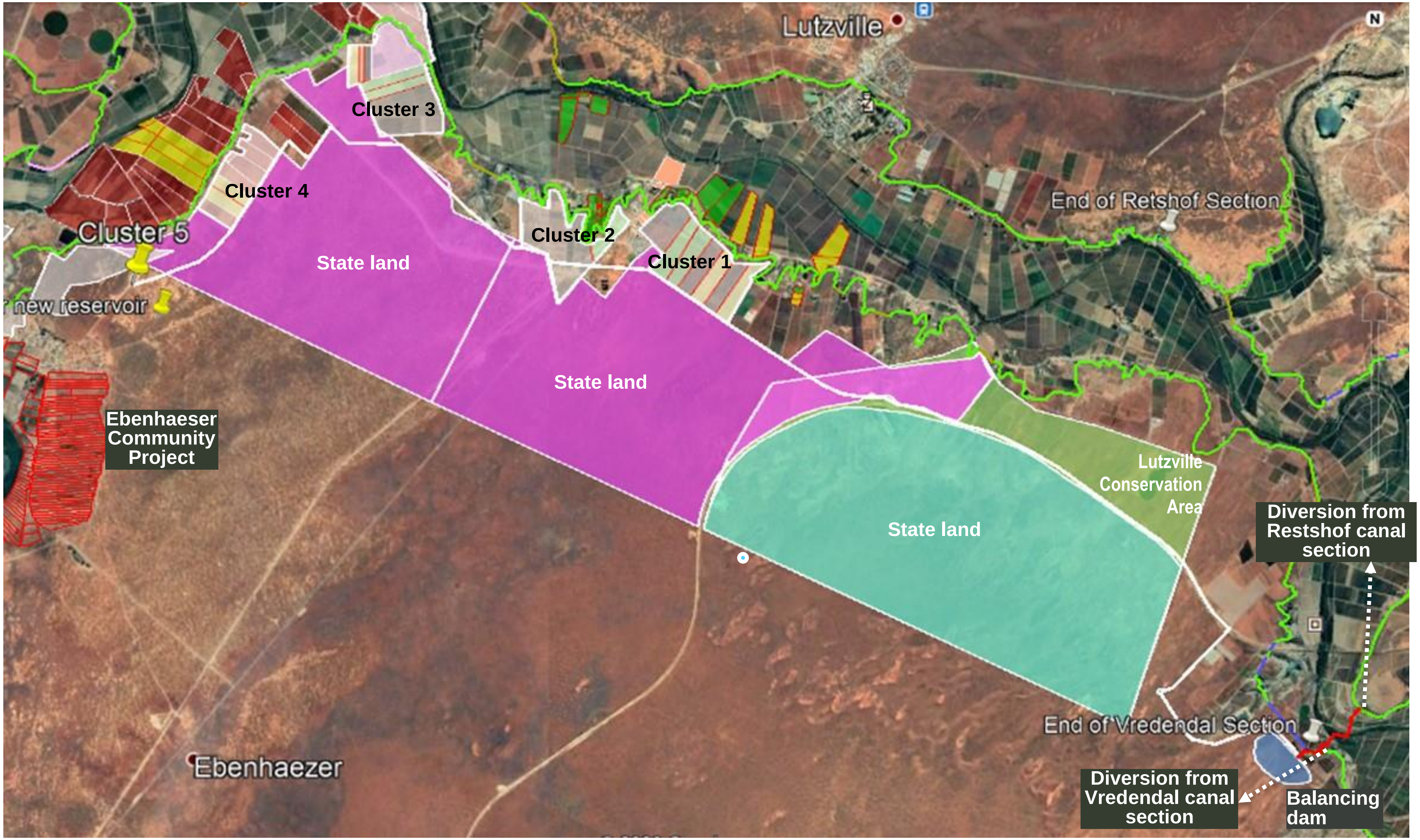
Lutzville
Cluster 3
Cluster 4
Cluster 5
Cluster 2
Cluster 1
State land
State land
State land
new reservoir
End of Retshof Section
Ebenhaeser Community Project
Lutzville Conservation Area
Diversion from Restshof canal section
End of Vredendal Section
Ebenhaezer
Diversion from Vredendal canal section
Balancing dam

Figure 6.13: Remaining state land at the Ebenhaeser Scheme

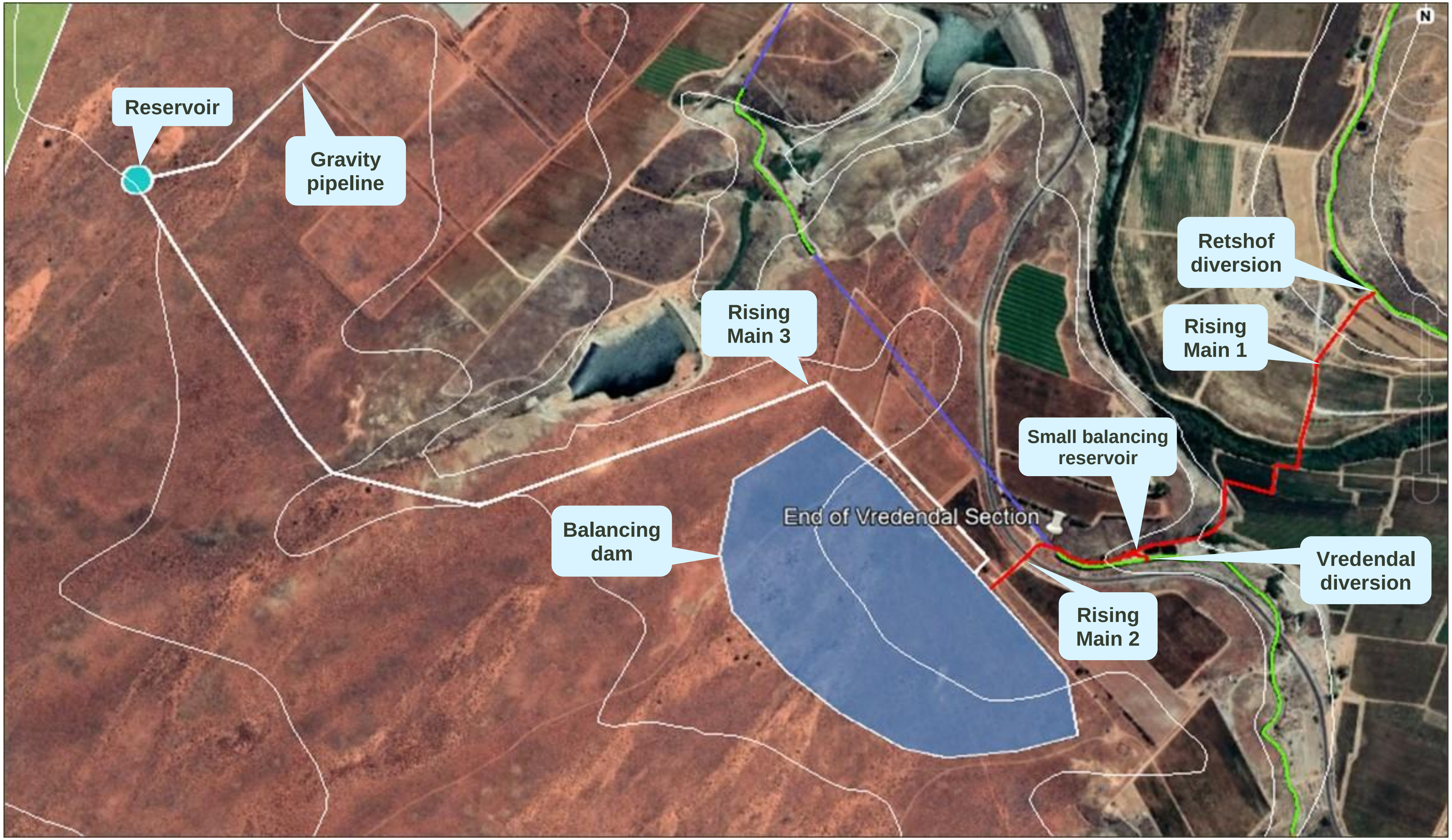

Figure 6.14: Bulk infrastructure components

7 Reconnaissance-level investigations

7.1 Trawal Government Water Scheme (GWS)

7.1.1 Introduction

At the PSC Meeting 9, held on 17 Jul 2019, concern was expressed about the large percentage of private land that formed part of the preferred irrigation development options. The PSC decided that an option should be identified where land could be made available to black farmers, either as a GWS or via an alternative institutional arrangement such as a co-operative.

7.1.2 Suitable options to include in a GWS

It was subsequently agreed that all or a portion of the proposed new irrigation development areas in the Trawal area are the most suitable for development as a government scheme (**Figure 7.1**), these being:

- Zypherfontein 1,
- Zypherfontein 2,
- Melkboom, and
- Trawal.

All the other option areas that will be located on private land are spread out and large portions of these properties are already farmed.

The four options located in the Trawal areas will all entail new irrigation development adjacent to existing irrigated areas, but with very limited existing development within these areas. The Trawal area is located on the left bank, while the other areas are located on the right bank and should in future be supplied from the new Right Bank Canal. The Trawal area will likely continue to be supplied from the existing main canal in the short-term to medium-term, until supply of the developed irrigation areas on the left bank is switched to the new right bank main canal in the longer-term.

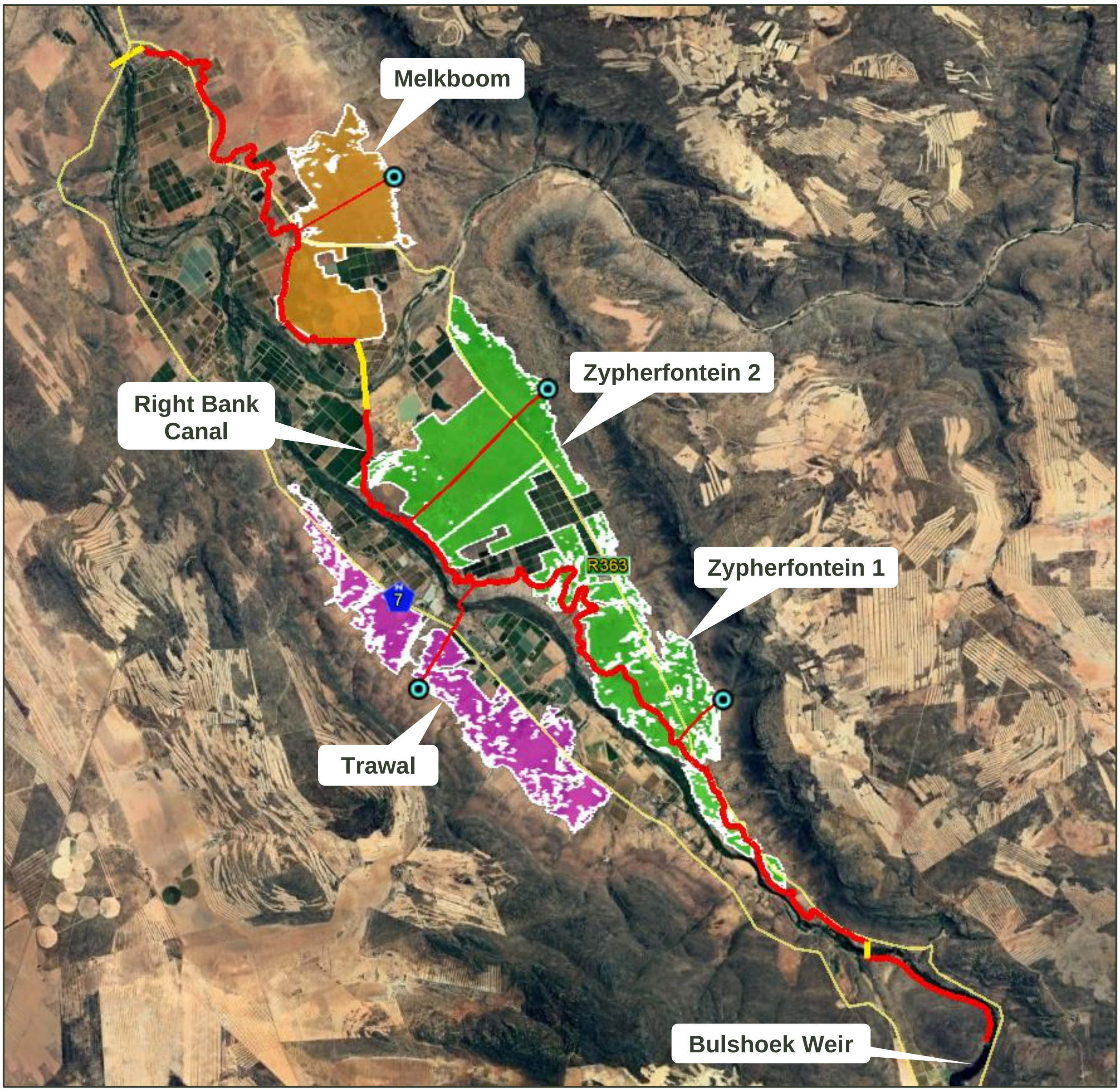

Figure 7.1: Potential Trawal GWS areas

7.1.3 Water Requirements

Water requirements of all four options have been determined at the aggregate water requirement of 8 680 m^3/ha/a calculated for sub-area 4 as part of this study, as shown in **Table 7.1**. The combined irrigable area for the four new areas is 2 339 ha. Leaching factors differ within the option areas. Total losses are 3.35 million m^3/a, assuming supply from the new Right Bank main canal, which is to be constructed. The water requirements, including losses, of these four potential irrigation development areas comprise 42% of the total volume of 61.05 million m^3/a available for new irrigation development.

Table 7.1: Trawal GWS Water requirements

Option area	Hectares	Water requirement (million m^3/a)
Zypherfontein 1	710	6.34
Trawal	510	4.87
Zypherfontein 2	614	5.87
Melkboom	505	5.23
Total	**2 339**	**22.31**

7.1.4 Scheme Overview and Components

The cost of the bulk water supply to these four option areas forms part of the cost of the new Right Bank canal. As these potential irrigation areas are all located on private land, the cost of the bulk water infrastructure (excluding the new main canal) can be separated for private development of these options areas, while the State can construct the Right Bank Canal. For a GWS development, the bulk water infrastructure can be simultaneously constructed.

7.1.5 Ownership and Operational Aspects

The DWS will be the owner of the scheme if it is developed as a GWS. It is not yet evident who will operate such a scheme, but as these areas would be supplied from the canal system, it is proposed that it be operated by LORWUA. It is a possibility that the DWS construction team could implement the scheme.

7.1.6 Affected Land and Infrastructure

The farms on which these irrigation areas are located are privately-owned. An effort was made to identify the farm owners, the extent of current development and their planned future development, inter-alia HDI development using additional water from a raised Clanwilliam Dam. The irrigation development areas were first sourced from the Verification and Validation (V&V) database, for the V&V undertaken for the Berg-Olifants Water Management Area (*Validation and verification of existing lawful water uses within the Berg Olifants WMA*, 2017). Some information regarding land owner details was forthcoming from the 'Interested and Affected Party' database compiled for the public meetings held for this study, and from the focussed meetings held with land owners in May 2019. Farm and land owner information is shown in **Table 7.2**.

Table 7.2: Farms and land owner information

Property ID number	Ha	Comment	Name of Owner	Property Name	Water User
Zypherfontein 1 irrigation area					
C02000000000006600000			De Vlei De Doorns Boerdery Pty Ltd		
C02000000000006600001	452.91		Trawal Fresh Fruit Co Pty Ltd	Zypherfontein 66	Trawal Fresh Fruit Company (Pty) Ltd
C02000000000006600005	116.66		Trawal Fresh Fruit Co Pty Ltd	Zypherfontein	Trawal Fresh Fruit Company (Pty) Ltd
C02000000000006600006	574.39		Trawal Fresh Fruit Co Pty Ltd	Zypherfontein 66	Trawal Fresh Fruit Company (Pty) Ltd
C02000000000006600034	241.15	developed	J H Le Roux Familie Trust	Oudrif	Mr JD Le Roux
C02000000000006600035	338.76	developed	Trawal Fresh Fruit Co Pty Ltd	Bet El Farm 66 Zypherfontein	Trawal Fresh Fruit Company (Pty) Ltd
C02000000000006600036	93.74	40% developed	Trawal Farm Development Co Pty Ltd		Trawal Fresh Fruit Company (Pty) Ltd
Trawal irrigation area					
C02000000000006600002	353.23		Trawal Plaas Pty Ltd	Zypherfontein	Trawal Plaas (Edms) Bpk
C02000000000007300000			JAH Coetzee		JAH Coetzee
C02000000000007300002	416.05	mountainous	Luzaki Trust		
C02000000000007300005	28.68		De Vlei De Doorns Boerdery Pty Ltd	Vaalwater	De Vlei Boerdery (Edms) Bpk
C02000000000007300007	1005.48	mostly mountain	JAH Coetzee		JAH Coetzee
C02000000000007300008			De Vlei Trust	Spook en Spartel	De Vlei Trust
C02000000000007400000			Rostra Grape Co (Pty) Ltd		027 216 1039
C02000000000007400001	396.39		Breekwal Trust	Zypherfontein	DCM Familietrust
C07800000000038400086			Laborare Trust		KA Janse van Rensburg
C07800000000038400087	420.8		Susanna E Visser	Zypher Fontein	

Property ID number	Ha	Comment	Name of Owner	Property Name	Water User
C07800000000038400088	335.67		Frederick W Coetzee	Melkboom	
C07800000000038400237	329.31		Frederick W Coetzee	Melkboom	
C07800000000038400238	53.94		Laborare Trust	Talana	Laborare Trust
Zypherfontein 2 irrigation area					
C02000000000006600034	339	partially developed			
C07800000000038400081	378.22		BJD Boerdery (Pty) Ltd		BJD Boerdery (Pty) Ltd
C07800000000038400160	351.22		Sigma Boerderye (Pty) Ltd		Sigma Boerderye
C07800000000038400267	267.17	developed			
Melkboom irrigation area					
C07800000000038400131			Vredehoek Trust	Vredehoek	Vredehoek Trust
C07800000000038400178	598.82		Agritech Inv Pty (Ltd)		
C07800000000038400188	239.34		James Frederik Van Wyk	Melkboom	Winterfresh Farming (Pty) Ltd
C07800000000038400189	243.44	limited development	JA van der Merwe Trust	Het-sluis	
C07800000000038400235					
C07800000000038400263					
C07800000000038400264					
C07800000000038400270					

Although a database has been compiled with the information sourced, this is incomplete and some of the information is regarded as unreliable. A general concern raised by the land owners was that they need to understand what the water will cost them before they can decide whether they can afford further irrigation development. Several land owners, or farming entities that would lease land, showed interest in taking part in joint venture HDI irrigation developments, with the caveat of the water being affordable. At least one farmer has indicated that he is interested in selling his land, but with conditions. Some following-up was done by phone, to try and obtain some of the outstanding information, but it is a significant task, and there are many information gaps.

Apart from the basic information shown in **Table 7.2** above, the spreadsheet database includes information on land owner names/contact persons and contact details, farm parcel sizes, scheduled irrigation areas and volumes, comments made by land owners regarding crops grown and their interest in further irrigation development.

It became obvious that, unless the influence of the cost of water can be clarified, there is not much point to currently proceed further with the evaluation of this option.

It is evident that the uncertainty regarding the cost of water from the LORGWS, following the raising of Clanwilliam Dam, needs to be clarified, so that the potential for a Trawal GWS can be assessed with more confidence. It is therefore recommended that the development of the Trawal areas be investigated further after the raising of Clanwilliam Dam, either as private JV developments or a GWS, or a combination of both.

7.2 Clanwilliam Scheme

7.2.1 Clanwilliam Scheme Location

The Clanwilliam Scheme will be located very close to the raised Clanwilliam Dam on the western side of the dam. Water can be pumped directly from the lake of the Clanwilliam Dam, although abstraction points will be affected by the rise/fall of the water level. The location and layout of the scheme are shown in **Figure 7.2**.

7.2.2 Net Water Requirements and Losses

Following the slope analysis to exclude steep areas, the irrigable area of the scheme was significantly reduced, and has become fragmented. Of the remaining 426 ha, only 298 ha (70%) is considered irrigable, after accounting for the fragmented nature of the area, as well as to allow for the many small watercourses crossing the area, and to limit environmental impacts.

The water requirement for the development is 2.75 million m^3/a. Minimal conveyance losses are expected, as water will be pumped via short pipelines.

There are some crop fields located in the identified area, with an existing scheduled water allocation. The existing water use authorisation is 0.29 million m^3/a, and the incremental water requirement is 2.46 million m^3/a.

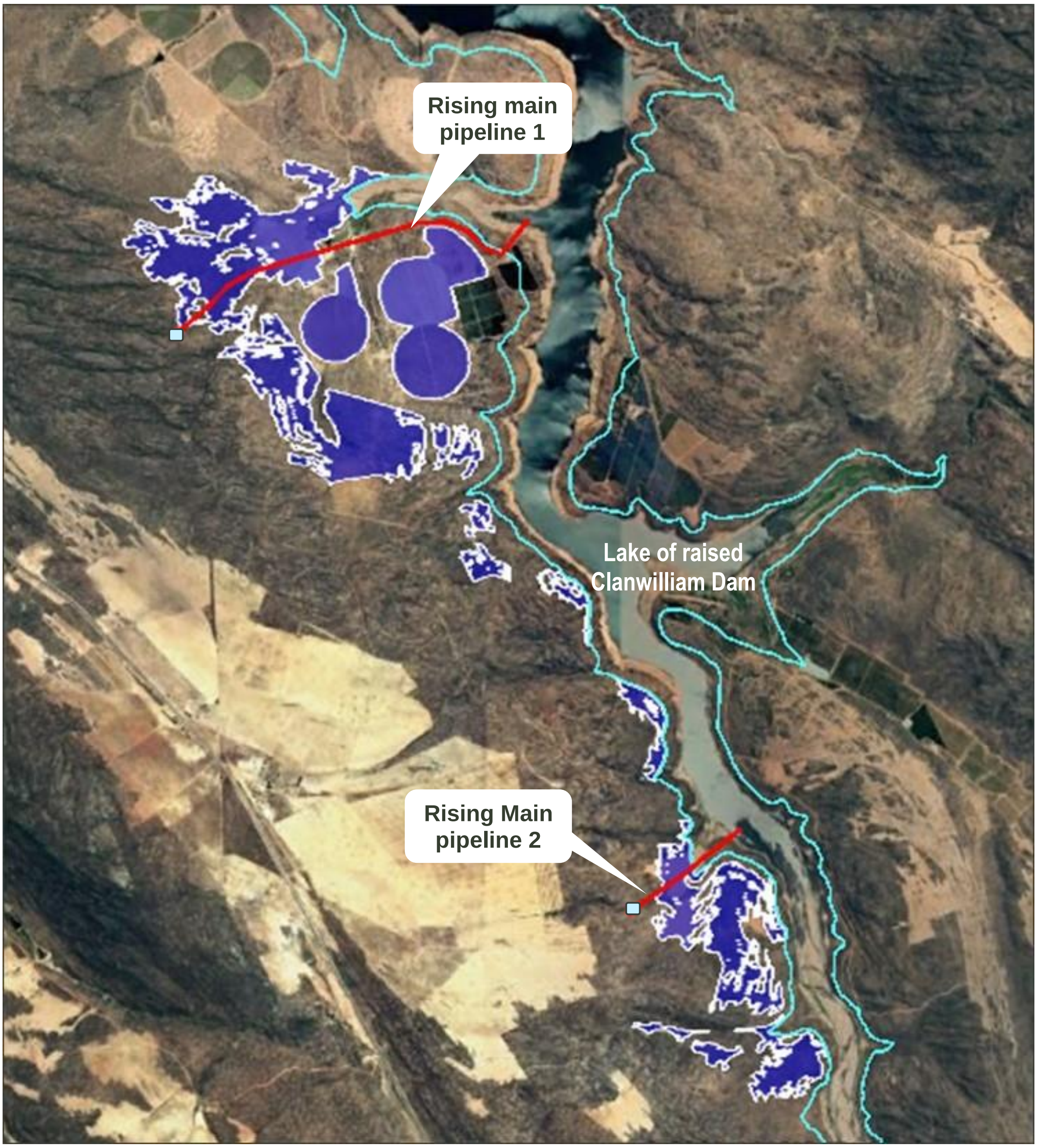

Figure 7.2: Location and layout of Clanwilliam Scheme

7.2.3 Description of Clanwilliam Scheme

This scheme involves the construction of the following infrastructure at two abstraction points:

- Rising Main pipeline 1: A 3 344 m long, 350 mm diameter uPVC/steel rising main from the 384 kW pump station, located at the edge of the raised Clanwilliam Dam, to a small farm dam, with a pumping head of 146 m. The storage capacity of the farm dam is 6 127 m^3.
- Rising Main pipeline 2: A 1 125 m long, 200 mm diameter uPVC rising main from the 73 kW pump station, located at the edge of the raised Clanwilliam Dam, to a small farm dam, with a pumping head of 95 m. The storage capacity of the farm dam is 1 777 m^3.

The cost of abstraction works is expected to be minimal and has not been allowed for in the comparative cost. The combined farm dam storage capacity is 7 905 m^3, to provide 12 hours of storage.

7.2.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

7.2.5 Cost and Unit Reference Value

The comparative capital costs (2020 prices, excluding VAT) are shown in **Table 7.3**. Cost values for this scheme are given in **Table 7.4**.

Table 7.3: Clanwilliam Scheme Comparative Capital Cost in million Rands

Pump stations	Pipelines	Farm dams	Purchase of land	Prof. design & support	Total Cost
15.05	9.03	0.65	6.35	3.43	**34.53**

Table 7.4: Clanwilliam Scheme Cost Values

Cost item	Discount Rate 8%
Total comparative capital cost (R million)	34.53
Annual operating cost (R million/annum)	1.51
NPV Cost (R million)	58.61
Unit Reference Value (R/m^3)	1.84

7.2.6 Ecological Impact

Sensitivity: **Medium:** The site consists of mostly undeveloped land with some agricultural development in the northern and southern sections. The rest of the site is mapped as ESA 1 with small ESA 2 corridors near watercourses in the south and north of the site. A small wetland area exists to the north outside of the site boundaries and should be buffered by a specialist. The most northern part of the site falls within a climate change adaptation corridor and should be avoided for new developments. The north western section also falls within an upland-lowland interface, which supports important ecological functions.

Recommendations:

- Avoid the upland-lowland interface and climate change adaptation corridor areas in the north and north west of the site as far as possible.
- The proposed site would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity.
- Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist).
- The site may require biodiversity offsets if residual impacts are significant.

7.2.7 Summary of Clanwilliam Scheme

The Clanwilliam Scheme has a good location, a low comparative capital cost and a medium URV with medium ecological impacts. There are no water quality concerns and insignificant water losses (short pipelines). There may be potential for 7.5 ha plots, as it is located reasonably close to Clanwilliam town. Potential power supply could be from a new hydropower plant at the raised Clanwilliam Dam.

7.3 Transfer of Lower Jan Dissels River Scheduled Allocations to the Olifants River

This is the only unchanged preferred 'scheme', following the finalisation of the *Suitable Areas for Agricultural Development Report* of this study. It has been included here for completeness.

7.3.1 Description of the Transfer of Allocations

The location and layout of the affected farms are shown in **Figure 7.3**.

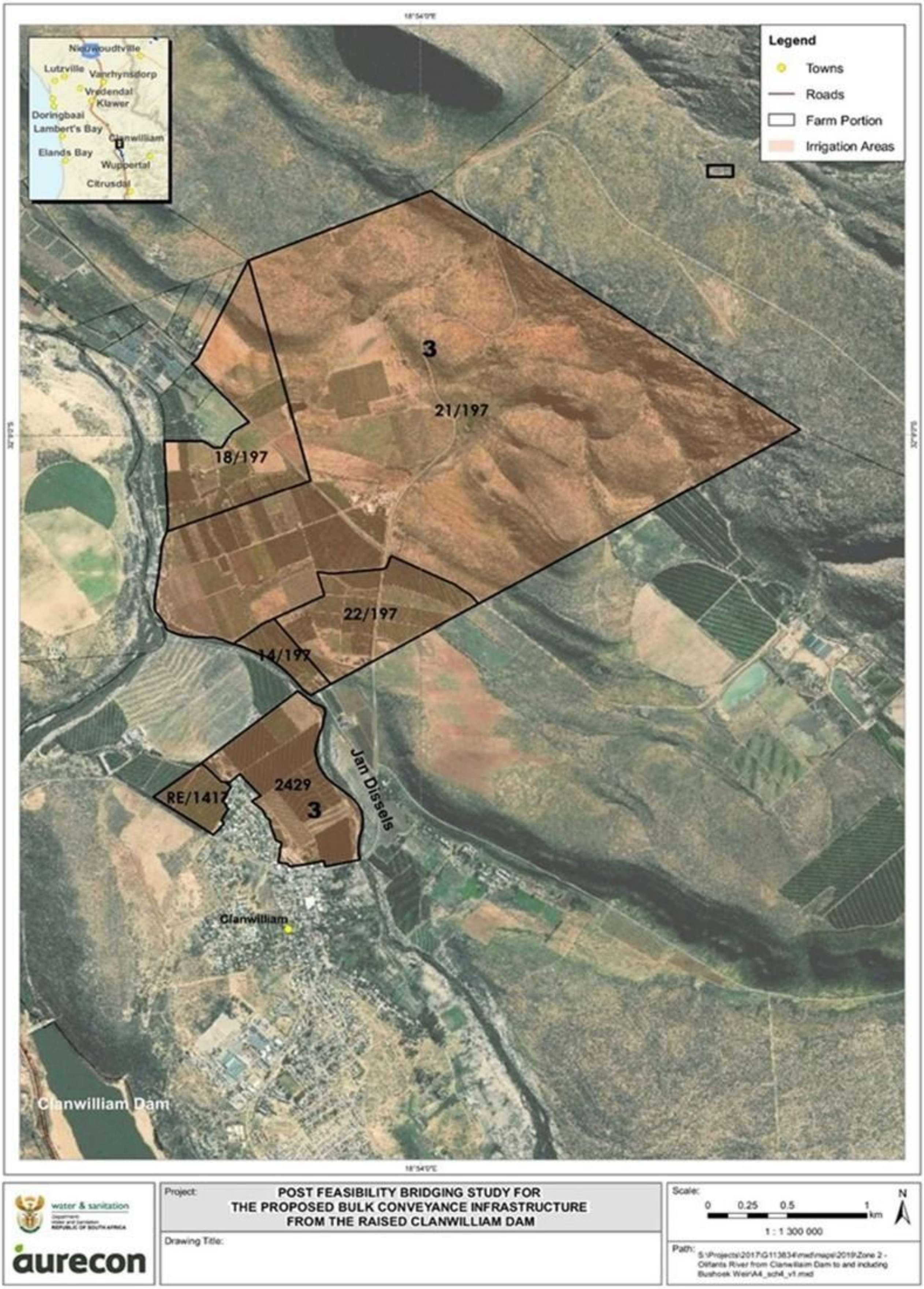

Figure 7.3: Layout of Transfer of Jan Dissels River Allocations

The Jan Dissels River Compulsory Licensing Study recommended moving some or all the existing allocations of irrigators in the lower Jan Dissels River to either the Olifants River or to the Clanwilliam Canal. This proposal was made to improve the ecological condition of the lower section of the Jan Dissels River. This recommendation is also contained in Section 4.2 of the 'Task 5' *Existing Infrastructure and Current Agricultural Development Report* of this study.

It is an opportunity for three water users in the lowest stretch of the Jan Dissels River to shift their abstractions to the Olifants River (Clanwilliam Canal fully used), thereby increasing low flows to improve the currently very poor ecological status of this stretch of the Jan Dissels River.

While this proposal is not focussed on 'new' irrigation development, it has previously been strongly recommended.

7.3.2 Current Water Allocations

The existing total water allocations of the three (3) farmers are 1.0 million m^3/a.

There are no associated water losses

7.3.3 Ecological Impact

This transfer of water allocations is expected to have a positive ecological impact. It will increase the historical low summer flows and thereby improve the ecological condition of the bottom stretch of the Jan Dissels River, which is currently very poor.

7.3.4 Summary of Transfer of Allocations

This transfer of water allocations is expected to relieve pressure on the lower Jan Dissels River in summer and contribute to the improvement of the ecological condition of the lower Jan Dissels River. There are no cost or water quality implications.

7.4 Zandrug Scheme

7.4.1 Zandrug Scheme location

The location and layout of the proposed Zandrug Scheme are shown in **Figure 7.4**. The southern portion of this area is located about 3 km from Clanwilliam town and the northern end stretches almost to the tailwater of Bulshoek Weir. The land is privately-owned. There is a significant extent of existing crop fields (typically potato/wheat farming) located in the identified area, with an existing scheduled allocation for water.

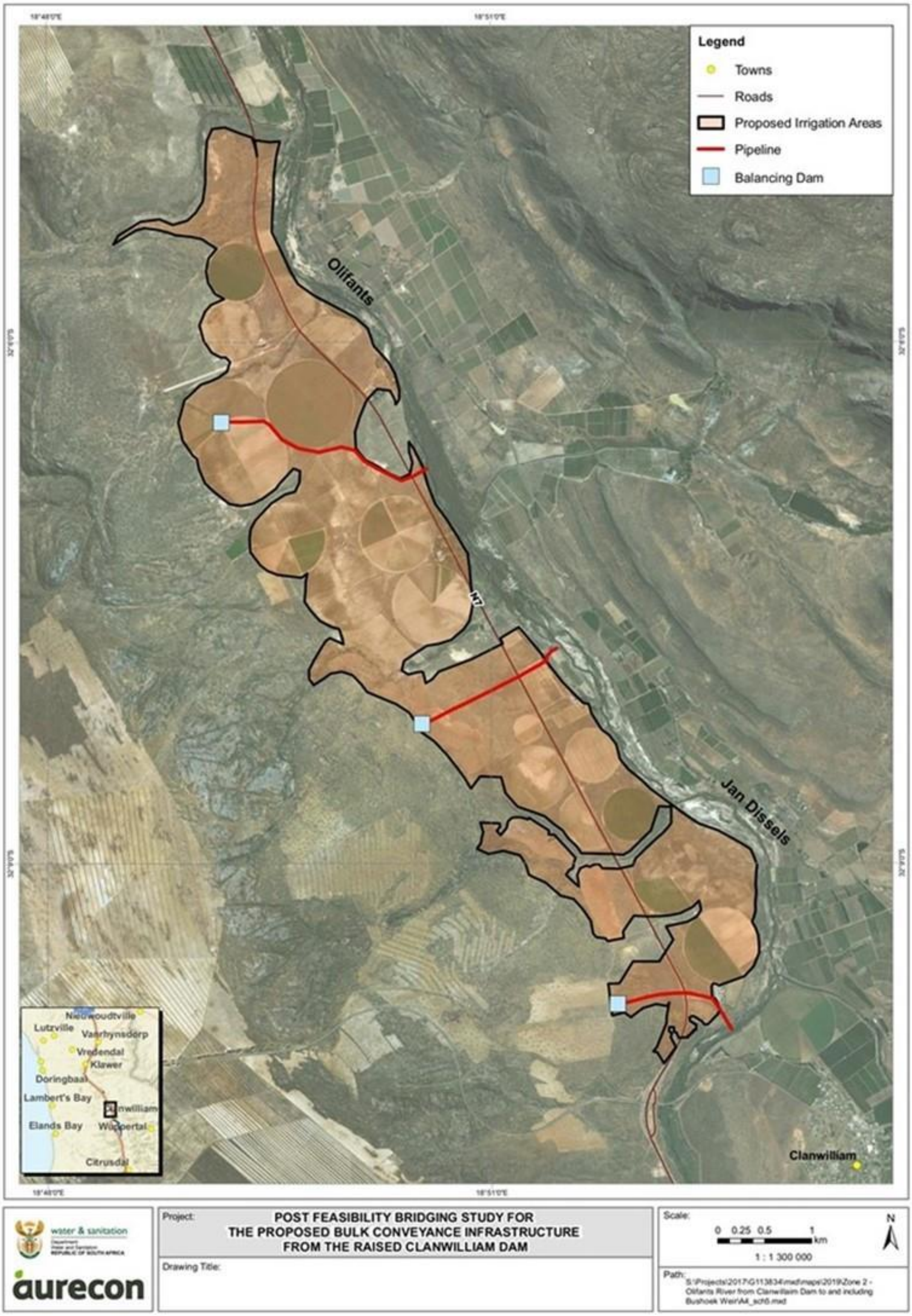

Figure 7.4: Location and layout of Zandrug Scheme

7.4.2 Net Water Requirements and Losses

The water requirement for the 1 209 ha irrigable area is 11.14 million m^3/a.

River losses of 0.56 million m^3/a (5%) are expected as the scheme is located close to Clanwilliam Dam. Infrastructure conveyance losses will be negligible (short pipelines).

The existing water allocation is 2.55 million m^3/a.

The incremental water requirement is 8.59 million m^3/a.

7.4.3 Description of Zandrug Scheme

The scheme entails that water will be released from the raised Clanwilliam Dam and then pumped from the Olifants River to farm dams with a combined capacity of 30 370 m^3 (30.37 Mℓ), with irrigation done under gravity.

This scheme involves the construction of the following bulk water infrastructure at three abstraction points:

- Rising Main pipeline 1: A 2 592 m long, 600 mm diameter steel rising main from a 1 090 kW pump station located at the Olifants River. The pumping head from the river to the farm dam is 143 m and the storage capacity of the farm dam is 16 757 m^3.
- Rising Main pipeline 2: A 1 714 m long, 400 mm diameter steel rising main from a 247 kW pump station located at the Olifants River. The pumping head from the river to the farm dam is 75 m and the storage capacity of the farm dam is 7 214 m^3.
- Rising Main pipeline 3: A 1 452 km long, 350 mm diameter uPVC/steel rising main from a 321 kW pump station located at the Olifants River. The pumping head from the river to the farm dam is 111 m and the storage capacity of the farm dam is 6 400 m^3.

There is some potential for smallholder plots of 7.5 ha, considering the proximity of the southern portion of the irrigable area to Clanwilliam town and existing markets.

7.4.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

7.4.5 Cost and Unit Reference Value

The comparative capital costs (2020 prices, excluding VAT) are shown in **Table 7.5**. The cost values for this scheme are given in **Table 7.6**.

Table 7.5: Zandrug Scheme Comparative Capital Cost in million Rands

Pump stations	Pipelines	Farm dams	Purchase of land	Prof. design & support	Total Cost
51.16	17.06	2.32	38.61	8.70	**117.85**

Table 7.6: Zandrug Scheme Cost Values in R/m³

Cost item	Discount Rate 8%
Total comparative capital cost (R million)	117.85
Annual operating cost (R million/annum)	4.97
NPV Cost (R million)	196.84
Unit Reference Value (R/m³)	1.52

7.4.6 Ecological Impact

Sensitivity: High: All remaining natural areas within the proposed site are mapped as ESA 1 and CBA 1, with all watercourse corridors mapped as ESA 2. Reasons for environmental sensitivity include threatened vertebrates, water resource and wetland protection and upland-lowland interface (southern half of the study area). The remaining natural vegetation across the bottom third of the site is mapped as Leipoldtville Sand Fynbos, which is classified as an Endangered ecosystem.

Recommendation:

- All CBA 1 and natural vegetation areas should be avoided, and the ESA 1 and ESA 2 areas would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity.
- Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist).
- The site may require biodiversity offsets if residual impacts are significant.
- All development should also be located outside of the 1:100-year floodlines of the Olifants and Jan Dissels rivers and other tributaries in the area.

7.4.7 Summary of Zandrug Scheme

The scheme has a good location, a low comparative capital cost and a low URV with high environmental concerns. There are no water quality concerns and water losses are very low.

There is some potential for 7.5 ha smallholder plots, for the southern portion of the area located closer to Clanwilliam town.

7.5 Bulshoek Scheme

7.5.1 Bulshoek Scheme Location

The location and layout of the proposed Bulshoek Scheme are shown in **Figure 7.5**. The scheme would be located on both sides of the lake of Bulshoek Weir.

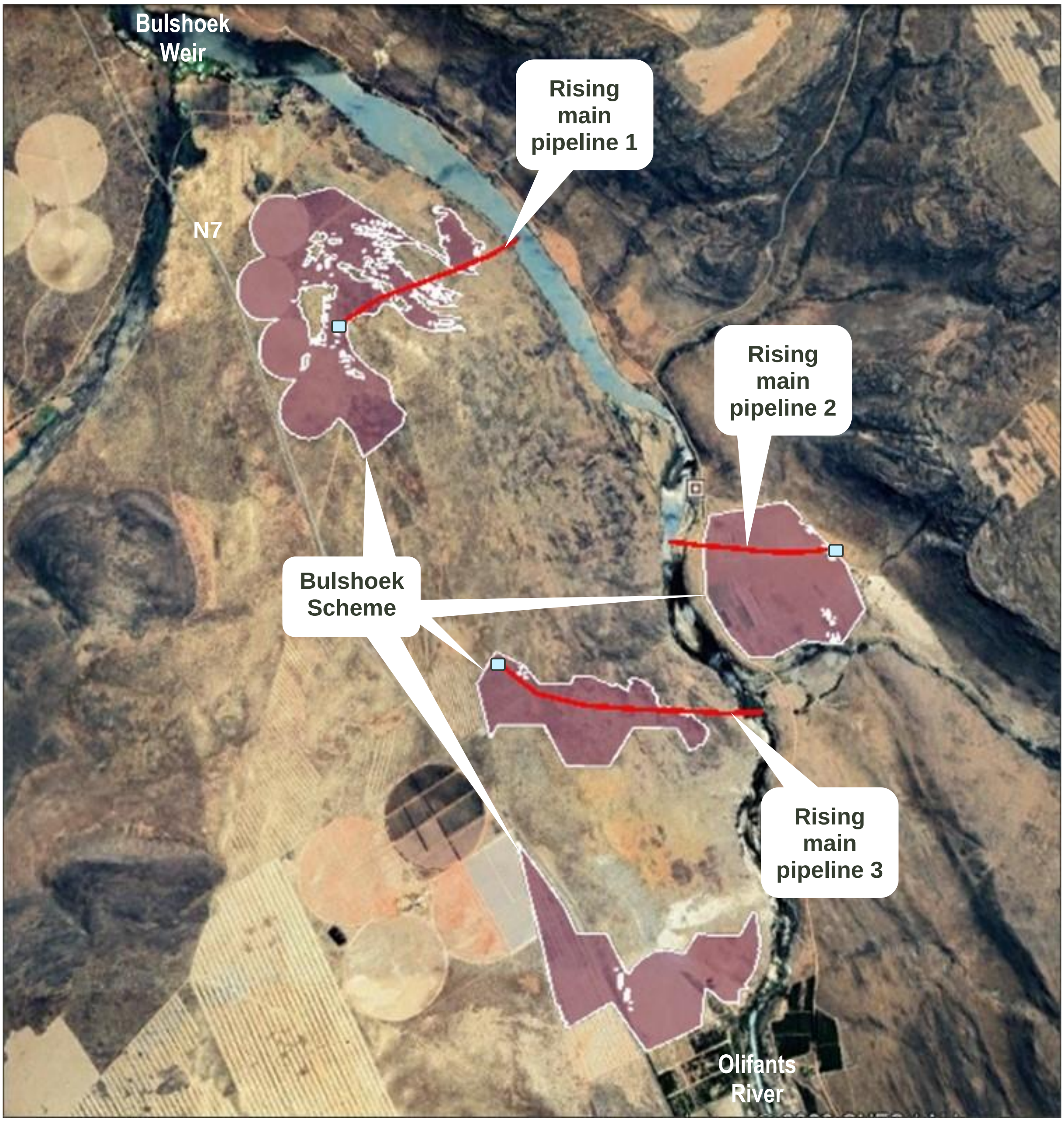

Figure 7.5: Location and layout of the Bulshoek Scheme

7.5.2 Net Water Requirements and Losses

Following the slope analysis to exclude steep slopes, the irrigable area of the scheme was significantly reduced, and the area has become more fragmented. The irrigable area is 266 ha. The water requirement for the development is 2.46 million m^3/a. Minimal conveyance losses are expected, as water will be pumped via short pipelines.

There are some crop fields located in the identified area, with an existing scheduled water allocation. The existing water use authorisation is 0.33 million m^3/a, and the incremental water requirement is 2.13 million m^3/a.

7.5.3 Description of Bulshoek Scheme

For this scheme, water will be pumped directly from the lake of the Bulshoek Weir to balancing dams with a combined capacity of 6 699 m^3 (6.7 Mℓ). Abstraction points will be affected by the rise/fall of the water level. The current operating rule of Bulshoek Weir is that the water level is kept at about 60% of capacity, to limit leakage from the weir.

This scheme will involve the construction of infrastructure at three abstraction points:

- Rising Main pipeline 1: A 1 193 m long, 250 mm diameter uPVC rising main from the 150 kW (including 50% spare capacity) pump station, located at the pumping point at the edge of the lake, to a small farm dam (2 693 m^3 storage capacity). The pumping head from the river to the farm dam is 123 m.
- Rising Main pipeline 2: A 1 002 m long, 200 mm diameter uPVC rising main from the 48 kW (including 50% spare capacity) pump station, located at the pumping point at the edge of the lake, to a small farm dam (1 516 m^3 storage capacity). The pumping head from the river to the farm dam is 69 m.
- Rising Main pipeline 3: A 1 726 m long, 250 mm diameter uPVC rising main from the 132 kW (including 50% spare capacity) pump station, located at the pumping point at the edge of the lake, to a small farm dam (2 489 m^3 storage capacity). The pumping head from the river to the farm dam is 116 m.

7.5.4 Water Quality

Water quality is good. A leaching requirement of 3% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

7.5.5 Bulshoek Scheme Cost Values

The comparative capital costs (2020 prices, excluding VAT) are shown in **Table 7.7**. The cost values for this scheme are given in **Table 7.8**.

Table 7.7: Bulshoek Scheme Comparative Capital Costs in million Rand

Pump stations	Pipelines	Farm dams	Purchase of land	Prof. design & support	Total Cost
12.12	4.94	0.55	5.99	2.32	**25.92**

Table 7.8: Bulshoek Scheme Cost Values

Item	Discount Rate 8%
Total comparative capital cost (R million)	25.92
Annual operating cost (R million/annum)	1.11
NPV Cost (R million)	44.37
Unit Reference Value (R/m^3)	1.56

7.5.6 Ecological Impact

Sensitivity: **Medium:** All watercourse corridors within the proposed site are mapped as ESA 1 for watercourse protection, as well as a very small section in the most western section across an existing pivot irrigation field. There are no CBAs in this area, but the area is mapped as an upland-lowland interface across the western half of the entire site. There is also a wetland to the south, outside of the boundaries of the study area, and a buffer should be provided for this by a specialist. The remaining natural vegetation across the western boundaries, as well as the most southern portion of the site, is mapped as Leipoldtville Sand Fynbos, which is classified as an 'Endangered' ecosystem.

Recommendation:

- The proposed site would require detailed site assessment by freshwater and botanical specialists to determine accurate on-site sensitivity, to confirm the areas to be excluded as an upland-lowland interface and those containing endangered vegetation or species of concern.
- Provide a buffer for all wetlands and watercourses (to be delineated by a freshwater specialist).
- The remaining sections may require biodiversity offsets if residual impacts are significant.
- The development should also be limited to outside the 1:100-year floodline of the river.

7.5.7 Summary of Bulshoek Scheme

This scheme has a good location, low comparative capital cost and a low URV, with medium environmental concerns. There are no water quality concerns and water losses are low. It is unsure to what extent existing farms would be willing to convert existing irrigation to higher-value crops.

7.6 Klawer and Coastal 1 Schemes

As explained in Section 2.3.4, these areas have changed following the slope analysis undertaken. For the Klawer and Coastal 1 area however the slope analysis has resulted in a very limited reduction in potential irrigation areas.

The full extent of the Klawer and Coastal 1 areas are shown in **Figure 7.6**. The full Klawer and Coastal 1 irrigable areas are 1 378 ha and 2 207 ha respectively. Until the Right Bank canal has been constructed and further canal sections have been upgraded or replaced, it is only possible to feasibly supply portions of these potential schemes by utilising the spare flow capacity in existing canal sections. The various schemes that have been identified, including sub-options, are described below for consideration for implementation, either immediately after raising of Clanwilliam Dam and/or after upgrading of existing distribution canal sections.

Canal flows required for the Ebenhaeser Scheme impacts on the remaining available spare flow capacity in canal sections to supply the Klawer and Coastal 1 schemes. Given the high social and political importance of the Ebenhaeser Scheme, the sizing of Klawer and Coastal 1 scheme options assume that flows destined for the Ebenhaeser Scheme are let through.

The Klawer potential irrigation area provides several options for implementation as shown in **Table 7.9**.

Table 7.9: Klawer conveyance options

Conveyance option	Irrigable area (ha)	Water requirement (Mm^3/a)	Description
Klawer - from river	1 378	13.95	Release of water from Bulshoek Weir down the Olifants River and pumping from the river to irrigate the full Klawer area. This option was screened out, being very expensive, because water quality will be significantly influenced by poor quality summer river flows, and blending will be needed.
Klawer Phase 1	398	4.17	Use of spare flow capacity in the right bank canal (Klawer canal section), allowing for Ebenhaeser Scheme flows to pass through, before the construction of the new Right Bank main canal, to irrigate a portion of the potential irrigation area.
Klawer Phase 2 - post-RB canal	966	9.779	Irrigation of the remainder of the Klawer potential irrigation area, following the implementation of the Ebenhaeser Scheme, Klawer Phase 1 Scheme and the new Right Bank main canal.
Klawer Phase 2 partial development - post-RB Canal	438	4.43	Irrigation of a portion of the remainder of the Klawer area, following the implementation of the Ebenhaeser Scheme, Klawer Phase 1 Scheme and the new Right Bank main canal, to fully use the remaining allocation of water from a raised Clanwilliam Dam, should this be the last scheme to be implemented (along with the Coastal Phase 1 Scheme).
Klawer - post-RB Canal	1 378	13.95	Implementation of the scheme to irrigate the full potential irrigation area, following the construction of the new Right Bank main canal.
Klawer partial development - post-RB Canal	850	8.61	Implementation of the scheme to irrigate a portion of the potential irrigation area, following the construction of the Ebenhaeser Scheme, Klawer Phase 1 Scheme and the new Right Bank main canal. The scheme's water requirement will be equal to the (Phase 1 plus Phase 2 partial scheme) water requirement, to make full use of the available water to be allocated from a raised Clanwilliam Dam, should this be the last scheme to be implemented (along with the Coastal Phase 1 Scheme).

The findings from the evaluation of these options are discussed in the following sub-sections.

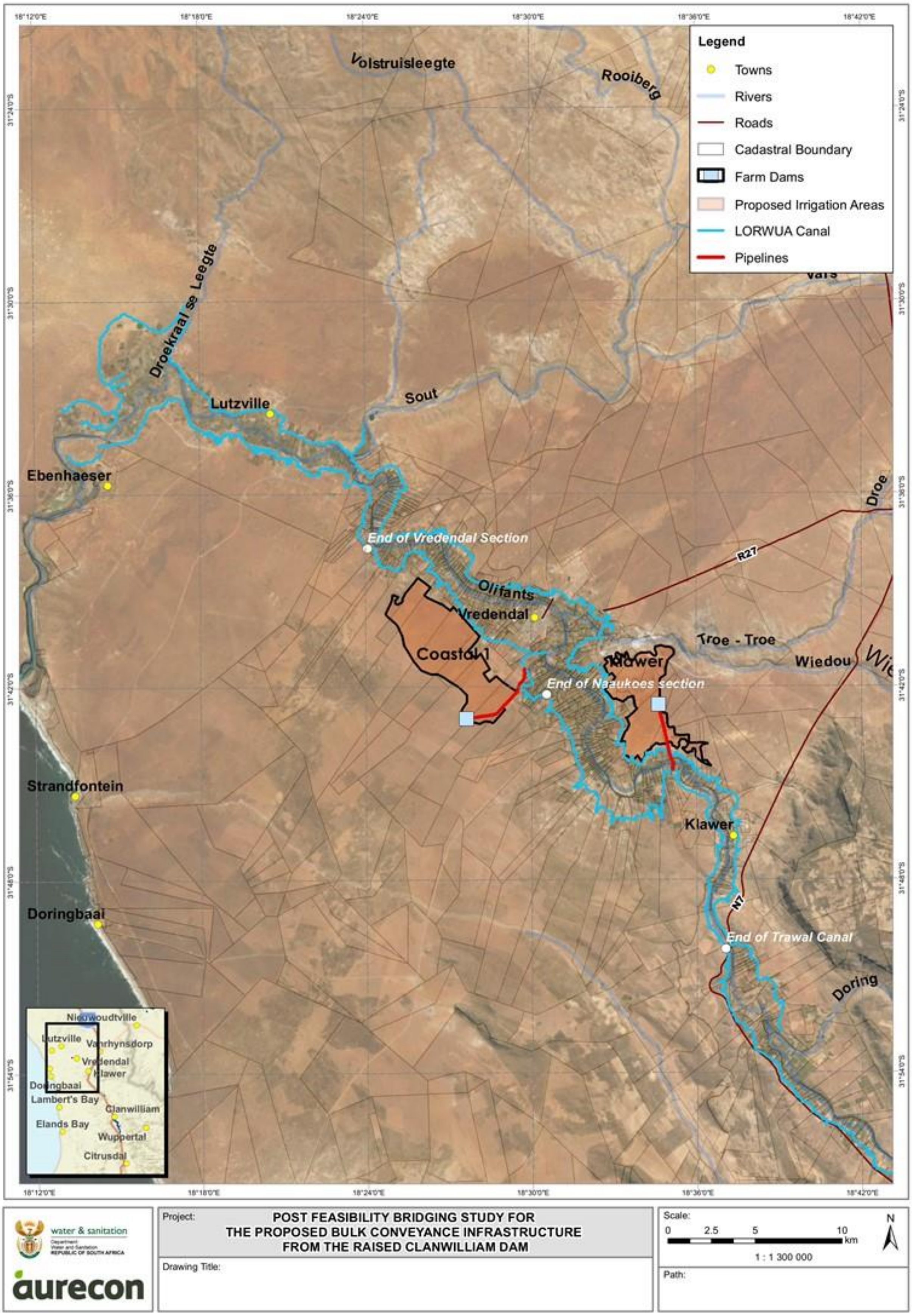

Figure 7.6: Layout of full Klawer and Coastal 1 potential irrigation areas

7.7 Klawer Phase 1 Scheme

7.7.1 Klawer Phase 1 Scheme Location and Layout

This scheme (**Figure 7.7**) involves the use of spare flow capacity in the right bank canal, before the construction of the new Right Bank main canal, to irrigate a portion of the full potential Klawer area. The scheme would be located South-East of Vredendal.

7.7.2 Spare canal flow capacity

The size of the Phase 1 scheme is determined by the extent of the canal flow that can be routed to and abstracted from the Karoovlakte canal section, after flows destined for the Ebenhaeser Scheme have been passed through.

The annual flow volume for the Ebenhaeser Scheme to be conveyed via the right bank canal is 1.815 million m^3/a (2.088 million m^3/a inclusive of canal losses).

The evaluation of spare capacity in canal sections was explained in Section 6.3. Where some discrepancies in the flow data were encountered, a conservative approach was taken. Some corrections were made to outlier weekly flow data of the Retshof canal, to be more representative of typical flow data for such weeks.

An evaluation of canal flows in the right bank canal sections was undertaken for the representative 2010/11 flow records (October to September). This flow record has the second lowest spare flow capacity of the 13 years of flow records evaluated and is deemed representative of a future situation of canal flow. The total spare flow capacities in the various canal sections (when comparing weekly actual flows to maximum weekly flow capacities) are as follows (canal sections are shown in a downstream direction):

- Klawer: 18.796 million m^3/a;
- Karoovlakte: 17.239 million m^3/a;
- Retshof: 4.176 million m^3/a.

Following a conservative approach, to also allow for future increased canal flows for existing farmers, only 50% of the identified spare flow capacity has been regarded as available for new irrigation development. In addition, the routing of additional flows destined for development, via the Main Canal to the Klawer Canal to the Karoovlakte section was then checked. The available flow capacity in the respective canal sections (inclusive of canal losses and not yet considering flows to be let through for the Ebenhaeser Scheme) for development is then:

- Klawer: 7.752 million m^3/a;
- Karoovlakte: 7.516 million m^3/a;
- Retshof: 2.088 million m^3/a.

This illustrates that, while the Ebenhaeser Scheme will use all the conservatively calculated spare capacity in the Retshof Canal Section, there is still significant spare capacity in the Klawer and Karoovlakte canal sections. The spare flows for the Klawer and Karoovlakte canal sections do not differ significantly. Fifty percent of spare flows in the Karoovlakte canal section, minus flows that will be let through to the Ebenhaeser Scheme (inclusive of the associated losses of Ebenhaeser flows) minus canal losses was considered as available flow for the Klawer Scheme development.

The evaluation of canal flows in the right bank canal sections concluded that 5.09 million m^3/a, inclusive of canal losses, is available from the Karoovlakte canal section for irrigation. Of this volume, 4.172 million m^3/a, is available for irrigation with total losses amounting to 1.13 million m^3/a, which reduces to 0.92 million m^3/a after the construction of the new Right Bank main canal. This also considers the evaporation losses from an off-channel balancing dam. The diversion flows from the Karoovlakte canal, not considering balancing dam evaporation losses amount to 4.260 million m^3/a.

The evaluation of the representative year of weekly flows indicates that flows can be diverted for 32 weeks of the year.

7.7.3 Scheme description

For this scheme, irrigators could pump water during weeks with surplus flow in the Karoovlakte canal section. Adjacent to the abstraction point from the canal, a small balancing reservoir of 32 054 m^3 (12-hour storage) and a reject will be constructed. From the reservoir, water will be pumped via a ±1.12 km long, 800 mm diameter steel rising main from the 623 kW pump station, located at the pumping point from the reservoir, at a pumping head of 43 m to a 0.942 million m^3 balancing dam. From the balancing dam, irrigators will be supplied under gravity. The area that can be irrigated is 358 ha.

7.7.4 Water Quality

Water quality will be excellent. In the determination of the irrigable areas, a leaching requirement of 20% has been assumed, to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

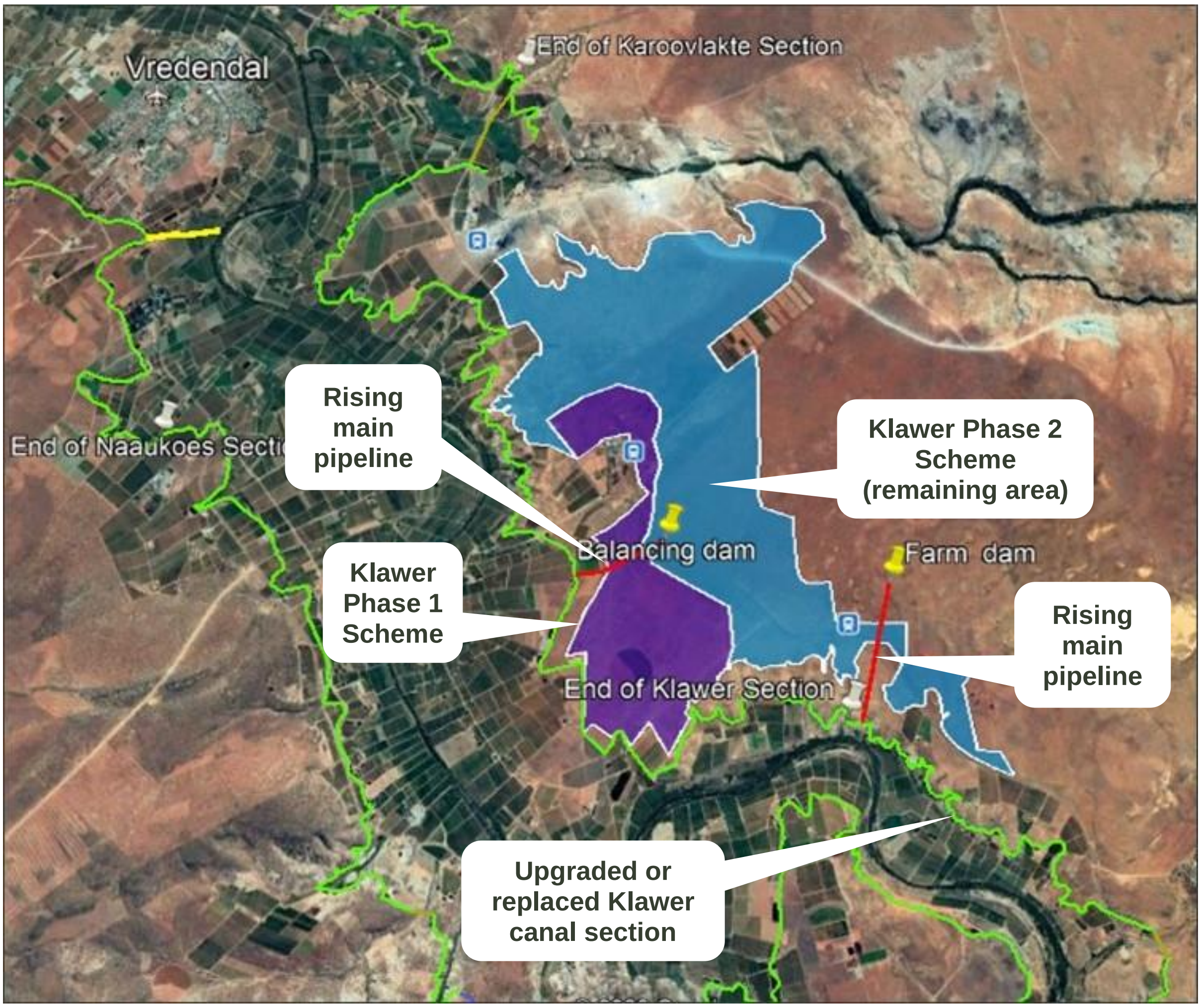

Figure 7.7: Klawer Phase 1 and Klawer Phase 2 schemes

7.7.5 Cost and Unit Reference Value

The comparative capital costs (2020 prices, excluding VAT) are shown in **Table 7.10**. The cost values for this scheme are shown in **Table 7.11**.

Table 7.10: Klawer Phase 1 Comparative Capital Costs in million Rand

Balancing dam	Pump stations	Pipelines	Purchase of land	Prof. design & support	Total Cost
30.71	19.13	8.43	9.51	9.31	**77.09**

Table 7.11: Cost values for Klawer Phase 1 scheme

Cost Item	Discount Rate 8%
Total comparative capital cost (R million)	77.09
Annual operating cost (R million/annum)	2.33
NPV Cost (R million)	108.53
Unit Reference Value (R/m^3)	2.25

7.7.6 Operational aspects

The operation of the scheme will introduce some complexity, as it involves three pump stations and a different way of determining flow releases for the scheme.

7.7.7 Ecological Impact

Sensitivity: **Low:** ESA 1 and ESA 2 features occur across the site along the watercourse corridors.

Recommendation:

- Avoid ESA 1 and ESA 2 along watercourse corridors as far as possible.
- Freshwater and botanical specialist input is required to determine appropriate mitigation measures for development.

7.7.8 Summary of Klawer Phase 1 Scheme

This scheme has low environmental concerns, low comparative capital cost and a medium URV. The scheme will have water losses of 22%. Water quality will be good. Operation of the scheme will be complex. This scheme may hold potential for the development of 7.5 ha smallholder plots, given its location between Klawer and Vredendal. There is some concern of the effect of the additional head on the integrity of the old canal, although this will be mitigated if the full capacity of the Klawer canal section is not used. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

7.8 Klawer Phase 2 Scheme and Partial Phase 2 Scheme

7.8.1 Klawer Phase 2 Scheme Location and Layout

This scheme, shown in **Figure 7.7**, involves the development of the remainder of the full Klawer irrigation area, following the completion of the new Right Bank main canal and the raising/lining or replacement of the full Klawer right bank canal section. The scheme is located South-East of Vredendal.

A sub-option of this potential scheme is the development of a portion of the remainder of the Klawer area, following the implementation of the Ebenhaeser Scheme, Klawer Phase 1 Scheme and the new Right Bank main canal, to fully use the remaining allocation of water from a raised Clanwilliam Dam, should this be the last scheme to be implemented (along with the Coastal Phase 1 Scheme).

7.8.2 Water Requirements

The remainder of the full Klawer irrigation area comprises an area of 1 073 ha, of which 90% or 966 ha is considered irrigable. The full Phase 2 water requirement is 9.78 million m^3/a, with total losses of 1.96 million m^3/a.

The sub-option, for a scaled-down Phase 2 development comprises an area of 487 ha, of which 90% or 438 ha is considered irrigable. The scaled-down Phase 2 water requirement is 4.43 million m^3/a, with total losses of 0.89 million m^3/a.

7.8.3 Upgraded Klawer Canal Section Design Flow

For this scheme, the entire Klawer right bank canal section from ‘Verdeling’ to a couple of kilometers North-West of the town of Klawer, will be concrete-lined/raised or replaced, to match required downstream requirements consisting of existing and potential future irrigation, other potential future uses, and canal losses. The existing 18.9 km Klawer canal section consists of three canal sections totalling ~16.8 km, a 1 772 m covered section, and a 314 m long syphon.

The capacity of the upgraded Klawer Canal section should consist of the following flow components:

- Current flow capacity of the canal section, providing existing irrigators;
- An allowance for increased flow for an increased assurance of supply, following the raising of Clanwilliam Dam;
- Future non-irrigation flows;
- Flow requirement of the Klawer Phase 2 Scheme; and

- Flow requirement for other new irrigation, either from the Klawer canal section, or further down the right bank canal, these being:
  - Klawer Phase 1 scheme,
  - Ebenhaeser Scheme diversion from the right bank Retshof canal section,
  - Future non-irrigation flows.

The design flow of the existing Klawer canal and the flow requirement for the increased assurance of supply of existing irrigators is shown in **Table 7.12**. It has been assumed that the current right bank irrigators will benefit from 45% of the total increase in assurance of supply.

Table 7.12: Canal flow component for existing irrigators

Flow component - existing irrigators	Requirements incl. losses (million m^3/a)	Existing Canal Design flow (m^3/s)
Existing flow capacity of Klawer canal	84.403	2.676
Increased assurance of supply	19.499	0.618
Totals	**103.901**	**3.295**

The flow requirement for the upgraded Klawer canal section for new irrigators and other future water uses are shown in **Table 7.13**, for the full Phase 2 area. For the sub-option (partial Klawer Phase 2), this is shown in **Table 7.14**.

Table 7.13: Canal design flow component for new irrigation - full Klawer Phase 2

Flow component - new irrigation & other future users	Requirement (million m^3/a)	Average requirement (m^3/s)	Peak factor	Component design flow (m^3/s)
Ebenhaeser - right bank canal flow	2.088	0.066	2.09	0.138
Klawer Phase 1	4.172	0.132	2.09	0.276
Klawer Phase 2	9.779	0.310	2.09	0.648
Future non-irrigation flows (50%)	1.246	0.040	1.50	0.040
Totals	**17.285**	**0.548**		**1.102**

Table 7.14: Canal design flow component for new irrigation - partial Klawer Phase 2

Flow component - new irrigation & other future users	Requirement (million m^3/a)	Average requirement (m^3/s)	Peak factor	Component design flow (m^3/s)
Ebenhaeser - right bank canal flow	2.088	0.066	2.09	0.138
Klawer Phase 1	4.172	0.132	2.09	0.276
Klawer Phase 2	4.430	0.140	2.09	0.294
Future non-irrigation flows (50%)	1.246	0.040	1.50	0.040
Totals	**11.936**	**0.378**		**0.748**

The flow components of an upgraded Klawer canal section with an increased flow capacity are summarised in **Table 7.15** for the full Phase 2 area. For the sub-option (partial Phase 2), this is shown in **Table 7.16.**

Table 7.15: Upgraded Klawer Canal Section Design Flows - full Phase 2 area

Flow component	Component design flow (m^3/s)	Component %
Existing irrigators - existing flow & increased assurance of supply, incl. losses	3.295	74.9%
New irrigation & other future uses	1.102	25.1%
Total	**4.397**	

Table 7.16: Upgraded Klawer Canal Section Design Flows - partial Phase 2 area

Flow component	Component design flow (m^3/s)	Component %
Existing irrigators - existing flow & increased assurance of supply, incl. losses	3.295	81.5%
New irrigation & other future uses	0.748	18.5%
Total	**4.043**	

For cost allocation following the evaluation of the Klawer Phase 2 Scheme, it has been assumed that 25% of existing irrigators abstracting from the Klawer section of the right bank canal will benefit from the lining/raising or replacement of the existing Klawer canal section. They will be able to receive an increased assurance of supply, as well as a more secure supply. The comparative flow components for the allocation of scheme cost are summarised in **Table 7.17** for the full Phase 2 area. For the sub-option (partial Phase 2), this is shown in **Table 7.18.**

Table 7.17: Upgraded Klawer Canal Section Design Flows for Cost Allocation - full Phase 2

Flow component	Component design flow (m^3/s)	Component %
25% of existing flow & increased assurance of supply, incl. losses	0.824	40.4%
Klawer Phase 2 irrigation/use + 10% losses	0.713	35.0%
Other new irrigation/use + 10% losses	0.500	24.5%
Total	**2.036**	

Table 7.18: Upgraded Klawer Canal Section Design Flows for Cost Allocation - partial Phase 2

Flow component	Component design flow (m^3/s)	Component %
25% of existing flow & increased assurance of supply, incl. losses	0.824	50.0%
Klawer Phase 2 irrigation/use + 10% losses	0.323	**19.6%**
Other new irrigation/use + 10% losses	0.500	30.4%
Total	**1.646**	

7.8.4 Scheme description

For raising of the existing Klawer canal section of the right bank canal, construction was envisaged as per the sketch shown in **Figure 7.8**. The canal can be raised if the existing lining is in an acceptable condition. If not, the canal will need to be re-lined. A by-pass system to provide access for re-lining of a reasonable length of canal was allowed for. Alternatively, the existing canal section can be replaced by a new canal section, should space allow.

Water will be released from Bulshoek Weir, to flow down the new Right Bank main canal to 'Verdeling', and then down the upgraded/replaced Klawer canal section. Water for the Klawer Scheme will be diverted just before the end of the Klawer canal section.

For the full Phase 2 development, water will be pumped via a 1 638 m long, 750 mm diameter steel rising main from the 800 kW pump station, located at the pumping point from the reservoir, at a pumping head of 63 m to a 0.224 million m^3 farm dam. From the farm dam, irrigators will be supplied under gravity.

For the partial Phase 2 development, water will be pumped via a 1 111 m long, 500 mm diameter steel rising main from the 320 kW pump station, located at the pumping point from the reservoir, at a pumping head of 56 m to a 0.102 million m^3 farm dam. From the farm dam, irrigators will be supplied under gravity.

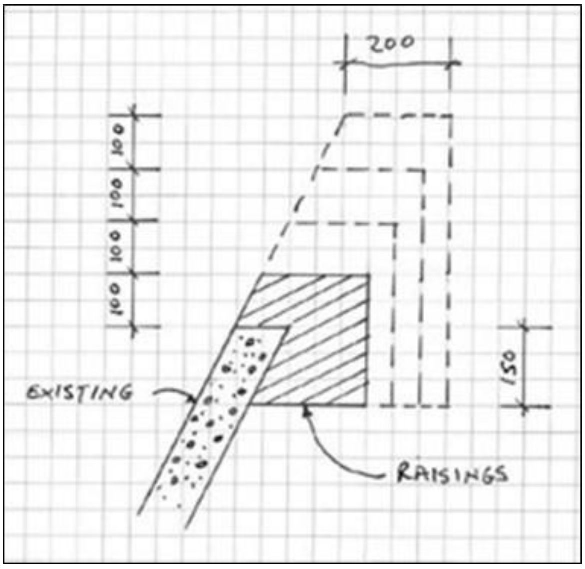

Figure 7.8: Raising of existing canals

An alternative sub-option for storage is to use the balancing dam constructed for the Klawer Phase 1 scheme, which will have significantly larger capacity for balancing storage than needed should the capacity of the Klawer canal section be increased. During Phase 2 water will mostly be pumped to irrigators.

7.8.5 Water Quality

Salinity at the abstraction point would be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l). A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

7.8.6 Cost and Unit Reference Value

The comparative capital costs for the Klawer Scheme (2020 prices, excluding VAT) are shown in **Table 7.19** for the full Phase 2 area. For the sub-option (partial Phase 2), this is shown in **Table 7.20**. The cost values for this scheme are shown in **Table 7.21** for the full Phase 2 area. For the sub-option, this is shown in

Table 7.22.

The division of capital cost in **Table 7.19** and **Table 7.20** has been done according to the relative flow percentages as shown in **Table 7.17** and **Table 7.18** respectively. The existing irrigators, Klawer Phase 1 and Ebenhaeser schemes irrigators, and other future users, will only be required to contribute to the cost of the raising/lining or replacement of the existing canal section.

Table 7.19: Klawer Phase 2 Comparative Capital Costs in million Rand - full Phase 2

Cost distribution	Lining/raising of existing canal	Pump stations	Pipelines	Farm dam	Purchase of land	Prof. design & support	Total Cost
Klawer Phase 2	184.26	24.34	10.15	18.49	21.7	39.35	**298.29**
Other new irrigation & uses	129.18	-	-	-	-	21.77	**150.95**
Betterment	212.89	-	-	-	-	31.93	**244.82**
TOTAL	**526.32**	**24.34**	**10.15**	**18.49**	**21.70**	**97.00**	**698.01**

Table 7.20: Klawer Phase 2 Comparative Capital Costs in million Rand - partial Phase 2

Cost distribution	Lining/raising of existing canal	Pump stations	Pipelines	Farm dam	Purchase of land	Prof. design & support	Total Cost
Klawer Phase 2	113.60	10.22	3.32	8.38	9.85	22.59	**167.95**
Other new irrigation & uses	175.81	-	-	-	-	29.63	**205.44**
Betterment	289.72	-	-	-	-	43.46	**333.18**
TOTAL	**579.13**	**10.22**	**3.32**	**8.38**	**9.85**	**101.05**	**711.94**

Table 7.21: Cost values for Klawer Phase 2 scheme - full Phase 2

Item	Discount Rate 8%
Total comparative capital cost (R million)	298.29
Annual operating cost (R million/annum)	6.02
NPV Cost (R million)	348.60
Unit Reference Value (R/m^3)	3.10

Table 7.22: Cost values for Klawer Phase 2 scheme - partial Phase 2

Item	Discount Rate 8%
Total comparative capital cost (R million)	167.95
Annual operating cost (R million/annum)	4.27
NPV Cost (R million)	203.40
Unit Reference Value (R/m^3)	1.71

7.8.7 Ecological Impact

Sensitivity: **Low:** ESA 1 and ESA 2 features occur across the site along the watercourse corridors.

Recommendation:

- Avoid ESA 1 and ESA 2 along watercourse corridors as far as possible.
- Freshwater and botanical specialist input is required to determine appropriate mitigation measures for development.

7.8.8 Summary of Klawer Phase 2 and Partial Phase 2 Schemes

The schemes have low environmental concerns and very high comparative total capital costs. The URVs are less helpful as it is determined by the relative size of the required canal flow portion for each option compared to the total flow in a raised/lined or replaced Klawer canal section. The scheme will have water losses of 20%. Water quality will be good. This scheme may hold potential for the development of 7.5 ha smallholder plots, given its location between Klawer and Vredendal. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

7.9 Full Klawer Scheme and Klawer Scaled-Down Scheme

7.9.1 Klawer Scheme Location and Layout

This full Klawer Scheme, shown in **Figure 7.9**, involves the development of the full Klawer irrigation area, following the completion of the new Right Bank main canal and the raising/lining or replacement of the Klawer right bank canal section. The scheme is located South-East of Vredendal.

A sub-option of this potential scheme (referred to as the Klawer Scaled-Down Scheme) is also shown in **Figure 7.9**. This option entails the development of a portion (944 ha) of the Klawer area, following the implementation of the Ebenhaeser Scheme and the new Right Bank main canal, to fully use the remaining allocation of water from a raised Clanwilliam Dam, should this be the last scheme to be implemented (along with the Coastal Phase 1 Scheme).

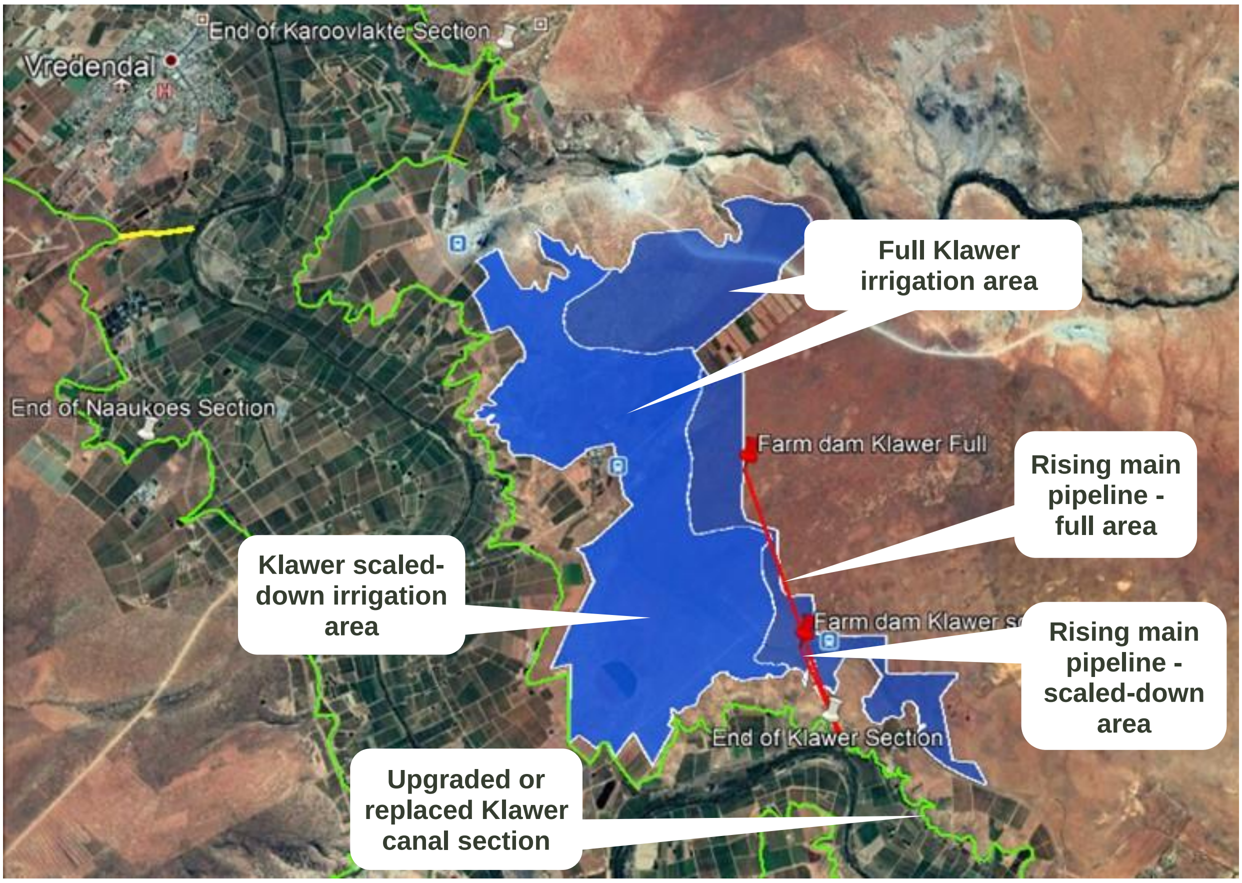

Figure 7.9: Full and scaled-down Klawer schemes

7.9.2 Water Requirements

The full Klawer irrigation area comprises an area of 1 531 ha, of which 90% or 1 378 ha is considered irrigable. The full Klawer water requirement is 13.95 million m^3/a, with total losses of 2.79 million m^3/a.

The sub-option, for a scaled-down Klawer development comprises an area of 944 ha, of which 90% or 850 ha is considered irrigable. The scaled-down Klawer water requirement is 8.61 million m^3/a, with total losses of 1.72 million m^3/a.

7.9.3 Upgraded Klawer Canal Section Design Flow

For the Full Klawer Scheme, the entire Klawer right bank canal section from 'Verdeling' to a couple of kilometers North-West of the town of Klawer, will be concrete-lined/raised or replaced, to match required downstream requirements. These requirements include existing and potential future irrigation, other potential future uses, and canal losses. The existing 18.9 km Klawer canal section consists of three canal sections totalling ~16.8 km, a 1 772 m covered section, and a 314 m long syphon.

The capacity of the upgraded Klawer Canal section should consist of the following flow components:

- Current flow capacity of the canal section, providing existing irrigators;
- An allowance for increased flow for an increased assurance of supply, following the raising of Clanwilliam Dam;
- Flow requirement of either the full Klawer Scheme or the scaled-down scheme; and
- Flow requirement for other new irrigation, either from the Klawer canal section, or further down the right bank canal, these being:
  - Ebenhaeser Scheme diversion from the right bank Retshof canal section,
  - Future non-irrigation flows.

The design flow of the existing Klawer canal and the flow requirement for the increased assurance of supply of existing irrigators is shown in **Table 7.23**. It has been assumed that the current right bank irrigators will benefit from 50% of the total increase in assurance of supply.

Table 7.23: Canal flow component for existing irrigators

Flow component - existing irrigators	Requirements incl. losses (million m^3/a)	Existing Canal Design flow (m^3/s)
Existing flow capacity of Klawer canal	84.403	2.676
Increased assurance of supply	19.499	0.618
Totals	**103.901**	**3.295**

The flow requirement for the upgraded Klawer canal section for new irrigators and other future water uses are shown in **Table 7.24**, for the full Klawer area. For the sub-option (scaled-down Klawer area), this is shown in **Table 7.25**.

Table 7.24: Canal design flow component for new irrigation - full Klawer area

Flow component - new irrigation & other future users	Requirement (million m^3/a)	Average requirement (m^3/s)	Peak factor	Component design flow (m^3/s)
Ebenhaeser - right bank canal flow	2.088	0.066	2.09	0.138
Full Klawer	13.940	0.442	2.09	0.924
Future non-irrigation flows (50%)	1.246	0.040	1.50	0.059
Totals	**17.274**	**0.548**		**1.121**

Table 7.25: Canal design flow component for new irrigation - scaled-down Klawer area

Flow component - new irrigation & other future users	Requirement (million m^3/a)	Average requirement (m^3/s)	Peak factor	Component design flow (m^3/s)
Ebenhaeser - right bank canal flow	2.088	0.066	2.09	0.138
Klawer scaled-down	8.690	0.276	2.09	0.576
Future non-irrigation flows (50%)	1.246	0.040	1.50	0.059
Totals	**12.024**	**0.381**		**0.774**

The flow components of an upgraded Klawer canal section with an increased flow capacity are summarised in **Table 7.26** for the full Klawer area. For the sub-option (scaled-down Klawer area), this is shown in **Table 7.27**.

Table 7.26: Upgraded Klawer Canal Section Design Flows - full Klawer area

Flow component	Component design flow (m^3/s)	Component %
Existing irrigators - existing flow & increased assurance of supply, incl. losses	3.295	74.6%
New irrigation & other future uses	1.121	25.6%
Total	**4.416**	

Table 7.27: Upgraded Klawer Canal Section Design Flows - scaled-down Klawer area

Flow component	Component design flow (m^3/s)	Component %
Existing irrigators - existing flow & increased assurance of supply, incl. losses	3.295	81.0%
New irrigation & other future uses	0.774	19.0%
Total	**4.068**	

For cost allocation, it has been assumed that 25% of existing irrigators abstracting from the Klawer section of the right bank canal will benefit from the lining/raising or replacement of the existing Klawer canal section. They will be able to receive an increased assurance of supply, as well as a more secure supply. The comparative flow components for the allocation of scheme cost are summarised in **Table 7.28** for the full Klawer area. For the sub-option (scaled-down Klawer area), this is shown in **Table 7.29**.

Table 7.28: Upgraded Klawer Canal Section Design Flows for Cost Allocation - full Klawer area

Flow component	Component design flow (m^3/s)	Component %
25% of existing flow & increased assurance of supply, incl. losses	0.824	40.0%
Full Klawer irrigation/use + 10% losses	1.016	**49.4%**
Other new irrigation/use + 10% losses	0.217	10.6%
Total	**2.057**	

Table 7.29: Upgraded Klawer Canal Section Design Flows for Cost Allocation - scaled-down Klawer area

Flow component	Component design flow (m^3/s)	Component %
25% of existing flow & increased assurance of supply, incl. losses	0.824	49.2%
Klawer scaled-down irrigation/use + 10% losses	0.634	**37.8%**
Other new irrigation/use + 10% losses	0.217	13.0%
Total	**1.675**	

7.9.4 Scheme description

For raising of the existing Klawer canal section of the right bank canal, construction was envisaged as per the sketch shown in **Figure 7.10**. The canal can be raised if the existing lining is in an acceptable condition. If not, the canal will need to be re-lined. A by-pass system to provide access for re-lining of a reasonable length of canal was allowed for. Alternatively, the existing canal section can be replaced by a new canal section, should space allow.

Water will be released from Bulshoek Weir, to flow down the new Right Bank main canal to 'Verdeling', and then down the upgraded/replaced Klawer canal section. Water for this scheme will be diverted just before the end of the Klawer canal section.

For the full Klawer development, water will be pumped via a 3 277 m long, 900 mm diameter steel rising main from the 1 273 kW pump station, located at the pumping point at the end of the raised/lined or replaced Klawer canal section, at a pumping head of 70 m to a 0.153 million m^3 farm dam. From the farm dam, irrigators will be supplied under gravity.

For the scaled-down Klawer development, water will be pumped via a 1 111 m long, 700 mm diameter steel rising main from the 610 kW pump station, located at the pumping point at the end of the raised/lined or replaced Klawer canal section, at a pumping head of 54 m to a 0.094 million m^3 farm dam. From the farm dam, irrigators will be supplied under gravity.

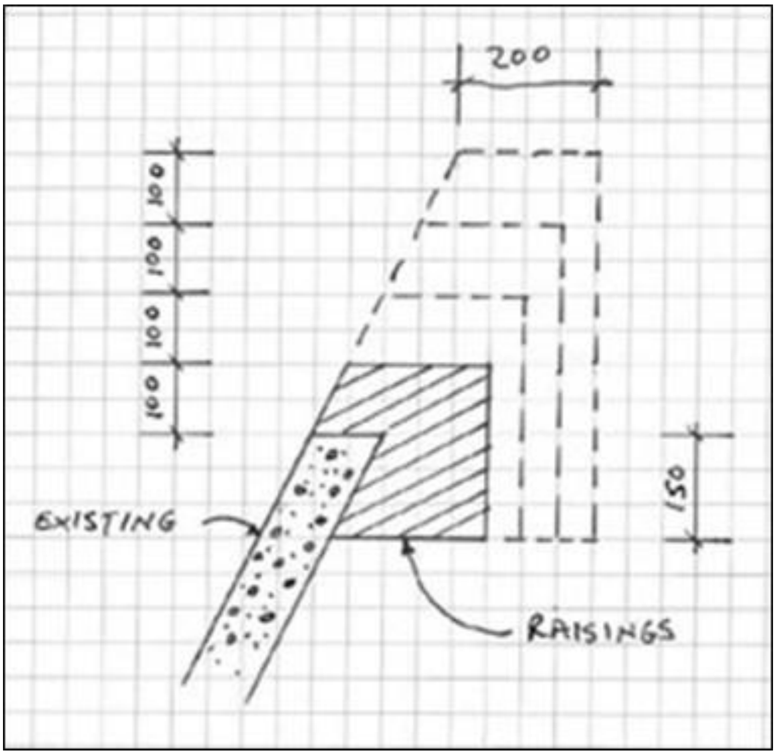

Figure 7.10: Raising of existing canals

7.9.5 Water Quality

Salinity at the abstraction point would be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l). A leaching requirement of 20% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

7.9.6 Cost and Unit Reference Value

The comparative capital costs for the scheme (2020 prices, excluding VAT) are shown in **Table 7.30** for the full Klawer area. For the sub-option (scaled-down Klawer area), this is shown in **Table 7.31**. The cost values for this scheme are shown in **Table 7.32** for the full Klawer area. For the sub-option, this is shown in **Table 7.33**.

The division of capital cost in **Table 7.30** and **Table 7.31** has been done according to the relative flow percentages as shown in **Table 7.28** and **Table 7.29** respectively. The existing irrigators and Ebenhaeser Scheme irrigators, and other future users, will only be required to contribute to the cost of the raising/lining or replacement of the existing canal section.

Table 7.30: Comparative Capital Costs in million Rand - full Klawer area

Cost distribution	Lining/raising of existing canal	Pump stations	Pipelines	Farm dam	Purchase of land	Prof. design & support	Total Cost
Full Klawer	264.68	38.22	31.08	12.62	30.96	57.13	**434.69**
Other new irrigation & uses	51.97	-	-	-	-	8.76	**60.73**
Betterment	216.61	-	-	-	-	32.49	**249.10**
TOTAL	**535.83**	**38.22**	**31.08**	**12.62**	**30.96**	**102.83**	**751.53**

Table 7.31: Comparative Capital Costs in million Rand - scaled-down Klawer area

Cost distribution	Lining/raising of existing canal	Pump stations	Pipelines	Farm dam	Purchase of land	Prof. design & support	Total Cost
Klawer scaled-down	224.29	18.75	6.43	7.79	19.09	42.89	**319.24**
Other new irrigation & uses	70.80	-	-	-	-	11.93	**82.74**
Betterment	295.10	-	-	-	-	44.26	**339.36**
TOTAL	**592.87**	**18.75**	**6.43**	**7.79**	**19.09**	**105.01**	**749.94**

Table 7.32: Cost values for full Klawer area

Item	Discount Rate 8%
Total comparative capital cost (R million)	434.69
Annual operating cost (R million/annum)	8.09
NPV Cost (R million)	495.89
Unit Reference Value (R/m^3)	3.09

Table 7.33: Cost values for scaled-down Klawer area

Item	Discount Rate 8%
Total comparative capital cost (R million)	319.24
Annual operating cost (R million/annum)	5.81
NPV Cost (R million)	356.13
Unit Reference Value (R/m^3)	3.59

7.9.7 Ecological Impact

Sensitivity: **Low:** ESA 1 and ESA 2 features occur across the site along the watercourse corridors.

Recommendation:

- Avoid ESA 1 and ESA 2 along watercourse corridors as far as possible.
- Freshwater and botanical specialist input is required to determine appropriate mitigation measures for development.

7.9.8 Summary of Full Klawer and Scaled-down Klawer Schemes

Both schemes have low environmental concerns, very high comparative capital costs and URVs. The schemes will have water losses of 20%. Water quality will be good. The schemes may hold potential for the development of 7.5 ha smallholder plots, given its location between Klawer and Vredendal. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

7.10 Coastal 1 Scaled-down Scheme

7.10.1 Location and canal spare flow capacity

Located South-West of Vredendal, this scheme (**Figure 7.11**) involves the use of spare flow capacity in the left bank canal below 'Verdeling', following the completion of the new Right Bank main canal. The size of the scheme is determined by the extent of the canal flow that can be routed to and abstracted from the end of the Naaukoes canal section, passing through flows (including losses) destined for the Ebenhaeser Scheme.

The annual flow volume for the Ebenhaeser Scheme to be conveyed via the left bank canal is 2.002 million m^3/a (2.403 million m^3/a, inclusive of canal losses).

The evaluation of spare capacity in canal sections was explained in Section 6.3. Where some discrepancies in the flow data were encountered, a conservative approach was taken.

An evaluation of canal flows in the left bank canal sections was undertaken for the representative 2012/13 flow records (October to September) for the left bank canal sections. This record has the third lowest spare flow capacity of the 10 years of flow records evaluated and is deemed representative of a future situation of canal flow, because the two lowest flow years are evidently drought years with restrictions and are not deemed to be representative of future flows for design purposes. The spare flow capacities in the relevant canal sections (when comparing weekly actual flows to maximum weekly flow capacities) are as follows (canal sections are shown in a downstream direction):

- Naaukoes: 8.122 million m^3/a;
- Vredendal: 4.805 million m^3/a;

Following a conservative approach, to also allow for future increased canal flows for existing farmers, only 50% of the identified spare flow capacity has been regarded as available for new irrigation development. In addition, the routing of additional flows destined for development, via the Main Canal to the Naaukoes Canal was then checked. The available flow capacity in the respective canal sections (inclusive of canal losses and not yet considering flows to be let through for the Ebenhaeser Scheme) for development is then:

- Naaukoes: 4.061 million m^3/a;
- Vredendal: 2.403 million m^3/a;

This illustrates that, while the Ebenhaeser Scheme will use all the conservatively calculated spare capacity in the Vredendal Canal Section, there is still significant spare capacity in the Naaukoes canal section. Fifty percent of spare flows in the Naaukoes canal section (4.061 million m^3/a), minus flows that will be let through to the Ebenhaeser Scheme (inclusive of the associated losses of Ebenhaeser flows) (2.403 million m^3/a) minus canal losses (0.677 million m^3/a), was considered as available flow for the Coastal 1 scaled-down Scheme development.

The evaluation of canal flows in the left bank canal sections, has indicated that flows can be diverted from the end of the Naaukoes canal section, of which 0.903 million m^3/a can be used for new irrigation, also considering the evaporation losses from an off-channel balancing dam. The diversion flows from the Naaukoes canal, not considering balancing dam evaporation losses amount to 0.981 million m^3/a. The irrigable area is 89 ha.

The evaluation of the representative year of weekly flows indicates that flows can be diverted for 26 weeks of the year.

Significantly more land is available for irrigation, if water feasibly could be conveyed to the area and if water to allocate is available. The remainder of the Coastal 1 irrigation area is 2 118 ha of irrigable area, with a water requirement of 21.44 million m^3/a. To develop the remainder of the potential Coastal 1 irrigation area, the entire Naaukoes canal section would need to be lined/raised or replaced. The Naaukoes canal, consisting of 11 canal sections, 5 tunnels and 4 siphons, has a length of 39.5 km. To raise/line or replace it, is estimated to cost R 1 053 million.

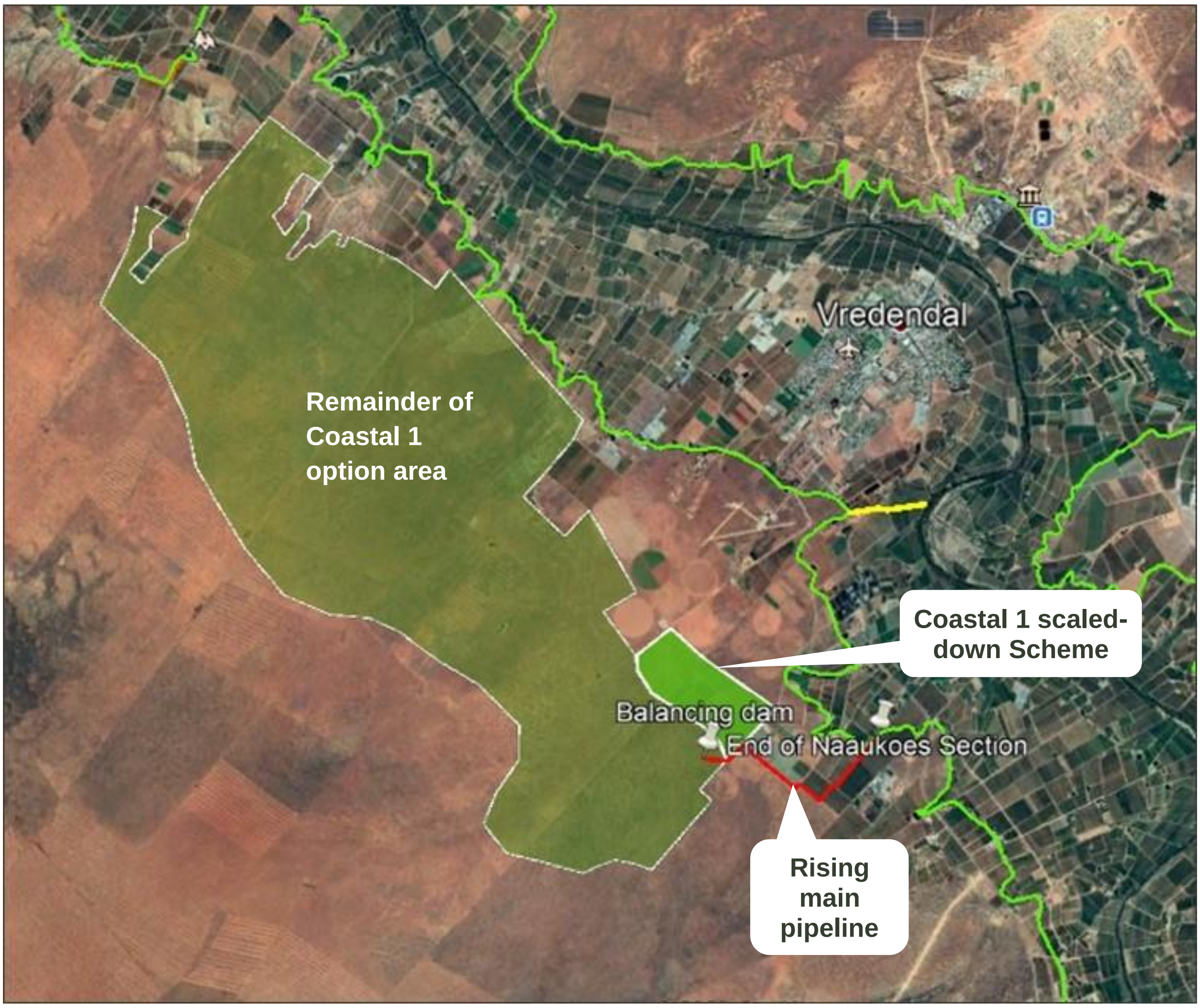

Figure 7.11: Coastal 1 scaled-down scheme

7.10.2 Scheme description

For the Coastal 1 scaled-down scheme, water could be pumped from the canal section during weeks with surplus flow in the Naaukoes canal section. Adjacent to the abstraction point from the canal, a small balancing reservoir of 8 035 m^3 (12-hour storage) and a reject will be constructed. From the reservoir, water will be pumped via a 2 657 m long, 400 mm diameter steel rising main by a 194 kW pump station, located at the pumping point from the reservoir, at a pumping head of 53 m to a 0.687 million m^3 balancing dam. From the balancing dam, irrigators will be supplied under gravity.

7.10.3 Water Quality

Water quality will be excellent. In the determination of the irrigable areas, a leaching requirement of 20% has been assumed, to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

7.10.4 Cost and Unit Reference Value

The comparative capital costs (2020 prices, excluding VAT) are shown in **Table 7.34**. The cost values for this scheme are shown in **Table 7.35**.

Table 7.34: Coastal 1 Comparative Capital Costs in million Rand

Balancing dams	Pump stations	Pipelines	Purchase of land	Prof. design & support	Total Cost
21.90	6.50	5.24	2.47	5.45	41.56

Table 7.35: Cost values for Coastal 1 scheme

Cost Item	Discount Rate 8%
Total comparative capital cost (R million)	41.56
Annual operating cost (R million/annum)	0.86
NPV Cost (R million)	51.48
Unit Reference Value (R/m^3)	4.92

7.10.5 Ecological Impact

Sensitivity: **Low:** ESA 1 and ESA 2 features occur across the site along the watercourse corridors.

Recommendation:

- Avoid ESA 1 and ESA 2 along watercourse corridors as far as possible.
- Freshwater and botanical specialist input is required to determine appropriate mitigation measures for development.

7.10.6 Summary of Coastal 1 Scheme

This scheme has low environmental concerns, low capital costs and a high URV. The scheme will have water losses of 34%. Water quality will be good. This scheme may hold potential for the development of 7.5 ha smallholder plots, given its location close to Vredendal. There is some concern regarding the effect of the additional head on the integrity of the old canal, although this will be mitigated if the full capacity of the Naaukoes canal section is not used. The potential need for additional drainage to mitigate impacts on lower-lying irrigation areas has not yet been included in the cost estimate.

8 Comparison and Phasing of Preferred Irrigation Schemes

8.1 Comparison of Schemes

The key features of the preferred schemes are documented in **Table 8.1**.

The following scheme features have been included in the table for comparison purposes:

- Scheme names and irrigable areas.
- Incremental water requirements, water losses and water loss percentages (total loss as a percentage of irrigation water requirements). Water loss percentages have been indicated as either low, medium or high.
- Costs: Comparative capital costs, NPVs, URVs, and URVs adjusted for the total water loss per option, both for irrigation development and betterment costs, where applicable. The adjusted URVs consider the total water losses. The adjusted URVs are calculated by multiplying the unadjusted URVs by (1 + total water loss / net water requirement) for each option. The URVs and adjusted URVs have been indicated as either low, medium or high. The adjusted URVs are proxies for the (lost) opportunity costs associated with options that have high water losses.
- Environmental impacts, indicated as low, medium or high.
- Implementation risks.
- Social development schemes, i.e. opportunities for either the development of 7.5 ha smallholder plots for social upliftment, or land restitution / augmentation of the existing Ebenhaeser scheme.

Table 8.1: Comparison of Preferred Schemes

Scheme	Zone	Irrigable Area (ha)	Incremental Requirement (Mm^3/s)	Total losses (Mm^3/a)	Incr. Req + Losses (Mm^3/a)*	Scheme Loss %**	Total Capital Cost (R million)	Total NPV Cost (R million)	Capital Cost Betterments (R million)	Total NPV Cost Betterments (R million)	Capital Cost Development (R million)	Total NPV Cost Development (R million)	URV (R/m^3)	URV (R/m^3) adjusted for losses	Environ-mental impact	Risks	Opportunity for smallholders/ restitution
Jan Dissels	2	462	4.26	0.00	4.26	0%	25.2	57.8	0.0	0.0	25.2	57.8	1.17	1.17	High	Environmental opposition	Yes
Clanwilliam		298	2.46	0.00	2.46	0%	34.5	58.6	0.0	0.0	34.5	58.6	1.84	1.84	Medium	Limited area of existing irrigation & land ownership	Yes
Transfer of lower Jan Dissels River irrigators		0	1.00	0.00	1.00	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.00	0.00	Low	Low but irrigators may potentially oppose it	-
Zandrug		1209	8.59	0.56	9.15	5%	117.8	196.8	0.0	0.0	117.8	196.8	1.52	1.60	High	Interest of land owners to switch existing irrigation to higher-value crops & land ownership	Partial
Bulshoek		266	2.13	0.12	2.25	5%	25.9	44.4	0.0	0.0	25.9	44.4	1.56	1.64	Medium	Interest of land owners to switch existing irrigation to higher-value crops & land ownership	No
Right Bank canal (incl. 4 Trawal irrigation areas)	4	2339	22.31	3.35	25.65	15%	1,475.6	1,501.0	1,081.2	911.8	394.5	589.2	2.29	2.63	Medium	Funding of betterments & land ownership	No
Klawer Phase 1 (flow-restricted)	5	412	4.17	1.13	5.30	27%	77.1	108.5	0.0	0.0	77.1	108.5	2.25	2.86	Low	Canal structural integrity, land ownership, operational complexity	Yes
Klawer Phase 1 (flow-restricted) post-Right Bank canal		0	0.00	-0.21	-0.21	22%							2.25	2.75			
Klawer Phase 2 (partial development)**		438	4.43	0.89	5.32	20%	711.9	697.5	544.0	494.1	168.0	203.4	1.71	2.05	Low	Funding of betterments & land ownership	Yes
Coastal 1 (flow-restricted)		89	0.90	0.30	1.21	34%	41.6	51.5	0.0	0.0	41.6	51.5	4.92	6.58	Low	Canal structural integrity, high cost, operational complexity	Yes
Ebenhaeser`		361	3.65	1.37	5.02	38%	304.7	341.4	13.3	13.9	291.4	327.6	7.75	10.66	Low	Canal structural integrity, high cost, operational complexity	Yes
Ebenhaeser post-Right Bank canal		0	0.00	-0.37	-0.37	28%							7.75	9.89			
TOTALS		**5874**	**53.90**	**7.15**	**61.05**		**2,814.4**	**3,057.5**	**1,638.4**	**1,419.8**	**1,176.0**	**1,637.8**					

** In addition to existing allocations*

*** A Klawer Phase 2 scheme of only 5.32 million m^3/a is needed to sum the water requirements plus losses up to the available total of 61.05 million m^3/a.*

URVs were classed in three categories, at 2020 prices (excl. VAT), as follows:

Low: Below R 1.80/m^3

Medium: Between R 1.80/m^3 and R 2.80/m^3

High: Greater than R 2.80/m^3

8.2 Phasing of Schemes

8.2.1 Proposed Phasing

The proposed phasing of the suite of preferred irrigation schemes is shown in **Table 8.2**.

Table 8.2: Preferred Schemes and Phasing

Scheme	Zone	Incremental requirement + losses (Mm^3/a)	Phase A	Phase B	Phase C
Jan Dissels	2	**4.26**	4.26	⊙	⊙
Clanwilliam		**2.46**	2.46	⊙	⊙
Transfer of lower Jan Dissels irrigators		**1.00**	1.00	⊙	⊙
Zandrug		**9.15**	9.15	⊙	⊙
Bulshoek		**2.25**	2.25	⊙	⊙
Right Bank canal & 4 Trawal irrigation areas	4	**25.65**		25.65	⊙
Klawer Phase 1 pre-Right Bank canal	5	**5.30**	5.30		
Klawer Phase 1 post-Right Bank canal		**-0.21**		-0.21	
Klawer Phase 2 partial development		**5.32**			5.32
Coastal 1 flow-restricted		**1.21**			1.21
Ebenhaeser pre-Right Bank canal		**5.02**	5.02		
Ebenhaeser post-Right Bank canal		**-0.37**		-0.37	
Water Requirements + Losses (Mm^3/a)		**64.22**	32.61	25.08	6.53
Incremental Water Requirements + Losses (Mm^3/a)		**61.05**	29.44	25.08	6.53
Water Requirements (Mm^3/a)		**57.07**	29.43	22.31	5.34
Incremental Water Requirements (Mm^3/a)		**53.90**	26.26	22.31	5.34
Losses (Mm^3/a)		**7.15**	3.18	2.77	1.19
Water Loss %		**12.5%**	10.8%	12.4%	22.3%
Water Loss Fraction		**0.13**	0.11	0.12	0.22
Hectares of new irrigation		**5 874**	3 008	2 339	527
Phase % of (Req. + Losses)		**100%**	48%	41%	11%
Development Capital Cost (R million)		**R 1 176**	R 572	R394	R 210
Betterment Capital Cost (R million)		**R 1 638**	R 13	R 1 081	R 544
Total Capital Cost (incl. Betterments) (R million)		**R 2 814**	R 585	R 1 476	R 754
Development NPV Cost (R million)		**R 1 233**	R 608	R 429	R 196
Betterment NPV Cost (R million)		**R 1 331**	R 12	R 852	R 467
Total NPV Cost (incl. Betterments) (R million)		**R 2 564**	R 620	R 1 281	R 663
Development Capital Cost apportionment (%)		**100%**	49%	34%	18%
Development NPV Cost apportionment (%)		**100%**	49%	35%	16%
Development NPV Cost per hectare (R 1,000/ha)		**R 210**	R 202	R 184	R 372
Jan Dissels River allocations moved to Olifants River		**1.00**	1.00		

8.2.2 Phase A Schemes

All the schemes in Zone 2 are recommended for implementation under Phase A, and implementation can continue through Phases B and C. These schemes all require infrastructure that can quickly be constructed, requiring limited capital costs and with low URVs. These private development schemes will also be easy to operate. These schemes are:

- Jan Dissels,
- Clanwilliam,
- Zandrug, and
- Bulshoek.

The *Jan Dissels Scheme* additionally offers potential for the development of many smallholder plots (say 60% of the potential scheme irrigation area), being located so close to Clanwilliam, and the scheme is a 'low-hanging fruit' that can be developed early as a GWS.

The *transfer of lower Jan Dissels irrigators* is recommended as a scheme that offers positive environmental impacts, with no associated costs.

The *Klawer Phase 1 Scheme* is proposed for implementation under Phase A. The scheme has a low capital cost and a medium URV with low environmental impacts, but the operation of the scheme would introduce some complexity.

The *Ebenhaeser Scheme* is recommended for implementation under Phase A. The scheme has a high capital cost and a high URV with low environmental impacts. The scheme is considered very desirable from a political and social perspective, to provide water to land restitution beneficiaries who do not have adequate water allocations, and to augment the supply to the existing Ebenhaeser community scheme. The operation of the scheme introduces some complexity.

8.2.3 Phase B Schemes

The *Right Bank Canal Scheme* is recommended for implementation under Phase B, and implementation can continue through Phase C. The canal should be constructed as a betterment to the LORGWS. The four associated schemes in the Trawal area should also be developed under Phase B, these schemes being:

- Zypherfontein 1,
- Trawal,
- Zypherfontein 2,
- Melkboom.

The Right Bank Canal Scheme has a very high total capital cost, because of the betterment cost component, with a medium URV and with medium environmental impacts. This scheme however provides water security (low risk of supply failure) for most of the existing supply area.

8.2.4 Phase C Schemes

The *Klawer Phase 2 Scheme* (partial development of the remaining area only, to use the full allocation available from a raised Clanwilliam Dam for new development) is recommended for development under Phase C. The scheme requires the upgrading/replacement of the Klawer canal section of the right bank canal, following the completion of the new Right Bank Canal main section. The scheme has a very high total capital cost because of the betterment cost component, with a low URV and with low environmental impacts.

The *Coastal 1 flow-restricted Scheme* is recommended for development under Phase C, as it is a small scheme with a low capital cost, but a high URV and low environmental impacts. The operation of the scheme would introduce some complexity.

8.3 Alternate Phasing

It is suggested that the alternates for the phasing of schemes are limited. In the post-Covid-19 situation, with an economy struggling to recover, approval of financing for the very high capital cost schemes will likely be a significant challenge. While the Right Bank Canal Scheme provides significant risk reduction and may be viewed in a more favourable light, this is not so for the Klawer Phase 2 Scheme (or the alternative Klawer Scheme). Because of the importance of the Right Bank Canal Scheme this should be implemented at least in Phase B.

The Klawer irrigation area provides several options for phasing. Because the implementation of the Klawer Phase 1 Scheme would introduce complex scheme operation, a phasing option is to rather implement a (combined) Klawer Scheme after the construction of the Right Bank canal, equal in size to the incremental water requirements and losses of the Klawer Phase 1 and Klawer Phase 2 partial development schemes.

9 Conclusions

The following conclusions have been drawn regarding the investigation of proposed irrigation development options.

9.1 Revision of identified irrigation schemes and further schemes to be evaluated

Changes were made to potential irrigation areas that could be supplied with water from a raised Clanwilliam Dam, following the finalisation of the *Suitable Areas for Agricultural Development Report* of this study. These changes mostly resulted from a slope analysis undertaken of identified irrigation areas. Water requirements and associated losses of the preferred irrigation schemes were subsequently updated. This led to a decline in the total volume required for the previously preferred schemes, and it was therefore necessary to identify additional schemes. As a result, new options and phases to convey water to the proposed Klawer irrigation area and the Trawal Government Water Scheme were conceptualised. The options to be re-evaluated at reconnaissance-level, as well as the schemes to be evaluated at feasibility level, were confirmed. A design field visit was undertaken.

9.2 Supporting investigations

The geotechnical and materials investigation team members attended the design field visit that was undertaken and have done some preliminary planning. The planned field investigations were however postponed due to the Covid-19 situation.

All environmental assessments of schemes that could be done at a reconnaissance-level have been done, and such findings have been incorporated in this report. The potential field investigations were postponed due to the Covid-19 situation.

A LiDar topographical survey was undertaken. There is a need for topographical surveying of limited further areas. This was however postponed as a result of the Covid-19 situation.

9.3 Schemes to be designed at feasibility level

The three schemes to be designed at feasibility level are described in adequate detail for the design teams, as well as the geotechnical and materials investigations, and the environmental screening to proceed. This description includes the identification and evaluation of sub-options and associated cost implications, and the recommendation of preferred sub-options. Final conveyance routes, balancing dam or farm dam sites, and design flows have been described and indicated on scheme layout maps. Information includes the features of these schemes and the assessments undertaken.

The **Jan Dissels Scheme** has been confirmed as a 'low-hanging fruit', being located on State land, having a low capital cost and URV, and as a scheme that can be quickly implemented as a GWS. As the scheme will be located close to the town of Clanwilliam, it further offers the opportunity to include a significant portion of smallholder plots, perhaps up to 60% of the area. A significant effort has been undertaken to address the concerns about most of the proposed irrigation development area being located in a sensitive environmental area, including working closely on this with DEA&DP and undertaking a botanical survey. Nevertheless the possibility of environmental objectives to the scheme remains, especially from an authority such as CapeNature.

The scheme involves pumping directly from the lake of the raised Clanwilliam Dam, via a floating intake, or from an outlet at the dam wall. Water will be pumped to a small farm dam, from where water can be gravitated to almost the full 462 ha irrigable area.

The **Right Bank Canal Scheme** offers a solution to ensure a more secure future supply for new as well as existing irrigators, by replacing the existing main canal with a new right bank canal. This will address the poor state of the existing main (Trawal) section, which poses a high risk of disruption and potential shortfall in supply to the lower Olifants River irrigators and other users, and ultimately the prosperity of the region.

The scheme will use the existing outlet works from the Bulshoek Weir and an upgraded 3 km section of the existing left bank main canal. The scheme then comprises a pipe bridge or syphon across the Olifants River and a new canal along the right bank of the Olifants River up to Verdeling. This Right Bank Canal will supply the four significant potential new irrigation areas in the Trawal region, which can potentially be considered for development as a GWS.

The success of the scheme will however be dependent on the availability of funds for the betterment portion of the scheme (new right bank canal).

The **Ebenhaeser Scheme** will meet the needs of some of the successful land claimants that received land parcels in 2019. This includes land parcels without water allocations, or with inadequate water allocations. In addition, the scheme would provide some augmentation to the people currently living in the Ebenhaeser community. This scheme has a high social and political priority.

The scheme involves the use of spare flow capacity in both the existing left bank and right bank distribution canals. Flow will be diverted at the end of the Vredendal canal section, on the left bank, in weeks when there is spare capacity. Similarly, flow will be diverted from the Retshof canal section on the right bank, in weeks when there is spare capacity. Water will be pumped to a small combined balancing dam on the left bank, from where it will be pumped to the main 2.302 million m^3 lined earthfill balancing dam, to be situated South-West of and close to the Vredendal left bank canal diversion point. This main balancing dam includes a (betterment) volume of 150 000 m^3 for operational purposes. From the main balancing dam, water will be pumped to a 11 000 m^3 (11 Mℓ) concrete balancing reservoir, and from there gravitated to irrigators and supplied under pressure.

9.4 Reconnaissance-level investigations

It was necessary to re-visit the preferred irrigation schemes that were investigated at reconnaissance-level, due to the changes in the potential irrigation areas. The new schemes and additionally identified sub-options were also evaluated. This involved the updating of irrigable areas, water requirements and losses, and scheme features. The required bulk infrastructure for the schemes includes diversion structures, pump stations, pipelines, syphons, and balancing dams or farm dams. Capital costs, NPVs and URVs were determined over the scheme lifetimes, at 2020 prices (excluding VAT). Water quality, environmental impacts and operational aspects, where relevant, were also addressed.

The following schemes were evaluated:

- Trawal GWS, consisting of the four potential irrigation areas in the Trawal area, namely Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom;
- Clanwilliam Scheme, pumping from the lake of the raised Clanwilliam Dam to the left bank;
- Transfer of Lower Jan Dissels River Scheduled Allocations to the Olifants River;
- Zandrug Scheme, irrigating from flows released down the Olifants River;
- Bulshoek Scheme, pumping from the lake of Bulshoek Weir;
- Klawer Phase 1 Scheme, making use of currently available spare flow capacity in the existing right bank canal, abstracting from the end of the Klawer canal section;
- Klawer Phase 2 Scheme, as well as a scaled-down Klawer Phase 2 Scheme, involving raising/lining or replacing the 19 km long Klawer canal section with an increased capacity, following the construction of the new Right Bank main canal;
- Klawer Scheme, as well as a scaled-down Klawer Scheme (i.e. no Phase 1 Scheme), involving raising/lining or replacing the 19 km long Klawer canal section with an increased capacity, following the construction of the new Right Bank main canal; and

- Coastal 1 (scaled-down) Scheme, making use of currently available spare canal flow capacity in the existing left bank canal, abstracting from the end of the Naaukoes canal section.

9.5 Comparison of Preferred Irrigation Options

The evaluated irrigation schemes were then compared, in terms of irrigation zone, irrigable areas, water requirements and losses, costs, environmental impact, risks and opportunity for smallholders or restitution. **Table 9.1** provides a summary of this comparison.

Table 9.1: Summary of Preferred Schemes Comparison

Scheme	Irrigable Area (ha)	Incr. Req + Losses (Mm^3/a)	Scheme Loss %	Capital Cost (R million)	Total NPV Cost (R million)	URV (R/m^3)	Environ-mental impact	Risks	Opportunity for smallholders/ restitution
Jan Dissels	462	4.26	0%	25.2	57.8	1.17	High	Environmental opposition	Yes
Clanwilliam	298	2.46	0%	34.5	58.6	1.84	Medium	Limited area of existing irrigation & land ownership	Yes
Transfer of lower Jan Dissels River irrigators	0	1.00	0%	0.0	0.0	0.00	Low	Low but irrigators may potentially oppose it	-
Zandrug	1 209	9.15	5%	117.8	196.8	1.52	High	Interest of land owners to switch existing irrigation to higher-value crops & land ownership	Partial
Bulshoek	266	2.25	5%	25.9	44.4	1.56	Medium	Interest of land owners to switch existing irrigation to higher-value crops & land ownership	No
Right Bank canal (incl. 4 Trawal irrigation areas)	2 339	25.65	15%	394.5	589.2	2.29	Medium	Funding of betterments & land ownership	No
Klawer Phase 1 (flow- restricted)	412	5.09	22%	77.1	108.5	2.25	Low	Canal structural integrity, land ownership, operational complexity	Yes
Klawer Phase 2 (partial development)	438	5.32	20%	168.0	203.4	1.71	Low	Funding of betterments & land ownership	Yes
Coastal 1 (flow-restricted)	89	1.21	34%	41.6	51.5	4.92	Low	Canal structural integrity, high cost, operational complexity	Yes
Ebenhaeser	361	4.66	28%	291.4	327.6	7.75	Low	Canal structural integrity, high cost, operational complexity	Yes
TOTALS	**5 874**	**61.05**		**1175.9**	**1637.8**				

While project-specific risks have been indicated in **Table 9.1**, the extent and type of implementation risks encompass the following:

- The significant extent of private land ownership and the associated acceptance of converting the use of land that is currently irrigated (and has associated water use authorisations) to higher-value crops.
- Structural integrity of the existing canal. This is relevant where sections of the existing Lower Olifants canal will be used to convey flow to new irrigation areas, either with no alterations, or raised, or raised and lined.
- Implementation and operational challenges of the new schemes, especially the schemes where sections of the existing canals will be used to convey flow to new irrigation areas, that will introduce operational complexity.
- The nature of the institutional implementation models and buy-in from existing farmers.
- Political support for costly schemes that will require continuous funding to sustain it. This could divert funds from more feasible schemes with a larger number of beneficiaries (in the context of this project) and divert funds from the fiscus in general.
- Sources of funding for bulk water infrastructure of new irrigation developments or for betterments.

9.6 Phasing of Schemes

The phasing of the preferred schemes has been recommended, in three phases, namely Phases A, B and C. Alternate phasing has also been identified. A summary of the proposed phasing is shown in **Table 9.2**.

Table 9.2: Summary - Phasing of Preferred Schemes

Scheme	Zone	Incremental requirement + losses (Mm³/a)	Phase A	Phase B	Phase C
Jan Dissels	2	**4.26**	●	⊙	⊙
Clanwilliam		**2.46**	●	⊙	⊙
Transfer of lower Jan Dissels irrigators		**1.00**	●	⊙	⊙
Zandrug		**9.15**	●	⊙	⊙
Bulshoek		**2.25**	●	⊙	⊙
Right Bank canal & 4 Trawal irrigation areas	4	**25.65**		●	⊙
Klawer Phase 1	5	**5.09**	●		
Klawer Phase 2 partial development		**5.32**			●
Coastal 1 flow-restricted		**1.21**			●
Ebenhaeser		**4.65**	●		

Incremental Water Requirements + Losses	**61.05**	29.44	25.08	6.53
Water Loss %	**12.5%**	10.8%	12.4%	22.3%
Hectares of new irrigation	**5 874**	3 008	2 339	527

9.7 In summary

The options located closest to the Clanwilliam Dam, especially those options located upstream of the Bulshoek Weir, are the most attractive options, as water can be provided for irrigation at low cost with limited losses.

The preferred suite of schemes offers the unique opportunity to start addressing the most significant risk currently posed to the LORGWS, namely the very poor structural integrity of the canal system. This suite of options includes replacement of the main (Trawal) canal section with a new Right Bank Canal, from Bulshoek Weir up to 'Verdeling', where the canal splits. This betterment would also offer the opportunity to lessen the restriction to flow in the main canal.

Several of the preferred schemes provide opportunities for the development of smallholder (assumed 7.5 ha) plots, being located reasonably close to towns. These options also provide the opportunity to support a restitution scheme or an existing HDI scheme (Ebenhaeser).

While a rigorous process has been followed to identify the preferred development options, there is a possibility that some private land owners, whose lands do not fall within the current identified scheme areas, may be interested in HDI development schemes. Such, likely smaller in extent, HDI schemes could still apply for additional water through the application process for water authorisations, if such schemes are deemed feasible. This should be encouraged especially in the area between Clanwilliam Dam and Bulshoek Weir.

While it is evident that many existing land owners are interested in HDI irrigation development schemes, there still seems to be significant uncertainty among them, until the completion of the raising of the dam is more certain, and cost implications (tariffs) are better understood.

Considering the current level of knowledge of planned HDI developments, the development of such schemes is more likely to be a combination of private development (one or more farms per venture), and community supply, specifically the Ebenhaeser restitution farms and some augmentation of the irrigation at Ebenhaeser. The requirement for the development of further government irrigation schemes may only become clear with insight into the actual trend of uptake of the additional water by existing land owners committed to HDI developments.

At this stage, schemes that can be designed as part of this study are the Jan Dissels Scheme (in close cooperation with the Augsburg Agricultural School), the Right Bank Canal, and the Ebenhaeser Scheme. The remainder of the schemes will likely be private developments. It is expected that private land owners will incrementally apply for HDI development schemes along with their HDI partners.

Apart from the recommended options, it is likely that small feasible BEE schemes, especially for the expansion of existing farms, could eventually be submitted by existing farmers as part of licence applications. This should be kept in mind as an alternative to developing the most expensive land for irrigation, within the recommended options.

It may be a requirement that land should also be made available to commercial black irrigators who do not wish to enter into a joint-venture arrangement with existing landowners, i.e. the development of a government water scheme. It is noted that the preferred irrigation schemes upstream of Bulshoek Weir are so interwoven with existing irrigated areas, as well as land that can be more intensely farmed with permanent crops, that these options do not lend themselves well to development as government water schemes.

Should there be a need to identify and design a government water scheme at this stage, the four irrigation areas located in the Trawal area, namely Zypherfontein 1 and Zypherfontein 2, Trawal and Melkboom, (or portions thereof) should rather be considered, as these options contain large tracts of undeveloped land in private ownership. Certain portions of these areas could be supplied by gravity from a new Right Bank main canal, but, for most of these areas, water would need to be pumped from the new canal. Since this land is privately-owned, an option will be for government to acquire the land.

10 Recommendations

10.1 Recommendations

The following recommendations are made:

1) Proceed with the geotechnical and materials investigation as soon as this is allowed in terms of the Covid-19 situation.
2) Proceed with the environmental assessment and, if necessary, undertake field clarifications as soon as this is allowed in terms of the Covid-19 situation.
3) The outstanding topographic survey for the Right Bank canal and Ebenhaeser Scheme, using Light Detection and Ranging (LIDAR) should be completed as soon as this is allowed in terms of the Covid-19 situation.
4) Proceed with the feasibility design of the following three schemes:
    a. Jan Dissels,
    b. Right Bank Canal, and
    c. Ebenhaeser.
5) Engage with land owners and LORWUA as required during the design phase,
6) The following additional feasibility design reports will be produced, using the scheme recommendations and layouts:
    a. Environmental Screening Sub-Report;
    b. Jan Dissels and Ebenhaeser Schemes Design Sub-Report; and
    c. Right Bank Canal Design Sub-Report.
7) The integrated Feasibility Design Report will be produced when the sub-reports have been approved.
8) Prepare a draft Terms of Reference to undertake an EIA process for the three schemes recommended for feasibility design above, in order to obtain environmental authorisation for their implementation.

10.2 Further issues to address

Issues to address during feasibility design are the following:

- Describe the risk associated with the poor state of the existing canals and the further risk associated with an increase of the canal flows. This applies to the main left bank (Trawal) canal section as well as the main distribution canals on the left and right banks, downstream of Verdeling.
- The splitting of capital costs and NPVs between new irrigation development and betterment costs (costs attributable to current irrigators) should be re-visited, to ensure equity.
- Clarify the uncertainty regarding the cost of water from the LORGWS, following the raising of Clanwilliam Dam, so that the potential for a Trawal GWS can be assessed with more confidence.
- Although not currently part of the study, a risk analysis of the current distribution system versus an upgraded canal system would add significant value, including economic and social implications of system failures, and the likelihood of these occurring over an economic period (considering historic failures). In addition, the legal obligations on DWS to ensure that the infrastructure remains functional should be clarified.
- The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the critical biodiversity areas, following acceptance of the recommendations. Evaluation of schemes has confirmed that the ecological impact and environmental issues relating to new development significantly influence and limit the scope of development options. Dialogue around these issues has started and further discussion should take place between departments as soon as possible, to agree on the way forward.
- Obtain clarity from DEA&DP regarding the best means to comply with environmental legislation and receive authorisation for the proposed new irrigation development areas. The majority of these areas are privately owned, and development will be via a joint venture agreement.
- To obtain greater clarity on funding options, it is suggested that DWS provide a presentation to National Treasury to explain implementation approaches, and to request confirmation of National Treasury's view on this, as well as any concerns and required procedures. For this purpose, it will be necessary to have information at hand regarding economic and job creation implications of new investment. It would further be valuable to also provide the risks for the economy and labour of potential canal failures if betterments are not undertaken, although this is not currently part of this study. These could potentially be determined as part of the Socio-Economic Impact Analysis task of this study.

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Appendices

APPENDIX A: EXCEL TOOL FOR EVALUATING THE USE OF CANAL SPARE CAPACITY

The Excel Tool was developed to evaluate historical canal section flows to determine potential abstraction volumes from canal sections for irrigation, the pattern according to which it can be abstracted, the associated balancing dam size required for a specified irrigation distribution pattern, and the maximum diversion flow rate required.

The various steps to use the Excel Tool is described hereunder.

- Historical weekly flows (2006/07 to 2018/19) for all the canal sections were obtained from LORWUA, which includes allowance added by LORWUA staff for canal losses.
- For each canal section, historical weekly spare capacities have been determined, when compared with the maximum weekly flow capacities in canal sections. Maximum weekly flow capacities, as provided by LORWUA are used to determine the spare capacity. Care must be taken to not identify weeks of no flow (or portions thereof), so-called ‘dry’ weeks, as weeks with spare capacity. Further note that the maximum specified flow is sometimes exceeded. The historical flows and spare capacities of each canal section is saved in a separate worksheet.
- Identify the year (weeks from Oct-Sep) to use for evaluation. For the left bank canal sections, 2012/13 was used for the evaluation and 2010/11 was used for the right bank canal sections. These years have been selected as they provide a conservative volume of spare annual flow, due to the higher historical flow, whereas years with higher restrictions and droughts are less useful. This would be more representative of future situations.
- The weekly flows for the selected year to evaluate for the various canal sections is then transferred to the ‘Storage’ worksheet. Corrected weekly flows have been highlighted in purple.
- To allow for increased use by existing irrigators when they receive an increased assurance of supply, following the raising of Clanwilliam Dam, the maximum annual diversion volume for new irrigation is assumed to be 50% of the annual canal spare capacity at the abstraction point, for the selected evaluation year/s.
- The selected weekly diversion volumes (m^3/week) are calculated for a canal section that the diversion point/s are located in. This can be for a diversion from a left bank section, or from a right bank section, or a combination, keeping in mind that the weekly diversion volume is equal to 50% of the maximum spare flow capacity for that week. It also needs to be confirmed that such flow can be conveyed through the up to that point via the preceding canal sections.
- The annual ‘water requirement,’ including losses, is equal to the maximum annual diversion volume for the canal section/s being evaluated. This value is entered in the orange cell in the

relevant 'Storage' worksheet of the Tool - labelled 'water requirement'. All further calculations are done in this worksheet.

- On the right of the 'Storage' worksheet is an embedded tool that distributes the annual water requirement among months and weeks. The weekly distribution of the annual water requirement is automatically calculated according to the monthly distribution of weighed monthly planning crop water requirements. for the sub-area where irrigation will take place, as determined in this study, from which weekly water requirements are calculated. The peak months are from November to March.
- Weekly distribution of evaporation from S Class Pan have been included in the spreadsheet.
- A selected total diversion volume, minus canal losses is determined in m^3/week. This can be diversion from either a left bank or right bank canal section, or a combination. It must be borne in mind that left bank and right bank canal losses differ. Post-Bank canal loss factors have been used and are indicated in the 'Storage' worksheet.
- A weekly surplus/shortfall in m^3 is calculated, comparing the weekly diversion volumes (minus losses) and the weekly irrigation water requirements.
- In the relevant 'weekly surplus/ shortfall' column, adjust the formula to calculate the total shortfall over the critical summer period in m^3 (sum of first to the last pink highlighted cell during the critical period), typically from Nov to Mar, from when the first shortfall is experienced, by entering the formula in the 'Continuous Shortfall over peak season' cell at the bottom of the spreadsheet.
- The formula for the continuous shortfall over the critical period should similarly be adjusted for the critical period for the dam evaporation loss in m^3 per week. The formula should be entered in the 'Evaporation over continuous shortfall period' cell for the critical period.
- A relationship of dam storage to height for an off-channel lined earthfill balancing dam has been pre-determined and included in the spreadsheet.
- The spreadsheet calculates an evaporation % from a starting value, to start an iteration procedure for the evaporation %. That is displayed in the 'check' cell. This % should then be entered by hand in the 'Plus % added for evaporation;' orange cell. This may need to be repeated up to two or three times, until the two % values match. This makes use of the target dam capacity vs dam area relationship information embedded in the spreadsheet.
- Similarly, a value must be entered manually in the iterative 'Evaporation Annual Total for Water Requirement Calc' cell to iteratively match the total annual dam evaporation loss (m^3/week). This may need to be repeated up to two or three times, until the two values match.
- An updated dam storage volume is then calculated, in the '(Shortage + Evaporation over critical period) x Evap factor' cell, equal to the shortfall over the peak season.
- Enter the updated dam value by hand in the 'Dam balance at end of week' column, one week before the critical season starts. This denotes the full dam live capacity so that the

dam just does not empty. If a zero value is reached in this column at the end of the critical period, the calculation to determine the minimum live dam capacity is complete.

- It is sometimes the case that there is a further small shortfall following the critical period. This value should be entered by hand in the 'Additional capacity needed (Mm^3)' cell, in which case the calculation is complete. Convert from m^3 to million m^3 before entering the value.
- A dead storage volume of an additional 5% is added to determine the full supply volume of the dam.
- Because the canal flows are released at a constant weekly rate, the abstraction rate from the canal should not exceed the release rate, as it will influence other irrigators. The maximum expected weekly flow that can be abstracted (over 7 full days) will then determine the maximum diversion flow rate from the canal section. In the 'Selected Total diversion volume (m^3/week) (50% of Max Capacity)' column, identify the biggest diversion value, which is populated in the 'Maximum weekly flow diverted (m^3)' cell.
- An Average Diversion Flow Rate for the maximum flow week (m^3/s) is then calculated.

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