DWS Report No. P WMA 09/E10/00/0417/1

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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

Main Report

June 2021

Department of Water and Sanitation
Directorate: Water Resource Development Planning

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

APPROVAL

Title	:	Main Report
DWS Report Number	:	P WMA 09/E10/00/0417/13
Consultants	:	Zutari (Pty) Ltd
Report status	:	Final
Date	:	June 2021

STUDY TEAM

Approved for Zutari (Pty) Ltd:

....

E VAN DER BERG
Technical Director

DEPARTMENT OF WATER AND SANITATION
Directorate Water Resource Development Planning

Approved for Department of Water and Sanitation:

....

M MUGUMO
CHIEF ENGINEER: WRDP (South)

....

C FOURIE
DIRECTOR: WRDP

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Document prepared by:

Zutari (Pty) Ltd

1977/003711/07

1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

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

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Author signature		Approver signature	
Name	Erik van der Berg	Name	Erik van der Berg
Title	Technical Director	Title	Technical Director

DEPARTMENT OF WATER AND SANITATION

Directorate: Water Resource Development Planning

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

MAIN REPORT

June 2021

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

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

Prepared for: Director: Water Resource Development Planning
Department of Water and Sanitation
Private Bag X313
Pretoria 0001
South Africa

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

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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
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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.

Report Index	Report Number	Report Title and Description of Content
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.
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.

Report Index	Report Number	Report Title and Description of Content
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.
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.

Report Index	Report Number	Report Title and Description of Content
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 and Background

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 (whether new developments, upgrading or rehabilitation) required for the equitable distribution of the existing and additional water from the raised Clanwilliam Dam.

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.

This report provides an integrated summary of the study tasks undertaken, public and stakeholder engagement, and study findings and recommendations.

The study area mainly included the Olifants River valley around and downstream of Clanwilliam Dam, up to a level of 100 m above either the river level or above existing distribution canals. The area outside of the Olifants River valley included the Jakkals River and small coastal towns. The study area and existing bulk water storage and conveyance infrastructure are shown in **Figure E1**.

Overview of the Existing Scheme and Users

Apart from the extensive irrigation, about 40 000 people in the various towns are dependent on the Lower Olifants River Government Water Scheme for water, as well as many industries and mining. Without the development of the scheme, the towns, significant irrigation development and associated industries in this very dry region would not exist.

There is approximately 11 000 ha of scheduled irrigation water downstream of the Clanwilliam Dam, with 318 ha scheduled water allocations directly from the dam's reservoir. Water is released from the dam, up to Bulshoek Weir, from where it is distributed further via an extensive canal system. Canal conveyance water losses are high, being close to 30%.

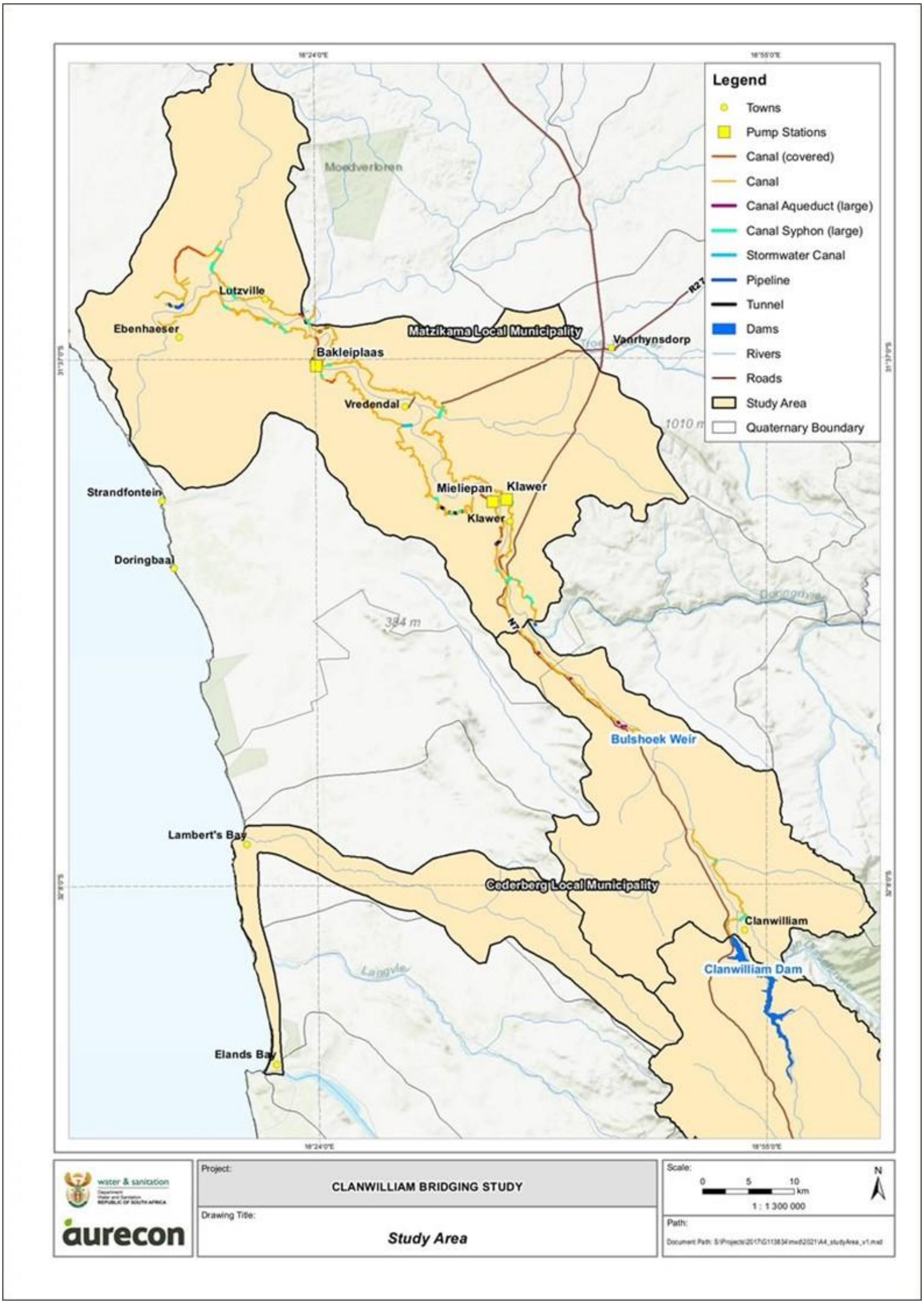

Figure E1: Study Area and Existing Bulk Water Infrastructure

The total irrigated agricultural water use for the area downstream of Clanwilliam Dam is approximately 140 million m^3 for 12 500 ha of actual development. The actual area planted varies from year to year, depending on the availability of water. Main irrigated crops are citrus, table grapes, wine grapes, vegetables and other fruit.

Water quality throughout the area is generally good. The Olifants River downstream of the Doring River confluence is progressively impacted by irrigation return flows, resulting in a steady increase in salinity in a downstream direction. The result is that water quality is poor in the lower Olifants River, upstream of the tidal effect zone, and salinity exceeds the requirement for irrigation use.

Only a small fraction of the properties in the study area is government-owned.

Water Distribution Options

The natural mean annual runoff of the Olifants River above the Clanwilliam Dam is 356 million m^3/a. The current average supply from the Scheme to users is estimated at 174 million m^3/a, although during droughts the supply has been curtailed.

The total available yield of Clanwilliam Dam, after first supplying the ecological water requirements, at a 91% assurance of supply (1:10 year drought return period), is 242 million m^3/a, following the raising of the dam. The total available water for distribution, after further accounting for water losses, is 206.6 million m^3/a at 91% assurance of supply. This provides an *additional* available yield after raising of the dam of 82.0 million m^3/a.

Table E1 summarises the potential uptake of the additional available yield by the respective water user groups. It is preferable that the uptake of the additional water be phased in.

Table E1: Summary table for distribution of additional yield (million m^3/a)

Proposed Allocation	Volume (million m^3/a) 98% assurance of supply	Volume (million m^3/a) 91% assurance of supply
1. Increase reliability to existing water users		15.2
2. New domestic, industrial and mining use	0.6	
3. New emerging farmer irrigation development		61.1
4. Keep in reserve to cater for hydrological and other uncertainties		5.1
Totals	**0.6**	**81.4**

It is recommended that the remaining volume of 5.1 million m^3/a be kept in reserve in the short-term to medium-term, to cater for the uncertainty of climate change and changing hydrology, until trends become better known through monitoring and research, to avoid over-allocation.

HDI Farmers Assessment

An independent historically disadvantaged individual (HDI) Farmers Specialist consultant undertook an evaluation of existing HDI Farmers policies and legislative context, identified, met with, mapped and analysed prospective HDI farmers and potential land for new irrigation, as well as proposed a mechanism for the identification and screening of HDI farmers to assist Department of Water and Sanitation (DWS) with water licence applications for the new irrigation development.

The work was supervised by an inter-departmental Sub-Committee for Historically Disadvantaged Farmers. Following the conclusion of the study, the Sub-Committee will continue its activities.

Some of the findings were as follows:

- The low level of organisation and visibility of emerging farmers continues to restrict their access to future opportunities and information.
- Some farmworkers are organised under the farmers.
- There needs to be a greater focus on enablers for youth, women and people with disabilities to participate as beneficiaries of the recommended development.
- Involvement from some key stakeholders was inadequate.
- The database of current and prospective HD Farmers that was compiled requires more work on the ground.

Soil Survey

The extension of the soil survey entailed identification of 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 Clanwilliam Dam and Klawer. This was used to extend the existing survey, completed during 2004 as part of the Clanwilliam Dam Raising Feasibility Study, which covered the area up to 60 m above river level.

Five soil suitability classes were used to rate the potential and recommendation of soil sub-groups for irrigated crop production. The classes are for annual (tuberous and non-tuberous respectively) and perennial crops, before and after amelioration of subsoil limitations.

Water Requirements

Mapping and analysis of existing agricultural areas in the study area was undertaken, and the area was classified into study zones, to assist with technical evaluations and summaries. Suitable areas for new irrigation was then identified, based on the four most suitable soil classes. Certain areas were then excluded, which include existing irrigated high-value crops, certain environmental protection areas, built-up areas, roads and other infrastructure.

Clusters of available land that can be developed as phased schemes were identified. It was found that land ownership did not influence the delineation. Irrigated areas of lower-value permanent crops were included, as higher-value crops could potentially be planted on such land.

Aggregate crop water requirements per study zone were determined for planning purposes. Water requirements of the identified potential irrigation areas were then calculated, considering aggregate crop water requirements, crop rotation factors where applicable and leaching requirements. The future requirement for industrial, domestic and mining use was determined as 0.6 million m^3/a.

Options Analysis

The next step in the study was to identify and unpack the characteristics of the range of potential bulk water schemes to supply the potential irrigation areas. The associated bulk water distribution costs and potential impacts of such scheme options were then determined. An initial, more qualitative evaluation helped to reduce the starting (comprehensive) list of potential irrigation development options. This was followed by quantitative evaluations, requiring iteration as information became available or options were better understood. This process was followed to select, evaluate and screen irrigation development options.

Irrigation design water requirements for the various options were calculated by taking into account run-of-river diversions, river and other conveyance losses, the need for blending of poor water with water of a better quality and associated storage requirements, and the need for on-farm bulk water storage. Bulk water scheme components were identified, sized and costed at a reconnaissance level of evaluation, and preliminary implementation programmes were established. Both capital costs and net present values were determined. A desktop-level assessment of the environmental and socio-economic impacts of each option was taken into account.

The evaluation of the short-listed distribution options were documented in a Background Information Document for the Options Workshop. Comment and input on the proposed options was received from various role players at the workshop. Following the workshop, the options were refined. The preferred options were identified, inter-alia considering cost, environmental and social impacts, political imperatives and the volume of water available for new irrigation, while considering water losses. A suite of preferred options was approved by the Project Steering Committee.

Preferred Suite of Irrigation Schemes

The preferred suite of proposed irrigation schemes comprise of five schemes located upstream of Bulshoek Weir and five schemes located downstream of Bulshoek Weir. The recommended schemes entail both the development of new land for irrigation as well as the replacement of lower-value crops of existing irrigation with higher-value crops. A total of 5 874 ha is recommended for new irrigation development. The comparison of the recommended schemes is shown in **Table E2**.

Table E2: Comparison of Recommended Schemes

Scheme	Irrigable Area (ha)	Incr. Req + Losses (Mm³/a)*	Scheme Loss %	Capital Cost (R million)	Total NPV Cost (R million)	URV (R/m³)	Environ-mental impact	Risks	Opportunity for smallholders/ restitution
Jan Dissels	462	4.26	0%	83.2	100.2	2.03	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 allocations	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%	573.2	782.3	3.05	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%	158.0	192.2	1.71	Low	Funding of betterments & land ownership	Yes

Scheme	Irrigable Area (ha)	Incr. Req + Losses (Mm³/a)*	Scheme Loss %	Capital Cost (R million)	Total NPV Cost (R million)	URV (R/m³)	Environ-mental impact	Risks	Opportunity for smallholders/ restitution
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%	512.9	536.7	12.77	Low	Canal structural integrity, high cost, operational complexity	Yes
TOTALS	**5 874**	**61.05**		**1624.3**	**2071.2**				

** In addition to existing allocations*

Implementation of the preferred schemes has been recommended in three phases, namely Phases A, B and C. A summary of the proposed phasing is shown in **Table E3**.

Table E3: Proposed Phasing of Recommended 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

The following schemes were identified for feasibility-level design:

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

These schemes are shown in **Figure E2**, except for the Ebenhaeser Scheme, which is located in the far North-West of the Olifants River catchment, between Lutzville and Ebenhaeser towns.

Figure E2: Location of recommended irrigation areas

Only partial development of the Klawer and Coastal 1 potential areas (as shown on the map) has been recommended, due to limitations or better opportunities being available.

Way Forward for Other Irrigation Developments

Besides the implementation of the Jan Dissels and Ebenhaeser Schemes and their associated irrigation areas, the remainder of the new irrigation development will be located on privately-owned land, while the *transfer of lower Jan Dissels River allocations* does not involve new development. The development of further Government Water Schemes was considered and briefly evaluated.

Various '*best approaches'* have been recommended for the uptake of water on private land, including strategic partnership / mentorship agreements. In terms of suitable group sizes, analysis of previous initiatives indicate that the larger the group, the less the chance of success is in general. The most ideal project structure, based on the examination of case studies, would be a JV company with at least 51% black ownership, which either owns the land and the business or just the business.

Development of smaller agricultural units (referred to as smallholder plots) has not been found to be commercially viable, and communal land ownership also has many pitfalls. The needs analysis undertaken indicates that a smallholder farmer would need assistance throughout the value chain for its operations to become commercially competitive. If models like these are to be successful, considerable inputs from Government, the commercial sector and the HDI communities would be required. If no such units are however developed, it would undermine Government policy that allows for 'quick wins' through smaller agricultural units. It is therefore recommended that a balance be found between commercial JV projects and smaller agricultural units.

Various public water infrastructure financing options were investigated, but it was found that allocation through the National Revenue fund is the most feasible financing option.

The recommended type of development per recommended irrigation development scheme (including all GWSs for completeness) is indicated in **Table E4**.

Table E4: Recommended type of development for irrigation schemes

Scheme	Hectares	Recommended type of development
Jan Dissels	462	GWS consisting of a combination of commercial farmers and smallholders (50% recommended) on state land. Ideal for smallholder development, being located very close to Clanwilliam Town.
Clanwilliam	298	Private land. Combination of JVs and some smallholder farmers.
Zandrug	1 209	Private land. Combination of JVs and some smallholder farmers.
Bulshoek	266	Private land. Combination of JVs and some smallholder farmers.
Right Bank Canal: Zypherfontein 1 Trawal Zypherfontein 2 Melkboom	 710 510 614 505	 Combination of JVs and some smallholder farmers. Private land located in the Trawal area, that can potentially all, or partly be considered for a GWS, in combination with the construction of a new Right Bank canal.
Klawer Phase 1 Klawer Phase 2	412 438	Private land. Combination of JVs and some smallholder farmers. Private land. Combination of JVs and some smallholder farmers, in combination with the construction of a new Klawer Canal.
Coastal 1	89	Private land. Combination of JVs and some smallholder farmers.
Ebenhaeser	361	63 Ha of smallholder development and 250 ha for restitution farms (with 12 000 m^3/ha/a allocations).

Note: 'JVs' in the table above can potentially include the option of black commercial farmers purchasing private land.

It became obvious, following engagement with farmer representatives and land owners, that unless the influence of the cost of water can be clarified, the evaluation of and likely uptake of water for private development cannot proceed with confidence.

Topographical Survey

A Light Detection and Ranging (LIDAR) topographical survey was undertaken for the Jan Dissels, Right Bank Canal and Ebenhaeser schemes. Good accuracies were achieved and the survey data can be used for detailed design.

Geological, Geotechnical and Materials Investigation

The geological and geotechnical evaluation comprised:

- A **desk study** of available information for recommended schemes to be designed, and a reconnaissance visit to the various scheme elements.
- Geotechnical **field investigations** for the preliminary conveyance infrastructure routes to inform the selection of the preferred pipeline routes and infrastructure positions.

- **Core drilling** of a total of four (4) syphon routes for the Right Bank Canal Scheme and Ebenhaeser Scheme respectively.

Environmental Screening and Scheme Assessments

An **environmental screening** of the early proposed development areas and activities was conducted as part of the study, to determine the best ecological options and to minimise impacts on the natural environment. This described and illustrated the opportunities and constraints, and potential ecological risks/impacts for the short-listed bulk infrastructure development options at reconnaissance level.

More detailed **environmental assessments** were then undertaken, in support of the feasibility design of the three schemes selected for implementation.

Two meetings were held with environmental authorities, to get greater clarity on the **environmental approvals process** of the proposed suite of irrigation schemes, and specifically the three schemes designed. It was confirmed that the Department of Environment, Forestry and Fisheries (DEFF) will be the Competent Authority (CA) for EIA decision-making, since Department of Water and Sanitation (DWS) will apply as the Proponent for the three Government Water Schemes. DEFF may delegate this responsibility to the Provincial Department of Environmental Affairs and Development Planning (DEA&DP). If the applicants will be private landowners, such as joint venture developments on private land, then the environmental authorisation entity will be DEA&DP.

Jan Dissels Scheme Feasibility Design

An area west of Clanwilliam Dam and close to Clanwilliam town, was identified as suitable irrigable land (refer to **Figure E3**). The area is *inter-alia* suitable for the development of smaller plots, given its proximity to Clanwilliam town and existing markets. A botanical survey was undertaken to confirm the extent of environmental sensitivity, and to define the scheme's irrigable area. The water requirement for the estimated 462 ha of irrigable land is 4.26 million m^3/a.

Two routes for a rising main pipeline were identified.

Route 1 will pump water directly from a floating intake low-lift pump station in the raised Clanwilliam Dam to a balancing tank approximately 70 m from shore. From the balancing tank water will be pumped with a high-lift pump station to a concrete reservoir at a suitable high point. From the reservoir, water can be gravitated to the identified irrigation areas.

Route 2 will pump water from an outlet point below the raised Clanwilliam Dam wall, on the right bank, to a concrete reservoir on top of the hill. The position of the concrete reservoir is the same for both options.

For both options an access road to the reservoir will have to be constructed, either from the "Ou Kaapse" Road or from the township development close by.

Additional electrical supply is required for the pump station(s), noting that the power supply for Clanwilliam Town must also 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. It is recommended that Eskom be engaged during detailed design.

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

The project cost estimates for the construction of the Jan Dissels Scheme options, including other miscellaneous costs, professional fees and land acquisition costs, are shown in **Table E5**. The Total Project capital cost estimate, at October 2020 prices, is R 71.7 million (including VAT) for Route 1 and R 95.7 million (including VAT) for Route 2. The scheme is very feasible from a cost perspective and is considered a high priority for implementation.

Table E5: Jan Dissels Scheme Route 1 and Route 2 Project Cost Estimate, incl. VAT

No	Description	Route 1 Amount (R million)	Route 2 Amount (R million)
1	Rising Main (pipelines, pump station/s and balancing reservoir)	52.626	72.069
2	Access road (1 km long)	1.000	0.500
3	Electrical supply	3.000	3.000
Total: Construction costs, incl. 40% P&G and 25% contingencies		**R 56.626**	**R 75.569**
4	Professional fees (10%)	5.663	7.557
	Value Added Tax (15%)	9.343	12.469
5	Land acquisition	0.013	0.071
TOTAL (October 2020 prices, incl. VAT)		**R 71.700**	**R 95.700**

Figure E3: Layout of the Jan Dissels Scheme

A comparison of the two sub-options was made by calculating the net present value (NPV) and unit reference value (URV) of each route option, which was found to be effectively the same. Other factors were therefore considered in order to choose the best option. Route 2 is recommended due to its pump installation, which is more secure, easily accessible and will require less maintenance than Route 1.

Right Bank Canal Feasibility Design

The Right Bank Canal Scheme is designed to replace the existing left bank main canal, which starts at Bulshoek Weir with a new canal on the right bank of the Olifants River.

A general layout arrangement of the proposed scheme is shown in **Figure E4**.

The new canal will have an increased capacity to also 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 scheme will supply the four proposed new irrigation areas in the Trawal region, namely the Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom irrigation areas. The scheme will be situated on privately-owned land.

The scheme infrastructure is designed for a flow of 11.4 m^3/s, providing for existing allocations (current canal flow capacity plus allowance for an increased assurance of supply), new irrigation from a raised Clanwilliam Dam and other future uses. At a Project Steering Committee meeting, the concern was raised that the design flow capacity should be higher to include all requirements of existing allocations, as well as to consider potential crop changes in future. A Sub-Committee was formed to address these concerns, and alternate potential design flows were formulated. The existing outlet structure of the Bulshoek Weir may however pose a constraint to increasing the design flow above 11.4 m^3/s, as well as the age and condition of the weir, which is a national monument.

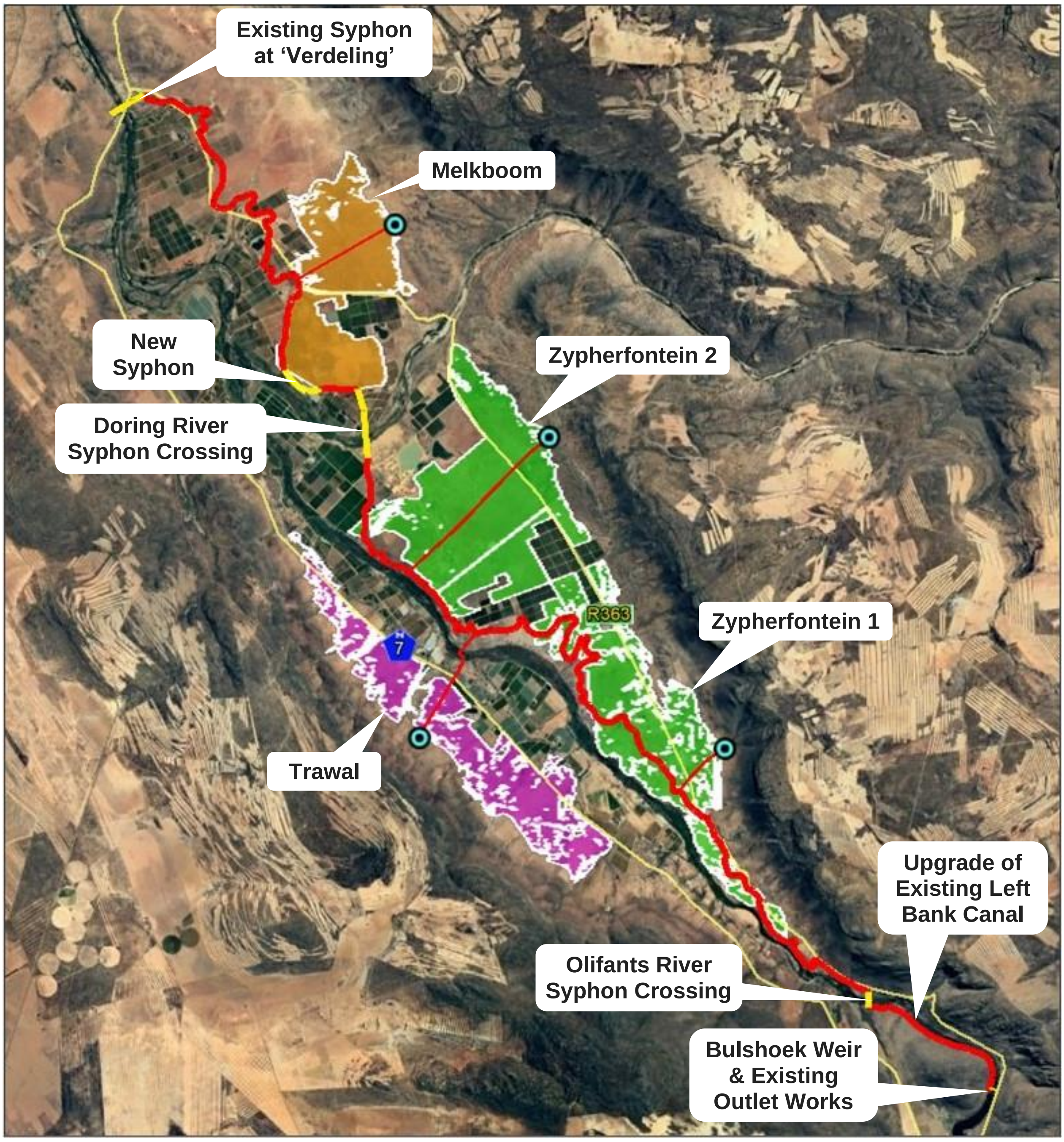

Figure E4: Layout of the Right Bank Canal Scheme

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. Bulk distribution and storage infrastructure of the four irrigation areas were designed at reconnaissance level.

The Total Project capital cost estimate (inclusive of reconnaissance-level costs to develop the distribution infrastructure for the four irrigation areas), at October 2020 prices, is as indicated in **Table E6**.

Table E6: Cost estimate for the proposed Right Bank Canal Scheme (October 2020 prices, incl. VAT)

Description	Rate	Cost (R million)
Outlet - existing Bulshoek Weir outlet		0
Canals		645.128
Syphons 1, 2A and 2B		140.409
Verdeling Inlet		4.458
R363 Road crossings and major farm road crossings		29.614
Sub-Total A		**819.611**
Preliminary & General (% of subtotal A)	40%	327.844
Sub-Total B		**1 147.455**
Contingencies (% of subtotal B)	25%	286.864
Sub-Total C		**1 434.319**
Professional Fees (% of subtotal C)	10%	143.432
Land Acquisition		15.979
TOTAL COST (excl. VAT)		**R 1 593.730**
VAT	15%	239.059
TOTAL (October 2020 prices, incl. VAT)		**R 1 832.789**

The cost of the Right Bank Canal Scheme amounts to R 1 832.8 million (including VAT), at October 2020 prices.

The scheme will offer significant benefits in the long-term, compared with the alternative of eventually being forced to refurbish the existing left bank main canal. The condition of the more than 90-year old canal will deteriorate further and place the community and industries reliant on it at greater risk of failure of supply, with potential disastrous concomitant socio-economic impacts..

The scheme consists of the following components:

- Upgrading of the Left Bank Canal for approximately 3.05 km;
- A 2.4 m diameter syphon crossing the Olifants River on a pipe bridge (300 m long);
- A new reach of trapezoidal canal on the right bank (approximately 18.56 km long);
- A rectangular in-situ concrete syphon at the Doring River crossing and a short reach of canal (1 270 m and 680 m long respectively);

- Another rectangular in-situ concrete syphon to avoid a steep sandy hill shortly after the Doring River crossing (840 m long);
- Another long reach of new trapezoidal canal (approximately 8.85 km long); and
- Upgrades to the existing syphon outlet at Verdeling to act as an inlet (chainage 33.55 km).

Ebenhaeser Scheme Feasibility Design

The Ebenhaeser Scheme will make use of spare flow capacity in the existing right bank and left bank canal sections. 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 current inadequate water allocations. In addition, this scheme can to a limited extent augment supply to the existing historically disadvantaged community at Ebenhaeser. Five water requirement clusters were identified, in consultation with community representatives. The water requirement of the scheme is 4.66 million m^3/a, including losses (conveyance losses and balancing dam evaporation) of 1.01 million m^3/a, to irrigate 361 ha of irrigable area. The volume of water available for irrigation (excluding water losses) is 3.65 million m^3/a.

A general layout arrangement of the proposed scheme is shown in **Figure E5**.

The scheme will divert flow from the end of the Vredendal left bank canal section, as well as from the Retshof right bank canal section. Canal diversion structures will be required to create off-take points. Canal flows will be diverted from the diversion structures during weeks with surplus flow and will gravitate to a balancing sump. From the sump, water will be pumped via the ‘diversion’ rising main to the Ebenhaeser balancing dam. From the Ebenhaeser balancing dam, water will be pumped via a rising main to a concrete balancing reservoir, from where water will gravitate to the edge of the water requirement clusters.

The Lower Olifants River Water Users Association (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 existing right and left bank canals. LORWUA has also requested that the scheme be able to divert 24 Mℓ/d (0.278 m^3/s) back from the balancing dam, which can be discharged into the right (12 Mℓ/d) and left bank (12 Mℓ/d) canals respectively, at times of low flow in the canal.

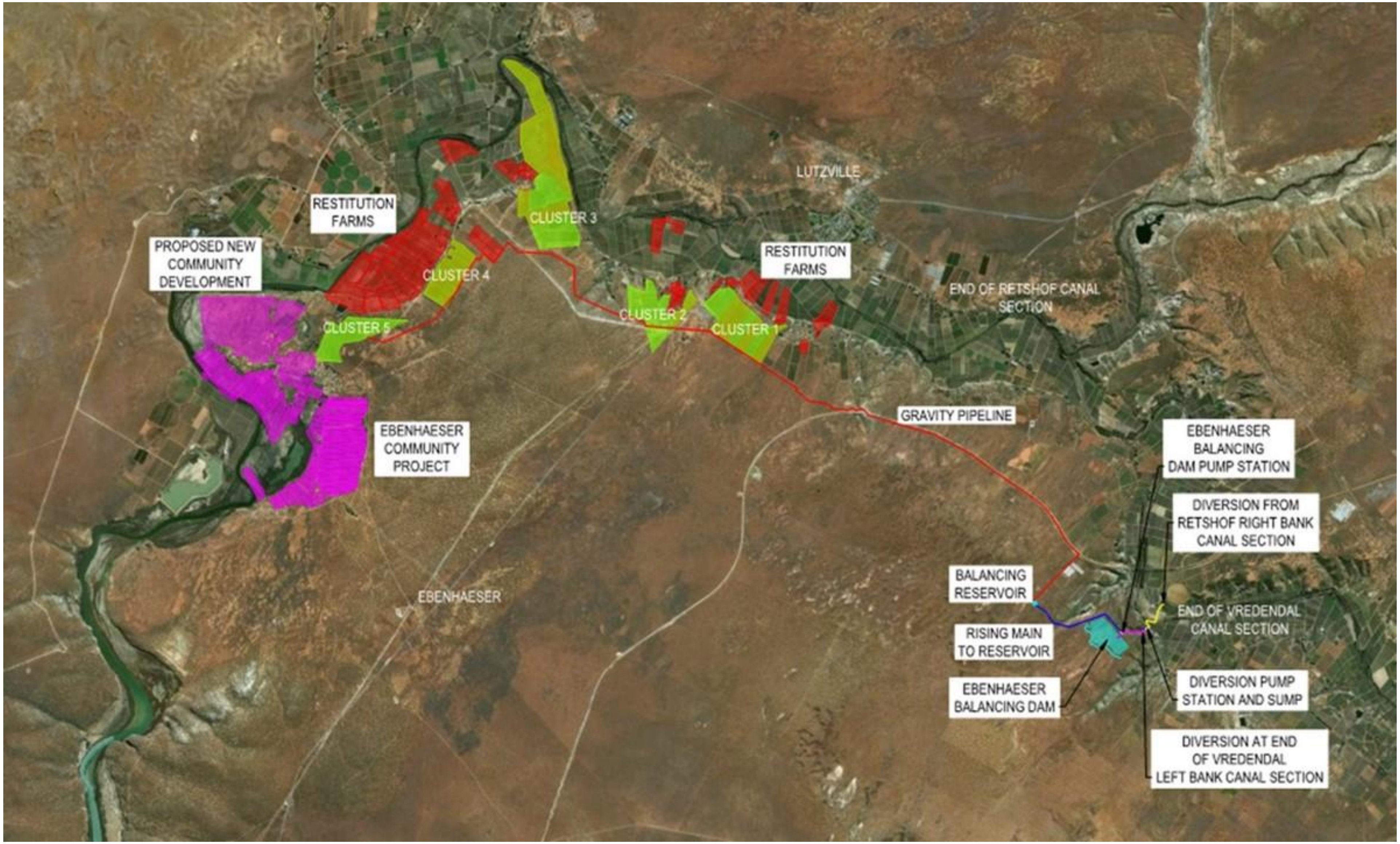

Figure E5: Layout of the Ebenhaeser Scheme

From the right bank Retshof diversion, water will be conveyed via a 500 mm diameter, 765 m long gravity pipeline, including a syphon underneath the Olifants River, to a 2.5 Mℓ diversion sump and pump station. Water will also be gravitated from the Vredendal canal to the sump, from the existing long weir via a 560 mm diameter, 93m long gravity pipeline.

From the sump, water will be pumped via a 700 mm diameter, 520 m long rising main pipeline, to a 2.32 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. The diversion rising mains are designed to allow water from the Ebenhaeser balancing dam to be supplied back under gravity to the left bank and right bank canals when needed.

From the balancing dam, water will be pumped to a 11 000 m^3 (11 Mℓ) concrete balancing reservoir, via a 560 mm diameter, 1 975 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 17 700 m long gravity pipeline, varying from 630 mm to 355 mm diameter.

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.

The Total Project cost, inclusive of VAT is R 601.1 million (refer to **Table E7**). A total of R 19.4 million of this amount is attributable to Betterment costs for improved operating purposes, for the additional 150 000 m^3 balancing dam storage and associated conveyance and other infrastructure. The scheme is comparatively very expensive.

Table E7: Ebenhaeser Scheme Project Cost Estimate (October 2020, incl. VAT)

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Cost (R million)
Pipelines, pumps and canals	174.238	1.736	175.974
Balancing dam	89.841	7.093	96.934
Total Capital Cost	**264.079**	**8.829**	**272.908**
Preliminary & General Items (40%)	105.632	3.532	109.163
Subtotal 1	**369.711**	**12.361**	**382.071**
Contingencies (25%)	92.428	3.090	95.518
Subtotal 2	**462.138**	**15.451**	**477.589**
Access roads	2.220	0.020	2.240
Electrical supply	1.040	0	1.040

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Cost (R million)
Sub-Total: Construction Costs	**465.398**	**15.471**	**480.869**
Professional fees (10%)	46.540	1.547	48.087
Value Added Tax (15%)	69.810	2.321	72.130
Land acquisition	0.930	0.041	0.971
TOTAL (October 2020, incl. VAT)	**582.678**	**19.380**	**601.086**

Financial Viability of Irrigation Farming

The evaluation of the financial viability of irrigation farming for various commercial-scale options and smallholders, determined that the crops that are best suited for the areas identified for development are as shown in **Table E8**.

Table E8: Identified Irrigation Zones and Suitable Crops

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

The minimum viable farm sizes resulting from the financial evaluations done are presented in **Table E9**, according to the identified commodities. The minimum viable farm size for a typical existing farm was calculated, as well as the minimum viable farm size for a new black-owned farm, where the land was obtained at no cost.

Table E9: Minimum Viable Farm Sizes

Crop	Existing Commercial (ha)	New Black Owned (ha)
Citrus	22	90 (@IRR 8%)[1)]
Table Grapes	16	46 (@IRR >9.25%)
Wine Grapes	Not currently viable	Not currently viable
Raisins	68/12[2)]	26 (@IRR >9.25%)
Tomatoes/Brassica seed - commercial	27	41 (@IRR >9.25%)
Tomatoes/Brassica seed - small scale production	6	6 (@IRR >9.25%)

1) Note that the IRR for new black-owned farms is 8% instead of > 9.25% to keep the farm size reasonable, reducing the 5% risk factor.

2) For raisins, the 68 ha minimum viable size relates to the current average study group yield of 22 tons/ha and the 12 ha minimum viable size is calculated at a potential yield of 50 tons/ha based on top varieties and best practice.

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

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

Socio-economic Impact Analysis

An analysis was undertaken to evaluate the relevant impacts that could emerge as a result of the implementation of the full suite of recommended schemes. The socio-economic impact was separately undertaken for the construction and operational periods.

The benefits of the short-term construction phase impacts for the area will be significant.

Findings from the Operational Phase Impacts indicate that the total GDP for development of the new irrigation areas is estimated to be R 2 674 million per annum (expressed in 2018 prices). The operational activities will create a total of R 4 894 million new capital annually, which is an important driver of economic growth. In total an estimated 15 031 job opportunities can be created and supported per annum, of which 10 924 in the direct category will be in the area and on the farms.

One of the crucial aspects of any socio-economic impact assessment is poverty alleviation. The extent to which poverty alleviation is achieved is measured by the impact on household income, specifically the extent to which low-income households will be affected by the additional water following the raising of Clanwilliam Dam. The annual impact of the expected wages to be paid to households is an estimated total of R 2 131 million annually, expressed in 2018 prices, of which 14% is to low income households, at an average income of R 3 500 per month.

Government income (taxes, etc.) will increase, on average, by R 766 million per annum. If this amount is translated into social services, by using the social expenditure portion of the current budget, it also produces increases in other social services.

The benefits to the Provincial and National Government from the increased assurance of supply to be provided to the present producers are:

- Total average GDP increase - R 601 million per annum.
- Number of jobs secured - 4 611. This is people that will have a higher job security.
- Average Increase in Household Income - R 650 million per annum.
- Fiscal Impact - R 171 million per annum.
- Average annual stabilising impact of the increase in Balance of Payments is R 328 million.

The analysis undertaken indicates that the productive use of the additional water from the raised Clanwilliam Dam, inclusive of the increased assurance of supply will have a substantial positive impact on the social and economic conditions prevailing in the area, and that this will lead to substantial poverty alleviation in the area.

Right Bank Canal Scheme Cost Analysis

This financial and socio-economic evaluation aimed to quantify the risks and implications of failure of the existing left bank main canal, to provide additional motivation for the betterment cost component of the Right Bank Canal Scheme. The costs and benefits associated with the construction of the Right Bank Canal Scheme were compared with the alternative scenario should the scheme not be built. The latter alternative is the development of two small bulk water schemes to supply the four recommended new Trawal irrigation areas, and refurbishment of the remainder of the existing main canal on the left bank.

A cost benefit assessment was done to determine the economic viability of the proposed construction over the long term, while a macro-economic impact assessment was employed to assess its socio-economic impacts. From a capital cost point of view, the costs of the two alternatives for the main canal are effectively the same, although implementation of production areas would differ.

It is estimated that the total loss of income at farm level over two years, resulting from a canal break could be in the region of R 1.2 billion for a 30-day water cut and R 1.5 billion for a 3-month water cut. At earnings before interest, tax, depreciations and amortisation, the losses are estimated at R 674 million and R 865 million respectively.

The development and betterment costs for the two long term scenarios are presented in **Table E10**.

Table E10: Development and Betterment costs of the two development scenarios

Main canal long-term alternative	Development Component	Betterment Component	Total Cost	Construction Period
Two small supply schemes and upgrading of left bank main canal	R 573.16	R 1 436.41	R 2 009.57	18 years
Right Bank Canal Scheme	R 573.16	R 1 421.50	R 1 994.66	4 Years

It is estimated that the right bank canal will be constructed over a 4-year period. The alternative two small water supply schemes will be constructed over 3 years and the betterment of the remainder of the existing left bank main canal will be implemented thereafter over a 15-year period.

The evaluation of social and economic conditions in the Cederberg and Matzikama Local Municipalities indicates that the future growth of the economy of the two municipalities will depend on increased irrigation.

The comparative evaluation of the two development scenarios indicates that the Right Bank Canal Scenario is preferable in terms of the baseline cost benefit analysis results, although both development scenarios show viable benefits. The Right Bank Canal Scenario presents the stronger financial and economic results.

A detailed risk and sensitivity analysis was also performed, for some of the cost items that might increase faster than the projected inflation rate, as well as the possibility that projected income levels may not be attained. The results show that both scenarios provided positive answers if no impact of the existing areas are taken into consideration, but the benefits of the Alternate Left Bank Canal Scenario are considerably lower than the benefits from the Right Bank Canal

Scenario. The second comparison indicate that, if the financial benefits are lower than 15% of the expected benefits, then the Alternate Left Bank Canal Scenario is not viable.

The financial and economic viability analysis undertaken supports the recommendation that the Right Bank Canal is the preferred long term development scenario for the main canal. Significant benefits have been identified for the construction of the Right Bank Canal Scheme, in comparison with the alternative development scenario. It is concluded that the recommended decision to include a 'Betterment' cost component for the scheme will have a positive socio-economic impact on the area and is strongly recommended.

Legislative Compliance

A water use licence will need to be obtained for each of the schemes, for storing water, and for affecting and altering the banks of a river (Section 21, National Water Act, 1998), as relevant for each scheme. The licence application process has been included in the scope of work for the EIA study.

In terms of Chapter 12 of the National Water Act (NWA), the Ebenhaeser balancing dam will be a "*dam with a safety risk".* This means that the design and construction of the dam must comply with the dam safety regulations (2012).

Provision should be made for an application to be submitted to Department of Mineral Resources and Energy (DMRE) for the authorisation of any borrow area(s) that may be required to source construction material.

No requirement for ecological water requirement releases is foreseen.

In terms of the National Environmental Management Act (No. 107 of 1998, as amended) (NEMA), separate Environmental Authorisations for the three proposed projects will be required. The Environmental Impact Assessment process for the proposed schemes is expected to start in 2021. It will follow a multi-staged approach to environmental impacts, public participation and stakeholder engagement as stipulated by these regulations, as well as include various specialist studies.

Implementation Arrangements

Jan Dissels Scheme

The land required for the rising main pump station at the (raised) dam wall falls within the Clanwilliam Dam area, which is owned by DWS. The rising main pipeline and reservoir will be located on land owned by Cederberg Municipality.

The rising main route will cross two surfaced roads and transect the Ramskop Nature Reserve, which is managed by Cederberg Municipality. An access road to the proposed concrete reservoir must be constructed.

DWS will be the owner of the scheme. It is anticipated that DWS will also be responsible for the operation of the scheme, but this still needs to be confirmed.

Right Bank Canal Scheme

The horizontal alignment for the proposed Right Bank Canal traverses privately owned farms. Land and servitudes for the canal will need to be acquired from these landowners.

The proposed canal will cross the existing R363 Provincial Road four times, and it will cross major farm roads a total of 11 times. The R363 is owned by the Western Cape Department of Transport and Public Works.

Once the proposed Right Bank Canal has been completed, it is proposed that the existing main canal (Trawal canal section) continues to supply the existing allocations and proposed new irrigators to be located on the left bank of the Olifants River, between Bulshoek Weir and Verdeling, in the short to medium-term. Following the significantly reduced flow in this canal section upon completion of the Right Bank Canal Scheme, the maintenance effort may be adjusted to focus on the bottom section of the canal profile. All other water requirements below Bulshoek Weir will be supplied by the Right Bank Canal.

In the long-term, the Right Bank Canal would supply all existing water users currently supplied via the existing main canal, as well as all new irrigation and other future water uses downstream of Bulshoek Weir.

It is expected that DWS will be the owner of the scheme and that it will be operated by LORWUA.

Ebenhaeser Scheme

The scheme will traverse several farms, owned by various landowners, as well as state land of the Department of Agriculture, Land Reform and Rural Development (DALRRD). Land and servitudes for the proposed infrastructure will need to be acquired from the private landowners.

The proposed diversion rising main (from the diversion pump station to the Ebenhaeser Balancing Dam) will cross the R363 road. The gravity pipeline (from the concrete balancing reservoir to the irrigation clusters) will cross the R362 road. Both roads are owned by the Western Cape Department of Transport and Public Works. The gravity pipeline from the concrete balancing reservoir to the irrigation clusters will cross the railway line once at an existing bridge. The railway line belongs to Transnet and forms part of the Transnet Freight Rail.

During weeks when 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 for the scheme, equal to the spare weekly capacity in the Vredendal and Retshof canal sections respectively.

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 rates. The balancing dam should be operated to be full just before the start of the irrigation peak season, likely in early November. From the balancing dam, water will be pumped to the concrete reservoir, and gravitated to irrigators as needed.

Additional balancing storage will be provided in the balancing dam for operational purposes. The scheme will divert water back from the balancing dam as needed, which can be discharged into the right and left bank canals at times of low flow in these canal sections.

DWS will be the owner of the scheme, and it is recommended that the scheme be operated by LORWUA.

Wayleaves

Wayleave applications will need to be submitted to all the relevant service authorities to (a) obtain information on the location of their existing services, (b) comment on the proposed pipeline alignments, and (c) to obtain their requirements that must be adhered to during construction. This process should be undertaken during the detailed design phase.

Project Implementation

Professional service providers, appointed via open tender processes, are recommended to undertake the detailed design and construction supervision of the schemes, with contractors also appointed via open tender processes. Chief Directorate Engineering Services would then provide the required management and guidance of the PSPs and contractors. The option to undertake detailed design in-house by Chief Directorate: Engineering Services may also be considered with a PSP appointed to assist with construction supervision. Detailed design for each scheme will commence once the EIA for that scheme has been concluded, and an Environmental Authorisation has been issued.

The proposed Jan Dissels Scheme will be located on State-owned land. The Right Bank Canal Scheme and the Ebenhaeser Scheme will form part of the Lower Olifants River Government Water Scheme. It is expected that all three schemes will be implemented as Government Waterworks. The Government would need to buy or expropriate agricultural land within the target geographical area, and this land may be leased to a Community Property Association (CPA) (or

Trust). The CPA would be responsible for productive use of the agricultural land, for such a project to be a success.

Funding from National Treasury will need to be secured. This will enable the project to be implemented as soon as the detailed design and tender documentation are ready, and environmental authorisation has been received. The potential need for alternative funding and associated implementation arrangements can however not be excluded, especially in a post-Covid-19 situation.

Conclusions

Conclusions of the Bridging Study are given in Chapter 21, which address the following aspects:

- Water distribution;
- Soil Survey and Options Analysis;
- Way Forward for Other Irrigation Developments;
- Topographical and Geotechnical Surveys;
- Environmental Screening and Scheme Assessments;
- Jan Dissels Scheme Feasibility Design;
- Right Bank Canal Scheme Feasibility Design;
- Ebenhaeser Scheme Feasibility Design;
- Socio-economic Implications;
- Legislative Compliance; and
- Project Financing and Implementation.

Recommendations

The study recommendations are the following:

Incremental Water Availability and Proposed Use

1) The development should promote equitable access to water, redress the results of past racial and gender discrimination, promote the efficient, sustainable and beneficial use of water in the public interest, and facilitate social and economic development.
2) The incremental yield of the raised Clanwilliam Dam should be used to provide water for new irrigation areas to establish HDI farmers, improve the assurance of supply to the existing scheduled irrigation area, augment the water supply to towns, industries and mines, as well as supply other local water users, inclusive of water losses.

3) The proposed development project will address the following national development objectives:
    - *Economy and Employment* - economic growth, rural job creation, increased income, broader ownership of HDIs, and increased capital formation;
    - *Economic Infrastructure* - providing water for agricultural growth, investment for water resource development in irrigated agriculture, and food security;
    - *Environmental Sustainability and Resilience* - development of adaptation strategies for the protection of rural livelihoods, expansion of commercial agriculture and support services for small-scale and rural farmers;
    - *Inclusive Rural Economy* - the creation of additional direct jobs and indirect jobs in the agriculture, agroprocessing and related sectors, activation of the rural economy through improved infrastructure, substantially increase investment in irrigation infrastructure, and creating tenure security for HDI and communal farmers, especially women and youth.
4) Based on an assurance of supply of 91% for irrigation and 98% for municipalities and industries, the additional available yield, after raising of the dam, is 82.0 million m^3/a.
5) Distribute 61.1 million m^3 to new HDI farmer development (75% of the incremental yield for irrigation use), 15.2 million m^3/a to increase the reliability to existing users (up to 25% of the incremental yield for irrigation use), and 0.6 million m^3/a to supply future domestic, industrial and mining water requirements, after the EWR has been met.
6) Keep 5.1 million m^3/a in reserve for the short-term to medium-term, to first account for hydrological and other uncertainties, at least until the hydrology of the Olifants River catchment has been recalibrated and updated, to avoid over-allocation.
7) Supported by the *HD Farmers Committee*, use the *Mechanism for the Identification of HDI Farmers* tool to aid the selection between different applicants for water licences, taking special cognisance of percentage of water to be allocated to women, the youth and the disabled, attaching weighting of the criteria in a logical and practical manner. The database of existing and prospective HDI water users, and potential land for new irrigation that has been compiled by the HDI Farmers Specialist, should be used as reference where applicable.

Soil Survey Variations

8) Take into account that the findings from soil surveys undertaken at a more localised level may vary from the soil classes that were determined during the feasibility study, from the regional-level soil survey that was undertaken.

9) It is therefore possible that potential irrigation areas identified from more localised investigations could differ from the recommended irrigation areas.

New Irrigation Schemes

10) The Jan Dissels Scheme, Right Bank Canal Scheme and Ebenhaeser Scheme have been identified for implementation as GWSs.Seven other irrigation schemes are recommended for private development, potentially via commercial JV models with a shared ownership or other farm implementation models. The development of some of these schemes as one or more GWSs has however not been excluded.
11) The development of the Trawal and Klawer irrigation areas should be investigated further following the raising of Clanwilliam Dam, either as JV developments or a GWS, or a combination of both.
12) The canal and directly associated bulk infrastructure of the Klawer Phase 2 Scheme should be implemented as a GWS, following further evaluation and other implementation measures.
13) The required extent of smallholder plots should be clarified and, where applicable, included as a condition in the relevant water use licences to be issued, both for the development of GWSs and private development. It is important to ensure a balance between commercial JV projects and smaller agricultural units.
14) Implement the schemes according to the proposed prioritisation and phasing of the uptake of water.

Topographical Survey

15) The LIDAR topographical survey was completed at a standard that is suitable to use for detailed design of the three schemes.
16) Undertake a ground centreline survey along the final chosen pipeline routes, prior to construction commencing. This will serve as a final check on the pipelines' vertical alignment and verification of the survey data.
17) A more site-specific survey is required for the railway and existing culvert crossings on the Ebenhaeser gravity pipeline.

Geotechnical and Materials Investigations

18) Conduct follow-up geotechnical investigations for the Jan Dissels Scheme, specifically where insufficient data was obtained for the recommended pump station site.
19) Conduct additional chemical testing to confirm the corrosiveness of the soils.

20) For the Right Bank Canal and Ebenhaeser Schemes, take into account findings from the core drilling that was undertaken along the syphon routes.

Jan Dissels Scheme Feasibility Design

21) It is recommended that the Rising Main Route 2 option be implemented for the Jan Dissels Scheme.
22) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.
23) Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.
24) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.
25) Confirm the choice of pipe material during the detailed design phase of the project, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.
26) Eskom should be engaged regarding electrical supplies to the pump stations.
27) Refine the selection of pump types.
28) Submit the proposed road crossing details to the relevant road authority for their approval.

Right Bank Canal Scheme Feasibility Design

29) If the required design flow capacity is revised, the scheme routing and sizing of infrastructure should be amended during the detailed design stage.
30) Conduct a more detailed analysis and survey of the existing Bulshoek Weir Outlet to verify the outlet capacity. This could influence the decision regarding an increase of the required canal design flow capacity.
31) Confirm the canal routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

Ebenhaeser Scheme Feasibility Design

32) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.
33) Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

34) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.
35) Confirm the choice of pipe material, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.
36) Eskom should be engaged regarding electrical supplies to the pump stations.
37) Refine the selection of pump types.
38) Submit the proposed railway crossing details on the Ebenhaeser gravity main to the relevant railway authority for their approval.
39) Submit the proposed road crossing details to the relevant road authority for their approval.
40) The assumptions made in the determination of the desired dam storage volume (e.g. siltation from the canal and infiltration losses) should be checked and refined.
41) The dam embankment zoning and dimensions are based on typical values for embankment dams of this size using similar materials. The zoning dimensions must thus be designed based on the actual material properties and design constraints for the particular zones, which are used as input into a slope stability analysis.
42) Further investigation into the required thickness and other properties of the lining for the balancing dam will be needed. Specifications for the stone size and protrusions of the materials layers above and below the liner must also be investigated to prevent damage during construction.

Financial Viability of Irrigation Farming

43) Refer to the *Financial Viability of Irrigation Farming Sub-report* for recommendations to inform and support the evaluation of water licence applications for new irrigation development, proposed irrigable areas, crop types for the different zones, farm sizes, and farm implementation models.
44) A balance between commercial JV projects and smaller agricultural units is required.
45) The Augsburg facility in Clanwilliam, which was formerly an agricultural school and is now used by the Department of Education as offices, could be used for the training of new HD farmers.
46) Selected beneficiaries should already be in training when construction of the bulk conveyance infrastructure starts.

Socio-economic Implications

47) The socio-economic impact analysis, undertaken for the use of incremental water availability from a raised Clanwilliam Dam, supports the recommended development

schemes as they will have a substantial positive impact on the social and economic conditions prevailing in the area, and significantly alleviate poverty in the area.

48) The extent of the lost opportunities, for every year that the Clanwilliam Dam raising project is delayed will be significant, because the benefits as described in Section 21.13 points 3), 4) and 5) will not materialise.

49) The Right Bank Canal Scheme provides a unique opportunity to combine long-delayed betterment works more cost-effectively with new development infrastructure. The opportunity to piggy-back on to the new development is a once-off. If missed, that opportunity will be gone forever. The scheme will significantly reduce the risk of canal breakage and supply interruptions to water users, lower water losses, lower the risk of damage to the regional economy, provide opportunity for improved irrigation to existing users and allow for future water provision.

Legislative Compliance

50) The water use licence applications for storing water, and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), NWA), as relevant for the three schemes, are included in the scope of work for the EIA study, as well as the application to DMRE for a Licence for Borrow Areas.

51) The Ebenhaeser Balancing Dam safety regulation requirements are as follows:

- Applications for licences for complying with the dam safety regulations will need to be completed before certain tasks may commence or continue.
- A licence to construct must be issued by the Dam Safety Office (DSO) before any construction may commence.
- Before the bottom outlets of the dam are closed, thereby commencing the impounding of water, the licence to impound must be obtained from the DSO.

52) DWS is required to undertake a comprehensive EIA process for each of the schemes, in accordance with NEMA and the 2014 EIA Regulations (GN R982 – 985, as amended). The EIA process is a legal requirement to obtain Environmental Authorisation from DEFF for implementation of the project.

Project Implementation Arrangements

53) Careful planning and coordination is required for the new irrigation developments and the implementation of the schemes, by following an integrated approach, involving all the other relevant Government departments.

54) Further investigations for detailed design should be undertaken, inclusive of topographical surveys, geotechnical investigations, construction materials, electrical power supply, and road and railway crossings.
55) Obtain environmental authorisations for the schemes.
56) Finalise scheme layouts and sizing of components, and undertake detailed design.
57) Obtain the necessary licences for implementation of the schemes.
58) Undertake land acquisition and obtain servitudes, as required for the schemes, including compensation for affected land and infrastructure.
59) Obtain wayleaves from the relevant authorities for road and railway crossings.
60) Finalise institutional agreements for implementation of the schemes.
61) The agreements that are in place between DWS and LORWUA should be reviewed and updated, and should take into consideration the operation of the Right Bank Canal and Ebenhaeser schemes, and the joint use of water from the Ebenhaeser balancing dam.
62) The RID should be finalised, after the Environmental Authorisation has been received, and issued to DWS Infrastructure Development to formalise the implementation of the schemes.
63) Funding needs to be secured from National Treasury to enable construction of the project to commence as soon as the detail design is complete and Environmental Authorisation has been received.
64) A range of infrastructure financing and cost-recovery sources is available for private irrigation schemes, but unless the influence of the cost of water can be clarified, the evaluation of and likely uptake of water for private development cannot proceed with confidence.
65) While the cost of the water is expected to be high, the water should be affordable to new HDI irrigators, else the uptake of the new irrigation may not materialise. The final tariff will have to be determined according to the approved Water Pricing Strategy, but some form of subsidy may need to be considered to enable the project to be implemented.
66) In accordance with the Water Pricing Strategy, the price of water must be negotiated with LORWUA, before the Right Bank Canal refurbishment is done, as they must know how much it will cost them.
67) Professional service providers, appointed via open tender processes, are recommended to undertake the detailed design and construction supervision of the schemes, with contractors also appointed via open tender processes. Chief Directorate Engineering

Services would then provide the required management and guidance of the PSPs and contractors.

68) Water Resource Development Planning should however consider and evaluate all the available implementation possibilities, and then confirm the recommended implementation process for detailed design and construction, or make any other necessary recommendation. DWS needs to create a platform for communication with other key government departments, to raise awareness regarding this project and its priorities, long before construction commences, as it is usually a lengthy process to implement large projects.

Further issues to address

69) The principles for 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.

70) Clarify the uncertainty regarding the cost of water from the LORGWS, following the raising of Clanwilliam Dam, so that the potential for a Trawal Government Water Scheme can be assessed with more confidence.

71) Clarify the legal obligations on DWS to ensure that the LORGWS infrastructure remains functional.

72) 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.

73) Receive authorisation for the proposed new irrigation development areas. The majority of these areas are privately owned, and it is expected that the majority of such development will be via joint venture agreements.

74) To obtain greater clarity on funding options, it is suggested that DWS provide a comprehensive and strong motivation to National Treasury to explain implementation approaches, broader economics and cost recovery aspects, which make it clear that the investment is in the national interest. DWS should request confirmation of National Treasury's view on this, as well as any concerns that they may have and the 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 indicate the risks for the economy and labour of potential canal failures if betterments are not undertaken.

Contents

Appendices

Figures

Tables

Abbreviations and Acronyms

APP	Approved professional person
BCR	Benefit cost ratio
CA	Competent authority
CASP	Comprehensive Agricultural Support Programme
CBA	Critical biodiversity area
CBAn	Cost Benefit Analysis
C/c	Centre to centre
CR	Conditionally recommended soil class
CPA	Community property association
CPI	Consumer price index
DALRRD	Department of Agriculture, Land Reform and Rural Development
DCP	Dynamic cone penetration
DEA&DP	Western Cape Provincial Department of Environmental Affairs and Development Planning
DEFF	Department of Environment, Forestry and Fisheries
DMRE	Department of Mineral Resources and Energy
DN	Nominal diameter
DRDLR	Department of Rural Development and Land Reform
DSO	Dam Safety Office
DTM	Digital terrain model
DWAF	(Previous) Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
ECBA	Economic cost benefit analysis
EIA	Environmental impact assessment
EMF	Environmental management framework
EMPr	Environmental management programme
ESRI	Environmental Systems Research Institute
EWR	Ecological water requirement
FALA	Financial Assistance Land Administration
FCBA	Financial cost benefit analysis
FSL	Full supply level

GDP	Gross domestic product
GIS	Geographical information system
GN	Government notice
GPS	Global positioning system
GWS	Government water scheme
Ha	Hectare
HD	Historically disadvantaged
HDF	Historically disadvantaged farmer
HDI	Historically disadvantaged individual
HDPE	High density polyethylene
HR	Highly recommended soil class
HWC	Heritage Western Cape
IRR	Internal rate of return
JV	Joint venture
ℓ/s	Litre per day
LIDAR	Light detection and ranging
LORWUA	Lower Olifants River Water User Association
Masl	Meters above sea level
MEIA	Macroeconomic impacts assessment
Mℓ	Megalitre
Mℓ/d	Megaliter per day
Mm^3/a	Million cubic meter per annum
MOL	Minimum operating level
MR	Marginally recommended soil class
MPRDA	Mineral and Petroleum Resources Development Act
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NFA	National Forests Act
NFEPA	National Freshwater Ecosystem Priority Areas
NHRA	National Heritage Resource Act
NOC	Non overspill crest
NPV	Net present value
NR	Not recommended soil class
NWA	National Water Act

NWRI	National Water Resources Infrastructure branch of DWS
LORGWS	Lower Olifants River Government Water Scheme
O&M	Operation and maintenance
P&G	Preliminary and general items
PGE	Partial general equilibrium
PSC	Project steering committee
PSP	Professional service provider
PV	Present value
RDF	Recommended design flood
RE	Recommended soil class
RID	Record of Implementation Decisions
RM	Rising main pipeline
SAD	South African Dried Fruit Association
SAM	Social accounting matrix
SANRAL	South African National Roads Agency
SANS	South African National Standards
SATI	South African table grape industry
SAWIS	South African wine industry statistics
SDF	Spatial development framework
SEA	Strategic environmental assessment
SEF	Safety evaluation flood
TDS	Total dissolved solids
TLB	Tractor-loader-backhoe
TOR	Terms of reference
uPVC	Unplasticised polyvinyl chloride
URV	Unit reference value
VAT	Value added tax
V&V	Validation and verification
WAR	Water allocation reform
WCDoA	Western Cape Provincial Department of Agriculture
WRC	Water Research Commission
WULA	Water use licence application
WUA	Water user association

Glossary

Air valves: Hydromechanical devices designed to automatically release air and wastewater gases or admit air during the filling, draining or operation of liquid piping systems for water and wastewater services.

Annual crops: Crops that perform their entire life cycle within a single growing season. Examples of true annuals include corn, wheat, rice, lettuce, peas, watermelon and beans.

Assurance of supply: The reliability at which a specified quantity of water can be provided, usually expressed either as a percentage or as a risk. For example, "98% reliability" means that, over a long period of time, the specified quantity of water can be supplied for 98% of the time, and less for the remaining 2%. Alternatively, this situation may be described as a "1 in 50 year risk of failure" meaning that, on average, the specified quantity of water will fail to be provided in 1 year in 50 years, or 2% of the time. The higher the assurance of supply, the less often there will be an annual shortage of supply.

Available Yield: This is the amount of water that can be expected to be "available" for commercial use for a certain percentage of the time (for 91% of the time in this case for irrigation and 98% for other water users), either from dams, directly from rivers, or from groundwater - during any one year.

Balance of Payments: The balance of payments (BOP) is a statement of all transactions made between entities in one country and the rest of the world over a defined period.

Balancing dam: A dam that balances the flow or water supply in a highly managed water supply system or scheme, taking in water during high flows and releasing it again during low flows.

Betterment cost: The cost relating to the rehabilitation or improvement of a water supply system or scheme that will benefit existing water users.

Bulk water supply infrastructure: This includes dams, weirs, canals, pipelines, pump stations and balancing reservoirs, and are used for everyday and emergency situations, and include potable and non-potable delivery systems that ultimately help ensure a safe and reliable water supply to the intended users. This is differentiated from distribution infrastructure. Also referred to as *Headworks*.

Cavitation: A phenomenon in which the static pressure of the liquid reduces to below the liquid's vapour pressure, leading to the formation of small vapor-filled cavities in the liquid.

Characteristic system curves for a pump station: A graphical representation of the pump head (a function of elevation - or the static head and the major and minor losses in the system) that is required to move fluid through a piping system at various flow rates. The system curve helps quantify the resistance in a system due to friction and elevation change over the range of flows.

Catchment: The area of land drained by a river. The term can be applied to a stream, a tributary of a larger river or a whole river system.

Capital cost: Fixed, one-time expenses incurred on the purchase of land, buildings, construction, and equipment used in the production of goods or in the rendering of services

Capital formation: Capital formation is a crucial element for economic growth. Capital formation increases investment, which stimulates economic development.

Commercial Farming: Large scale farming, the products of which are normally sold for profit. Also referred to as a *Commercial Enterprise*.

Centre pivot: An irrigation system that irrigates in a circular pattern around a central pivot point.

Commercial farmer: A producer that makes use of advanced technology and crop production and farm for profit on a large scale in a competitive market system. Scale here refers to productive output and not farm size.

Commodities: A basic good (an items that satisfy human wants and provide utility) used in commerce that is interchangeable with other goods of the same type. Commodities are most often used as inputs in the production of other goods or services.

Community property association: Juristic entity, formed by a community to acquire, hold and manage communal property on a basis agreed to by members of a community in terms of a written constitution.

Competent authority for EIA approval: The organisation that has the legally delegated or invested authority, capacity, or power to approve or delegate the EIA of a scheme.

Crop rotation: The practice of planting different crops sequentially on the same plot of land to improve soil health, optimise nutrients in the soil, and combat pest and weed pressure.

Crump weir: A Crump weir is a broad-crested weir and is a flow gauging control structure with a triangular profile, built in rivers or canals.

Dam safety classification: Every dam with a safety risk must be classified on the basis of its size and hazard potential (either Category I, II or III if it has a wall height of greater than 5 m and a volume of greater than 50 000 m^3), to determine the level of control over the safety of the structure that is applicable in terms of the dam safety regulations. The size classification of dam is based on the maximum wall height.

Deficit: Describes the situation where the availability of water at a particular assurance of supply is less than the unrestricted water requirement.

Development cost: Total cost relating to the construction of new infrastructure.

Digital terrain model: A mathematical representation (model) of the ground surface, most often in the form of a regular grid, in which a unique elevation value is assigned to each pixel.

Direct impact: Impact created in the project area where the capital is spent or production is generated.

Discount rate: Is the rate used to convert current Rand values of cost which occur in a future year to a present value in the base year. The recommended inflation free rate is *r*. To convert an amount which will be paid *n* years in the future to a present value, divide the future value by $(1+r)^{n}$. Discount rates can be reflected in real or nominal terms where 'real' indicates that the effects of general inflation have been removed. The discount rate used depends on the type of Rands to be adjusted. Discounting translates projected cash flows into present value terms using specified discount factors.

Distribution water infrastructure: Infrastructure located downstream of bulk water infrastructure, and can generally be defined as the infrastructure (conveyance and storage) required to deliver water from balancing reservoirs to end-users.

Ecological water requirement / Reserve: The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act No. 108 of 1997) for people, who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in the National Water Act (Act No. 36 of 1998).

Ecosystem: A unit made up of all the living and non-living components of a particular area that interact and exchange materials with each other.

Embankment: A dam wall constructed from natural materials excavated or obtained nearby, commonly earth or rock, to hold back water.

Embankment zoning: Embankment designs in earth dams including zoning to control seepage, or to provide transition layers to prevent finer grained material from migrating into rockfill, to improve dam safety.

Emerging farmer: Middle class of mostly black smallholder farmer, between the subsistence orientated smallholder farmer that farms to meet household food security, and the fully commercial orientated smallholder farmer, whose objective is to sell produce .

Environmental authorisation: The authorisation by a competent authority of a listed activity, or specified activity in terms of the National Environmental Management Act and EIA regulations.

Environmentally sensitive area: A fragile ecosystem, which will be maintained only by conscious attempts to protect it.

Equity development: Development that provides individuals with equal opportunities to pursue a life of their choosing and be spared from extreme deprivation, especially with respect to the access to water.

Extension services: A systematic process of working with farmers or communities to help them acquire relevant and useful agriculture or related knowledge and skills to increase farm productivity, competitiveness and sustainability.

Farmworker forum: A forum created to provide representation of farm workers, with the aim of voicing workers' collective demands and grievances and bargaining for improved conditions.

Feasibility Study: An analysis that takes all of a scheme's relevant factors into account, including technical, environmental, social, financial, economic, legal, and scheduling considerations, to ascertain the likelihood of successfully implementing and operating the scheme.

Freeboard: For a **dam** this refers to the vertical distance between the upstream water level (headwater) and the top of a dam, while for a **canal** it refers to the vertical distance measured from the maximum water level to the uppermost watertight portion of the surrounding canal.

Full supply level: The normal dam maximum operating water level when not affected by floods.

Geophysical survey: Field-based survey to produce a computer-based contour map, that displays variation of a geological variable, such as thickness, depth, or porosity, over an area of interest with contour lines of equal value.

Government Waterworks: Water supply system or scheme that is developed and owned by the State. Synonymous with *Government Water Scheme*.

Gravity main pipeline: Bulk pipeline water conveyance where the water supply surface is higher than all points in the pipeline and no pump is required to convey the water.

Gross domestic product: A monetary measure of the market value of all the final goods and services produced in a specific time period, often annually within a specific country.

High-lift pump station: A pump station designed to pump water into the water reticulation system at pressure.

High value crops: Crops with higher market prices that generally requires a smaller area to grow.

Historically disadvantaged farmers: Farmers who come from previously disadvantaged groups. This includes certain race groups, women, youth and people with disabilities. Used interchangeably with resource-poor farmers.

Historically disadvantaged individual: A South African citizen who, due to the apartheid policy that had been in place, had no franchise in national elections prior to the introduction of the Constitution of the Republic of South Africa, 1983 (Act 110 of 1983) or the Constitution of the Republic of South Africa, 1993 (Act 200 of 1993); and/or who is a female, and/or who has a disability, provided that a person who obtained South African citizenship on or after the coming into effect of the interim Constitution, is deemed not to be an HDI.

Hydraulic gradient: For pipes, this is determined by subtracting the (vertical) head/pressure loss in a pipeline from the static head (pressure in a pipe when there is no flow, as determined by the height differential over the pipe) over distance. The difference between the ground profile and the hydraulic gradient line is the pressure in the pipeline at that point while the water is flowing.

Hydrology: Evaluation of the occurrence, distribution, movement and properties of rainfall and river flows, typically to determine water quantity, quality and availability.

Indirect impact: Impact created by service providers and could be in the project area or outside as part of the marketing of the products.

Internal rate of return: Is the discount rate that sets the net present value of the programme or project to zero. While the internal rate of return does not generally provide an acceptable decision criterion, it does provide useful information, particularly when budgets are constrained or there is uncertainty about the appropriate discount rate.

Irrigation efficiency: The amount of water removed from the water source that is used by the crop. This value is determined by irrigation system management, water distribution characteristics, crop water use rates, weather and soil conditions.

Joint venture: a business arrangement in which two or more parties agree to pool their resources for the purpose of accomplishing a specific task.

Induced impact: Impact generated by the salaries and wages paid and the spending of the income.

Irrigation Quota: The quantity of water, usually expressed as m^3/ha/a, or mm/a, allocated to land scheduled under the scheme. This is the quantity to which the owner of the land is entitled at the point at which he or she takes delivery of the water and does not include conveyance losses to that point.

Leaching: Applying a small amount of excess irrigation to avoid soil salinity.

Light Detection and Ranging (LIDAR): A remote sensing method that uses light in the form of a pulsed laser to measure ranges (variable distances) to the Earth. These light pulses, combined with other data recorded by the airborne system, generate precise, three-dimensional information about the shape of the Earth and its surface characteristics. Airplanes and helicopters are the most commonly used platforms for acquiring lidar data over broad areas.

Live storage capacity: Portion of the reservoir that can be used for downstream releases, flood control, or power production, i.e. excluding the *dead* storage capacity that cannot be used.

Long weir: A structure (permanent or temporary) built in a configuration other than perpendicular in a canal (or river) to obstruct the flow and raise the water level to allow for pumping or to increase the offtake discharge.

Low-lift pump station: A pump station where water is lifted between two open water surfaces through a pumped total head up to about 10m.

Non-tuberous crops: Crops that grow above ground, including crops such as tomatoes, pumpkins and beans.

Mean annual runoff: Frequently abbreviated to MAR, this is the long-term mean annual flow calculated for a specified period of time, at a particular point along a river and for a particular catchment and catchment development condition.

National Water Act: South Africa's Act that gives guidance on the need for reform in water usage by ensuring the equitable and sustainable access to water resources.

Net Present Value: Is defined as the difference between the present value of benefits and the present value of costs. The benefits referred to in this calculation must be quantified in cost of monetary terms in order to be included.

Non-overspill crest: The top of the dam, not designed to let water spill.

Ogee spillway: A weir where the spillway crest, slope, and bottom form an "S" or ogee curve.

Options analysis: The practice of evaluating every possible pathway that leads to a desired outcome. In water resources development, it is the analytical process to identify intervention options (development schemes and other measures), evaluate and compare them, and screen them to arrive at a short list of preferred options or the preferred option.

Parshall flume: A flow measurement structure with both a section that has a contraction in the width of the flume as well as a dip in the elevation of the bottom of the flume.

Partial equilibrium: Partial equilibrium is a condition of economic equilibrium which takes into consideration only a part of the market (assuming all other parts of the market constant) to attain equilibrium.

Peak design flow: Increasing the required average design flow with a peak flow factor, to allow for expected water requirement peaks, typically monthly or weekly.

Perennial crops: Crop that have a lifespan of several seasons, on up to very long periods. This refers mainly to dry, wine and table grapes and citrus.

Probable maximum flood: The most extreme flood peak possible in a catchment located in a particular hydro-climatic region under conditions of maximum storm rainfall possible in that region and minimum retention of storm rainfall by that catchment.

Pumping head: The height at which a pump can raise water up.

Reliability of supply: Synonymous with assurance of supply.

Recommended design flood: A single flood hydrograph or a family of hydrographs, determined with site specific methods, having return periods suggested in Table 5.4 of the SANCOLD Guidelines on Safety in Relation to Floods (1991), which must, after routing, be accommodated by the spillway system without damage.

Reject: A structure providing a drain for excess flows in emergency or other situations.

Reservoir: The lake formed behind a dam wall. In this report the colloquial term dam is generally used for reservoir.

Restitution farms: Farms handed to successful claimants for restitution for land, in terms of the Restitution of Land Rights Act. It involves the restitution of land to individuals and communities who lost their homes and land due to forced removals.

Rising Main pipeline: Pipeline conveying the pumped discharge of water to a balancing reservoir or distribution chamber under hydrostatic pressure.

River system: A network of rivers ranging from streams to major rivers and, in some cases, including rivers draining naturally separate basins that have been inter-connected by man-made transfer schemes.

Safety Evaluation Flood: A single flood hydrograph or a family of hydrographs, determined with site specific methods, which after routing through the reservoir and spillway system may bring the dam to the point of failure but the resulting damage, although possibly substantial, must not be such as to cause failure of the dam.

Servitude: A registered right that someone has over the immovable property owned by another person.

Scour valves: Valves located at low points or between valved sections of the pipeline. Their function is to allow periodic flushing of the lines to remove sediment and to allow the line to be drained for maintenance and repair work.

Social accounting matrix: A SAM is a comprehensive, economy-wide database that contains information about the flow of resources that takes place between the different economic agents that exist within an economy. The SAM forms the basis of the model to calculate socio -economic impacts of the project.

Syphon: A particular form of culvert or pipe in which the conduit drops down to pass under a river and then rises up at the other side, such that the center part of the conduit is always full of water. Synonymous with *siphon*.

Tuberous crops: Crops grown underground that form tubers (enlarged stems or roots), such as potatoes, onions, sweet potatoes, and carrots.

Salinity: The concentration of dissolved salts in water. The most desirable drinking water contains 500 parts per million or less of dissolved minerals.

Smallholder farmer: A producer that also farms for subsistence, typically producing one or two cash crops. These producers have the potential to produce for the market at profit in the long term but often lack the infrastructure and technology that more developed farming enterprises have.

Study Zones: The geographical sub-divisions of the study area used as evaluation regions for this study, also referred to regions or sub-areas.

Subsistence farming: Someone that produces primarily for consumption at a household level and usually employs family labour.

Sump: Low storage space for collection of water.

Transfer of scheduled water allocations: An approved change of the water use authorisation to a different water source, property or user, which can affect the assurance of supply, volume and water quality allocated.

Value chain: A set of activities that a firm operating in a specific industry performs to deliver a valuable product (i.e., good and/or service) for the market.

Validation & Verification: South African national process in terms of the NWA to validate (confirm the quantum of) and verify (establish the lawfulness of) water uses, for both qualifying (defined as two years before the enactment of the NWA) and the current period.

Valve: Device fitted to a conduit in which the closure member is either rotated or moved transversely or longitudinally in the waterway to control or stop the flow

Yield: The maximum quantity of water obtainable on a sustainable basis from a dam or river in any hydrological year, in a sequence of years, and under specified conditions of catchment development and dam operation.

Water table: Underground boundary between the soil surface and the area where groundwater saturates spaces between sediments and cracks in rock. Water pressure and atmospheric pressure are equal at this boundary.

Wayleave: Right of way granted by a landowner (generally the government) for the purpose of carrying out work on the land.

Water service authority: Regulator of the service and is responsible to ensure that services are provided effectively, efficiently, sustainably and affordably. A water services authority may either provide water services itself or contract a water services provider to provide water services.

Water service provider: Provide water services in accordance with the Constitution, the Water Services Act and the by-laws of the water services authority, and in terms of any specific conditions set by the water services authority in a contract.

Water user association: Water user associations are formal organisations created to bring together farmers for the purpose of managing a shared irrigation system, although it generally includes water supply to other water users.

Weir: A barrier built across the width of a stream to raise the upstream water level, called a fixed-crest weir, when the top is at a permanent elevation and cannot be moved up or down. Weirs can also be built across a stream, channel or discharge point to measure or gauge flow. Types of weirs include broad crested, sharp crested, ogee, and V-notched weirs.

Wet well: An installation with only one chamber or tank to receive and hold water until it is pumped out.

1 Introduction

1.1 Background and Need for the Study

The Clanwilliam Dam, a mass gravity structure, 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 is released from the Dam, and is diverted at Bulshoek Weir, 24 km downstream, into an extensive canal system. Water use in the region is predominantly for irrigated agriculture, and is also supplied to several towns, industries and to the Exxaro Mine (Namaqua Sands), as well as to some other smaller users. The Clanwilliam Dam is shown in **Figure 1-**.

Figure 1-1: Clanwilliam Dam

Photo courtesy of DWS

Following a dam safety inspection, the Department of Water and Sanitation (DWS) Dam Safety Surveillance sub-directorate became concerned about the risks associated with the Clanwilliam

Dam for extreme flood events. The construction of a concrete gravity wall against the downstream side of the current dam wall with an uncontrolled spillway, to replace the crest gates, was recommended. This provided an opportunity to simultaneously raise the dam wall and significantly increase the yield of the dam, at an acceptable incremental cost.

The Dam Raising feasibility study was completed in 2008, and concluded that the raising of Clanwilliam Dam, and further associated agricultural development, is economically viable and socially desirable. The resultant increase in the capacity of the dam from 122 million m^3 to 344 million m^3, following the 13 m raising, will provide additional water for new irrigation by historically disadvantaged farmers and for other water uses.

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.

1.2 Study Objectives and Approach

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.

Apart from the technical evaluation, specific attention was also given to social, environmental, broad economic and equity development. The public and stakeholders were informed and consulted throughout the study by means of a well-planned involvement programme.

1.3 Study Area

The study area mainly included the Olifants River valley around and downstream of Clanwilliam Dam, up to a level of 100 m above either the river level or above existing distribution canals. Towns in the study area include Clanwilliam, Klawer, Vredendal, Lutzville and the Ebenhaeser community. The area outside of the Olifants River valley included the Jakkals River and small coastal towns. The study area and existing bulk water storage and conveyance infrastructure are shown in **Figure 1-**.

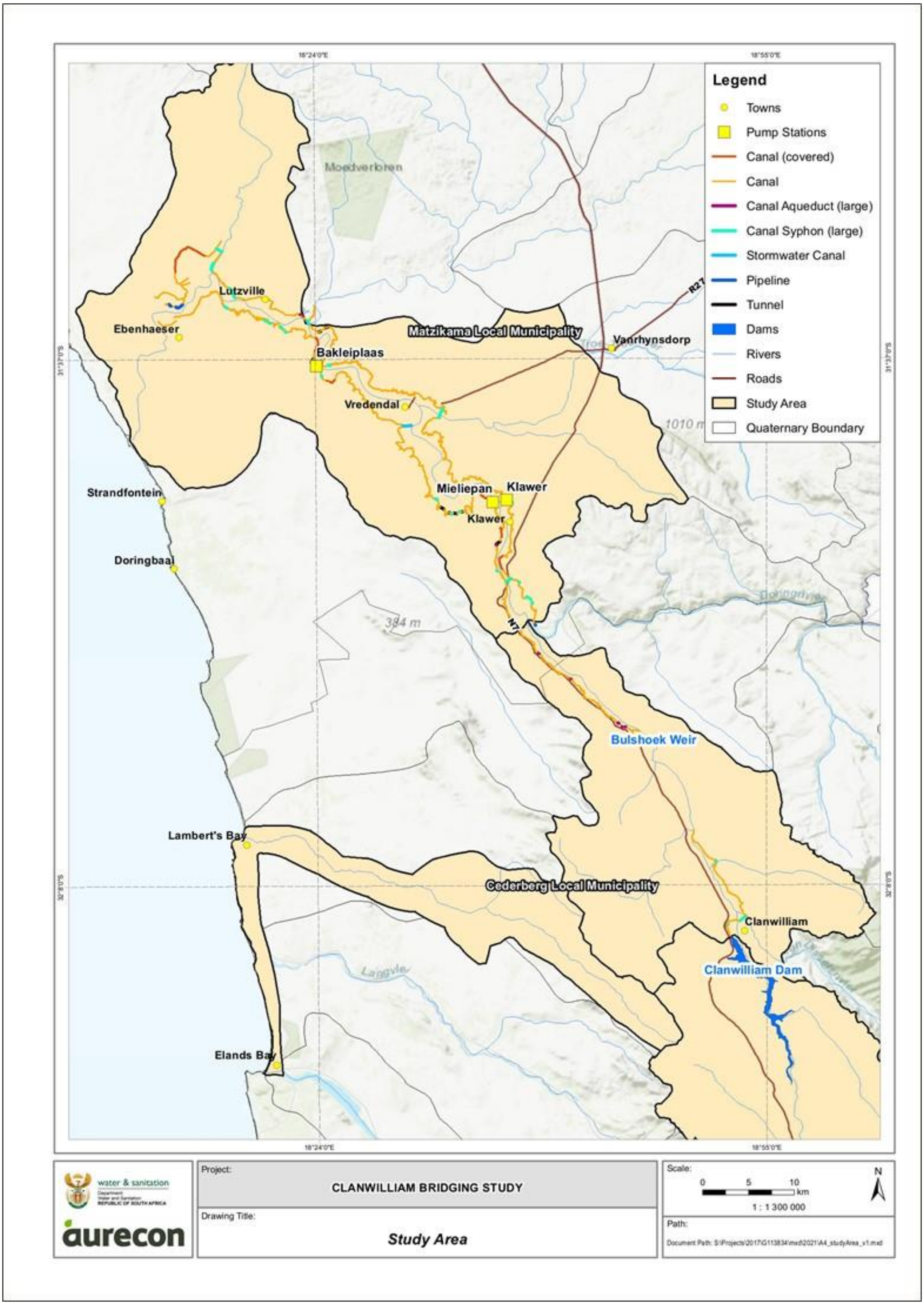

Figure 1-2: Study Area and Existing Bulk Water Infrastructure

1.4 Objective of this Report

This report provides an integrated summary of study tasks undertaken, and describes study findings and recommendations made.

1.5 Study Management and Oversight

The study was managed by a DWS Project Management team, with close involvement by key officials of the Provincial and local DWS offices. Official management engagement included quarterly Study Management Committee meetings and more regular study liaison meetings. Formal progress reporting was done monthly. Study oversight was provided by a Project Steering Committee (PSC) that met quarterly. The PSC Membership is included under **Appendix A**.

1.6 Public Engagement and Other Stakeholder Liaison

The background to and objectives of the study, approaches to study tasks, and expected outcomes were presented to the public at three well-advertised public meetings during February 2018, held in Clanwilliam (**Figure 1-**), Vredendal and Ebenhaeser respectively. This provided an opportunity for comment and contributions by members of the public, affected parties and other stakeholders.

Figure 1-3: Management and Team Members at the Clanwilliam public meeting

Photo by Mariaan Smuts, Ons Kontrei 25 February 2018

Due to the Covid-19 situation, it was not possible to hold the public meetings, scheduled towards the end of the study, which were planned to convey the study outcomes and recommendations. A Newsletter describing the study tasks and outcomes was instead developed, to be used to inform interested and affected parties, stakeholders and officials. A Brochure was in addition developed for DWS Departmental use.

Meetings were held with the provincial Department of Environmental Affairs and Development Planning (DEA&DP) and the Department of Environment, Forestry and Fisheries (DEFF) regarding environmental approvals, which are described in Chapter 11. Engagement meetings were also held with water user associations (WUAs), local authorities, land owners and prospective historically disadvantaged individual (HDI) irrigators. Several technical meetings were held with stakeholders to discuss specific technical aspects such as irrigation crop water requirements, development options, water quality and feasibility design aspects.

1.7 Content of this Report

The various chapters in this report are as follows:

Chapter 1: Introduction and Background (this Chapter)

Introduces and provides background to the study.

Chapter 2: Description of the Existing Scheme and Users

Describes the existing bulk storage and conveyance infrastructure, irrigated land, other water users, water quality aspects and land ownership.

Chapter 3: Water Distribution Options

Describes the revisiting of the available yield assessment following the dam raising, and the proposed distribution of the additional available water.

Chapter 4: HDI Farmers

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.

Chapter 5: Soil Survey

Describes the soil survey undertaken.

Chapter 6: Water Requirements

Describes existing agricultural areas, the process followed to identify suitable new irrigation areas, associated irrigation water requirements and other future water requirements.

Chapter 7: Options Analysis

Describes the identification, evaluation and screening of potential new irrigation development options, the recommended schemes and implementation phasing.

Chapter 8: Way Forward for Other Irrigation Developments

Describes the way forward for the recommended development schemes, which excludes the irrigation areas to be developed for the three GWSs to be implemented.

Chapter 9: Topographical Survey

Provides an overview of the topographical survey undertaken for the three schemes selected for feasibility design.

Chapter 10: Geological, Geotechnical and Materials Investigation

Provides an overview of the geology and the outcomes and conclusions of the geotechnical and materials investigations undertaken at the three schemes selected for feasibility design.

Chapter 11: Environmental Screening and Scheme Assessments

Describes the environmental screening undertaken for the study area, environmental evaluations undertaken for the three schemes selected for feasibility design and environmental approval engagements with responsible authorities.

Chapter 12: Jan Dissels Scheme Design and Cost Estimate

Documents the feasibility evaluation of the Jan Dissels Scheme, provides the scheme layout, describes the infrastructure components and features, provides the scheme cost estimate and describes further investigations to be undertaken.

Chapter 13: Right Bank Canal Scheme Design and Cost Estimate

Documents the feasibility evaluation of the Right Bank Canal Scheme, provides the scheme layout, describes the infrastructure components and features, provides the scheme cost estimate and describes further investigations to be undertaken.

Chapter 14: Ebenhaeser Scheme Design and Cost Estimate

Documents the feasibility evaluation of the Ebenhaeser Scheme, provides the scheme layout, describes the infrastructure components and features, provides the scheme cost estimate and describes further investigations to be undertaken.

Chapter 15: Financial Viability of Irrigation Farming

Describes the evaluation of the financial viability of irrigation farming for various commercial-scale options and smallholders.

Chapter 16: Economic Implications

Provides an overview of the socio-economic impact analysis undertaken to measure the nature and magnitude of the socio-economic impacts emanating from the distribution and use of additional water from a raised Clanwilliam Dam.

Chapter 17: Right Bank Canal Scheme Cost Analysis

This Chapter describes the socio-economic assessment relating to the Betterment cost of the Right Bank Canal Scheme.

Chapter 18: Legislative Compliance

Describes water use licensing, dam safety legislation and the need for compliance, as well as the environmental requirements and processes that are required to make the schemes implementation ready.

Chapter 19: Implementation Arrangements

Identifies the various legislative considerations required for effective implementation, affected land, land acquisition and wayleaves, operation and maintenance requirements and institutional arrangements.

Chapter 20: Project Implementation

Provides information on the recommended implementation process as well as the possible timeframe and milestone dates.

Chapter 21: Conclusions

Summarises the conclusions of the feasibility study.

Chapter 22: Recommendations

Lists the recommendations emanating from the feasibility study.

2 Overview of the Scheme and Land Ownership

This chapter describes the existing bulk storage and conveyance infrastructure, irrigated land, other water users, water quality aspects and land ownership.

2.1 Historical Perspective of the Scheme's Development

With the intention of providing perennial irrigation, construction of the Bulshoek Weir and 80 km of unlined distribution canals started in 1913, and lining of the canals with concrete started in 1927. The Clanwilliam Dam was constructed in 1935 in the Olifants River near the town of Clanwilliam, to secure the water supply for the existing irrigation scheme, and also allow for the expansion of agricultural activities. The dam was raised twice to increase the capacity to 128 million m^3 and raise the wall height to 43 m. Curtailments have increasingly been experienced as the extent of irrigation and other uses increased.

About 40 000 people in the various towns are dependent on the scheme for water, as well as many industries and mining. Without the development of the scheme, the towns, the significant irrigation development and associated industries in this very dry region would not exist.

Figure 2- shows the Lower Olifants Canal at different locations.

Figure 2-1: The Lower Olifants Canal near Bulshoek Weir (left) and downstream

2.2 Description of the Scheme

2.2.1 Clanwilliam Dam

The Clanwilliam Dam reservoir currently has a live storage capacity of 122 million m^3. The dam, which is owned and operated by DWS, currently supplies approximately 11 000 ha of scheduled irrigation water downstream of the dam. There are 318 ha scheduled water allocations directly from the dam reservoir.

2.2.2 Clanwilliam Canal and Olifants River

The Clanwilliam Canal is owned by the DWS. The Clanwilliam WUA manages abstractions from the Clanwilliam Dam catchment, the Clanwilliam Canal and the Olifants River up to the Bulshoek Weir. They are also responsible for the canal's operation and maintenance. The canal is approximately 18 km in length, originates at the Clanwilliam Dam wall, passes through Clanwilliam town and crosses the Jan Dissels River. The canal, which was built during 1940, supplies water for irrigation. There are 564 ha of scheduled allocations from the Clanwilliam Canal and 665 ha allocated from the Olifants River for Clanwilliam town. The canal does not have spare capacity to allow for further development. Canal losses are estimated at 30%.

2.2.3 Bulshoek Weir

The Bulshoek Weir (**Figure 2-2**), a stone-masonry gravity structure, was constructed across the Olifants River about 26 km downstream of Clanwilliam town, and has a current capacity of 4.2 million $m^{3.}$ The weir's catchment area is 2 679 km^2 in extent. A series of connected arches and buttresses supporting a bridge deck and a gantry for the spillway gate hoists make up the dam wall. Sixteen gates are positioned between the buttresses on top of the ogee-shaped crests. The dam is operated at close to its full supply capacity to divert water into the irrigation canal. Bulshoek Weir is a national monument.

2.2.4 Lower Olifants River (Vanrhynsdorp) Government Water Scheme

The Lower Olifants River (Vanrhynsdorp) Government Water Scheme (LORWGS) consists of the canal system fed from Bulshoek Weir with water released from the Clanwilliam Dam. Downstream of the Bulshoek Weir, water is diverted into the lower Olifants canals, which is the main conveyance system in the LORGWS.

Bulshoek Weir is shown in **Figure 2-**.

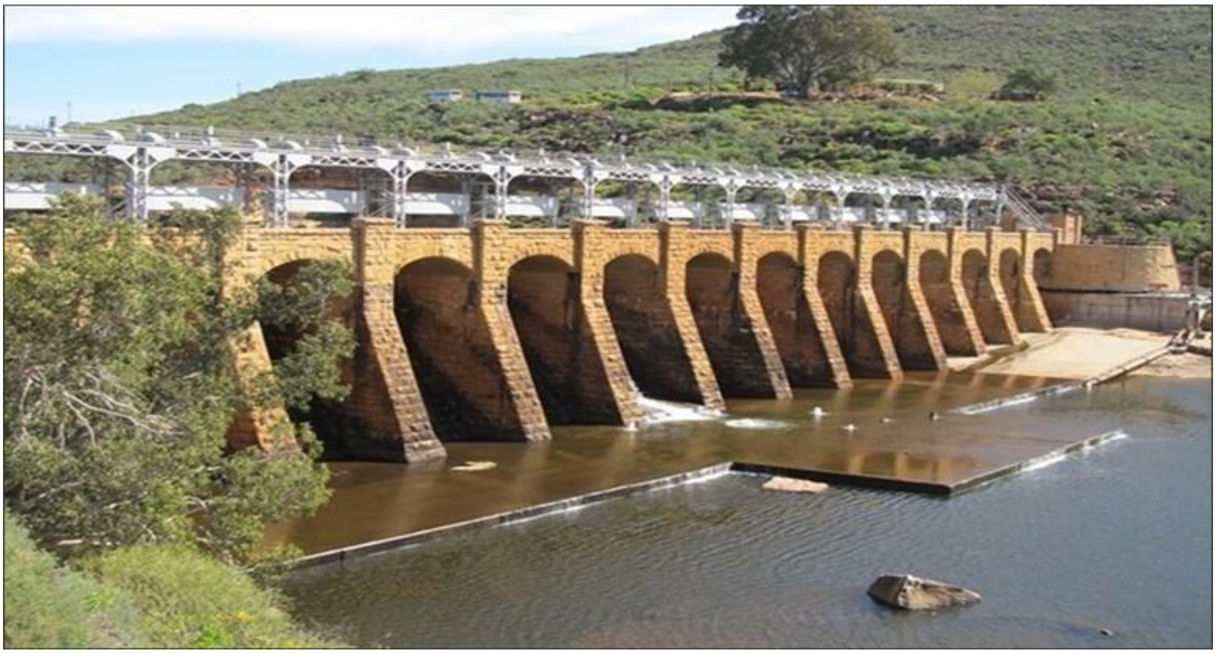

Figure 2-2: Bulshoek Weir on the lower Olifants River

The lower Olifants canals are shown in **Figure 2-2**. The canal runs on the left bank (western side) of the Olifants River for approximately 21 km (the so-called main canal / Trawal canal section), before it bifurcates and the river is crossed with a syphon, whence it runs on both sides of the river, with a small section of the canal running upstream along the right bank. The canals continue towards Lutzville, gradually becoming smaller downstream. Water is abstracted at numerous points along the canal (approximately 529 off-takes). Secondary canals distribute water from near Lutzville towards the coast. The lead time for water to travel in the canal from the Bulshoek Weir to the last point at Ebenhaeser is about three days. The total length of the canal system is some 237 km.

Water losses from the canals are high, with water losses for the current left bank main canal estimated at 20%. Losses for the left bank canal sections below Verdeling are estimated at 35% and for the right bank canal sections below Verdeling at 20%. Overall, canal losses are estimated at close to 30%.

The system is currently over-allocated. The maximum release into the canal is 26 000 m^3/h (7.2 m^3/s). The canal was designed for a maximum abstraction rate of 280 m^3/ha/week. This was increased to 325 m^3/ha/week in some sections where bricks were used to raise the canal walls, which equates to a water allocation of 8 200 m^3/ha/a released in the canal from 1 October to 30 April, equivalent to two-thirds of the currently scheduled allocations of 12 200 m^3/ha/a.

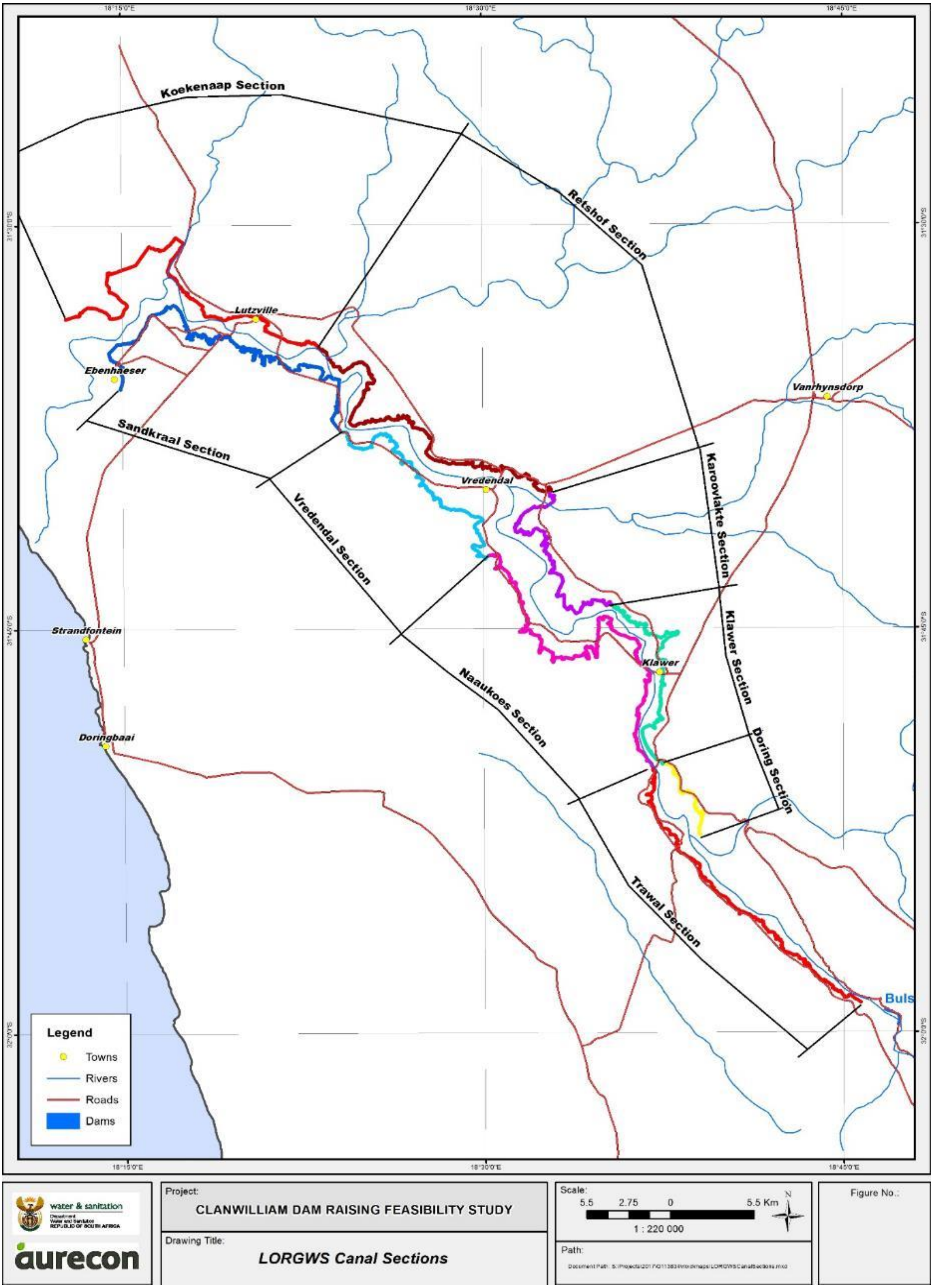

Figure 2-3: Lower Olifants River Canals

The remainder of the allocation is released during the remaining months of the year if water is available. During years of drought, which historically occurred very regularly in this region, both quotas are reduced, and restrictions are imposed on water users.

As the owner of the bulk infrastructure, the State retains responsibility for major betterment works, upgrading and refurbishment, including repairs of major breaks. The Lower Olifants River Water User Association (LORWUA) is responsible for the operation and maintenance of the water conveyance system from Bulshoek Weir to Ebenhaeser and Koekenaap, and does maintenance and repairs.

2.2.5 Ebenhaeser Community Property

The LORGWS also supplies the Ebenhaeser Community Irrigation Project, located approximately 12 km from Lutzville. The Ebenhaeser community is scheduled under LORWUA for 257 ha of water use entitlements, which is distributed to 153 plots (1.68 ha each) plus a commercial farmer with 8.6 ha. The successful land claim lodged by the Ebenhaeser Community has resulted in thirteen farm parcels handed over to the Ebenhaeser Community Project Association during March 2019, with further farms incrementally being handed over (44 farms are part of the longer-term restitution deliberations). The water allocations to some of these farm parcels are inadequate. There is for example a 14 ha farm with no water allocation, and a 62 ha farm with a 13 ha allocation.

2.3 Risks

The very poor state of canal infrastructure poses a high risk to the regional community and economy. The Bulshoek Weir and canal infrastructure is more than 90 years old, which is significantly more than its design lifetime, and is deteriorating. Canal breakages represent a significant risk, due to the disruption, periods of non-supply (including supply to towns, industries and mines), and associated commercial and cost implications. The frequency and severity of these breakages seems to be worsening. Breakages on the current main canal poses the biggest risk, as all downstream water users, which represents most scheme users, are affected.

The region has experienced regular droughts, some severe and, as a result, regular water restrictions have been implemented. The situation will be improved once Clanwilliam Dam has been raised and existing allocations will receive an improved assurance of supply, with the raised dam storing surplus water to be used for defined drought situations.

There is excessive conveyance water losses and leakage from the existing canals, estimated to be up to 30% by DWS, due to the age and poor condition of the canals, which represent very ineffective use of available water in a dry region.

It is evident that the lower Olifants River valley and community is almost exclusively dependent on the sustainability and longevity of the scheme, which has brought livelihoods and prosperity to a poor region of the country. Without the scheme, economic activities would have been very limited in this arid region.

2.4 Water Users Dependent on the Scheme

The total agricultural water use for the area downstream of the Clanwilliam Dam, according to the Farm Mapper online Western Cape Provincial Department of Agriculture (WCDoA) tool, is approximately 142 million m^3 for 14 500 ha, which is similar to the irrigation water usage of 140 million m^3 as determined in this study and as described in the '*Water Requirements Assessment*' Report (of this study). The actual area of crops planted in this study was estimated at about 12 500 ha, although the actual area planted varies from year to year, depending on the availability of water. Main irrigated crops are citrus, table grapes, wine grapes, vegetables and other fruit.

Besides supplying irrigation water (including the Ebenhaeser community irrigation project), the lower Olifants River canals also supply water for domestic use to towns within the Matzikama Municipality, various industries and mines. Untreated water is also supplied for household purposes to farmers and their workers on the scheme, for domestic use or irrigation of gardens on farms.

The annual allocation below Bulshoek Weir to the various water use categories is summarised in **Table 2-1**.

Table 2-1: Water allocations below Bulshoek Weir

Water Use Category	Area (ha)	Scheduled Allocation (m^3/ha)	Annual Allocation (m^3)
Scheduled irrigation	9 013	12 200	109 958 600
Ebenhaeser small farmers	257	12 200	3 135 400
Emerging farmers	240	12 200	2 928 000
Matzikama Municipality	-	-	5 151 000
Industries	-	-	3 200 000
Total	**9 510**		**124 373 000**

Source: (R Nieuwoudt, DWS, 2018)

The major crop cultivated below Bulshoek Weir is wine grapes. The remainder is export table grapes, raisins and tomatoes, as well as a variety of smaller crop types.

The canal system also supplies irrigation, industrial, and domestic water to the Matzikama Municipality for the following towns and communities: Vredendal, Klawer, Lutzville, Koekenaap, Ebenhaeser, Papendorp, Strandfontein, Doring Bay and Vanrhynsdorp.

Industries in the Study area consist mainly of wine cellars and a tomato processing industry. Mining operations supplied are the Cape Lime plant and the Namakwa Sands (Tronox) heavy mineral mining at Brand-se-Baai and its smelter near Koekenaap.

2.5 Water Quality

Water quality in the upper Olifants River, upstream of Clanwilliam Dam, is suitable for all uses. Good quality water is stored in Clanwilliam Dam and Bulshoek Weir, from where it is distributed via a system of canals to irrigation farmers in the middle and lower Olifants River valley.

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

2.6 Land Ownership

Land (properties) owned by government and privately-owned land were identified for development. The land ownership details have been recorded for each property in the study area. Only properties with possible development potential up to the town borders were considered. Only a small fraction of the properties in the study area are government-owned.

Depending on the suitability of the government-owned land parcels, development of new farms on these properties should, if possible, be considered first. Potential development on privately-owned land may include the expansion of existing irrigation as well as new development.

3 Water Distribution Options

This Chapter describes the revisiting of the additional yield made available as a result of the increased storage capacity of Clanwilliam Dam, and the proposed distribution of the additional available water.

3.1 System Modelling

Detailed analysis and modelling of the existing and potential water resource availability in the Olifants River Catchment resulting from the proposed raising of the Clanwilliam Dam was done as part of the *Feasibility Study for the Raising of the Clanwilliam Dam* and is presented in the *System Analysis Report* (DWA, 2007) of that study. The analysis was based on extended, uncalibrated hydrology up to 2005.

The natural mean annual runoff of the Olifants River above the Clanwilliam Dam is 356 million m^3/a. The average supply from the LORGWS to users over the 25 years before 2008 was estimated as 174 million m^3/a, although during droughts the supply would have been curtailed.

The interpretation of the previous modelling undertaken was revisited in this study, with refinement of information where considered necessary and documented in the *Distribution of Additional Available Water Report* (report number P WMA 09/E10/00/0417/5).

3.2 Ecological Water Requirements

If the Clanwilliam Dam is raised, it will no longer spill almost annually as is currently the case. This reduction in spillage will have a negative impact on the environmental conditions downstream. To compensate for this, the ecological water requirement (EWR) base flow releases from the Bulshoek Weir were modelled to increase from the (present) 'drought' level to class E.

Flows from the Doring River were assumed to supply the winter flood requirements at the estuary. A minimum summer base flow of 1.5 m^3/s was maintained as part of the simulations at the causeway at Lutzville. During the peak summer irrigation months, up to 1.2 m^3/s is supplied by return flows from irrigation along the lower Olifants River canals. The shortfall in the required summer base flow for the estuary (in addition to irrigation return flows) was augmented by modelled releases from Clanwilliam Dam. These releases made via Bulshoek Weir are about 21 million m^3/a.

3.3 Assurance of Supply

Respective yields were determined for the 1:10 and 1:20 recurrence periods. It is proposed that water allocation be based on a recurrence interval of 1:10 years (at 91% assurance of supply), which is the generally accepted assurance of supply for irrigated agriculture in South Africa. This should be acceptable, as the other future uses, which require a higher assurance of supply, are very small compared to the current and prospective irrigation water use. For municipalities and industries, the assurance of supply is deemed to be 98%.

3.4 Allocable Water

The total available yield, after supplying the EWR requirements first in a 1:10 year return period, is 242 million m^3/a, following the raising of the dam. The total available water for distribution after accounting for losses and the EWR is 206.6 million m^3/a, for a 1:10 return period. This provides an additional available yield after raising of the dam of 82.0 million m^3/a.

3.5 Proposed Distribution of Additional Water

The additional available yield after raising of Clanwilliam Dam is 82.0 million m^3/a. Allowing a total of 0.6 million m^3/a for future domestic, industrial and mining use (at a 98% assurance of supply), this leaves 81.4 million m^3/a to allocate for new irrigation.

In accordance with DWS guidance for distribution of the remaining additional available yield, 75% should be allocated to new emerging farmer dominant projects (historically disadvantaged farming projects and other broad-based black economic empowerment opportunities), which amounts to 61.1 million m^3/a.

Some of the additional water will be used to provide irrigation water to existing allocations at a higher level of assurance (at 91% assurance). The required volume for the increase in assurance of supply for the existing users with full use of scheduled allocations was calculated as 15.2 million m^3/a, which is less than the estimated 25% of the incremental yield that may be allocated for this purpose.

This would leave an unallocated amount of 5.1 million m^3/a. It has been recommended that this unallocated portion provisionally not be distributed to users, to cater for the uncertainty of climate change and changing system hydrology, until better trends become known through monitoring and research. Such an arrangement can be reviewed as needed.

Not all available water needs to be allocated immediately, unless there is a sufficient equity demand to take up this water.

Table 3-1 summarises the proposed take-up of the additional available yield from the raising of the Clanwilliam Dam to the respective water user groups. It is recommended that the take-up of the additional water be phased in.

Table 3-1: Summary table for distribution of additional yield (million m^3/a)

Proposed Allocation	Volume (million m^3/a) 98% assurance of supply	Volume (million m^3/a) 91% assurance of supply
1. Increase reliability to existing water users		15.2
2. New domestic, industrial and mining use	0.6	
3. New emerging farmer irrigation development		61.1
4. Unallocated portion of increased assurance of supply to existing users		5.1
Totals	**0.6**	**81.4**

4 HDI Farmers

This Chapter 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. A mechanism is proposed for the identification and screening of HDI farmers, who are also referred to as HD Farmers. Both terms are defined in the Glossary of this report.

4.1 Introduction and Background

An HDI is a South African citizen who, due to the previous government policy that had been in place, had no franchise in national elections prior to the introduction of the Constitution of the Republic of South Africa, 1983 (Act 110 of 1983) or the Constitution of the Republic of South Africa, 1993 (Act 200 of 1993); and/or who is a female, and/or who has a disability, provided that a person who obtained South African citizenship on or after the coming into effect of the interim Constitution, is deemed not to be an HDI.

The need to undertake an assessment of HDI farmers, that could be considered for taking up the additional water, following the raising of Clanwilliam Dam, was identified at a PSC meeting. This would include both existing and prospective HDI farmers. The need to revisit and review policies, and to provide a mechanism for the identification and screening of HDI farmers was further identified, to assist DWS during the water licence application process. It was agreed that an independent HDI Farmers specialist should be appointed.

A process was followed to identify and shortlist potential candidates as an external HDI Reviewer. Following approval, Ms Sharron Marco-Thyse was appointed as the HDI Farmers independent specialist. The HDI Farmers Specialist reported directly to the Project Manager of DWS, although appointed as a sub-consultant under the Post Feasibility Bridging Study by the PSP for the study (Zutari). Zutari provided study context and guidance on the study evaluation process to the independent Specialist as well as providing technical support where necessary.

The work undertaken is documented in the *Historically Disadvantaged Farmers Report*, report number P WMA 09/E10/00/0417/15.

4.2 Approach and Methodology

The key objectives of the Clanwilliam Bridging Study were adopted as the starting point for the HD Sub-Committee's work. Sub-Committee members then identified the key areas and tasks required for the HD Farmers evaluation, to meet the study objectives.

By using interpretive inquiry, people were engaged by means of an interactive process. The engagement started with each interest group through individuals and existing groups. The aim was to build support for the process, to gather information and bring the collective or part thereof together, and to obtain references to other relevant stakeholders. The approach followed was to collect relevant supporting data and information, create opportunities for interest groups to identify ways of working together. Input for the development of selection criteria for HDI farmers was also obtained as well as information for a framework to develop a mechanism to identify historically disadvantaged (HD) farmers.

The initial list of interviewees was drawn from existing lists and contacts of the members of the Sub-Committee. The 'snowballing' approach was used to identify subsequent respondents, i.e. interviewees were asked to recommend others that might be interested and/or can add valuable information.

Face-to-face interviews were conducted in the initial phase of the project. Subsequently, due to COVID19, new and follow-up interviews were conducted via phone and online platforms.

4.3 Management Meetings

4.3.1 Project Steering Committee Meetings

The HD Farmers Specialist attended Project Steering Committee meetings to ensure that the PSC members were updated on developments, and to source additional contacts and information. This assisted in incorporating the needs of resource-poor farmers into the planning and strategising process to find the most sustainable options to meet the State's transformational imperative within the agricultural sector.

4.3.2 TOR for HD Farmers Sub-Committee

A Terms of reference (TOR) was compiled and approved for the *Sub-Committee for Historically Disadvantaged Farmers*, which was shortened to *HD Farmers Sub-Committee*.

The Sub-Committee forms part of the PSC of the *Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam* study and was an advisory committee to DWS during the study. The sub-committee was established to inform the identification of subsistence, emerging and commercial farmers to benefit from the additional yield from the raising of the Clanwilliam Dam. Following the conclusion of the study, the Sub-Committee will continue its activities.

The TOR addresses the following aspects:

- Committee name;
- Aim;
- Purpose;
- Membership;
- Roles and responsibilities
- Meeting arrangements;
- Reporting; and
- Review.

4.3.3 HD Farmers Committee Meetings

Seven meetings of the HD Farmers Sub-Committee were held to manage this task.

Membership comprised representatives of the following organisations:

- DWS, Options Analysis, National Water Resources Planning and Western Cape Region
- WCDoA;
- DALRRD, Water Use and Irrigation Development;
- DRDLR;
- HDI Farmers Specialist; and
- Study Leader from Zutari.

4.4 Stakeholder Engagement, Mapping and Analysis

The HDI Farmers Specialist engaged with HDI stakeholders to gauge their interest, to ask people whether they would like to participate in the planned irrigation schemes, gauge the interest by white commercial farmers, identify ways for HDIs to participate in irrigation schemes, gauge the availability of land for sale, and determine the interest of white commercial farmers / land owners in joint ventures with other black farmers or their farm workers.

The HDI Farmers Specialist met with identified role-players to obtain specific targeted information and obtain their views. This mainly entailed dealing with individuals or very small groups. The semi-structured interviews also lead to suggestions, issues, references to other prospective farmers to be considered, etc. Caution was exercised to not raise unnecessary expectations during engagement, by *inter-alia* being mindful to describe timeframes.

Meetings were held with the following role-players:

- HDI worker trusts;
- Farmworker forums;
- Commodity groups, including smallholder farmers;
- Different spheres of Government (local/provincial/national government);
- Commercial black farmers;
- Key informants in civil society organisations ;
- Small HDI users in municipal areas; and
- Commercial enterprises and farmers.

Concerns and challenges experienced were the following:

- Confidentiality was identified as a significant issue. Interviewees were very concerned about whether details of the discussions would be shared, and because no confidentiality agreement is in place;
- Lack of trust in the process;
- Lack of organisation of HDI farmers, which meant obtaining information from them was slow and tedious;
- Requests for more detailed information were not responded to, e.g. asking for the size of land available, ownership, etc.; and
- The difficulty of verifying information.

4.5 Database Mapping and Analysis

Information obtained from the stakeholder engagement was used to populate the database of *Existing and Prospective HDI Water Users and Potential Land* for new irrigation. All interest expressed, both inside and outside of the West Coast District Municipality, was included in the database.

This activity involved:

- Updating the database with detailed information and responses of interested existing or potential black farmers (either subsistence, emerging or commercial);
- Noting the (gauged) interest of white commercial enterprises/land owners in joint ventures (JVs); and
- Updating the database with suitable land available to farm under irrigation.

The current total requests for land to irrigate is 4 890 ha, both for new farmers and farmers requesting expansion, as populated in the database. Stellar Wines and Crispy Crop have each requested 1 000 ha for expansion.

The information in the database includes a pool of people related to subsistence and smallholder farming in and around the study area, as Government's focus is on smallholder farmers, to enable them to grow to commercial farmers.

4.6 Policy and Legislative Context

A sub-report titled *A Review of Existing Policy Support for Historically Disadvantaged Farmers* was compiled. This sub-report provides a comprehensive review of existing policies related to HDI farmers in post-apartheid South Africa.

The objective of the review is:

- To draw attention to the central points of the various policies;
- To identify consensus and overlaps in policies;
- To identify policy gaps and shortfalls as it relates to the targeted beneficiaries; and
- To provide recommendations to improve relevant implementation of existing policies.

The sub-report synergises policies developed by the Department of Agriculture, Forestry and Fisheries (DAFF), DWS and the Department of Rural Development and Land Reform (DRDLR). It addresses the aim, responsible department/s, and the gaps of the various relevant policies. The following policies and other documents have been addressed:

- Comprehensive Agricultural Support Programme (CASP), aimed at post-settlement support to land reform beneficiaries;
- Resource-Poor Farmers Policy, aimed at sustainable water supply to contribute towards eradicating poverty and increase food security;
- Comprehensive Producer Development Support Policy, aimed at harmonising, guiding and overseeing the support services provided to HDI Farmers;
- National Water Act (NWA), as it relates to the group under discussion;
- AgriBEE;
- Water and Sanitation Master Plan;
- Joint venture irrigation enterprises; and
- Challenges and impact of pricing strategies.

Taking into account the slow pace of land reform, the limitations of policies to address the myriad of issues encountered has been acknowledged.

Recommendations made address the following aspects:

a) The lack of youth/women benefiting from the said policies;
b) The need for training and skills development;
c) Joint ventures as a solution;
d) The shared burden of the cost of redress;
e) Political imperatives and return on investment – addressing the continuum of needs in the various categories of intended beneficiaries;
f) One-stop shop: cooperation and collaboration amongst all spheres of government;
g) Reducing administrative red tape and speeding up water use licence processes;
h) Upskilling extension services/farmer support divisions, etc.; and
i) The impact of climate change:
    - Green technology; and
    - Sustainable agricultural practices.

4.7 Mechanism for Identification of HD Farmers

The *Mechanism for the Identification of HDI Farmers* is a tool that was developed to aid the selection between different HDI applicants for water licences.

The criteria in the mechanism are sorted into five categories, as follows:

a) Work experience: Farm management, general farm work and existing (farming) business;
b) Support available: Mentors, relation with commodity groups, extension services and on-going training programmes;
c) General: Passion for farm work: general management skills and experience, age (youth) and women.
d) Education**:** Formal training in agriculture and business, informal training and education levels; and
e) Land available.

The percentage of water that will be allocated to woman, the youth and the disabled would need to be noted and allowed for. It will however be important that they productively make use of the water. Weighting can be attached to the criteria.

A committee is needed that will be responsible for the selection of HDI farmers to whom water can be allocated.

4.8 Findings and Recommendations

4.8.1 Summary of the Study and the Results

Resource-poor farmers face multi-layered challenges and constraints that impact on their social capital. Social capital refers to the network of relationships and flow of information that enables their access to resources and opportunities. The low level of organisation and visibility of resource-poor farmers continue to restrict their access and growth. This has been evident in the slow process of identifying interested parties. HD farmers lack the means to identify available private land for irrigation development and build relationships with existing land owners.

Some farm workers are organised through existing employer relations. Some of the advantages of this arrangement are existing business opportunities and an available mentor relationship. The disadvantages may be that there is limited independent growth, and that employer-employee problems may adversely impact the empowerment of HD farmers and the growth of their business.

Numerous government policies identify youth, women and people with disabilities as key to long-term growth and sustainability of the South African economy. To ensure that this key objective is met, it has to reflect in both budgets and plans of the stakeholder departments. An increase of youth, women and people with disabilities in training programmes, such as business management, farming production and new mentorships, will contribute to achieving this objective.

Institutional processes are important to help unlock support and coordinate successful implementation across inter-departmental and different spheres of Government. Such a collaborative engagement requires buy-in from senior leadership to bring about changes in institutional practices that enable collaborative implementation through the sharing of plans, budgets and resources (staff and time). The involvement of local and provincial Government, especially the WCDoA, DALRRD, and the Local Economic Development Unit of the Matzikama and Cederberg Municipalities, are vital to the success of this initiative.

4.8.2 Recommendations

The following recommendations will be the responsibility of the HD Farmers Sub-Committee to either implement and/or mandate other stakeholders to undertake.

4.8.2.1 Maintaining Stakeholder Interest

a. The HD Farmers Sub-committee needs to maintain contact with the interested HD farmers through regular updates on their progress.
b. To host public meetings specifically for farmworkers, subsistence, smallholder farmers and HDIs interested in farming.

4.8.2.2 Trust and Confidentiality

a. Establish clear procedures of management and confidentiality of information gathered. This is especially relevant to information regarding possible joint ventures and/or land available for sale to individuals. The engagement with individual HD farmers to verify and follow up on the lack of specific information, concerning available land, should be done with sensitivity.
b. Discuss the possibility that landowners may engage in land speculation where there is an interest.
c. The identification of farmworkers participation and other joint venture proposals to have open and direct sessions with farmworkers to ensure full understanding of the process.

4.8.2.3 Policy Guidelines

a. Project implementation strategy to collaborate across Government departments to expedite the inter-changeable use and management of land through exploring the availability of State land, other than municipal commonage and land under DALRRD.
b. To develop clearer contracts under the Joint Venture option that will ensure long-term benefits for HD farmers and reduce the risks of fronting.
c. To identify and explore strategies where Government departments have implemented programmes that target youth, women and people with disabilities to participate as beneficiaries.
d. Establish mentorship programmes in business management, farm practices and market access with support from government departments and commodity groups to address blockages that limit growth.
e. Identify opportunities to fast-track support for smallholder HD farmers who are achieving success and producing for the market, within Government departments and commodity groups.
f. Duplication of policies should be avoided, and it should be made clear which Government Departments take responsibility and who provides support.
g. Emphasis needs to be placed on the agricultural future shifting towards green investment for eco-friendly technology at primary agriculture levels, upstream and downstream in the supply chain and which contributes to sustainable agriculture.
h. Provide mechanisms, through organised HD farmers groups that enable them to improve their negotiating power base for input materials and other resources.

4.8.3 Mechanism for Selection and Screening of HD Farmers

a) Continuation of the current HD Farmers Sub-committee: The sub-committee should continue holding the responsibility for identification and selection of HD farmers, and make recommendations for allocation of land and water.
b) Coordinate a multi-year programme: A programme is required to prepare resource-poor farmers to farm sustainably and on a larger scale.
c) Appoint an Adjudicating Committee: A responsible committee is required for the selection of HD farmers and allocation of land and water. The Committee should consist of representatives of DWS, DALRRD, WCDoA, Matzikama Municipality and individual(s) with experience and knowledge of the agricultural sector and HD farmers. The members of such an Adjudication Committee should reflect individuals that have a good understanding of the transformational agenda of the agricultural sector and have knowledge of challenges within an agri-business, and who understand State processes.
d) Mentorship programme: A programme of mentorship needs to be developed and the appropriate Government Department is to establish and monitor this process, with clear deliverables to be developed by all partners.
e) Roles and Responsibilities: The roles and responsibilities of relevant Government Departments needs to be specified. Clear tasks and deliverables should be agreed on and assigned to the respective Departments and levels of Government. The cooperative plan should be agreed upon at senior management level, with the assignment of staff and budgets to ensure the implementation of each stakeholder’s contribution towards the overall plan.

4.8.4 Concluding Remarks

The majority of respondents during this task are hopeful that the additional water and support to HD farmers will bring relief to the many resource-poor families. Smallholder farmers and especially existing HD farmers/agri-businesses are looking forward to accessing land to expand existing agri-businesses, such as black brand owners who want to produce wine from their vineyards. The possibilities are numerous for growing jobs and the economy for the West Coast District Municipality, the Western Cape Province and the country.

5 Soil Survey

This Chapter describes the soil survey undertaken.

5.1 Introduction

The extension of the soil survey entailed identification of the soil types, soil suitability and amelioration measures of the additional area covering about 10 300 ha of land lying between 60 m to 100 m above river level, between Clanwilliam Dam and Klawer. This 60 m to 100 m zone was identified and added to the existing survey area that was completed during 2012 as part of the Clanwilliam Dam Raising Feasibility Study, which covered the area up to 60 m above river level. The survey entailed the following:

- The soil suitability for irrigated crop production was extended from the previous extent of soil mapping undertaken, to a height of 100 m above either river, dam, weir or canal level; and
- The methodology followed to update the maps was the same as the previous methodology used in the Clanwilliam Dam Raising Feasibility Study (2012), and included:
  - Carrying out pit profiling and logging the profile information using a global positioning system (GPS);
  - Appending additional soil map units within the survey area to the soil map shapefile;
  - Providing GIS data in a geodatabase; and
  - Compiling soil maps.

The *Soil Survey Report* describes the task requirements, methodology and outcomes.

5.2 Map legend

The 2012 soil map legend was used for this extension of the soil survey. As this survey is also a reconnaissance soil survey, the legend stayed the same, except for any new soil-terrain units that were identified. This was done in an effort to make sure that the new areas would join up smoothly with the previous (2012) boundaries and that information on soil suitability and other soil-related interpretations are the same for both soil surveys.

5.3 Site Visits

Firstly, the 2012 soil boundaries were plotted on the latest Google Earth background with 5 m contour lines also visible. Two separate and independent visits were made to the survey area. The first visit was done for the staff to familiarise themselves with the existing (2012) soil-terrain units (Messrs F Ellis and B Schloms have been involved in that survey). With limited field work, a first draft of soil-terrain units of the new areas was prepared using the 2012 legend. This first draft map was thereafter taken to the field on a second site visit to prepare the final map.

5.4 Methodology

The procedure followed to undertake this soil survey is described in this section.

Based on soil properties and variation in soil types and terrain form, uniform soil-terrain units were delineated during the field excursion on the draft map that covered the 2018 survey area. During the field excursion, soil observations were made at all available soil exposures, such as road cuts and drainage trenches, and a hand auger was used for additional observations. In a few cases none of the existing map units could accommodate a particular delineated area. In those cases, new map units were created and defined in terms of terrain type and dominant soils.

It was decided to retain the relatively simple two-level legend that consisted of an upper level of soil groups and a second level of soil sub-groups used in the 2012 soil survey. Twelve soil groups were defined on the basis of two or more of the following properties: general soil type, soil colour, texture of the topsoil, soil depth, drainage, terrain position. An identification letter symbol (A to L) was given for each soil group. The legend covers the soils from Keerom to the coast, as used for the 2012 survey.

The soil groups mapped and defined included 33 of the 2012 soil groups, but another seven sub-groups, under the soil complexes upper level, were identified and described.

A combined soil map legend for the new survey area was defined and used for the soil maps.

Hereafter, the soil suitability for irrigated crops was determined for the same crops mentioned in the 2012 report. Soil limitations were identified as for the 2012 soil survey. An additional non-soil limitation (namely slope) was added for the additional soil survey. Slope influences the cultivation of land and is therefore regulated by the "*Conservation of Agricultural Resources Act (Act, 43 of 1983) Regulations*". For this additional survey, total areas (ha) of the three classes that occur within the 60 m – 100 m above river level (totalling 10 332 ha) were determined as 4 951 ha (0 – 12 % class), 2 850 ha (12% – 20%) and 2 531 ha (>20 % class) respectively. The >20 % slopes therefore covers about 25 % of the total survey area.

5.5 Soil Classes

Five classes were used to rate the potential and recommendation of soil sub-groups for irrigated crop production, for annual and perennial crops, before and after amelioration of subsoil limitations (see **Table 5-1**). Due to the negative effect, indirect and direct, of free lime on growth and production, soils with calcareous horizons were rated one unit lower than non-calcareous soils with similar properties. Although it was difficult to accommodate salinity in these evaluations, soil sub-groups with a very high salinity were downgraded compared to similar non-saline soils.

Table 5-1: Classes used to evaluate the potential and recommendation of soil sub-groups

Soil potential	Recommendation for irrigated crop production	Percent of maximum potential
Low	Not recommended (NR)	≤ 40%
Medium-Low	Marginally recommended (MR)	> 40 - ≤ 50%
Medium	Conditionally recommended (CR)	> 50 - ≤ 60%
Medium-High	Recommended (RE)	> 60 - ≤ 80
High	Highly recommended (HR)	>80%

The information given in **Table 5-1** above was applied to each soil sub-group identified to derive a "*potential of soil units for irrigated annual and perennial crop production*". Thereafter the surface areas of the five potential suitability and recommended classes were summarised, as indicated in

Table 5-2.

This table shows the surface area of five potential suitability classes for the production of tuberous and non-tuberous crops and perennial crops, before and after amelioration of subsoil limitations, in four main areas in the Olifants River catchment from Clanwilliam Dam to Klawer, between 60 m and 100 m above river level.

Table 5-2: Surface area of five potential suitability classes for irrigation

Potential class and recommendation	Annual tuberous crops (ha) 1)	Annual non-tuberous crops (ha) 2)	Perennial crops 3)	
			Before amelioration (ha)	After amelioration (ha)
Clanwilliam Dam to Klawer (between 60 m and 100m)				
≤ 40 % (NR)	8 457	7 132	9 259	5 729
> 40 - ≤ 50 % (MR)	802	1010	973	2 280
> 50 - ≤ 60 % (CR)	100	1 693	20	1 107
> 60 - ≤ 80 % (RE)	973	497	80	1 217
> 80 % (HR)	0	0	0	0
Total area (ha) Clanwilliam Dam to Klawer: 10 332				

1) *This includes crops such as potatoes, onions, sweet potatoes, and carrot; usually without hardpan amelioration.*
2) *This includes crops such as tomatoes, pumpkin, and bean; usually after hardpan amelioration.*
3) *This refers mainly to dry, wine and table grapes and citrus.*

From

Table 5-2 it is clear that most of the soil classes identified fall within the *Not Recommended* category.

Lastly, amelioration measures have been recommended per soil sub-group.

6 Water Requirements

This Chapter describes existing agricultural areas, the process followed to identify suitable new irrigation areas, associated irrigation water requirements and other future water requirements.

6.1 Study Zones

The existing agricultural areas located within the study area were originally split into fives zones (also referred to as regions or sub-areas), to assist with technical evaluations and summaries, as follows:

- Zone 1: Upstream of Clanwilliam Dam;
- Zone 2: Clanwilliam Dam to Bulshoek Weir;
- Zone 3: Areas located outside the Olifants River Valley;
- Zone 4: Bulshoek Weir to Lutzville; and
- Zone 5: Klawer to Coast.

Zone 1 has only been briefly considered in this study, but has not been included in the focus area of the study.

6.2 Existing Agricultural Areas and Water Requirements

Figure 6- shows the distribution of crop types according to the Cape Farm Mapper Crop Census (2013) data. **Table 6-1** summarises the areas per crop type in each region downstream of the Clanwilliam Dam.

The total agricultural water use for the area downstream of the Clanwilliam Dam (i.e. Zones 2, 4 and 5) is approximately 142 million m^3 for 14 500 ha, which is similar to the irrigation water usage of 140 million m^3 as determined and documented in the '*Water Requirements Assessment*' Report.

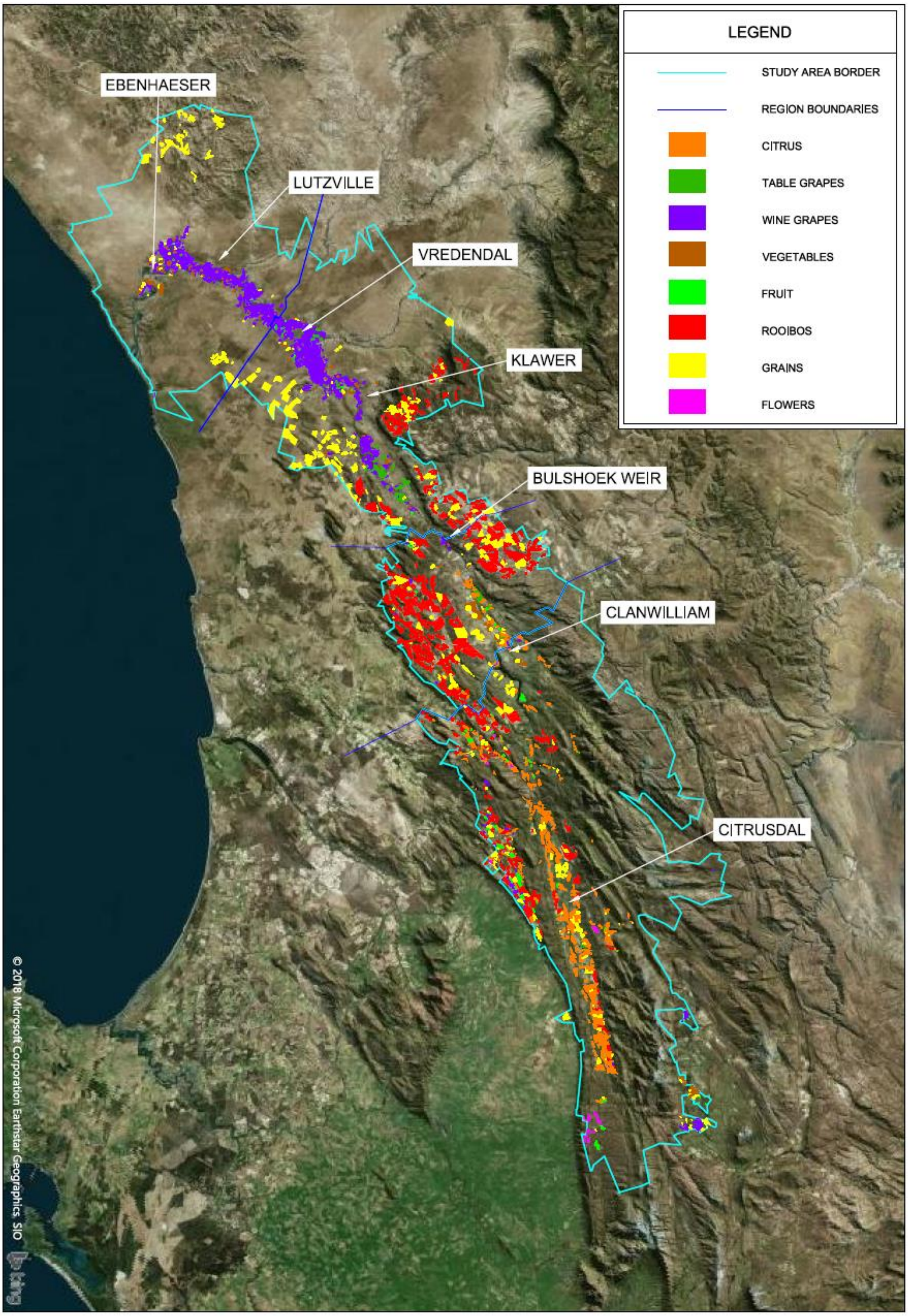

Figure 6-1: Cape Farm Mapper Crop Census Data

Table 6-1: Existing irrigated crop areas per region downstream of Clanwilliam Dam

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

6.3 Identification of Suitable Irrigation Areas

The *soil suitability types* identify areas in terms of the recommended irrigated crop production suited for tuberous crops, non-tuberous crops and perennial crops (after amelioration), according to five soil classes, as described in Section 5.5, *Soil Classes* .

Initially only the *three* most suitable soil classes were selected for the identification of irrigable areas, but this was later extended to the *four* most suitable classes. From engagement with farmers and comparison of the *Marginally Recommended* soil class with irrigated areas, it was deduced that it is sensible to also include this soil class in the determination.

The following methodology was used to identify irrigable areas to consider for options analysis:

- Potential irrigable areas were determined by considering existing land use and overlaying the various soil suitability shapefiles for tuberous crops, non-tuberous crops and perennial crops respectively, for the identified four soil suitability categories, using either Google Earth or AutoCAD Civil 3D/QGIS;
- The soil survey already excluded slopes that are too steep for irrigated agriculture (>12%);
- Irrigable area were delineated by selecting areas falling in any of the top four soil classes for any of the type of crop classes;
- Existing irrigated high-value crops, roads, buildings and other infrastructure were excluded;
- The irrigable area in hectares that can realistically be farmed was determined, by reducing the area according to built-up areas, roads, areas of farm dams, and permanent irrigated crops;
- Irrigated areas that did not include permanent crops were included, as higher-value crops could potentially be planted on such areas;

- The areas were reduced to exclude environmental protection areas, except for the Jan Dissels area where further investigation was deemed necessary, and not all protection areas was excluded;
- The total area that can be developed from the identified land parcels was determined, according to study sub-areas, and compared with the volume of available water; and
- Clusters of available land that can be developed as phased schemes were determined, considering the range of options identified.

It was found that land ownership did not influence the delineation, as identified private land was so limited.

6.4 Water Use Values for Planning Purposes

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

The extent of the main crops that are currently irrigated in the study area were firstly identified. These crops are indicated in **Table 6-2**. Note that Zone 3 was included with Zone 2 for calculation purposes.

Table 6-2: Main irrigated crops grown in study area

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

Source: GIS data obtained from Department of Agriculture

The net crop water use requirements were then calculated, by removing the irrigation efficiency factors (90% for permanent crops and 80% for annual crops). The net crop water use requirements are shown in **Table 6-3** for the identified crops.

Table 6-3: Net crop water use requirements

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

The percentage (%) breakdown of identified crops that are planted in each zone was then calculated. Please refer to **Table 6-4** for the percentage breakdown of identified crops per zone.

Table 6-4: Percentage breakdown of identified crops per zone

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

Lastly, the weighted average of the crop percentages per zone in **Table 6-4** and the net crop water requirements in **Table 6-3** were used to calculate the aggregate crop water requirements. **Table 6-5** indicates the final aggregate crop water demand per zone, used in this study for planning purposes.

Table 6-5: Aggregate crop water demand

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

The extent of losses was addressed for each option during the options analysis process. Losses have thus not been included in these aggregate water use values.

6.5 Determination of Irrigation Water Requirements

To calculate irrigation water requirements of the identified potential irrigation areas, excluding conveyance and storage losses, in million m^3/a, the potential irrigation areas were firstly listed by study zone (1 to 5) and named. The following process was followed:

- The percentage of land that can be farmed was estimated for each irrigation area, or portion thereof, allowing for farm buildings and roads, as well as the extent to which potential irrigation areas were fractured as a result of slope or rocky outcrops. For most of the areas it was assumed that 90% of the area can be farmed.
- Based on the aggregate water demand (m^3/ha/a), which was determined for each study zone, a water requirement is determined, to be refined further.
- A *Rotation Factor* is applied, where applicable. Citrus, table grapes, wine grapes and fruit are usually irrigated whole year round (100%). For potatoes a 1 in 2-year rotation (50%) was used and for other vegetables a 1 in 4-year rotation (25%). For permanent crops, no rotation factor was applied.
- A *Leaching Factor* is applied, determined by the soil type/s for the various zones, source water, river reach, and whether it is a greenfield development or not.

Water losses are determined for each irrigation development option during options analysis, which consists of relevant river losses, seepage losses on long pipelines, canal conveyance losses and balancing dam losses.

6.6 Other Considerations

6.6.1 Covering crops with netting

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

6.6.2 Influence of groundwater quality

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

6.7 Other Future Water Requirements

A small volume of water will be used to improve the low assurance of supply of municipalities. This will not increase their current water entitlements but will provide better assurance to avoid the current regular restrictions experienced due to limited water availability.

Urban users and light industries are not large individual users of water in the area. It is unlikely that such use will compete significantly with agriculture for any additional water made available by the raising of the Clanwilliam Dam wall. The future requirement for industrial, domestic and mining use is estimated at 0.6 million m^3/a.

7 Options Analysis

This chapter describes the identification, evaluation and screening of potential new irrigation development options, the recommended schemes and implementation phasing.

7.1 Approach and methodology

An iterative approach was followed for the options analysis process. Once a refined range of potential irrigation areas had been identified, the next step was to identify and unpack the characteristics of the range of potential bulk water schemes to supply such potential areas, and determine the bulk water distribution costs and potential impacts of such scheme options. An initial, more qualitative evaluation helped to reduce the starting (comprehensive) list of potential irrigation development options. This was followed by quantitative evaluations, requiring iteration as information became available or options were better understood, to focus on the "better" development options.

The following process has been followed for the selection, evaluation and screening of options:

a) Compilation of a Long List of potential options. The Long List describes potential options that could be considered for the study area, and was as inclusive as possible.
b) First-level screening of the Long List of options by elimination of evidently flawed options. The results of this initial evaluation, with motivations, are documented in a *Distribution Options Discussion Paper*, which was workshopped.
c) Compilation of a Preliminary Short List of options, following the mini-workshop.
d) Preliminary qualitative screening of the Preliminary Short List of options, to refine the range of options.
e) Compilation of a Short List of options to be evaluated further.
f) Evaluation of the short-listed options from a technical, financial, social, and environmental perspective, whilst considering other influences such as e.g. political imperatives.
g) Documentation of the evaluated options according to a standard template, in a *Background Information Document*.
h) Discussion of options at a two-day Options Workshop with key stakeholders.

i) Refining the suite of options and their characteristics following the workshop.

j) Recommendation and approval of a suite of preferred options.

7.2 Evaluation of Short-listed Options

The below sub-sections provide information on the evaluation of the short-listed options (Section 7.1(f) above).

7.2.1 Technical Evaluation

Design Water Requirements

Irrigation design water requirements were calculated considering current farm water allocations, irrigable new areas, aggregate zone crop water requirements, the need for crop rotation, monthly peaking factors, leaching requirements and conveyance and storage water losses.

Water Losses

Incremental and total conveyance losses for releases down either the Olifants or Jakkals rivers were estimated by river reach, as indicated in **Table 7-1**.

Table 7-1: Estimated River Conveyance Losses

Zone and river section	Incremental % river losses for river reach	% River losses up to abstraction point
Olifants River		
Zone 2: Clanwilliam Dam to Bulshoek Weir	5%	5%
Zone 4: Bulshoek Weir to Verdeling	24%	29%
Zone 5: Verdeling to Klawer	4%	33%
Zone 5: Klawer to Spruitdrift	9%	42%
Zone 5: Spruitdrift to EB de Waal	3%	45%
Zone 5: EB de Waal to Lutzville	6%	51%
Jakkals River		
Zone 3: Jakkals River	50%	50%

Conveyance infrastructure losses were estimated as follows:

- Short pipelines: 0%;
- Longer Pipelines: 3%;
- Lined (new) concrete canal: 15%;
- Existing LORGWS canals: 27% on average;
- Existing Clanwilliam canal: 30%; and

- Balancing dam losses based on surface evaporation.

Engineering Calculations

The following criteria were used for the technical evaluation:

- Bulk pipelines and pump stations were sized to cater for peak monthly water requirements.
- The sizing of farm dams and larger balancing dams for blending were based on topographical variation (either lined rectangular or U-shaped farm dams) with the required extent of storage determined by the source of the water.
- Run-of-river abstraction rates were determined as a function of the flow regime in the Olifants River below the Doring River confluence.
- Reservoirs with limited storage were provided between rising main and gravity main pipelines to allow for some operational flexibility.
- In-house spreadsheets were developed and used for reconnaissance-level design and costing of pipelines, syphons, pump stations, farm dams, larger balancing dams for blending and balancing reservoirs.

Implementation Programmes

- Implementation programmes for options were compiled, to ascertain practical dates at which first water from such schemes can be delivered or savings can be made (when better conveyance infrastructure is implemented during the lifetime of a scheme). This also provided the construction programmes that influences some costing.

7.2.2 Ecological and Socio-economic Considerations

A desktop-level assessment of the environmental and socio-economic impacts of each option was carried out. Maps showing threatened ecosystems, critical biodiversity areas, heritage sites, protected areas and National Freshwater Ecosystem Priority Areas (NFEPA) wetlands / rivers were used to identify sensitive areas in the proposed development areas, and possible mitigation measures were explored. Specific impacts related to the various developments were identified, as well as their predicted severity and mitigation measures. Specific impacts include:

- Inter-basin transfer of raw water, which has environmental implications;
- Impacts on environmentally sensitive areas and social infrastructure;
- Impacts of construction on the environment and communities in the area;
- Positive impacts such as increased water supply to rural communities and small towns lacking treated water supply; and
- Socio-economic benefits arising from high-value irrigation development.

7.2.3 Water Quality Considerations and Constraints

Water Quality

The irrigation water requirements are affected by the quality of the irrigation water. Two aspects were considered, namely the leaching requirement, and the storage of good quality water needed to blend with poor quality water, which would be abstracted from the lower Olifants River during the dry summer months.

To assess the changes in salinity between Bulshoek Weir and Lutzville, the monitoring data collected by WCDoA has been reviewed **(Figure 7-**).

An analysis of spatial and seasonal water quality trends was done.

It was found that the water quality in Clanwilliam Dam and in Bulshoek Weir is ideally suited for irrigation use. There is also very little change in salinity in the river between Clanwilliam Dam and Bulshoek Weir. The salinity in the Doring River is also low, although higher than in Bulshoek Weir during the summer months. However, there is a large increase in salinity between Bulshoek Weir and the low water bridge at Lutzville, mainly as a result of irrigation return flows. The salinity increases to such a degree that the water in the lower reaches is unsuitable for irrigation at certain times of the year.

The quality of any water released from Bulshoek Weir down the Olifants River, for abstraction lower down will therefore incrementally worsen during especially the summer months; the lower down the river the water is abstracted.

Leaching requirements

The leaching requirement refers to the volume of additional water that needs to be applied to crops to prevent the build-up of salts in the soil. This volume is a function of the salt concentration of the irrigation water, and the salinity of the soils being irrigated.

If the irrigation water being used comes from Clanwilliam Dam or its canal, the Olifants River between Clanwilliam Dam and Bulshoek Weir, or the canal from Bulshoek Weir, then an additional 3% needs to be added to the water requirement to prevent salinization of the irrigated soils.

If the source of irrigation water is water abstracted directly from the Olifants River downstream of Bulshoek Weir, leaching requirements have been calculated, based on the water quality at the abstraction point and the soil types of the area to be irrigated. The higher the salt concentration in the irrigation water, the higher the water requirement is to leach salts from the irrigated soils.

The soils in some of the new areas identified for future irrigation development are naturally saline and additional leaching water needs to be applied for the first five years, to leach the salts from the soils.

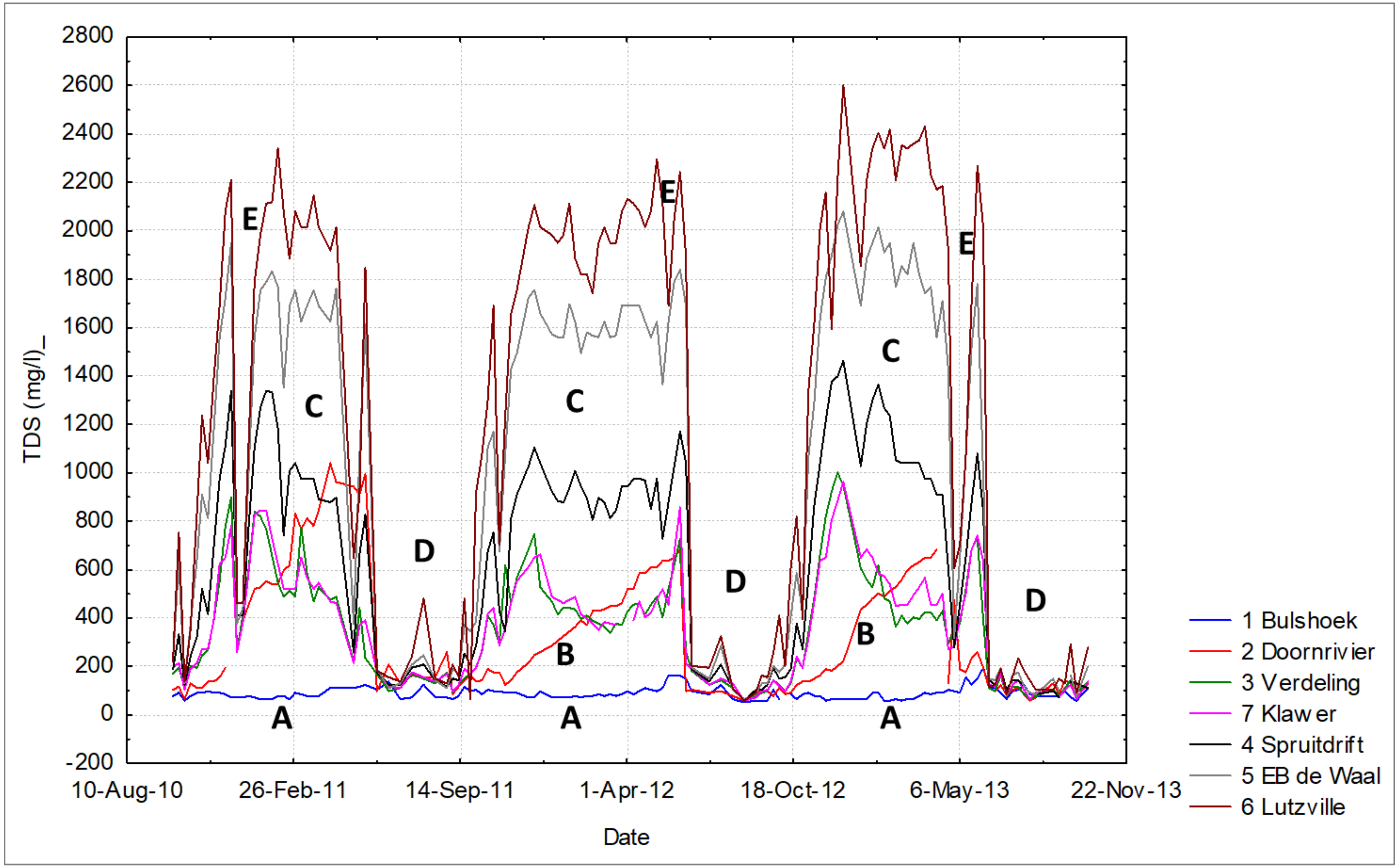

Figure 7-1: Change in salinity along the Lower Olifants River - Bulshoek Weir to Lutzville

Storage requirement for good quality water for blending

For some irrigation options in the lower Olifants River valley, good quality irrigation water may need to be released down the lower Olifants River during the irrigation season to meet the requirements of new schemes. However, irrigation return flows during the summer months currently results in a gradual increase in salinity downstream of Bulshoek Weir, to the extent that the quality of water at Lutzville is in an Unacceptable category (> 1440 mg/l TDS) for most of the dry summer season. One strategy to compensate for the increase in salinity along the length of the lower Olifants River is to abstract good quality water from the river during the high flow winter months, store it, and then blend it with the poor quality water abstracted from the lower Olifants River to meet a specified quality of irrigation water.

A mass balance approach was used to calculate the volume of good quality water that needs to be stored to dilute the poor quality water abstracted from the river, to a minimum average TDS concentration of 800 mg/l (Tolerable category).

Costing

Certain capital costs were based on costs available from previous most recent and relevant studies or costs of similar sized infrastructure, while typical costs were developed for the costing of canals. Costs were escalated to be representative of the base year costs (October 2020) if such costs were not too dated. In some cases, costs have been estimated from basic principles, as some options have not been evaluated before or available costs were too outdated.

The purchasing of privately-owned land was estimated from recent land sales in the study area, and

Unit Reference Values (URVs) and Net Present Values (NPVs) were determined. The URV is a means of comparing different options on an equal basis by calculating a cost per unit (in R/m^3) for each option. The URV calculation is based on the same assumptions in terms of evaluation period, equipment replacement periods, electricity costs, etc. It provides a *comparative indication of the unit cost of water* supplied from the scheme during a scheme's lifetime. A URV refers to the cost per unit, which in this case is the cost per cubic metre of water to be used. Multiplication factors were added to allow for additional unforeseen costs. A comparative scheme lifetime evaluation period of 32 years was selected for all water augmentation schemes, for determination of URVs.

URVs were classed in three categories as follows:

- **Low** unit cost: Below R 1.80/m^3;
- **Medium** unit cost: Between R 1.80/m^3 and R 2.80/m^3; and
- **High** unit cost: Greater than R 2.80/m^3.

Descriptions of Options

The short-listed distribution options were evaluated according to the methodology described above and documented according to a standard template per option. The descriptions of the options were included in a Background Information Document, in preparation for the Options Workshop, which was held for the screening of the evaluated, short-listed options.

7.3 Options Workshop

At the Options Workshop held on 11 and 12 December 2018, the background to and findings of the evaluation of options were presented to a group of key stakeholders. The stakeholders provided comment and made suggestions regarding improvements to or variations of the potential options to consider or clarified specific facts. Several options were then revised or refined following the workshop and some newly-identified options (based on previously-identified options) were evaluated and documented.

The preferred options were identified, inter-alia considering cost, environmental and social impacts, political imperatives and the volume of water available for new irrigation, while considering water quality and water losses. The preferred options were presented to the PSC members for consideration. Some further refinements were made to the options and a suite of options was recommended and approved.

7.4 Preferred Suite of Irrigation Schemes

The *Conceptual Design Sub-Report* documents the process of identification, evaluation and screening of the potential new irrigation options. The preferred suite of proposed irrigation schemes are the following:

Schemes located upstream of Bulshoek Weir:

- **Jan Dissels Scheme** located near Clanwilliam Town, to receive a pumped water supply directly from the Clanwilliam Dam.
- **Transfer of** scheduled water allocations, which entails transferring identified existing allocations of irrigators in the lower Jan Dissels River to the Olifants River. This will relieve over-allocation and improve the ecological condition of the lower section of the Jan Dissels River.
- **Clanwilliam Scheme** entails pumping from the lake of the raised Clanwilliam Dam to identified irrigation development areas.
- **Zandrug Scheme** entails pumping from the Olifants River to identified irrigation development areas below the raised Clanwilliam Dam and upstream of Bulshoek Weir.

- **Bulshoek Scheme** entails pumping from the Olifants River and the lake of Bulshoek Weir to identified irrigation development areas.

Schemes located downstream of Bulshoek Weir:

- **Right Bank Canal Scheme**, consisting of the construction of a new main canal section on the right bank of the Olifants River to replace the existing main canal section on the left bank. This scheme will supply four proposed irrigation development areas near Trawal, namely the Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom irrigation areas. This scheme will overcome the current flow restriction up to the bifurcation of the canal ('Verdeling' syphon) and significantly reduce the risk of supply failure.
- **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 Partial Development Scheme** entails developing a portion of the remaining Klawer irrigation area, following the completion of the new Right Bank main canal and the upgrading of the Klawer canal section.
- **Coastal 1 Scheme**, using spare capacity in existing 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 small portion of the Coastal 1 irrigation area.
- **Ebenhaeser Scheme**, using spare capacity in existing canal section/s to provide water to restitution farms and to augment the supply to the existing community at Ebenhaeser.

The recommended schemes entail both the development of new land for irrigation as well as the replacement of lower-value crops of existing irrigation with higher-value crops. The comparison of the recommended schemes is shown in **Table 7-2**. A total of 5 874 ha is recommended for new irrigation.

Table 7-2: Comparison of Recommended Schemes

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%	83.2	100.2	2.03	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 allocations	0	1.00	0%	0.0	0.0	0.00	Low	Low but irrigators may potentially oppose it	-

Scheme	Irrigable Area (ha)	Incr. Req + Losses (Mm³/a)*	Scheme Loss %	Capital Cost (R million)	Total NPV Cost (R million)	URV (R/m³)	Environ -mental impact	Risks	Opportunity for smallholders/ restitution
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%	573.2	782.3	3.05	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%	158.0	192.2	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%	512.9	536.7	12.77	Low	Canal structural integrity, high cost, operational complexity	Yes
TOTALS	**5 874**	**61.05**		**1624.3**	**2071.2**				

** In addition to existing allocations*

7.4.1 Phasing of Recommended Irrigation Schemes

The phasing of the preferred schemes has been recommended in three phases, namely Phases A, B and C. A summary of the proposed phasing is shown in **Table 7-3**.

Alternate phasing has also been identified. It is likely that implementation of the schemes sorted under phases will overlap.

It should be noted that all schemes, except the *Right Bank Canal Scheme*, are reliant on the additional water, which can only be provided when the raising of Clanwilliam Dam has been completed.

Table 7-3: Proposed Phasing of Recommended 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

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 relative cost, with limited losses. Implementation of these schemes have been included in Phase A as they can be implemented quicker than most schemes located below Bulshoek Weir. The *Ebenhaeser Scheme* and *Klawer Phase 1 Scheme, which* will make use of existing canal conveyance infrastructure, have also been included in Phase A. The Ebenhaeser Scheme is considered to have a high importance, to supply water to recent recipients of restitution farms and to augment water supply to the existing Ebenhaeser community.

The *Right Bank Canal Scheme* will be a Government Waterworks, which includes betterment works for the existing irrigation scheme as well as a small development component, and is not reliant on additional water that will be provided by the raising of Clanwilliam Dam. The project can therefore be implemented as soon as the detailed design and tender documentation are ready, environmental authorisation has been received and funding from National Treasury has been secured. This scheme can therefore be implemented sooner than Phase B, as indicated in **Table 7-3**, although it is expected to be a very long implementation process.

The *Klawer Phase 2 partial development Scheme* and the *Coastal 1 flow-restricted Scheme* have been included under Phase C. The *Coastal 1 flow-restricted Scheme* is a very small scheme and the *Klawer Phase 2 partial development Scheme* will require significant investment to upgrade the Klawer canal section on the right bank.

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

The development of the recommended schemes will:

- Broaden the ownership base of the economy to HDI farmers through new development.
- Mostly focus on high-value and export crops, whilst planning for some subsistence-plus farming.
- Sustainably create jobs and alleviate poverty in a poor region.
- Improve utilisation of existing infrastructure and resources by combining planned new development with overdue and long-delayed betterment works.

These schemes are shown in **Figure 7-**, except for the Ebenhaeser Scheme, which is located towards the bottom end of the study area, in the far North-West of the Olifants River catchment, between Lutzville and Ebenhaeser towns. Only partial development of the Klawer and Coastal 1 potential areas (as shown on the map) has been recommended due to limitations or better opportunities being available.

7.5 Schemes Designed at Feasibility Level

The following schemes are recommended for implementation as government water schemes (GWS) and have been designed at feasibility 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 town.
- **Right Bank Canal Scheme**, replacing the existing main canal with a new canal of 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 secure future water supply to the lower Olifants River irrigators and other users, and to the existence and prosperity of the region. There is currently a high risk of disruption and shortfall in supply due canal breakages as a result of the poor state of the existing canals, especially the existing main (Trawal section) canal.
- **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.

Figure 7-2: Location of recommended irrigation areas

8 Way Forward for Other Irrigation Developments

This chapter describes the way forward for the recommended schemes which excludes the irrigation areas to be developed for the three GWSs to be implemented.

8.1 Irrigation Areas to be Privately Developed

Besides the implementation of the three GWSs (Jan Dissels, Right Bank Canal and Ebenhaeser schemes) and associated irrigation areas, the following proposed new irrigation schemes (refer to **Figure 7-**) have been identified for development on privately-owned land:

- Clanwilliam (462 ha);
- Zandrug (1 209 ha);
- Bulshoek (266 ha);
- Klawer Phase 1 (412 ha);
- Klawer Phase 2 partial development (438 ha); and
- Coastal 1 flow-restricted (89 ha).

The following four irrigation areas (with a total of 2 339 ha), to be supplied from the proposed Right Bank Canal Scheme, have been identified for development on privately owned property:

- Zypherfontein 1 (710 ha);
- Trawal (510 ha);
- Zypherfontein 2 (614 ha); and
- Melkboom (505 ha).

The *transfer of lower Jan Dissels River allocations* does not involve new development. This will require the transfer of water licences of existing allocations from the Jan Dissels River to the Olifants River.

8.2 Potential Trawal Government Water Scheme

8.2.1 Suitable Recommended Irrigation Areas to Include in a GWS

At the PSC Meeting 9, held on 17 July 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.

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. The Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom recommended irrigation areas, (or portions thereof) should therefore be considered, as these options contain large tracts of undeveloped land in private ownership. All the other recommended irrigation areas that will be located on private land are spread out and large portions of these properties are already farmed. The potential GWS was subsequently assessed at reconnaissance level, as described in Section 7.1 of the unnumbered *Conceptual Design Sub-Report* of this study.

8.2.2 Overview of the Potential GWS

The combined irrigable area for the four new development areas is 2 339 ha. The combined water requirement of 22.31 million m^3/a, including losses, for these four areas, to be supplied via the new right bank canal, comprises 42% of the total volume of 61.05 million m^3/a that is available for new irrigation development following the raising of Clanwilliam Dam.

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 currently within these areas. The Trawal irrigation area is located on the left bank of the Olifants River, while the other three areas are located on the right bank, and will be supplied from the new Right Bank Canal Scheme, as soon as it has been constructed up to the relevant areas. The Trawal irrigation 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 be supplied from the new right bank main canal in the longer-term.

8.2.3 Implementation and Ownership

The cost of the bulk water supply infrastructure to supply these four irrigation areas is included in the total development cost of the new Right Bank Canal Scheme. Because these four irrigation areas are all located on private land, the cost of the bulk water infrastructure (excluding costs relating to the construction of the new main right bank canal) will be separated from the private irrigation development costs of these areas, when the State constructs the Right Bank Canal

Scheme. For a GWS development though, the new right bank canal and the remainder of the infrastructure (conveyance infrastructure and storage for the four irrigation areas) can be simultaneously constructed.

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, should it be developed.

For the GWS development scenario, the Government would buy or expropriate agricultural land within the target geographical area, and this land will be leased to a Community Property Association (CPA) (or Trust). The CPA would be responsible for productive use of the agricultural land, for such a project to be a success. It should be noted that in terms of the lessons learnt from the *Joint Ventures in Land Reform project*, CPAs should be provided with legal and administrative support to manage their affairs, including commercial agreements, distribution of benefits and to promote democratic participation of their members.

Other factors to take into account for the development of a GWS include the provision of on-farm water distribution infrastructure, other structures such as sheds, development of the land for agriculture, provision of farm implements, crops to be planted, supply of fertiliser and pesticides, training and support of new farmers, marketing of products and farm management. In the case of a GWS, many or all of these aspects would need to be addressed and possibly funded or subsidised by the State.

8.2.4 Affected Land and Infrastructure

The farms on which these irrigation areas are located are currently 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. Farm and land owner information for the four areas that could be obtained is shown in Section 7.1.6 of the unnumbered *Conceptual Design Sub-Report* of this study. Although a database has been compiled with the information sourced, this is incomplete and some of the information is regarded as unreliable.

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 following the raising of Clanwilliam Dam, either as private joint venture (JV) developments or a GWS, or a combination of both.

8.3 Potential Klawer Government Water Scheme

The Klawer irrigation area is another potential new irrigation area where land could be made available to HD farmers, either as a GWS, or via an alternative institutional arrangement, such as a co-operative. The area is situated between Klawer and Vredendal, on the right bank of the Olifants River. The area is very well positioned, being close to Vredendal and all the existing services there. There are also existing smallholding plots that can easily be added to.

Two phases for the development of portions of the Klawer irrigation area have been recommended, namely Klawer Phase 1 (412 ha) and Klawer Phase 2 (438 ha). The Klawer Phase 2 Scheme will be one of the more expensive schemes. While the Klawer Phase 1 Scheme would make use of spare flow capacity of the existing canals, the Klawer Phase 2 scheme includes the construction of a new Klawer canal section, to replace the existing Klawer canal section, following the completion of the Right Bank Canal Scheme. The full Klawer irrigable area is 1 378 ha.

The development of a Klawer GWS potentially implies the development of a larger portion of the Klawer irrigable area than currently recommended for the Klawer phases 1 and 2 schemes. This would require that new development elsewhere be curtailed, because of the limited amount of additional water that would become available.

8.4 Potential Farm Implementation Models for Private Irrigation Development

8.4.1 Needs and Best Approach Analyses

In order to determine the best scenarios for the development of the proposed areas, a needs analysis was performed, inclusive of analysis from the perspective of the smallholder farmer, as documented in the *Agricultural Production and Farm Development Report* of this study, report number P WMA 09/E10/00/0417/11. It was determined that a smallholder farmer would need assistance throughout the value chain for its operations to become commercially competitive.

Various "**best approach options**" are recommended for the uptake of water and development of the study area. Strategic partnership / mentorship agreements with the commercial sector should *inter-alia* be in place, to ensure that the whole value chain is serviced in order to ensure high yields, competitive prices and a secure off-take of crops. The way that the strategic partner or mentor derives benefit from the project should be scrutinised, to ensure that no exorbitant fees are charged, and that project income reaches the communities. It may be possible for the Citrus and/or Table Grape industry to provide a commitment to such projects, where they in turn receive the fruit produced to be marketed. Although small farm sizes have not been found to be financially viable, a productive unit of 7.5 ha could provide a family with a basic income (e.g. the income of R 96 000 p/a for a small vegetable growing unit).

If **strategic partnerships or JVs** are to be undertaken it is important that the suitable group size be chosen. From past experience, the size of the group has been found to be a significant factor of likely success of a project (the larger the group, the less chance of success in general). Further success factors for JVs require that the strategic partner remains accountable to the project and that the HDIs in the project are involved in the management thereof and enjoy a degree of upskilling, both in terms of technical expertise and in terms of management capabilities.

In addition to the above, support would be needed from DALRRD in terms of CASP, from Industry Bodies, from DWS in terms of Resource-Poor Farmer Assistance, and from DALRRD in terms of the One Household-One Hectare Project and the Agri-Parks project. It needs to be determined whether these programmes still hold the capacity to undertake an irrigation project at scale.

Private development in this instance refers to commercial development with a black-owned counterpart (51-100% black-owned). This was recommended as the most feasible development option in the *Feasibility Study for the Raising of Clanwilliam Dam*[1] and was confirmed. Private development was also identified as the most feasible option in terms of the Land Reform Panel Report.

The funding mechanisms from a Government perspective are also discussed in this report. It was found that the strategic nature of South Africa's water resources infrastructure, and the typically long payback periods associated with these investments, imply that a predominantly public sector institutional arrangement is the most appropriate, with money coming from the National Revenue Fund.

8.4.2 Recommendations

The following recommendations are made:

1. Calculation of the socio-economic benefits for the development of the recommended new irrigation development schemes are based on commercial principles and profitability, in very specific circumstances. Some of the factors include economic viable farm sizes, high yields and good market prices. Should the socio-economic benefits of the scheme be realised, equity objectives need to be aligned with the objectives of commercial viability. For this purpose, the commercial JV model with a shared ownership has been found to be the most feasible option, given that it makes provision for black ownership, but could be commercially viable if the correct safeguards are in place.
2. Development of smaller agricultural units (referred to as *smallholder plots*) has not been found to be commercially viable, and communal land ownership also has many pitfalls. If

[1] DWS, 2007

models like these are to be successful, considerable inputs from Government, the commercial sector and the HDI communities would be required. The scale of such projects is also important – if the whole of the scheme is developed to smaller agricultural units, the socio-economic benefits of the scheme would not be met. If no such units are developed, it would undermine Government policy that allows for "'quick wins" through smaller agricultural units. It is therefore recommended that a balance be found between commercial JV projects and smaller agricultural units. It is *inter-alia* for this reason that the recommendation has been made to develop one or more GWSs for the new areas to be irrigated from the Jan Dissels, Right Bank Canal and Ebenhaeser schemes, inclusive of smallholder 7.5 ha plots.

3. It should however be noted that further study may be needed into the feasibility of schemes for smaller agricultural plots, as the financial viability thereof could not be established within the ambit of this current study. Smaller agricultural units do not possess the economy of scale to compete commercially. Should a few smaller agricultural units be farmed together under a central mentoring agent, the issue of group size and weakened decision-making might surface. The case studies presented in this report also do not support such a centralised structure.
4. The most ideal project structure, based on examination of case studies, would be a JV company with at least 51% black ownership, which either owns the land and the business or just the business. This model may provide for the target of 75% of all allocations to be made to HDIs if licences are allocated to the HDI component of the JV. The HDI component could be a company or a trust and could use the water rights to "buy in" to the project in question.
5. The JV model could be implemented within any of the private development schemes. Given that a JV is a private initiative by the commercial sector, it would be up to individual applicants to make proposals for their ideal project structure during the WULA process.
6. Various public water infrastructure financing options were investigated, but it was found that allocation through the National Revenue fund is the most feasible option.
7. The recommended type of development per recommended irrigation development scheme (including all GWSs for completeness) is indicated in **Table 8-1**.

Table 8-1: Recommended development per recommended irrigation scheme

Scheme	Hectares	Recommended type of development
Jan Dissels	462	GWS consisting of a combination of commercial farmers and smallholders (50% recommended) on state land. Ideal for smallholder development, being located very close to Clanwilliam Town.
Clanwilliam	298	Private land. Combination of JVs and some smallholder farmers.
Zandrug	1 209	Private land. Combination of JVs and some smallholder farmers.
Bulshoek	266	Private land. Combination of JVs and some smallholder farmers.
Right Bank Canal: Zypherfontein 1 Trawal Zypherfontein 2 Melkboom	 710 510 614 505	 Combination of JVs and some smallholder farmers. Private land located in the Trawal area, that can potentially all, or partly be considered for a GWS, in combination with the construction of a new Right Bank canal.
Klawer Phase 1 Klawer Phase 2	412 438	Private land. Combination of JVs and some smallholder farmers. Private land. Combination of JVs and some smallholder farmers, in combination with the construction of a new Klawer Canal.
Coastal 1	89	Private land. Combination of JVs and some smallholder farmers.
Ebenhaeser	361	63 Ha of smallholder development and 250 ha for restitution farms (with 12 000 m^3/ha/a allocations).

Note: 'JVs' in the table above can potentially include the option of black commercial farmers purchasing private land.

The Jan Dissels and Ebenhaeser schemes could thus ensure the development of about 5% of the total new development for smallholder farmers. Should the Trawal or Klawer GWSs be considered, this will provide a significant opportunity for the development of an additional 5% for smallholder farmers. The development of private land could alternatively be implemented with the premise that a few smaller agricultural units be farmed together under a central mentoring agent, i.e. a JV or black commercial farmer, to meet Government policy for "'quick wins" through smaller agricultural units.

8.4.3 Cost concerns

A general concern raised by land owners / commercial farmers was that they need to understand what the water will cost them before they can decide whether they can afford to become involved with 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. It became obvious that, unless the influence of the cost of water can be clarified, the evaluation of and likely uptake of water for private development cannot proceed with confidence.

8.5 Implementation Process for Private Development

The proposed schemes will require separate WULAs in terms of Section 21(b) of the NWA.

If the applicants will be private landowners, such as joint venture developments, then the environmental authorisation entity will be DEA&DP. Separate environmental authorisations will be required for each development application.

9 Topographical Survey

This chapter provides an overview of the topographical survey undertaken for the three schemes selected for feasibility design. The details of the topographical surveys undertaken are reported in the *Topographical Survey Report* (Report No. P WMA 09/E10/00/0417/7).

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 9-** to **Figure 9-**. The survey mapping was done in November 2019 and small extensions to the survey were done in August 2020.

Figure 9-1: Survey area for the Jan Dissels Scheme

The survey areas were defined to allow for flexibility in the options and scheme evaluations.

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.

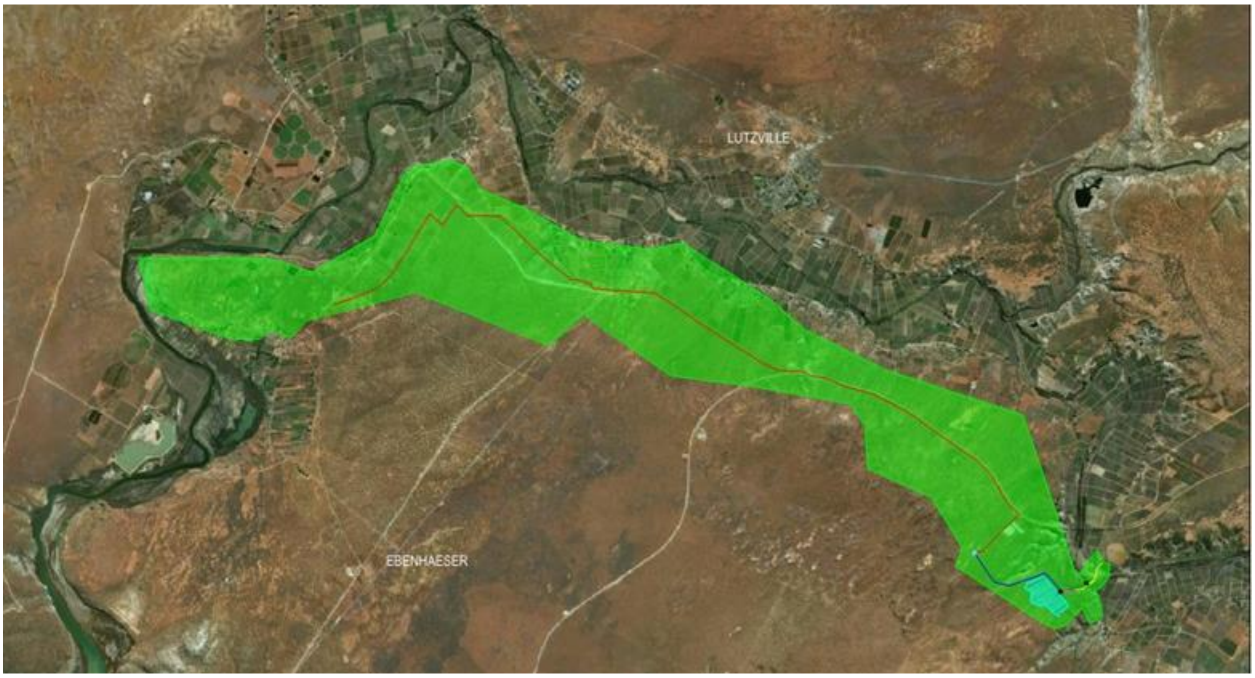

Figure 9-2: Survey area for the Ebenhaeser Scheme

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 Environmental Systems Research Institute (ESRI) Grid format files;
- Digital ortho-photography Image files;
- A field book (*.fbk) and landXml (*.xml) data file in TDS format (compatible with AutoCad Civil 3D);
- Contours generated at 0.5 m 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 supporting *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. A separate report on the establishment of ground control points is included in an Appendix of the report.

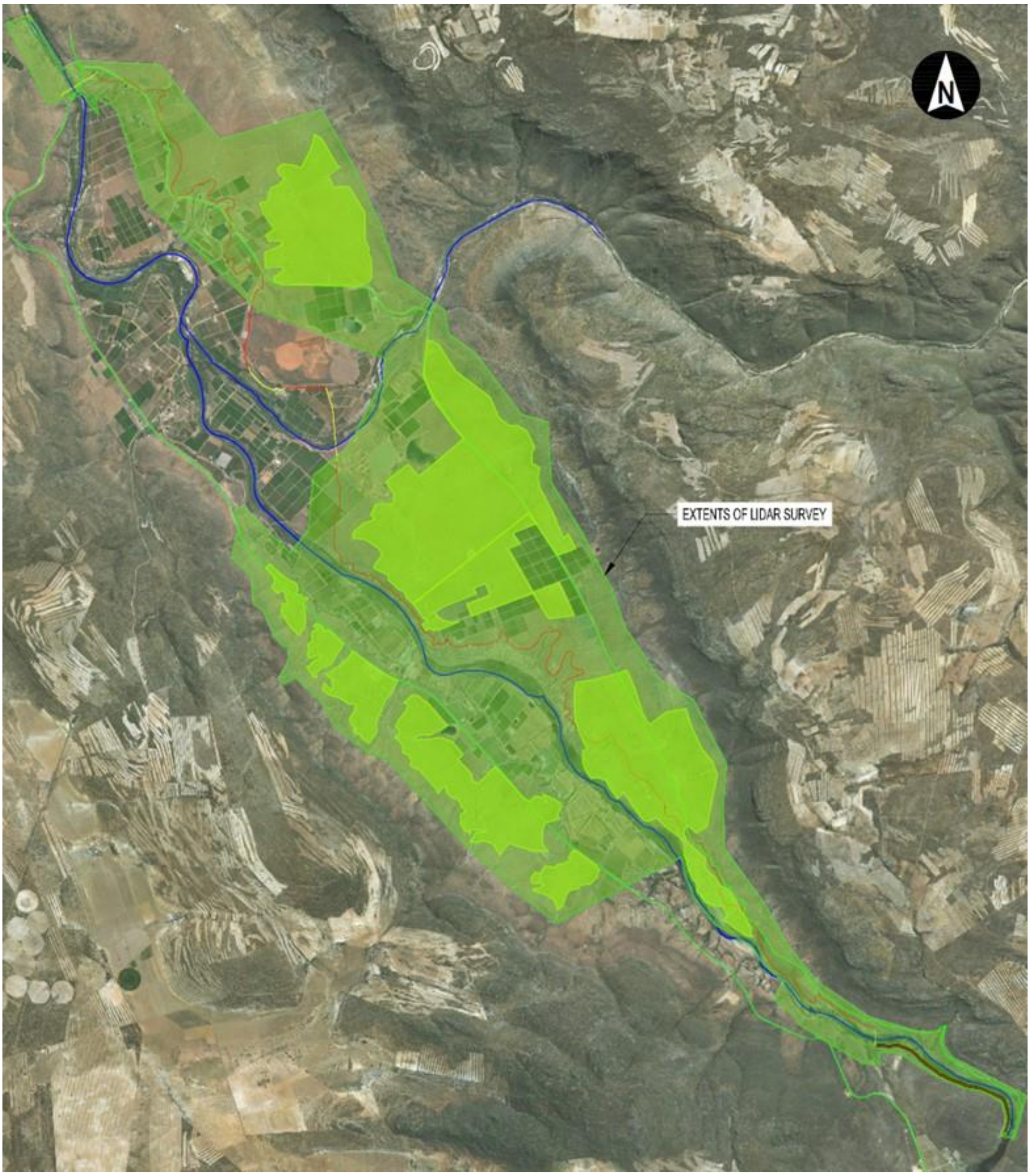

Figure 9-3: Survey area for the Right Bank Canal

DWS National Water Resources Infrastructure (NWRI): Survey Services (Southern Operations), contact person Mr Hein Lodewyk, reviewed the survey report and expressed satisfaction with the accuracies that were achieved.

10 Geological, Geotechnical and Materials Investigation

This Chapter provides an overview of the geology and the outcomes and conclusions of the geotechnical and materials investigations undertaken at the three schemes selected for feasibility design .

10.1 Introduction

The geological and geotechnical evaluation comprised:

- A desk study of available information for recommended schemes to be designed, and a reconnaissance visit to the various scheme elements, conducted during March 2020,
- Geotechnical investigations for the preliminary conveyance infrastructure routes were conducted in July 2020 to inform the selection of the preferred pipeline routes and infrastructure positions. It included geophysical surveys (resistivity), test pitting using a tractor-loader-backhoe (TLB), in-situ field testing including dynamic cone penetration (DCP) tests, sampling and laboratory testing.
- Compilation of detailed geotechnical interpretive reports for the three schemes, and
- Core drilling of three syphons for the Right Bank Canal Scheme and one syphon for the Ebenhaeser Scheme in early 2021, and updating of the reports.

The findings of these investigations are reported in the *Geotechnical Investigations Report* (Report No. P WMA 09/E10/00/0417/8 Vol I, Vol II and Vol III). Findings and conclusions from the geotechnical reports are summarised below.

10.2 Regional geology

The 1:250 000 Geological Series mapping and other publications were consulted to describe the regional geology. The area is underlain by rocks of the Cape Supergroup, with isolated remnants of the Gariep Supergroup. 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.

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. In this region of the country, residual soils are generally of limited thickness and disintegration is the dominant form of weathering.

The seismic hazard of the area is considered to be very low. The peak ground acceleration associated with the area is roughly 0.05g, with a 10% probability of being exceeded in a 50-year period. It is considered a non-seismic activity zone and as such, no specific seismic design requirements, other than normal structural design requirements, are required.

10.3 Jan Dissels Scheme

The Jan Dissels Scheme Sub-option 1 refers to abstraction from the lake of the raised Clanwilliam Dam, while Sub-option 2 refers to abstraction from the outlet of the raised dam.

The engineering geological / geotechnical implications and considerations for this scheme are described in more detail in the *Geotechnical Investigations Report. Vol I: Jan Dissels Scheme* (P WMA 09/E10/00/0417/8).

10.3.1 Geology

The underlying geology comprises quartzitic sandstone from the Table Mountain Group, Cape Supergroup, which is overlain by colluvium soils.

10.3.2 Geotechnical considerations

10.3.2.1 Excavation considerations

It is recommended that a track excavator be employed to ensure effective advance within the boulder colluvium and up to soft to medium hard rock, quartzitic sandstone. Excavation by means of power tools, such as pneumatic rock breaker attached to a track excavator for instance, should be considered within the hard rock quartzitic sandstone. Blasting may be required in some instances. However, it should be noted that blast vibration may cause damage to the dam structure. If possible, blasting should be avoided and must be controlled if it is implemented.

10.3.2.2 Slope stability and lateral support

Major sidewall collapse occurred in the colluvium layer, which often led to the termination of the test pit excavations. In addition, sidewall stability can worsen drastically if water is to be encountered in excavations, albeit in the form of a perched water table or poor surface water run-off, which may accidently be draining into excavations during construction. Therefore, excavation slopes being formed through the boulder colluvium and deeper than 1.50 m must either be battered back to safe slopes or shored. This is essential to ensure safe working conditions for workers in excavations.

10.3.2.3 Soil corrosiveness

The soils in the area of the **reservoir** site should be considered mildly corrosive. The material towards the south east of the recommended **Rising Main 2** ranges from moderately to highly corrosive for buried steel elements. Therefore, special consideration should be given in the design regarding the deterioration of buried steel and concrete structures in these soils.

10.3.2.4 Foundations

All foundation excavations of possible pedestals for Rising Main 1, as well as for the foundation of the reservoir, should be inspected by an experienced geotechnical engineer or engineering geologist prior to placing of concrete, to ensure that the correct founding material has been obtained in the excavations. This is an important aspect because the investigation findings rely on point information (test pits) and localized variations may be revealed in the excavation of the foundation for these structures.

According to the classifications, the colluvium is mainly suitable as bedding cradle and selected fill blanket, i.e. SC1 and SC2 bedding material types, and the residual quartzitic sandstone is generally suitable for foundations. Occasional sandy clay material found within the residual quartzitic sandstone horizon is not suitable as bedding and backfill material.

A reinforced concrete slab foundation is a common approach for small reservoirs, as proposed for the Jan Dissels Scheme. Adequate bearing capacity may be obtained from the hard rock quartzitic sandstone that was intersected at a maximum depth of 1.10 m along the perimeter of the reservoir footprint. Bedrock that will provide the desired bearing capacity is therefore found at shallow depths on the footprint. Excavation of hard rock, by blasting or other means, will be required for the reservoir foundation to ensure a level foundation on the bedrock.

10.3.2.5 Access Road

There is an existing gravel road from the ‘Ou Kaapse’ Road to the site 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 is against a steep hill, which is not practical for an access road. The rising main would be readily accessible for the remainder of the route.

10.3.2.6 Further Investigations

Further investigations have been recommended for:

- Geotechnical conditions at the pump station sites;
- Geological continuity (laterally and with depth) across the site; and
- Chemical testing needs to be conducted to confirm the corrosiveness of the soils.

10.4 Right Bank Canal Scheme

10.4.1 Geology

The Right Bank Canal Scheme is located in an area underlain by rocks of the Cape Supergroup, primarily sandstone and quartzitic sandstone. A variety of younger soils overlie the bedrock. The area is located within the Cape Fold Belt, and the strata are characterised by folding and faulting.

The project area is located to the north of elevated seismicity. The Peak Ground Acceleration associated with the area is roughly 0.05 g, with a 10% probability of being exceeded in a 50-year period. It is considered a non-seismic activity zone and as such, no specific seismic design requirements, other than normal structural design requirements, are required.

10.4.2 Geotechnical Considerations

The engineering geological / geotechnical implications and considerations for each of the respective components of the Right Bank Canal Scheme have been described in the *Geotechnical Investigations Report. Vol II: Right Bank Canal Scheme (P WMA 09/E10/00/0417/8).*

The geotechnical considerations for the scheme are summarised below.

10.4.2.1 Upgrading of the First 3 km of the Existing Left Bank Canal

The **geological profile** for the initial 1 900 m essentially comprises bedded, very hard rock quartzitic sandstone. For the remainder of this section similar bedrock is expected, but beneath a cover of colluvial talus material. None of the test pits intersected the **water table**.

In terms of **excavation**, the hard rock / very hard rock quartzitic sandstone bedrock can be considered to represent ‘hard excavations’ in terms of South African National Standards (SANS) 1200D, i.e. where blasting would be required.

The **stability** of the excavated faces within the bedrock will be controlled by the geological structure, but the bedding on its own is not considered susceptible to sliding failure. Excavations within overlying colluvial materials would need to be battered to safe angles or shored.

10.4.2.2 New Right Bank Canal

The **geological profile** over the approximate 30 km route of the new Right Bank Canal is naturally highly variable and comprises combinations of soil overburden comprising sands, silts and clays, with coarse fractis comprising gravels and cobbles; all over quartzitic sandstone or shale bedrock. Bedrock commonly occurs at depths beneath refusal on cemented sand or terrace gravels. The canal routing was sub-divided on the basis of expected similar geological conditions, i.e. similar geotechnical influences.

None of the test pits encountered any seepage, or evidence of a shallow **water table.**

In terms of evaluating **excavation**, a depth of 3 m is considered relevant. The upper soil horizons would generally be classified as 'soft excavation'. TLB refusal was however commonly recorded at reasonably shallow depths, either on shallow bedrock or large boulders or very dense pedogenic horizons, and excavation below these depths can be considered 'hard'.

Sidewall instability was a common feature of the test pits and serves to highlight the potential risk of slope instabilities that will be associated with the upper soil horizons.

10.4.2.3 Road crossings

The **geological profile** at the various road crossings comprises varied sand and gravel horizons in places overlying shale bedrock.

None of the test pits encountered any seepage, or evidence of a shallow **water table**.

Generally, shallow refusal was recorded; either on shallow bedrock or calcified / ferruginised materials, and **excavation** below these depths can be classified as 'hard'.

In terms of **slope stability**, the excavated faces would be susceptible to ravelling and spalling, and must be cut to safe angles, and / or shored.

10.4.2.4 Olifants River Crossing (Syphon 1)

The **geological profile** is variable. The left abutment is characterised by steep, near-vertical cliffs and outcrop of quartzitic sandstone bedrock. Within the river section alluvial sand deposits and boulders as well as outcrop of very hard rock quartzitic sandstone occur. The left abutment comprises talus deposits of sand and gravels / cobbles, and boulders overlie the quartzitic sandstone bedrock.

A shallow **water table** must be expected in the river as well as on the right abutment.

Assuming the river crossing will comprise a pipe bridge; recommended **founding depths** vary between 0.8 m and 1.0 m on the left abutment and central pier, and 1.8 m on the left abutment.

Excavations within the bedrock are expected to be negligible, i.e. founding will be on or near the upper bedrock surface. Alluvial and colluvial overburden can be considered as 'soft excavation'.

Only shallow excavations would be required for the bridge footings and abutments and there are no concerns regarding **stability** of excavated faces. The near-vertical cliff on the left abutment deserves mention. To date no detailed consideration has been given to the location of the bridge abutment with respect to the cliff, and the cliff edge in particular. This consideration is in terms of additional loading surcharge that would be introduced, and the impact, if anything, on the global stability of the cliff. This aspect needs to be considered during the detailed design stage.

10.4.2.5 Doring River Crossing (Syphon 2A)

The **geological profile** is characterised by alluvium comprising sand with cobbles and boulders, underlain by residual shale, and soft rock to medium hard rock shale.

By definition, the location of the river crossing within an active river channel implies a shallow **water table**.

Excavation within the upper alluvial sands will be classified as 'soft excavation', but will include variable amounts of cobbles (approximately 30%). The medium hard rock shale bedrock may be considered as 'intermediate / hard excavation'.

In terms of **slope stability**, excavations within the saturated sands will be prone to collapse. All excavations will require support.

10.4.2.6 Extended Doring River Syphon (Syphon 2B)

The **geological profile** is highly variable. In general, the area is covered by alluvium that it is underlain by residual schist, which is in turn underlain by soft rock to hard rock schist.

This extended syphon is located at the edge of the floodplain, and therefore not part of the active river channel. Nevertheless, a relatively shallow **water table** (5 m to 6 m depth) is to be expected.

The variable geological profile also implies that the **excavation** will be variable. The soils can be considered 'soft excavation', while the schist bedrock will be considered 'hard excavation', where this bedrock comprises medium hard rock to hard rock.

Consideration must be given to the **stability** of both temporary as well as permanent cut slopes. It is also pertinent that the syphon excavation up to 8 m depths will be at the toe of the existing steep slope.

10.4.3 Conclusions and Recommendations

Ground investigations are typically phased, as is the project itself, and a single round of investigations will not necessarily meet all the requirements for detailed design and the construction phase. Thus, any subsequent refinements to the Right Bank Canal Scheme during the detailed design phase might require additional geotechnical information. This will depend on the details of these refinements and the level of available information in the affected areas.

10.5 Ebenhaeser Scheme

The engineering geological / geotechnical implications and considerations for this scheme are described in more detail in the *Geotechnical Investigations Report. Vol III: Ebenhaeser Scheme (P WMA 09/E10/00/0417/8).*

10.5.1 Geology

According to the 1:250 000 scale geological map 3118 Calvinia (Council for Geoscience, 2001), the site is covered by aeolian sands, which are in turn underlain by calcareous soils, graphitic and sericitic schist, phyllite, greywacke, quartzite, impure dolomite, limestone and marble of the Aties Formation, Gariep Supergroup.

10.5.2 Excavation stability

The test pit sidewalls largely collapsed in the very loose to medium dense aeolian sands during the field investigations. The stability of excavations during construction may be compromised and shoring or battering of excavations will be required. Attention must be paid to the presence of seepage and terrace gravels. As part of safe practice during construction, stability assessment would be required for deeper excavations that are left open for longer periods. These assessments need to be conducted by a suitably qualified and experienced geotechnical practitioner.

10.5.3 Soil corrosiveness

The soils along the Ebenhaeser Scheme corridor are generally non-corrosive to extremely corrosive. This indicates that special consideration needs to be given to steel and concrete components, in particular for the concrete reservoir, and inlet and outlet structure for the balancing dam. The HDPE pipe, which is proposed for the scheme, generally has excellent corrosion resistance. Therefore, no corrosion problems are likely to be encountered for the pipelines.

10.5.4 Other factors

It is recommended that foundation excavations at the balancing dam and the concrete reservoir be inspected by an experienced geotechnical engineer or engineering geologist, prior to placing of concrete or earthfill, respectively, to ensure that suitable founding material has been obtained in the excavations. This is an important aspect because the investigation findings rely on point information (test pits) and localized variations may be revealed in the excavations.

The Olifants River crossing is expected to comprise a syphon, not more than 8 m deep, within deep alluvial soils with high water levels.

The scheme is located outside natural seismic activity zones, and outside regions of mining-induced seismic activity. The area is considered a non-seismic activity zone and as such, no specific seismic design requirements other than normal structural design requirements are required.

Groundwater seepage was only encountered along the Retshof Diversion. However, the possibility of intersecting seepage elsewhere cannot be completely ruled out, as the presence of pedogenic materials suggests the occurrence of fluctuating water levels.

The suite of laboratory tests conducted to determine the dispersivity of the soils indicate that the materials encountered on site are non-dispersive to highly dispersive.

The aeolian sands, pedogenic materials and terrace gravels along the route are suitable as backfill materials.

The Concrete Reservoir should be founded on the very dense, calcretised and ferruginised sand (hardpan calcrete) to allow for adequate bearing capacity. The ground conditions at the reservoir can be subdivided into shallow hardpan on the western side and deeper pedogenic material on the eastern and southern sides. This is likely to require a cut of 2.5 m or deeper to found on the hardpan. Alternatively, compacted backfill below the structure could be considered on the eastern and southern sides of the reservoir.

Soft excavations in terms of SANS 1200D are to be expected in aeolian sand, alluvium and terrace gravels. Hard excavations, as per SANS 1200D, are encountered in hardpan calcrete and schist bedrock.

10.5.5 Balancing Dam

10.5.5.1 Foundation indicators

The aeolian sands in the proposed balancing dam basin predominantly comprise poorly graded sand (SP) and silty sands (SM). These sands are non-plastic. The pedogenic materials (calcrete) predominantly comprise poorly graded sand (SP), silty sands (SM) and occasionally clayey sands (SC). These gravely sands are generally non-plastic. The terrace gravel typically sampled at test pit E-TP 16 comprises poorly graded gravel (GP). The gravel fraction is very high, and the sand content is medium to high. The clay and silt fractions are negligible. The terrace gravels in the area are generally non-plastic.

10.5.5.2 Material strength and permeability

The sand material of aeolian origin generally exhibits permeabilities which are considered highly pervious. There is insufficient material for an impermeable lining. The angle of friction suggests that these sands can be used for embankment construction.

10.5.5.3 Embankment foundation and materials

The balancing dam will be lined with high density polyethylene (HDPE) to prevent leakage and the permeable sandy material below will act as a natural drain to relieve pressure under the lining. There is no need for a cut-off trench as this is a lined dam and the aeolian sand has good bearing capacity. The rock toe should however be founded on the dense, calcritised and ferruginised sand with occasional hardpan calcrete.

10.5.5.4 Foundation of spillway

The geology in the vicinity of the spillway on the right flank and its discharge channel comprises much the same materials as that of the embankment, although it may become rocky as it leads towards a drainage path to the east of the dam basin. The excavation depth is expected to be about 1.4 m based on trial pit results. The dam will be filled by pumping and the spillway will very rarely spill. Erosion is therefore not a big concern in the spillway discharge channel and excavating to rock is not critical.

10.5.5.5 Embankment fill materials

General fill for the embankment can comprise both the slightly gravelly and gravelly sands. The layer directly under the liner can comprise the upper layer aeolian sands, which are sufficiently permeable to help with underdrainage.

Sand and gravel will need to be imported for the drainage system along the upstream toe of the embankment and possible underdrain pipes beneath the liner. The need for a drainage system should be evaluated during the detail design stage, as it may not be required due to the natural permeability of the *in-situ* material.

11 Environmental Screening and Scheme Assessments

This Chapter describes the environmental screening undertaken for the study area, environmental evaluations undertaken for the three schemes selected for feasibility design and environmental approval engagements with responsible authorities.

11.1 Environmental Screening

An environmental screening of the proposed development areas and activities was conducted as part of the study, to determine the best ecological options and to minimise impacts on the natural environment. The *Environmental Screening Sub-report* describes and illustrates the opportunities and constraints, and potential ecological risks/impacts for the short-listed bulk infrastructure development options at reconnaissance level, and provides recommendations. Relevant legislation that applies to the proposed irrigation developments is also described in terms of the following:

- National Environmental Management Act (NEMA) (Act No. 107 of 1998, as amended)
- National Heritage Resources Act (NHRA) (Act No. 29 of 1999)
- National Water Act (NWA) (Act No. 36 of 1998, as amended)

11.2 Environmental Assessment of Schemes

Further environmental assessments were undertaken for the three recommended schemes. The findings of this assessment, relevant to the Jan Dissels, Right Bank Canal and Ebenhaeser schemes, are reported in the *Environmental Screening Sub-Report.* The relevant conclusions from this report are listed below.

11.2.1 Jan Dissels Scheme

Refer to Chapter 12 for a description of the Jan Dissels Scheme options. The environmental considerations for this scheme are as follows:

- Rising Main Route 1 (RM 1) is located within an area mapped as a Critical Biodiversity Area (CBA). This option would include the removal of indigenous vegetation, but with the pipeline route being much shorter than the alternative, Rising Main Route 2.
- Rising Main Route 2 (RM 2) is not located in any mapped CBA, but does transect the Ramskop Nature Reserve (**Figure 11-**). This reserve is managed by the Cederberg Municipality.

Figure 11-1: Location of the Ramskop Nature Reserve along the RM Option 2

- There are indications that existing pipelines are present in the area of RM2 and that the construction of the pipeline could potentially be approved by the Management Authority, which would be the Municipality in this case.
- The RM2 route does however include the removal of indigenous vegetation and would probably require temporary and permanent access tracks to be constructed.
- The proposed scheme will be subject to further on-site specialist assessments by a botanical specialist.
- The proposed infrastructure would require a Basic Assessment to obtain authorisation from DEFF.
- If borrow pits are proposed, an application for authorisation should also be submitted to the Department of Mineral Resources and Energy (DMRE) for mining activities.
- The proposed infrastructure would also require heritage authorisation in terms of Section 38 (a) and (c) of the NHRA.

- Water use authorisation in terms of the NWA is discussed in Chapter 18.1 of this report.

11.2.2 Right Bank Canal Scheme

Refer to Chapter 13 for a description of the Right Bank Canal Scheme. The environmental considerations for this scheme are as follows:

- The upgrading of 3 km of the existing Left Bank Canal should consider limiting vegetation clearance, since the site is located partly within a CBA, the Rondeberg Oord Private Nature Reserve and an endangered vegetation type.
- The proposed works should be subject to further on-site specialist assessments by a freshwater and botanical specialist to determine the best environmental options within the sensitive areas and especially the watercourses.
- The work to be undertaken as part of the Left Bank Canal upgrade, syphons through the Olifants and Doring rivers, construction of the Right Bank Canal and any other associated infrastructure would require a Basic Assessment to obtain authorisation from DEFF.
- If borrow pits are proposed, an application for authorisation should also be submitted to DMRE for mining activities.
- The proposed infrastructure would also require heritage authorisation in terms of Section 38 (a) and (c) of the NHRA.
- The two syphons that will be constructed through rivers would require Section 21 (c) and (i) WULAs to be undertaken for each of these.
- Water use authorisation in terms of the NWA is discussed in Chapter 18.1 of this report.

11.2.3 Ebenhaeser Scheme

Refer to Chapter 14 for a description of the Ebenhaeser Scheme. The environmental considerations for this scheme are as follows:

- The proposed works should be subject to further on-site specialist assessments by a freshwater and botanical specialist to determine the best environmental options within the sensitive areas and especially the watercourses.
- The work to be undertaken as part of the diversions, syphon through the Olifants River, balancing reservoirs, a large earthfill dam and any other associated infrastructure would require an environmental impact assessment (EIA) to obtain authorisation from DEFF.
- If borrow pits are proposed, an application for authorisation should also be submitted to DMRE for mining activities.
- Should the earthfill dam be removed from the scope of works, then only a Basic Assessment would be required for the authorisation of the remaining infrastructure.
- The proposed infrastructure would also require heritage authorisation in terms of Section 38 (a) and (c) of the NHRA.

- The Ebenhaeser balancing dam will require a WULA in terms of Section 21 (b), (c) and (i) of the NWA. The syphon to be constructed through the Olifants River would require a Section 21 (c) and (i) WULA to be undertaken.
- Water use authorisation in terms of the NWA is discussed in Chapter 18.1 of this report.

11.3 Environmental Approval Process Engagement

Two meetings were held with environmental authorities to get greater clarity on the environmental approvals of the proposed irrigation schemes. The first meeting was held on 13 August 2019 to bring authorities up to date on the project and to engage on the environmental authorisation processes for the proposed development options and the need for specialist involvement. Various potential processes to be followed to obtain environmental authorisation were discussed. The environmental sensitivity of the Jan Dissels Scheme was discussed and it was recommended that a Botanist be appointed to undertake a botanical assessment of the identified potential irrigation area.

A follow-up meeting was held on 5 November 2020, with DEFF representatives, in addition to the Provincial Department of Environmental Affairs and Development Planning (DEA&DP) and CapeNature representatives.

It was confirmed that DEFF will be the Competent Authority (CA) for EIA decision-making, since DWS will apply as the Proponent. They may delegate this responsibility to DEA&DP.

Following the second meeting, a process was followed to confirm which protected areas will be affected. The Lutzville Conservation Area (applicable to the Ebenhaeser Scheme) fell away as it is not considered a conservation area. It was confirmed that the Rondeberg Oord Private Nature Reserve (applicable to the Right Bank Canal Scheme) as well as the Ramskop Nature Reserve (applicable to the Jan Dissels Scheme) are operated as Nature Reserves.

The main outcome of the second meeting was that the entire infrastructure for the development of the schemes will require a new environmental authorisation, as this infrastructure was not included in the raising of the Clanwilliam Dam wall and N7 road realignment projects. If the schemes are to be implemented by DWS, then DEFF will be the competent authority for authorisation.

If the applicants will be private landowners, such as joint venture developments, then the environmental authorisation entity will be DEA&DP. In order to streamline applications, it is required that DWS, DEA&DP and DEFF hold a pre-application clarification meeting to discuss requirements, phasing, listed activities and options. The private joint venture schemes with the commercial farmers will therefore be a separate process, going forward.

Additionally, it was mentioned that it is strongly recommended to separate the GWS development into three different applications (one per scheme), running concurrently. This will avoid one authorisation holding back the others if there is an issue on one section or scheme. Thus, it is important that the authorities are able to authorise the schemes separately, especially because they are geographically located far apart.

Another important issue relates to the phasing of the schemes, not only because of funding of the schemes, but also due to the authorisations only being valid for a limited time, usually five years. It is therefore important to verify which of these schemes are reliant on the raising of the dam wall.

The importance of continuing with stakeholder engagement to determine where private developments will take place was also highlighted in the meeting. This is important to ensure that stakeholders are not misinformed about the process, which could result in potential delays in the implementation of the schemes.

11.4 Environmental Recommendations for Feasibility Design

The following recommendations are made regarding the environmental considerations of the development options, which have been recommended for feasibility design:

1) Undertake site specific specialist assessments and field clarifications to guide engineering design, prior to undertaking the EIA process.
2) Consider an alternative to constructing a rising main (RM) pipeline through the Ramskop Nature Reserve (RM Route 2 of the Jan Dissels Scheme).
3) Determine the preferred RM sub-option for the Jan Dissels Scheme.
4) Determine the exact road and power supply related infrastructure and assess the proposed impacts as part of the EIA process.
5) 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 CBAs, 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.
6) The DWS should consult internally to determine whether integrated WULAs should be submitted for each scheme, including abstraction, storage and working in watercourses.
7) Alternative options for, or prior to, environmental authorisation in terms of NEMA, should be considered, such as the undertaking of a Strategic Environmental Assessment (SEA) or Environmental Management Framework (EMF) for all the schemes and associated infrastructure.

12 Jan Dissels Scheme Feasibility Design and Cost Estimate

This chapter describes the feasibility design of the Jan Dissels Scheme. A design was done for two potential route options.

12.1 Scheme Conceptualisation

An area east of Clanwilliam Dam was identified as suitable irrigable land (**Figure 12-**). The area is *inter-alia* suitable for the development of smaller plots, given its proximity close to Clanwilliam town and existing markets. The land is owned by the State. Following a botanical survey to account for environmental sensitivity concerns by environmental authorities, and meetings held with the land users, being Cederberg Local Municipality and Augsburg Agricultural Gymnasium, the scheme was conceptualised.

Figure 12-1: Jan Dissels Scheme irrigation area

The water requirement for the estimated 462 ha of irrigable land is 4.26 million m^3/a.

The feasibility design of the scheme is described in the unnumbered *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* of this study.

12.2 Overview of the Scheme

Two routes for a rising main were identified:

Rising Main Route 1 will pump water directly from a floating intake low-lift pump station in the raised Clanwilliam Dam to a balancing tank approximately 70 m from shore. The tank will be located above the full supply level of the raised dam, i.e. 118.25 masl, but with the floating pump station located such that water can be abstracted under minimum operating levels, i.e. 100 masl. From the balancing tank water will be pumped with a high-lift pump station to a concrete reservoir at a suitable high point. From the reservoir water can be gravitated to the identified irrigation areas.

Rising Main Route 2 will pump water from an outlet point below the raised Clanwilliam Dam wall, on the right bank, to a concrete reservoir on top of the hill. The position of the concrete reservoir is the same for both options.

Figure 12- shows the irrigable area and the layout of the bulk water infrastructure components for the scheme route options.

For both options an access road to the reservoir will have to be constructed, either from the "Ou Kaapse" Road or from the township development close by.

Additional electrical supply is required for the pump station(s), noting that the power supply for Clanwilliam Town must also 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. It is recommended that Eskom be engaged during the detailed design phase of the project.

Figure 12-2: Layout of the Jan Dissels Scheme

12.3 Intake Pump Stations

12.3.1 Rising Main Route 1 Option

The pump selection for the floating low-lift pump station was based on the minimum operating and the full supply levels of the raised Clanwilliam Dam.

A pump configuration of two (2) duty pumps and one (1) standby pump is proposed for the Rising Main Route 1 **Low-Lift Pump Station**. **Figure 12-** shows the characteristic and pump curves for the Rising Main Route 1 low-lift pump, equipped with KSB Amarex KRT K 150-401 pumps. It is evident from **Figure 12-** that the low-lift pump station has a duty point of 23.2 Mℓ/d (0.269 m^3/s) at a total pumping head of approximately 30 m. The low-lift pumps would need to be fitted with variable speed drives (VSDs) due to the large variation in the levels of the Clanwilliam Dam (i.e. at a fixed speed, the pump curves do not intersect the lower system curve).

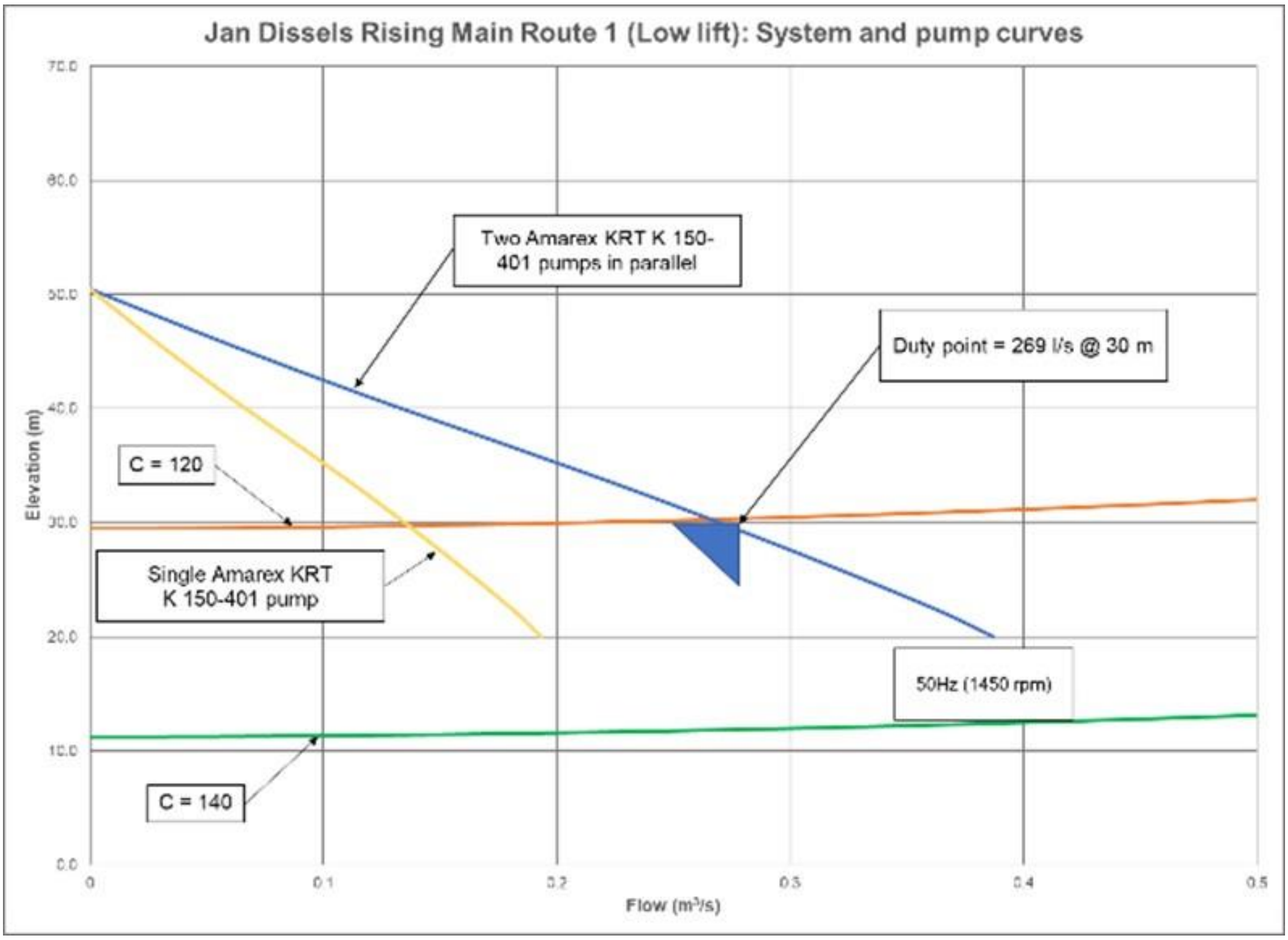

Figure 12-3: Characteristic and pump curve for RIsing Main Route 1 Low-Lift pump station

A pump configuration of one (1) duty pump and one (1) standby pump is proposed for the Rising Main Route 1 **High-Lift Pump Station**. The details of a commercially available pump that could be used are shown in **Figure 12-**.

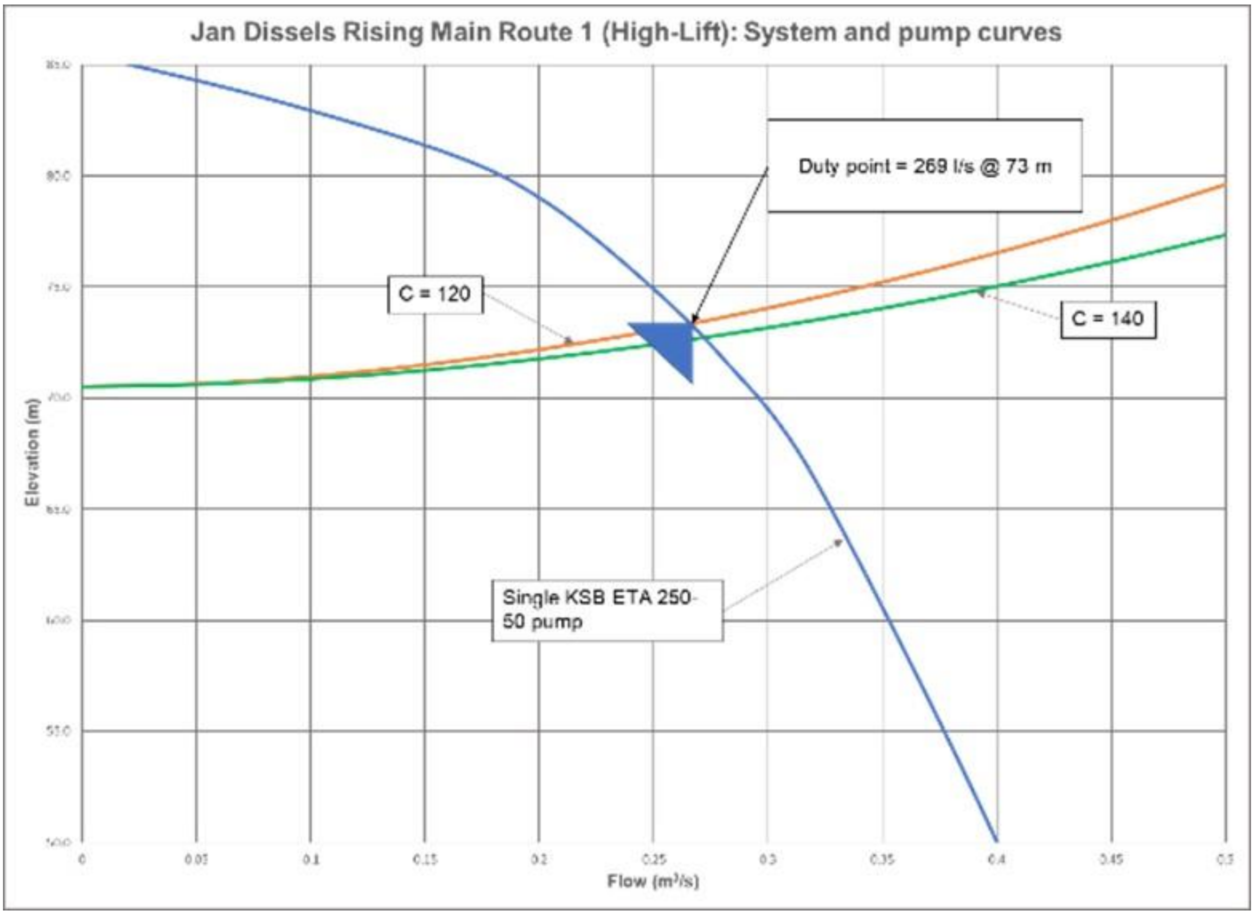

Figure 12-4: Characteristic and pump curve for Rising Main Route 1 High-Lift pump station

It is evident from **Figure 12-** that the high-lift pump station has a duty point of 23.2 Mℓ/d (0.269 m^3/s) at a total pumping head of approximately 73 m.

12.3.1.1 Balancing Tank

The balancing tank is designed to store the flow of 269 ℓ/s pumped over 1 hour, which equates to a balancing tank with an active capacity of 970 m^3 (0.97 Mℓ). It is proposed that a reinforced concrete tank/reservoir with a 1 000 m^3 (1 Mℓ) capacity be provided. A new access road will have to be constructed to the balancing tank, as well as to the low-lift and high-lift pump stations. The proposed layout plan for the low-lift and high-lift pump stations is shown in **Figure** 12-.

Figure 12- shows the hydraulic gradient line of the Rising Main Route 1 to the concrete reservoir for a flow of 23.2 Mℓ/d (0.269 m^3/s).

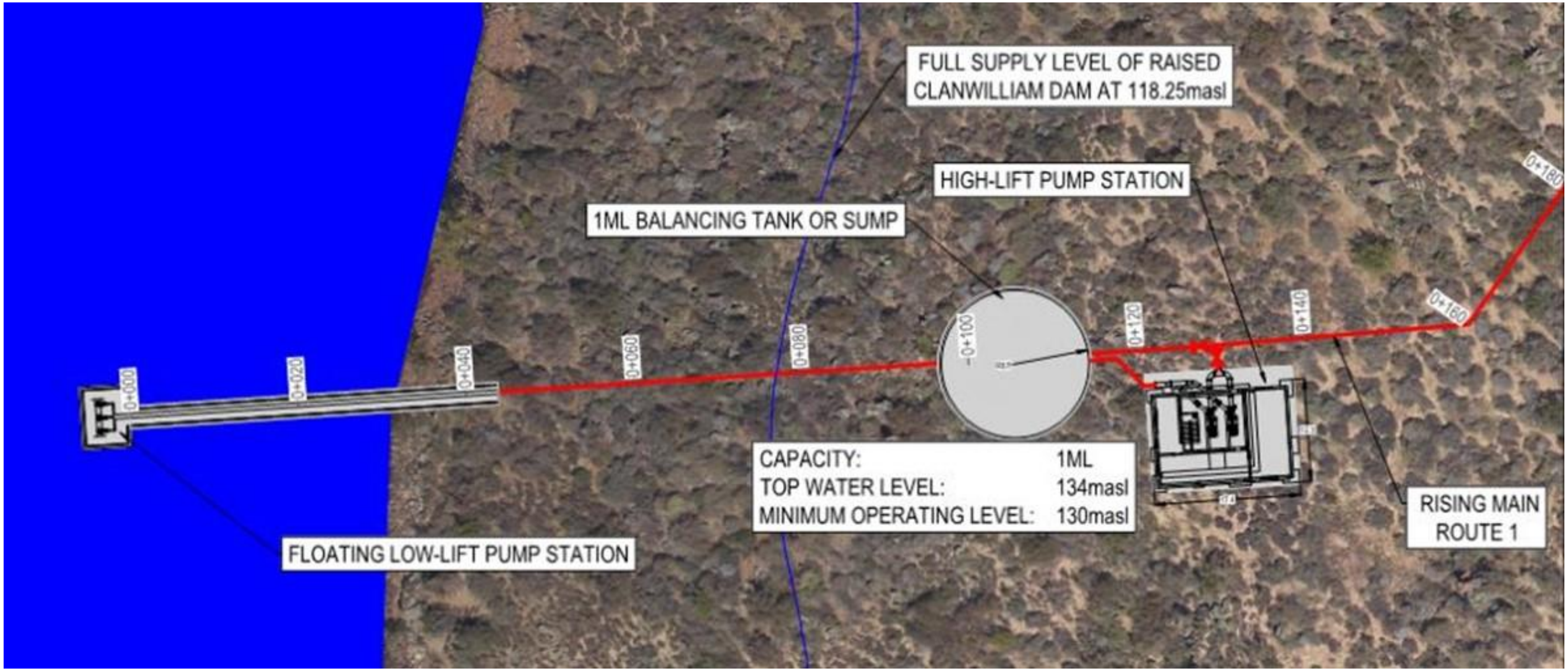

Figure 12-5: Rising Main 1 Low-lift and High-lift pump station layout

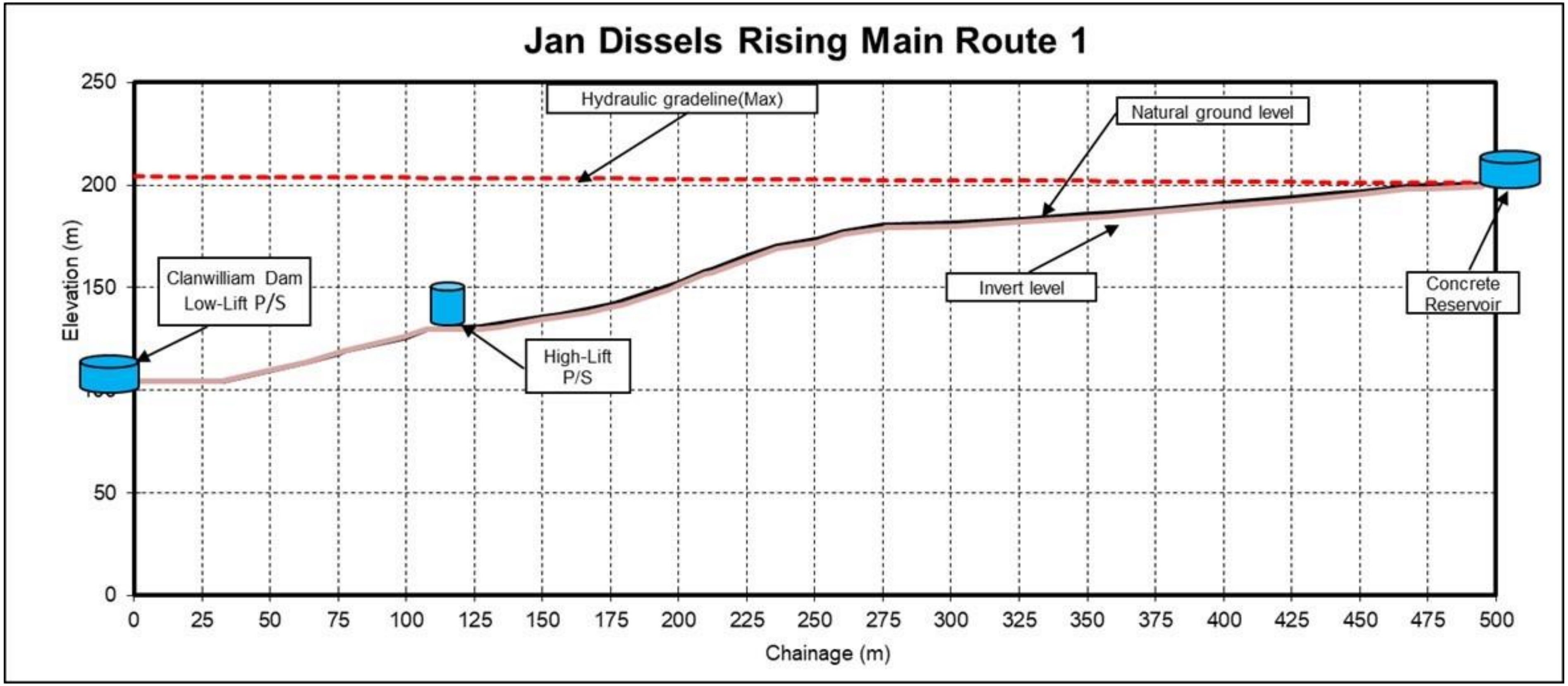

Figure 12-6: Rising Main to Reservoir: HGL for 23.2 Mℓ/d in aged DN 500 pipeline

12.3.2 Rising Main Route 2 Option

The Rising Main Route 2 option entails pumping water from an outlet point below the raised Clanwilliam Dam wall on the right bank, to the balancing reservoir. With the raising of the dam wall the existing pump station, supplying the town of Clanwilliam, will be demolished and a new pump station will be constructed. Two options are available for the new pump station, namely:

- Integrate the Jan Dissels Pump Station with the new proposed pump station for the town; or
- Construct a new pump station in the same position as the existing pump station after it is demolished.

A pump configuration of one (1) duty pump and one (1) standby pump is proposed for the Rising Main Route 2 pump station. The characteristic system curves for Rising Main 2 pump station are shown in **Figure 12-**.

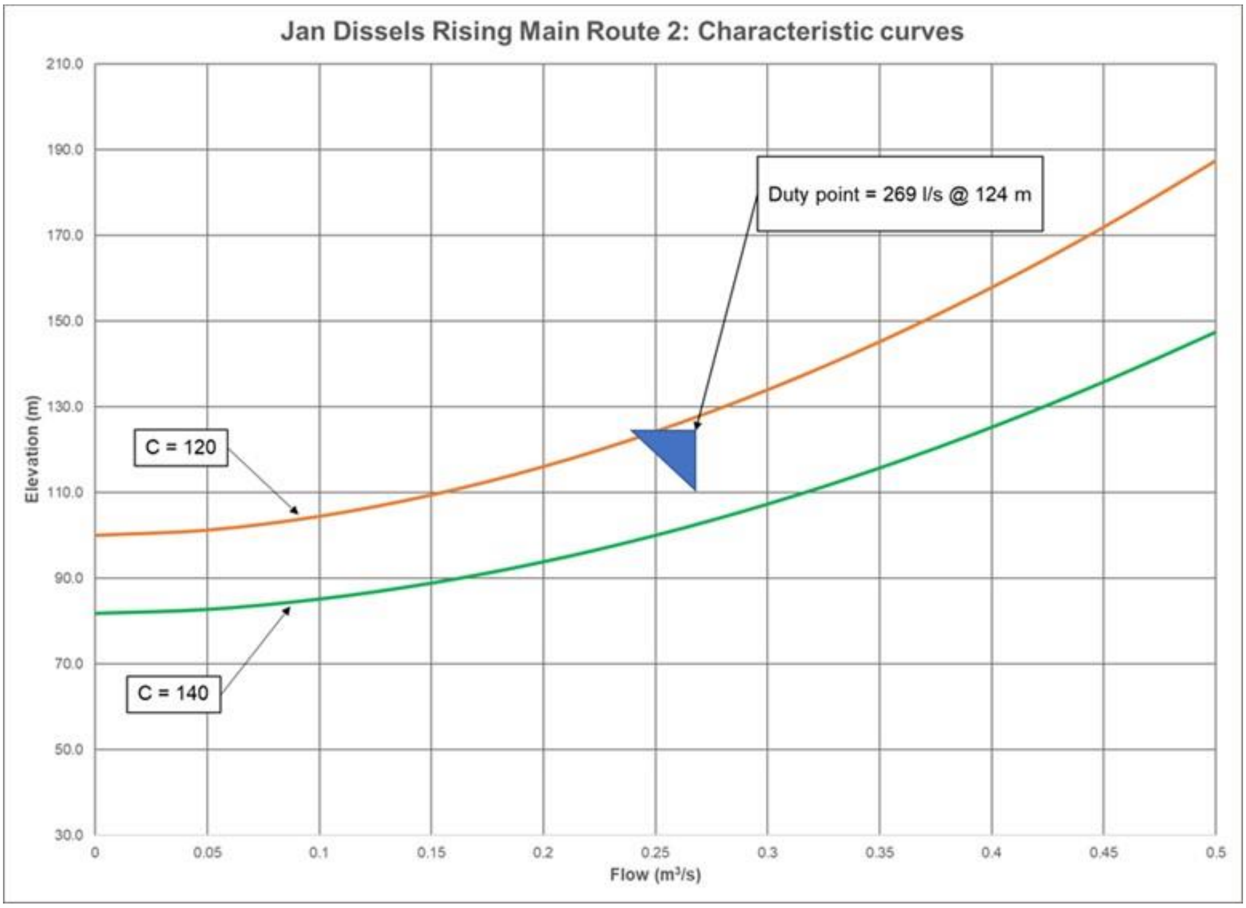

Figure 12-7: Characteristic and pump curve for Rising Main 2 pump station

It is evident from **Figure 12-** that the high-lift pump station has a duty point of 23.2 Mℓ/d (0.269 m^3/s) at a total pumping head of approximately 124 m.

Figure 12- shows the hydraulic gradient lines of the Rising Main Route 2 to the concrete reservoir for a flow of 23.2 Mℓ/d (0.269 m^3/s).

12.4 Farm Dam/Reservoir

The 12 Mℓ reinforced concrete reservoir is designed to store the flow of 269 ℓ/s pumped over 12 hours. A new access road will have to be constructed to the reservoir and a new power supply provided.

12.5 Cost Estimates

The project cost estimates for the construction of the Jan Dissels Scheme options, including other miscellaneous costs, professional fees and land acquisition costs, is shown in **Table 12-1**.

Table 12-1: Jan Dissels Scheme Route 1 and Route 2 Project Cost Estimate

No	Description	Route 1 Amount (R million)	Route 2 Amount (R million)
1	Rising Main Route 1 (pipelines, pump station/s and balancing reservoir)	52.626	72.069
2	Access road (1 km long)	1.000	0.500
3	Electrical supply	3.000	3.000
Total: Construction costs, incl. 40% P&G and 25% contingencies		**56.626**	**75.569**
4	Professional fees (10%)	5.663	7.557
	Value Added Tax (15%)	9.343	12.469
5	Land acquisition	0.013	0.071
	TOTAL (October 2020 prices)	**71.700**	**95.700**

To determine the project cost estimate at the date of project commencement, an escalation of 6.5% per year can be applied from the base date of October 2020.

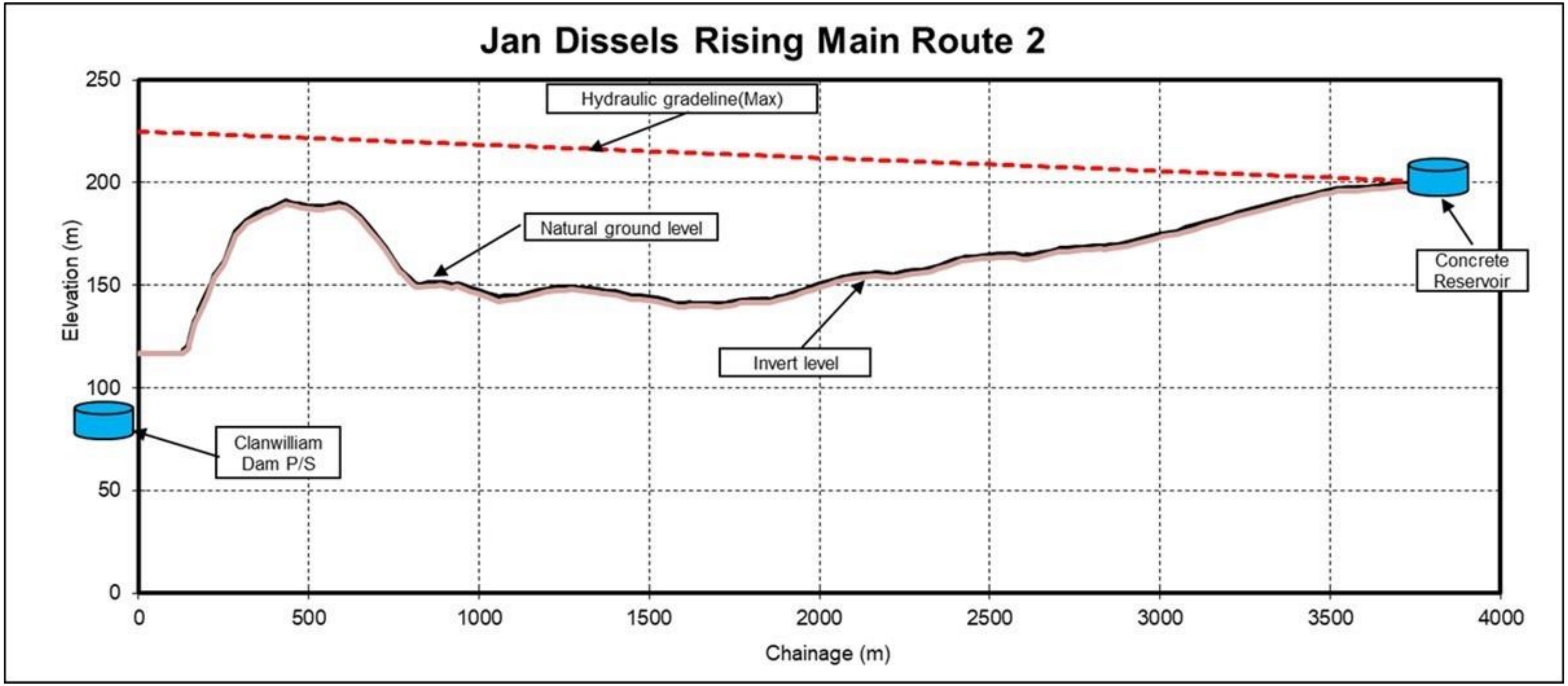

Figure 12-8: Rising Main Route 2 to Reservoir: HGL for 23.2 Mℓ/d in aged DN 500 pipeline

Annual operation and maintenance (O&M) costs for the two options were calculated as a percentage of the construction value, namely 0.5% of the civil works and 4% of the mechanical works. The O&M costs for the two scheme options are R 255 000/a for Route 1 and R 256 000/a for Route 2.

12.6 Option Recommended for Implementation

A comparison of the two sub-options (excluding VAT) was made by calculating the net present value (NPV) and unit reference Value (URV) of each. As can be seen in **Table 12-2**, the NPVs and URVs are the same. Other factors were therefore considered in order to choose the best option.

Rising Main Route 2 is recommended due to its pump installation, which is more secure, easily accessible and will require less maintenance than Rising Main Route 1.

Table 12-2: Comparative costing of sub-options RM1 and RM2

Sub-option	Capital cost (R million)	Total NPV cost (R million)	URV (R/m^3)
1. Rising main from floating intake	R 62.3	R 99.8	R 2.02
2. Rising main directly from dam wall	R 83.2	R 100.2	R 2.03

12.7 Further Investigations for Detailed Design

Recommendations applicable to the detailed design and construction phases of the Jan Dissels Scheme have been made regarding the following aspects:

a) The extent of the irrigation to be developed.
b) Follow-up geotechnical investigations and additional chemical testing.
c) A ground centreline survey.
d) Volume and sources of suitable pipeline bedding material.
e) Confirmation of pipeline routes and infrastructure locations.
f) Independent quality control inspections of the pipes and the choice of pipe material.
g) Engagement with Eskom regarding electrical supplies to the pump stations.
h) Refinement of the selection of pump types.
i) Approval by relevant road authorities of proposed road crossing.
j) Sizing of the concrete balancing reservoir.
k) Energy costs used in the cost calculations.

13 Right Bank Canal Feasibility Design and Cost Estimate

This chapter of the report provides an overview of the feasibility level design of the Right Bank Canal Scheme. Refer to the '*Right Bank Canal Design Sub-Report*' for additional details regarding the scheme.

13.1 Introduction

Several major breaks have been experienced along the Bulshoek / Lower Olifants Canal due to ageing infrastructure that is over 90 years old. The Right Bank Canal Scheme is designed to replace the existing left bank main canal starting at Bulshoek Weir 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.

13.2 Water Requirements and Design Capacity

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

- Current flow capacity of the main canal, providing water to existing allocations as well as towns, industries, mines and primary users;
- An increased flow capacity for existing allocations, 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.

The total peak design flow rate for the proposed Right Bank Canal, at the outlet of the Bulshoek Weir, is calculated as **11.40 m^3/s**. The various flow components of this design flow rate are shown in **Table 13-1**.

Table 13-1: Right Bank Canal peak design flow rates

Flow component	Flow rate (m^3/s)
Current irrigation, domestic and industrial supply	7.222
Increased flow capacity for existing allocations, based on an improved assurance of supply	1.374
Future additional non-irrigation flows	0.079
Additional irrigation	2.723
Total peak design capacity	**11.398**

13.3 Alternate Peak Design Flow Capacity

It was suggested (by Mr Keuck of WCDoA), at the Project Steering Committee Meeting 12, held on 29 July 2020, that a larger increase in the flow capacity of the canal for existing allocations should be considered, and that the influence of potential future changes in crop mixes should be considered, or else the 11.4 m^3/s capacity may be too small to adequately improve the situation for existing allocations. A subcommittee was formed to address this concern. The resultant alternate design flow determination memorandum has been included in Appendix A of the *Right Bank Canal Feasibility Design Sub-Report.*

Two approaches were followed, either assuming the worst-case scenario for crop-changes and alternate water loss scenarios, or assuming that the full volume of 5.1 million m^3/a, which has not yet been identified for distribution, is allocated for new development below Bulshoek Weir, although this is an unlikely scenario.

The restrictive capacity of the existing outlet structure of the Bulshoek Weir (which is a national monument) and is estimated as 11.5 m^3/s, may pose a challenge to an increase of the design flow capacity of the Right Bank Canal above 11.4 m^3/s. The outlet capacity of the weir needs to be more accurately determined. Evaluation of an increase in the canal design capacity above 11.4 m^3/s would need to consider the restrictive capacity of the existing Verdeling syphon, with a peak design flow of 4.02 m^3/s, where the flow would be reversed for the new Right Bank canal. Potential changes in canal alignment and associated impacts would also need to be considered.

13.4 Scheme Overview and Components

The proposed scheme is required to serve the identified new irrigation areas of Trawal, Zypherfontein 1, Zypherfontein 2, and Melkboom as shown in **Figure 13-**.

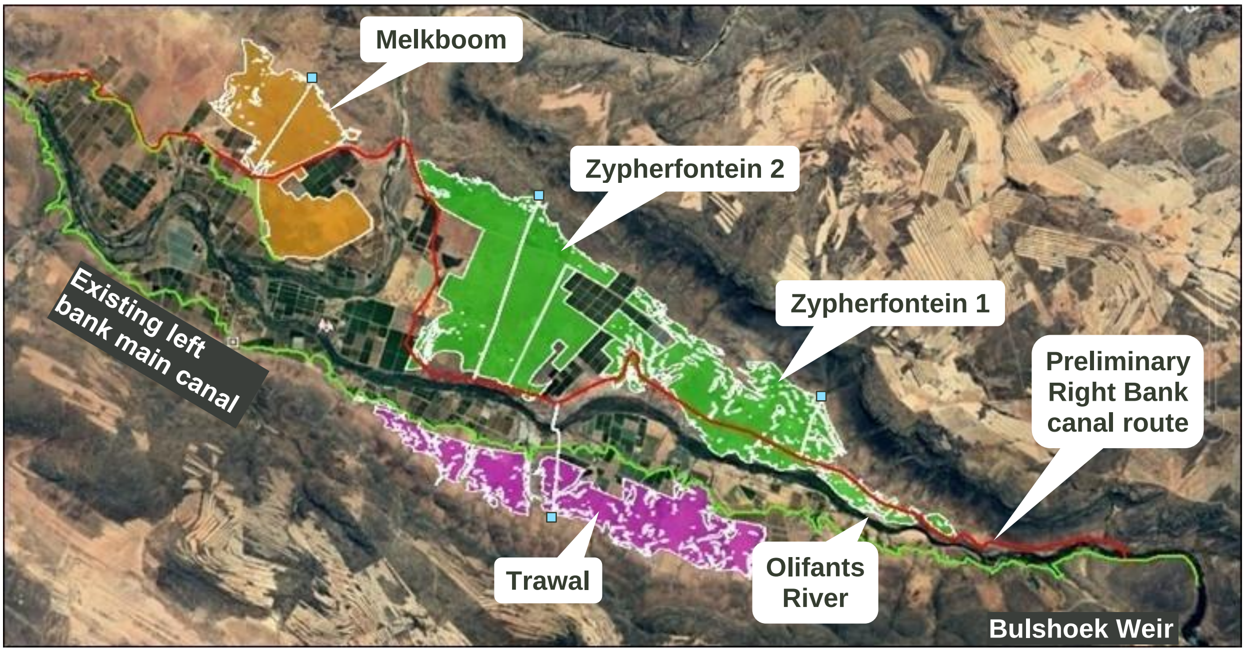

Figure 13-1: New irrigation schemes between Bulshoek Weir and Verdeling Syphon

Several options were compared and evaluated for the different components of the Right Bank Canal Scheme. A general layout arrangement of the proposed scheme is shown in **Figure** 13- and consists of the following:

- Upgrading of the Left Bank Canal for approximately 3.05 km;
- A 2.4 m diameter syphon crossing the Olifants River on a pipe bridge (300 m long);
- A new reach of trapezoidal canal on the right bank (approximately 18.56 km long);
- A rectangular in-situ concrete syphon at the Doring River crossing and a short reach of canal (1 270 m and 680 m long respectively);
- Another rectangular in-situ concrete syphon to avoid a steep sandy hill shortly after the Doring River crossing (840 m long);
- Another long reach of new trapezoidal canal (approximately 8.85 km long); and
- Upgrading of the existing syphon outlet at Verdeling to act as an inlet (chainage 33.55 km).

13.5 Canal Design

The proposed new Right Bank Canal starts on the left bank at the Bulshoek Weir. It continues on the left bank for approximately 3 km before crossing to the right bank and connects to the existing syphon at Verdeling. Design of the Right Bank Canal is based on the DWS (1980) '*Guidelines for the Design of Canals and Related Structures*'.

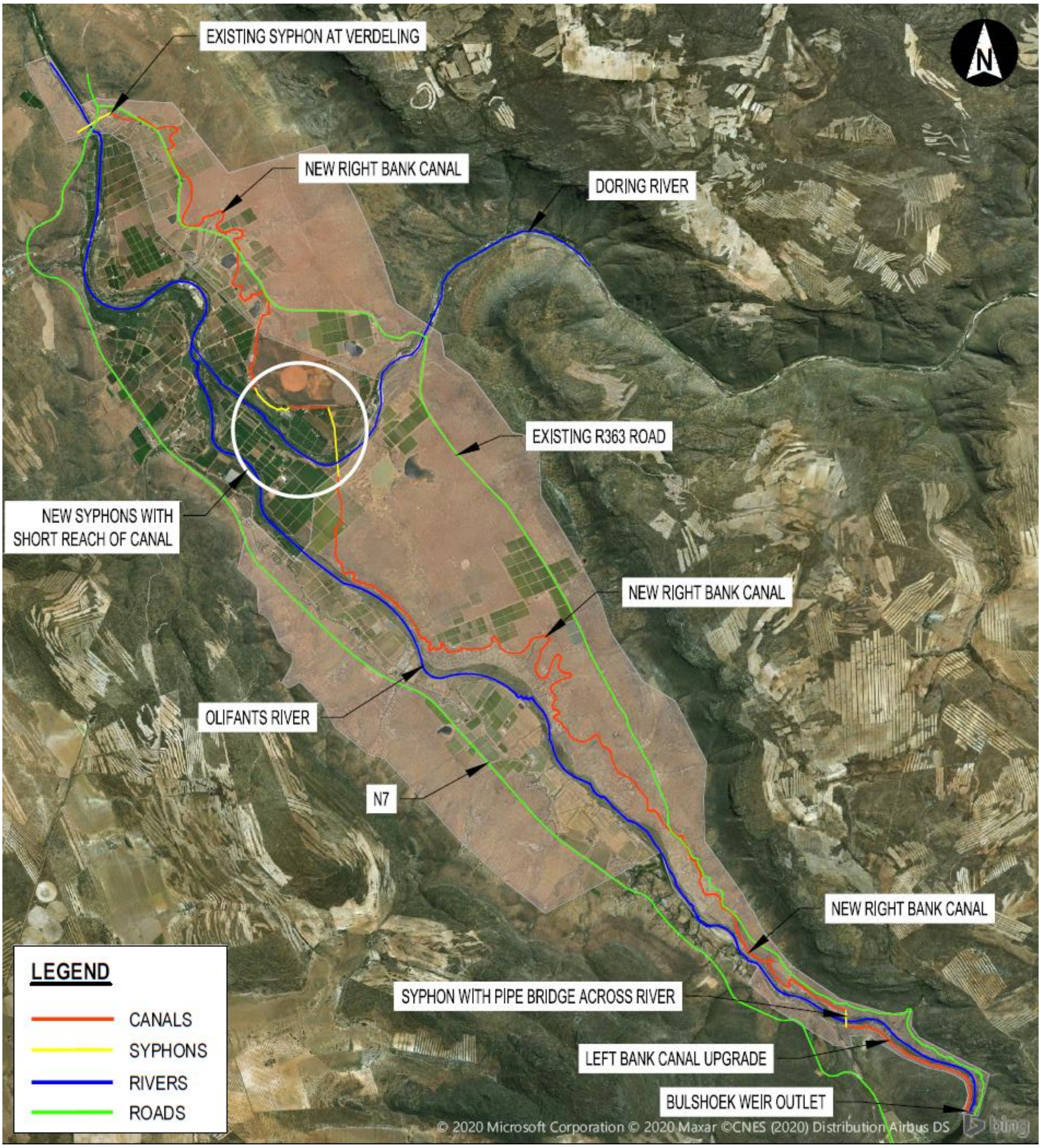

Figure 13-2: Overall layout of the Right Bank Canal Scheme

13.5.1 Bulshoek Weir Outlet Works and Available Hydraulic Energy

Due to the age and condition of the Bulshoek Weir (**Figure 13-**), 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 13-3: Concrete masonry Bulshoek Weir

Based on an analysis of the existing outlet works, it is estimated that the existing outlet structure has a flow capacity of 11.5 m^3/s and does not need to be modified to release the peak design flow of 11.4 m^3/s into the proposed Right Bank Canal. The water level immediately downstream of the five sluice gates (**Figure** 13-) is controlled by the gates themselves and is approximately 61.0 masl. This level was used as the starting level for the feasibility design.

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 will be applied to any future construction works affecting the weir.

Figure 13-4: Bulshoek Weir outlet structure sluice gates

13.5.2 Vertical Alignment

The hydraulic gradient of the open channel is dictated by the canal slope. The available gradient (slope) between the upstream water surface elevation (61.0 masl) at the start of the existing canal (outlet of the Bulshoek Weir) and the existing Verdeling Syphon is 1:5000, which has been used for the hydraulic design of the Right Bank Canal. This slope is fairly flat and requires a relatively large canal cross-section and relatively low flow velocities. It can be expected that the canal will require more frequent maintenance as the low velocities will result in suspended solids being deposited. However, the lower velocities may improve the effective life of the canal lining and joint seals.

13.5.3 Horizontal Alignment

The routing of the canal is north, north-west from Bulshoek Weir to the existing syphon at Verdeling.

The first 3 km of the proposed new main canal follows the current horizontal alignment of the existing Left Bank Canal. The existing canal 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.

After approximately 3.05 km, the main canal will cross the Olifants River by means of a pipe bridge and follow the contours of the right bank. The topography is still quite steep, and a deeper and narrower trapezoidal canal section will be used.

After about 6.41 km the valley opens up and is flatter, and more favourable terrain for a canal becomes prevalent. The main canal will then follow the natural contours. The alignment crosses the Doring River at approximately 21.91 km with a syphon, followed by a short reach of canal and another short syphon to avoid a steep sandy hill. From approximately 24.70 km to the Verdeling Syphon at 33.55 km, the canal again follows the natural contours of the land.

13.5.4 Canal Hydraulics and Cross-Section

Normal flow conditions in the canal are calculated using the Manning formula. A Manning n-value of 0.015 is used as the design value for the canal.

For the entire canal route, a trapezoidal cross-section is proposed to convey the design flow, with the bottom slope of the canal fixed at 1:5000. This trapezoidal canal was divided into two types of cross-section, based mainly on side slope and bottom width. Because of this, the two types of cross-section have different hydraulic characteristics. Due to different hydraulics, the freeboard also differs for each canal type. Refer to **Figure** 13- for the differences between the two cross-sections of trapezoidal canal recommended.

13.5.5 Canal Freeboard

Freeboard is provided in canals to allow for possible runoff from the roadway, accommodation of waves or periodic operational overloading in times of unusual heavy irrigation demands.

In order to avoid any risk of overtopping due to velocity and curve wave action at bends in the canal, the greater of the two values calculated from the following freeboard equations was used as the canal freeboard:

- A 20% overload + velocity wave action (current DWS practice); and
- Normal loading velocity wave action + curve wave action (SANRAL Drainage Manual).

Due to the larger freeboard value being used, a 20% overload could be allowed for short periods of time.

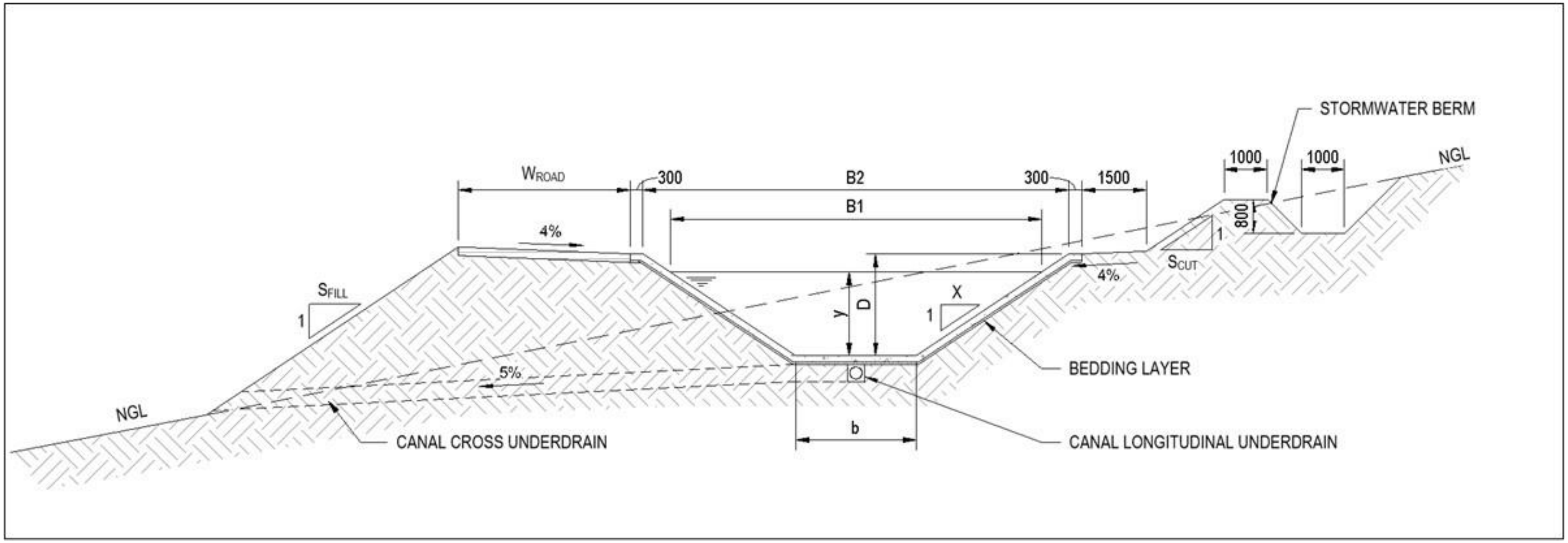

Figure 13-5: Trapezoidal canal cross-section (Types T1 and T2)

13.5.6 Canal Lining

The design water depth in the new Right Bank Canal will range from 1.82 m to 2.00 m.

The design parameters adopted for canals were dictated by BS EN 1992-3:2006, and a lining thickness of 150 mm and mesh reinforcement of Y10 at 200 mm (Mesh ref. 617) is recommended. Construction joints should be spaced at 3.0 m, contraction joints at 9.0 m and expansion joints at 27 m. A wood float finish will be satisfactory.

Polymer coal-tar (hot-pour) type joint sealant should be used with an IR hardness value between 5 and 15. An expanded polyethylene (10 mm thick) strip should first be installed at the exposed concrete side faces of the first casting before the intermediate slabs are cast. The top 30 mm should then be reamed and filled with the polymer coal-tar (hot-pour) sealant. This type of joint will be watertight and will allow for expansion and contraction.

Interlocking of panels is recommended. Dowel bars of size R16 should be installed at 300 mm c/c across the joints. The bars should be sleeved on one side and cast into the concrete at the other to allow for axial movement at the joints.

13.5.7 Typical Canal Underdrainage

Longitudinal underdrainage should be installed along the full length of the canal to avoid floatation of the canal panels, which can be caused by buoyancy forces due to groundwater when the canal is empty. The canal will also affect normal drainage paths of percolated rain and irrigation water, which will build up below the canal lining if not effectively drained.

The proposed single longitudinal underdrain will consist of a 300 mm deep by 300 mm wide boxed drain, lined with 3.4 mm thick (Bidim type) geofabric filled with 19 mm aggregate, with the geofabric overlapped at the top. The longitudinal drain will run along the centreline of the canal invert for the entire length of the canal, except where the canal is in fill. The drain is made up of a perforated DN200 pipe surrounded by an aggregate layer wrapped in a geotextile. The perforated pipe allows the ingress of water and conveys the water to the outfall. The perforations must be smaller than the smallest sized aggregate. The geotextile layer prevents the ingress of soil, which can cause blockage of the subsurface drainage leading to lining failure.

Cross drains must be provided regularly, typically every 200 m. The spacing thereof must be optimised during the detail design phase. These cross drains typically consist of a DN200 mm pipe with a slope of at least 1% downhill away from the cut side to daylight on the fill side of the canal. These pipes should either be connected to the longitudinal drainage pipes with tee pieces or be placed end to end, wrapped in 3.4 mm thick (Bidim type) geofabric, as shown in **Figure 13-** and **Figure 13-**.

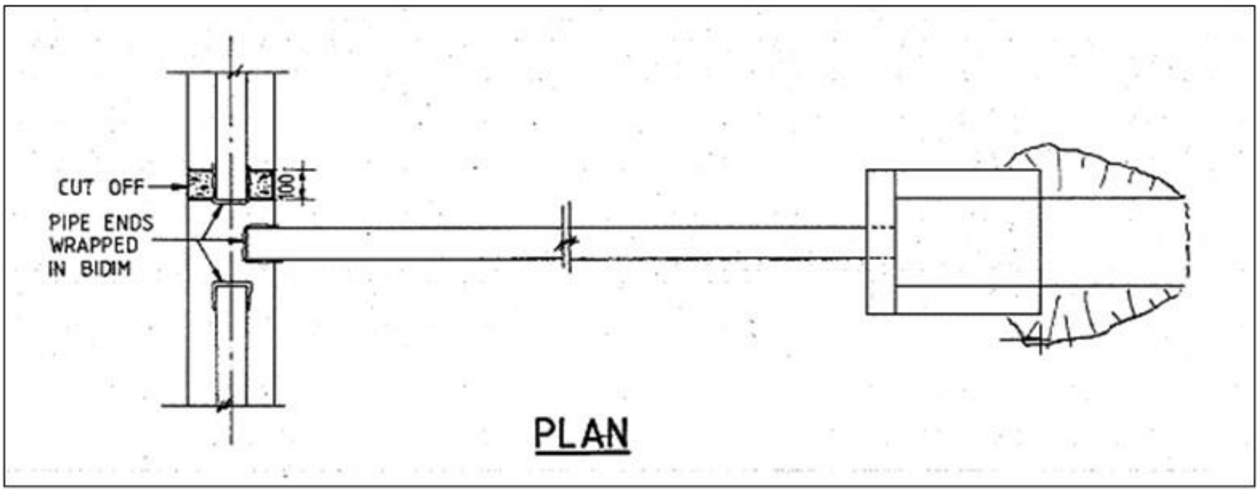

Figure 13-6: Typical longitudinal and cross underdrain connection

The underdrainage should be analysed in more detail during the detailed design phase of the project. The solution described above is a typical solution for lined canals.

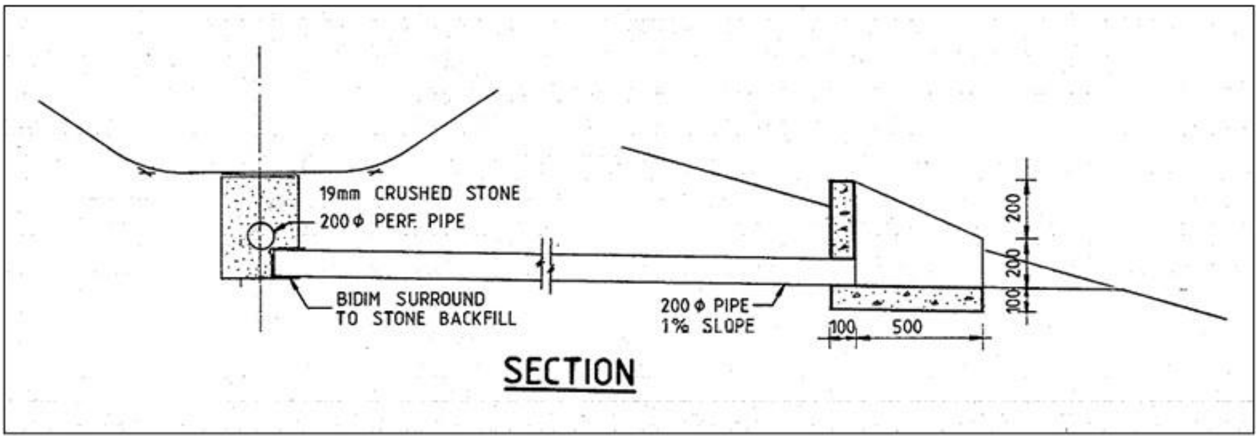

Figure 13-7: Typical section through cross underdrainage

13.5.8 Storm Water and Cross-Drainage Culverts

The new canal will create storm water catchments on natural slopes or when crossing natural drainage lines. To account for this, a storm water drain shall be constructed to intercept the natural flow. In the case where the canal is in cut, this drain shall be located where the cut daylights to the natural ground level on the upstream side of the canal. In the case where the canal is in fill, the drain shall be placed at the bottom of the fill. See **Figure 13-** for the location of this storm water drain. The drain shall be trapezoidal in shape, with a bottom width of 1 000 mm and a depth of 1 000 mm. The side slopes shall be 1:1 and sufficiently protected from erosion by means of either a concrete lining or drop structures, depending on the slope and flow characteristics.

In order to convey the 1:20 year peak runoff from the north eastern ridge across the canal, a series of culvert pipes ranging from 600 mm diameter to 1 050 mm diameter would need to be placed along the canal route at low points. This amounts to 73 culvert crossings. All culvert pipes would need to be encased in concrete below the canal with at least 200 mm clearance around the pipes.

To avoid differential settlement of the canal at these encased pipes, a 150 mm layer of soft board between the concrete casing and the canal bedding is recommended.

13.5.9 Overhaul and Limited Haul

A cut-fill balance is important for the economy of the canal construction. It is not always possible to achieve this balance due to the topography of the natural ground together with other design parameters. When a cut-fill balance cannot be achieved, material needs to be imported from borrow pits where there is more fill or spoiled in spoil areas where there is less fill. The route of the canal achieves a cut-fill balance over several reaches, indicating that there will be very limited mass haul needed. Where fill is needed under the canal, the material can be obtained from the cut material in adjacent canal reaches.

13.5.10 Flow Measurement

Flow measurement should be incorporated into the canal design to improve the water management of the system, including loss detection and management. The use of Crump weirs for flow measurement is recommended.

A minimum of four flow measurement locations are recommended for the canal:

1. Directly downstream of the Bulshoek Weir where the existing Parshall Flume must be replaced by a Crump Weir;
2. On the existing Left Bank Canal, downstream of the inlet to the pipe bridge syphon, to measure flow to existing farms on the left bank;
3. On the new Right Bank Canal, directly downstream of the pipe bridge syphon; and
4. On the new Right Bank Canal, directly upstream of the existing Verdeling syphon inlet.

If practical, it would be optional to place more measuring stations along the route to verify usage.

Ideally flow measurement structures should be provided at each of the new canal off-takes (refer to **Section 13.5.14**) to improve the performance monitoring of the canal and improve the water management of the system.

13.5.11 Rejects

Long weir rejects are proposed at all syphon inlets. These rejects will be placed on the wall of the canal directly upstream of these inlets. The length of the reject weir will be optimised so that the water level does not fluctuate too much when rejecting flow. At the same time erosion protection will be provided to safely convey the flow back to a natural water course.

13.5.12 Canal Road Access

A 4.0 m wide canal service road next to the canal is planned. This road will link to existing roads at locations where the canal crosses these roads. It is envisaged that the service road will be used as access road during the construction of the canal.

13.5.13 Special Considerations of the Left Bank Canal Upgrade

There are some other considerations that are particular to the upgrading of the Left Bank Canal (as shown in **Figure 13-**), most notable the fact that the existing canal would be closed during construction.

Figure 13-8: Existing Left Bank Canal looking downstream (approx. ch 1.2 km)

To overcome the temporary closing of the canal, it would be necessary to pump water from the Olifants River into the existing canal downstream of the 3 km section to be upgraded. A flow of approximately 12 000 m^3/h (3.33 m^3/s) would need to be pumped at a head of 20 m, over a distance of 75 m from the Olifants River to the canal.

It is anticipated 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 pumping. To mitigate this risk the construction can be undertaken over two consecutive calendar years.

Electrical power supply sources will need to be investigated for the temporary pumping.

The existing access road next to the canal can be used, but will need to be improved for construction.

13.5.14 New Canal Off-Takes

New off-takes from the canal will be required to supply the irrigation farmers of the recommended development options, such as the new irrigation schemes in the Trawal area. The off-takes will either be supplied under gravity or via a pump system due to the topography of the irrigation areas.

The phasing out of the existing Doring canal section, once the Right Bank Canal Scheme has been completed, will require that the farmers currently being supplied by this canal will need to be provided with off-take points from the Right Bank Canal.

13.6 Syphons

Syphons are required in two sections along the new Right Bank Canal route:

1. Syphon 1 (S1) crosses the Olifants River at approximately 3.05 km downstream of the Bulshoek Weir;
2. Syphon 2A (S2A) crosses the Doring River; and
3. Syphon 2B (S2B) avoids a steep, sandy hillside shortly after the Doring River crossing.

13.6.1 Routing of Syphons

The routing of Syphon 1 is north, north-east from the existing main Left Bank Canal to the right bank of the river. It is located between chainage 3.05 km and 3.35 km. It includes a 46 m stretch of concrete encased steel pipe, a 120 m long pipe bridge, followed by a 133 m long stretch of concrete encased steel pipe.

The routing of Syphon 2A is north, north-west and crosses the Doring River between chainage 21.91 km and 23.18 km. The syphon discharges into a short reach of canal, before Syphon 2B heads north-west from chainage 23.86 km to 24.70 km. Syphon 2A and 2B are both rectangular concrete culverts.

13.6.2 Hydraulic Design

Syphons are designed to minimise frictional losses as far as possible to ensure that the tie-in at Verdeling has a positive head of at least 1.0 m. Some key syphon design parameters are shown in **Table** 13-2.

The concrete culvert should be cast in-situ. Water stops should be added at all joints to ensure proper sealing against any leakage at the syphon design pressures. At the detailed design phase of the project, structural analysis needs to be done to confirm the detail (reinforcement and wall thickness) of the culvert for the expected loading conditions.

Table 13-2: Key syphon design parameters

Parameter	Syphon 1	Syphon 2A	Syphon 2B
Length (m)	300	1 270	840
Type	X42 Steel pipe	Reinforced concrete culvert	Reinforced concrete culvert
Shape	Circular	Rectangular	Rectangular
Size (mm)	DN 2400	2800 x 2400 (W x H)	2800 x 2400 (W x H)

13.6.3 Installations Above and Below Ground

Syphon 1 is designed to cross the Olifants River with a 120 m long pipe bridge. Up to the bridge abutments on each riverbank though, the syphon should be placed below ground. This is similar to the existing pipe bridge at Verdeling.

Syphon 2 is placed below ground to allow future farming development over the syphon. Because the Doring River is not a perennial river, it would make sense to construct the syphon below ground during the dry season. There would be no need for a pipe bridge or pipe jacking, as these options are both impractical for these sites.

13.6.4 Syphon Inlet Structure

The Syphon 1 inlet on the left bank, consisting of an open reinforced concrete structure, will supply flow to the Right Bank Canal, across the Olifants River, and also service the now secondary Left

Bank Canal. The structure will thus have a side syphon inlet, with gates that can control the flow for either the new Right Bank Canal or the existing Left Bank Canal. The inlet structure is to be provided with a trash rack at the entrance to screen out large floating debris and reduce possible ingress of any other foreign material into the syphon pipe. A long weir reject with erosion protection is also provided upstream of the Syphon 1 intake. Silt will be flushed out of the syphon using scour valves.

13.6.5 Syphon Outlet Structure

An open reinforced concrete structure is proposed for the typical syphon outlet. All three syphon outlet structures will be similar as there are no unique requirements at any of the outlets.

13.6.6 Syphon Dewatering

The proposed scour installations should be designed to ensure a minimum scour velocity in the pipeline of 0.5 m/s and maximum velocity through the scour outlet not exceeding 6 m/s. A sacrificial valve will have to be added in some cases to get the velocity under the maximum scour velocity. Where necessary, scour pipework and valve diameters should be increased in order to lower friction sufficiently through the valves. Scour valve chambers will be used to house the scour valves.

Orifice plates should be incorporated to limit flow velocities through the valves and to prevent cavitation of the scour pipes downstream of the orifice plates.

Access points should be provided on each of the syphon pipes for maintenance purposes. These access points will be used to drain the remaining water out of the syphon, which cannot be drained under gravity, by allowing the insertion of dewatering pumps.

The water released through the scour valves would be channelled to natural drainage channels, streams or rivers. Lined channels, to prevent erosion, will be provided to convey the water from the scour valves to the natural water courses.

13.6.7 Air Valves on Syphon

Sizing and positioning of air valves is based on the rate at which air will be introduced or expelled from the pipeline. Care should be taken to provide at least 5 m of positive head at an air valve to ensure that it closes properly.

13.7 Existing Verdeling Syphon

13.7.1 Existing Outlet Structure and Syphon

The proposed Right Bank Canal needs to tie in with the existing syphon at Verdeling. This syphon currently operates by conveying flow from the Left Bank Canal, across the Olifants River, to the outlet and distribution canals on the right bank. At the outlet the flow divides west and south-east. The south-eastern small canal (Doring section) will be replaced by the new Right Bank Canal. **Figure** 13- shows the layout and operation of the existing Verdeling syphon.

According to correspondence with design engineers of the syphon at Verdeling (Element Consulting Engineers), it is a DN 2000 steel pipe and approximately 650 m long. The current left bank inlet's operating level is at 50.443 masl and the right bank outlet's operation level is at 49.488 masl. It was concluded that the syphon does not currently operate at its peak capacity and that there should be spare head room for increased flows from the left bank to the right bank.

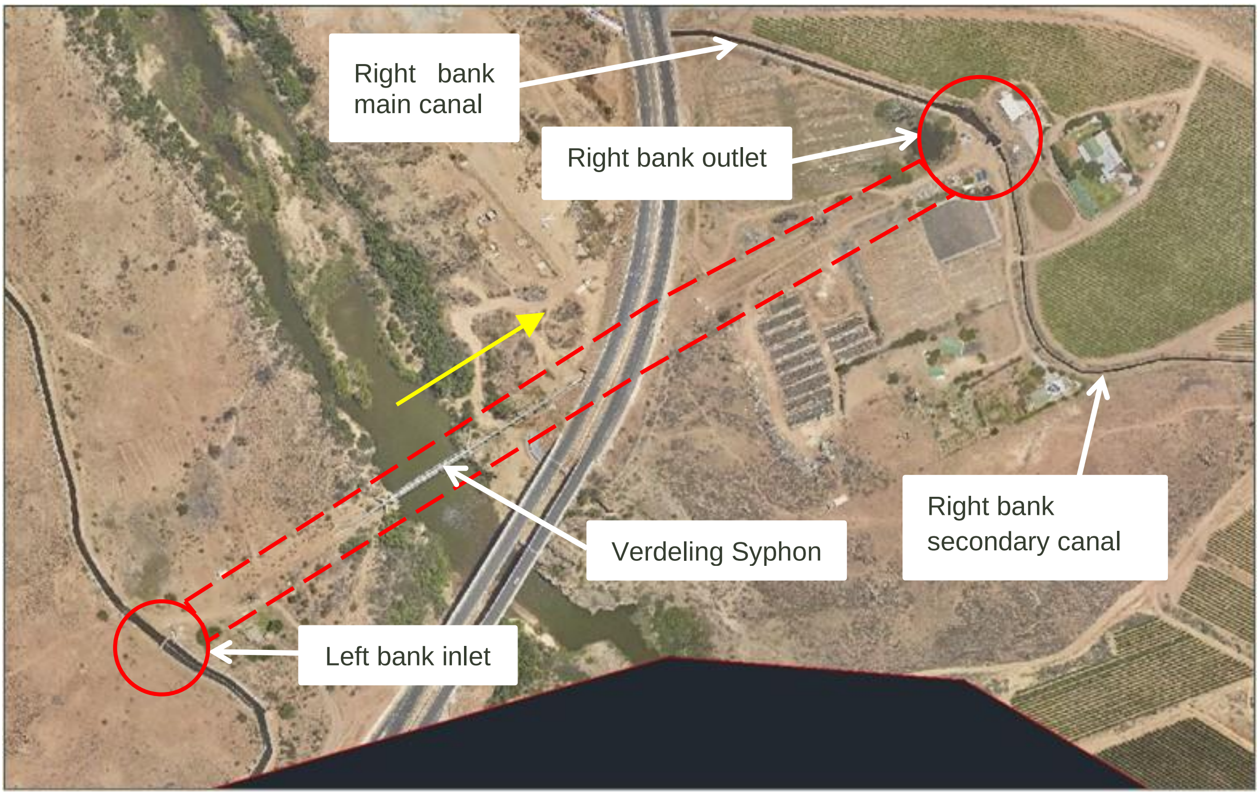

Figure 13-9: Layout and operation of existing Verdeling Syphon

13.7.2 Proposed Inlet Structure

For the proposed Right Bank Canal, the flow in the Verdeling syphon will be reversed. The right bank outlet will be altered to become an inlet with gates to continue servicing the existing downstream right bank distribution canal.

As the current syphon has a physical level difference of approximately 0.96 m to accommodate the design flow from left bank to right bank, the height of the proposed new inlet must be increased by at least the 0.96 m, plus the design head difference, to reverse the flow (as discussed in **Section 13.7.4**). The walls of the new inlet will be placed on top of the existing structure and strengthened. Vertical sluice gates will control the flow through the syphon and to the existing right bank distribution canal. A Crump weir flow measuring station must be placed downstream of the inlet to confirm flow to the right bank distribution canal. A trash rack will be placed upstream of the inlet, as well as a reject with relevant erosion protection and a stream path back to the river.

13.7.3 New Syphon Design Flow Capacity

The total peak design flow for the reversed Verdeling Syphon is calculated as **4.02 m^3/s**, as shown in **Table** 13-3.

Table 13-3: Verdeling Syphon peak design flows

Flow component	Flow rate (m^3/s)
Current Left Bank Canal capacity	2.706
Improved assurance of supply to existing allocations	0.687
Future non-irrigation flows	0.271
Additional irrigation	0.357
Total peak design capacity	**4.021**

The peak design capacity can be revisited should there be a need to make additional provision for existing allocations.

13.7.4 Proposed Reversed Verdeling Syphon Hydraulics

The reversed (right bank to left bank) syphon duty is based on the above total peak design flow of 4.021 m^3/s. As the pipe diameter and design flow are fixed, the available head and assumed pipe roughness will equate the flow velocity. The scenario with an old syphon with maximum flow and higher friction factors (aged pipe) was investigated. An aged steel pipe roughness of 0.15 mm was assumed.

13.8 Cost Estimate

The basis of the cost estimate for the canal and associated infrastructure was to price each scheme element at feasibility level of evaluation by listing design items and structural volumes. All rates were gathered from previous South African projects from years between 2015 and 2020, and by contacting relevant manufacturers. All rates were then escalated to October 2020 values at 6% per annum for comparison.

Although the abstraction works, pump stations, pipelines and farm dams associated with water supply to the four irrigation areas were not designed at feasibility level, estimated costs were separately determined for such (likely privately-owned) bulk water infrastructure at reconnaissance level.

The capital cost of the Right Bank canal and directly associated infrastructure is estimated to be R 1 832.8 million (incl. VAT). Refer to **Table** 13-4 for the cost summary. This estimate excludes the capital cost of pump stations, pipelines, farm dams, professional design and support, and land acquisition to supply the four irrigation areas).

Table 13-4: Cost estimate for the proposed Right Bank Canal Scheme (incl. VAT)

Description	Rate	Cost (R million)
Outlet - existing Bulshoek Weir outlet		0
Canals		645.128
Syphons 1, 2A and 2B		140.409
Verdeling Inlet		4.458
R363 Road crossings and major farm road crossings		29.614
Sub-Total A		**819.611**
Preliminary & General (% of subtotal A)	40%	327.844
Sub-Total B		**1 147.455**
Contingencies (% of subtotal B)	25%	286.864
Sub-Total C		**1 434.319**
Professional Fees (% of subtotal C)	10%	143.432
Land Acquisition		15.979
TOTAL COST (excl. VAT)		**R 1 593.730**
VAT	15%	239.059
TOTAL COST (incl. VAT) (October 2020 prices)		**R 1 832.789**

The total annual operation and maintenance (O&M) costs estimated for the Civil and Mechanical Works is R 3. 6 million (excl. VAT), i.e. R 4.1 million (incl. VAT).

13.8.1 Comparative Capital Costs (NPV and URV)

The full comparative capital cost (2020 prices, excluding VAT) of the 'full' Scheme is shown in **Table** 13-5. The full comparative capital cost includes the required additional bulk water infrastructure for the abstraction of water from the new Right Bank canal (pump stations, pipelines, farm dams, etc.), and pumping it to each of the four new irrigation areas. The additional bulk water infrastructure was assessed at reconnaissance level.

Table 13-5: Right Bank Canal Scheme Comparative Capital Costs in million Rand (October 2020 costs, excl. VAT)

Pump stations	Pipelines & syphon	Farm dams	Right Bank main canal	Purchase of land	Prof. design & Support	Total Cost (R million)
153.04	83.86	27.42	1 434.32	83.30	213.72	**R 1 994.66**

Should a new Right Bank main canal not be constructed, then two small bulk water schemes would supply the same four irrigation areas. The estimated costs of these small schemes are described in Chapter 5.7 of the *Conceptual Design Sub-Report*. The reconnaissance (desktop) level capital cost estimate for the combined small schemes to supply the four irrigation areas amounts to R 573.16 million, at October 2020 prices excluding VAT. This estimate is regarded as the attributable 'Development' capital cost component of the Right Bank Canal Scheme. The 'Development' capital cost is the cost attributable to the development of new irrigation areas, as opposed to the 'Betterment' capital cost of replacing the existing main canal, which serves the new and existing irrigation areas.

The difference between the development cost of the two small schemes and the full cost of the Right Bank Canal Scheme is therefore deemed the 'Betterment' capital cost. The betterment capital cost component of the scheme is therefore R 1 421.5 million, excluding VAT (R 1994.66 - R 573.16). The Development and Betterment cost components are shown in

Table 13-6.

Table 13-6: Development and Betterment Cost Components of the Scheme (October 2020, excl. VAT)

Scheme infrastructure component	Development Cost (R million)	Betterment Cost (R million)	Total Cost (R million)
Lining/raising 8 km portion of existing main canal & small high-level canal	172.24	1 262.08	1 434.32
Right Bank Canal Scheme	-		
Pump stations (small schemes)	153.04	-	153.04
Pipelines & syphons (small schemes)	83.86	-	83.86
Farm dams	27.42	-	27.42
Land	66.32	15.98	82.30
Professional design and support	70.29	143.43	213.72
Total Capital Cost (excl. VAT) October 2020 prices	**R 573.16**	**R 1 421.50**	**R 1 994.66**

The NPV and URV of the scheme are given in **Table** 13-7. The attributable betterment costs are the difference between the NPVs of the development costs (two small schemes) and the cost of the Right Bank Canal Scheme. The URV is applicable to development of the new irrigation areas.

Table 13-7: Right Bank Canal Scheme: NPV and URV (costs excl. VAT)

Cost Item	Development costs - 2 small schemes	Right Bank Canal	Betterment costs
Total NPV Cost (R million)	R 782.28	R 2 046.33	R 1 264.05
Unit Reference Value (R/m^3)	**R 3.05**		

13.9 Further Investigations for Detailed Design

Recommendations applicable to the detailed design and construction phases of the project have been made regarding the following aspects:

a) Confirmation of scheme routing and sizing, and location of infrastructure.

b) A more detailed analysis and survey of the existing Bulshoek Weir Outlet.

c) Taking account of findings from the further geotechnical investigations undertaken, i.e. the geophysical evaluation and core drilling of syphon routes.

d) A ground centreline survey along the final chosen canal routes.

e) Discussions with affected landowners and authorities.

f) Adjusted offtake points for the four new irrigation developments, and offtake points to farmers of the phased-out Doring canal section.

g) Influence of the approved Marblesharp farm dam.

14 Ebenhaeser Scheme Feasibility Design and Cost Estimate

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

The feasibility design of the scheme is explained in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*.

14.1 Spare Flow Capacity in Canals and Scheme Sizing

An assessment of historical flows in the various existing canal sections vs. their maximum flow capacity identified the spare flow capacity in each canal section for each year. 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. The location of the abstraction point/s from the canals influences the sizing of the scheme.

To allow for the likely increase in flows to existing allocations before most of the canal infrastructure has been upgraded, and to limit the risk of shortfall in supply to 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 were further based on selected non-drought years where flows are high, to further limit the risk of a shortfall in supply to the Ebenhaeser Scheme and to be more representative of the situation after the Clanwilliam Dam has been raised. Canal losses are a significant factor and this has been taken into account, for the various canal sections.

Water availability from the scheme was determined as 4.66 million m^3/a, including losses of 1.01 million m^3/a (conveyance losses and balancing dam evaporation), to irrigate 361 ha of irrigable area. The water availability (excluding water losses) for the selected sub-option is thus 3.65 million m^3/a and the minimum balancing dam capacity needed is 2.152 million m^3.

14.2 Water Requirements

The existing Ebenhaeser Community, that is located approximately 12 km from Lutzville, has expressed a strong need for expansion of the mostly subsistence farming activities. The successful land claim lodged by the Ebenhaeser Community, which has resulted in farms being handed over to Ebenhaeser Community Project Association, with existing water allocations to some of these farms being inadequate.

Five water requirement clusters have been identified. It has been assumed that the restitution farms, to be commercially farmed, will use 80% of the scheme's supply volume in four water requirement 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.

14.3 Overview of the Scheme

Canal diversion structures will be required at the Retshof right bank and Vredendal left bank canals to create off-take points. Canal flows will be diverted from these diversion structures during weeks with surplus flow and will gravitate to a balancing sump. From the sump, water will be pumped via the "diversion" rising main to the Ebenhaeser balancing dam. From the Ebenhaeser balancing dam, water will be pumped via a rising main to a concrete balancing reservoir, from where water will gravitate to the edge of the water requirement clusters.

The Lower Olifants River Water Users Association (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 existing right and left bank canals. LORWUA has also requested that the scheme be able to divert 24 Mℓ/d (0.278 m^3/s) back from the balancing dam, which can be discharged into the right (12 Mℓ/d) and left bank (12 Mℓ/d) canals, respectively, at times of low flow in the canal.

Figure 14- and **Figure** 14- show the layout and bulk water infrastructure components for the Ebenhaeser Scheme.

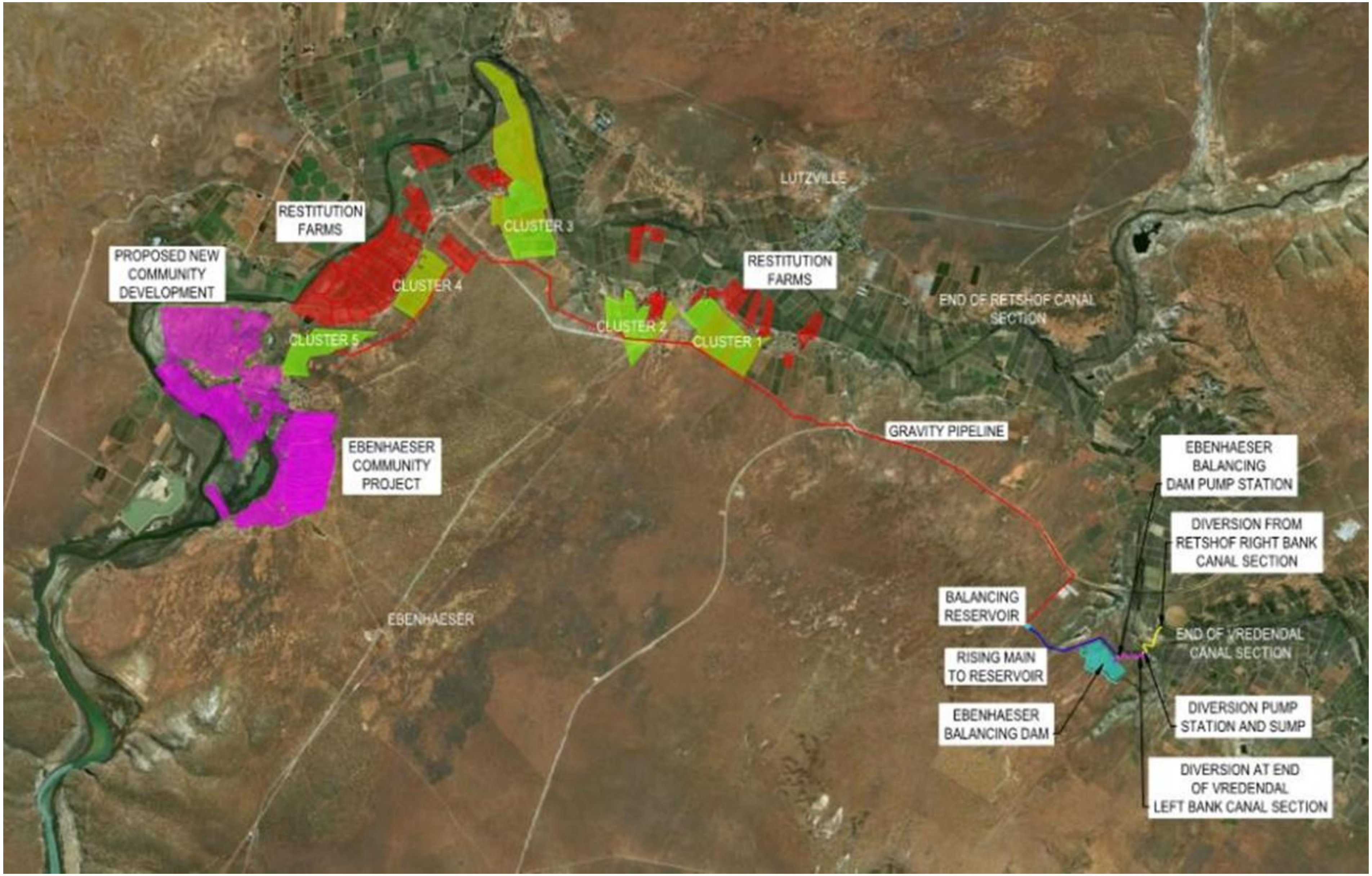

Figure 14-1: Layout of Ebenhaeser Scheme

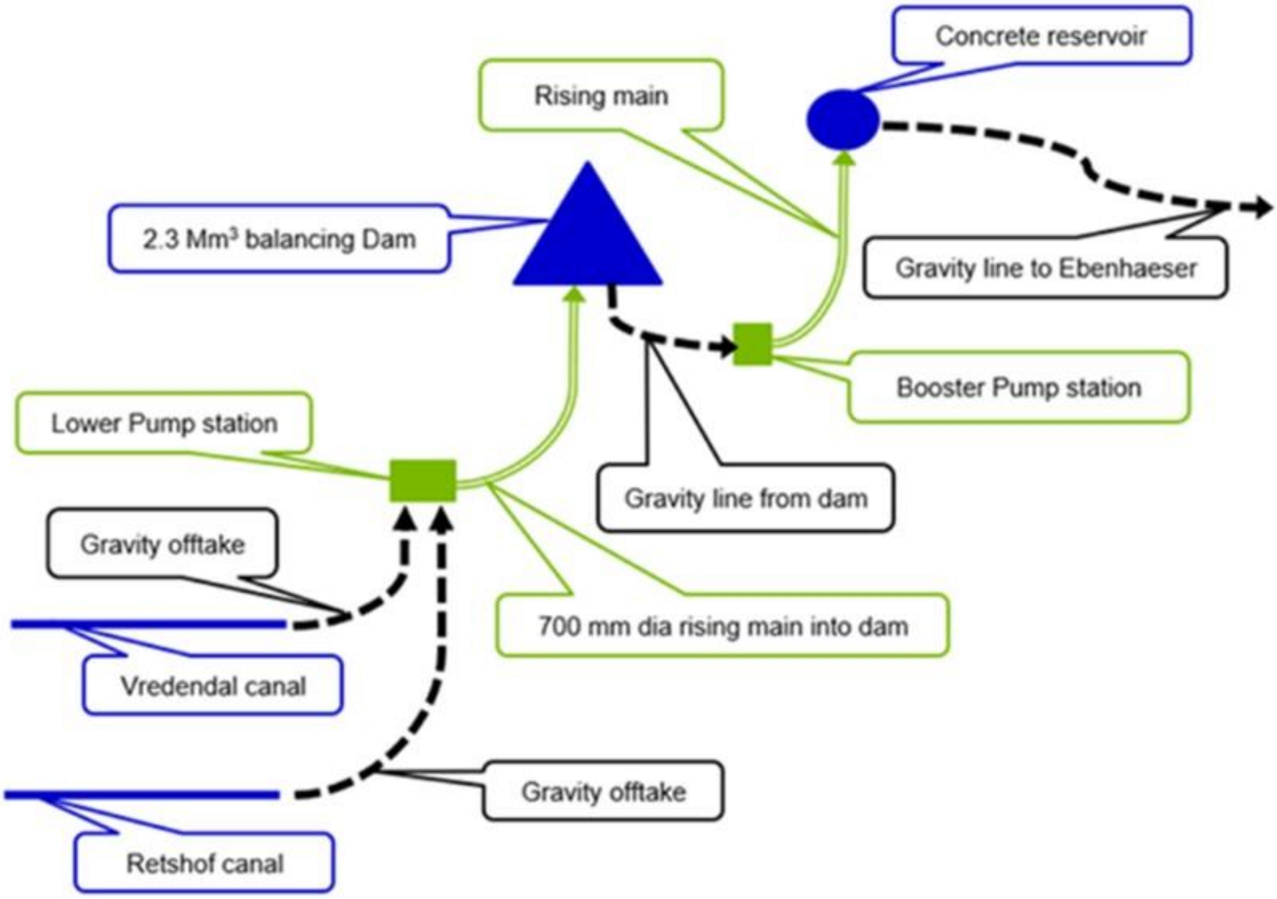

Figure 14-2: Schematic Layout of Ebenhaeser Scheme

14.4 Canal Diversion Structures

Two diversion structures will be required, on the right bank canal at the Retshof canal section and on the left bank canal at the end of the Vredendal canal, respectively. The diversion point in the right bank Retshof canal section is in the middle of a long bend, as shown in **Figure** 14-, with the Sishen-Saldanha railway line visible in the background. The proposed diversion point in the left bank Vredendal canal section is in a cutting upstream of a long weir, just before a tunnel, as shown in **Figure** 14-.

It is proposed that the diversion structures comprise an adjustable weir that would allow for regulating of the flow that could be discharged from the canal to the diversion sump. The water from the diversion structures will discharge into a wet well that will be piped through a mechanical or electro-magnetic flow meter. The display from the flow meter will be positioned next to the adjustable sluice gate, which will allow the weir to be adjusted to discharge a certain flow.

Figure 14-3: Proposed position of the Retshof right bank canal diversion structure

Figure 14-4: Proposed position of the Vredendal left bank canal diversion structure

The proposed diversion structure configurations are shown in **Figure 14-** (typical section view) and in **Figure 14-** (typical plan view).

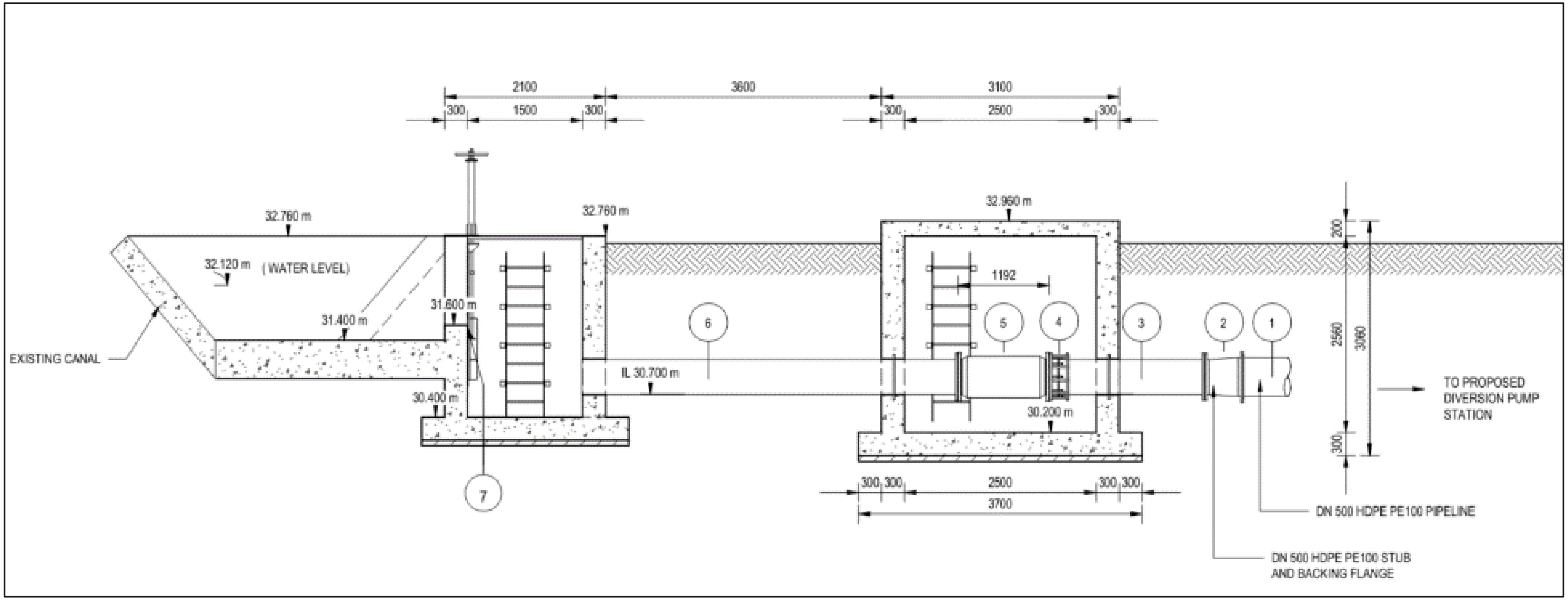

Figure 14-5: Typical section of Canal Diversion Structure

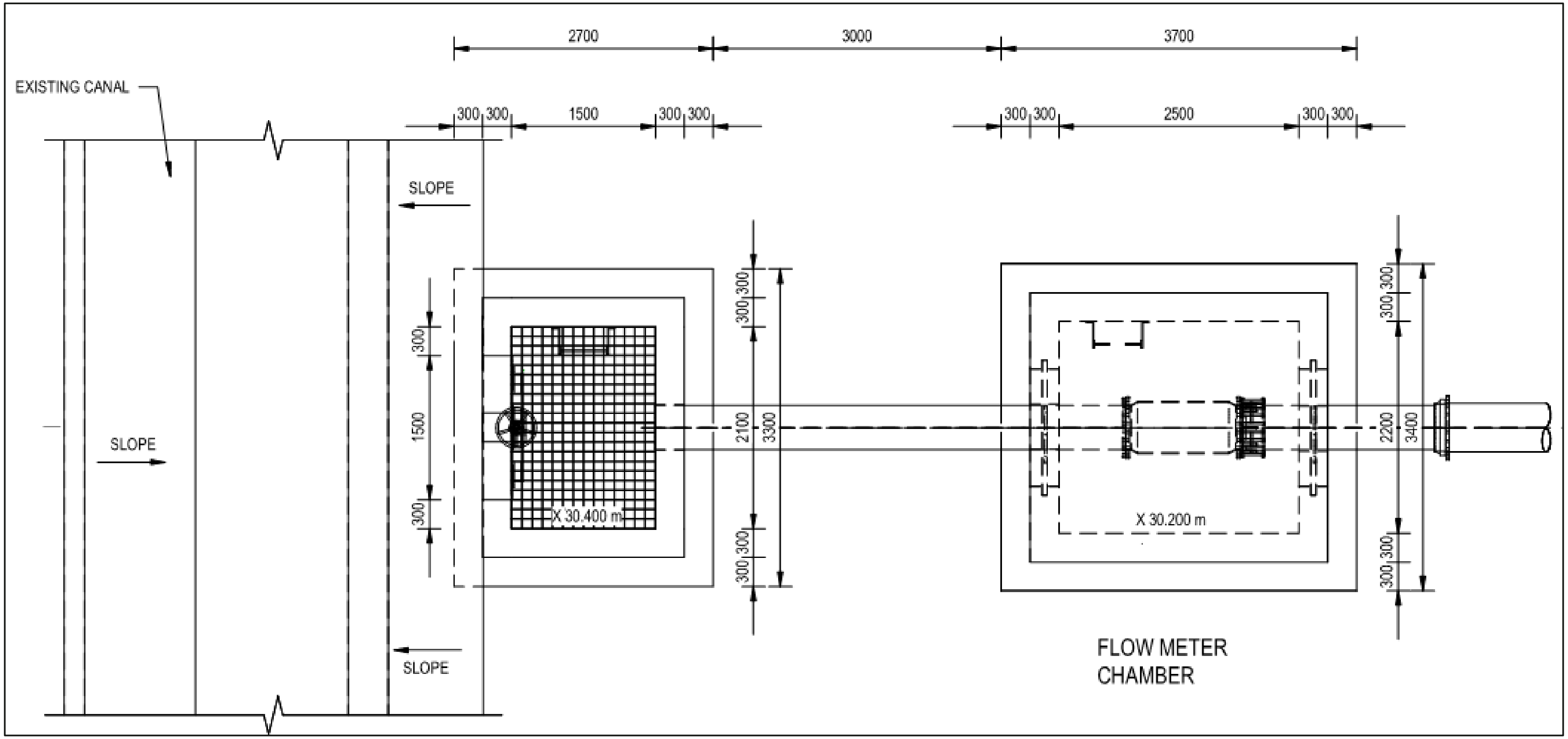

Figure 14-6: Typical plan view of Canal Diversion Structure

14.5 Diversion Gravity Pipelines

14.5.1 Description of the pipelines

The proposed diversion gravity mains comprise two gravity pipelines, namely:

- A pipeline supplying water from the Retshof canal to the diversion sump and pump station (765 m in length), which includes a syphon through the Olifants River; and
- A pipeline supplying water from the Vredendal canal to the diversion sump and pump station (93 m in length).

From the sump, the raw water will be pumped to the Ebenhaeser balancing dam. The design flow for the Retshof canal diversion gravity main is 0.29 m^3/s, as recommended in the *Conceptual Design Sub-Report*. The design flow for the Vredendal canal diversion gravity main is 0.36 m^3/s. **Figure 14-** shows the hydraulic gradient line of the Retshof Canal Diversion Gravity Main for a flow of 25.5 Mℓ/d (0.29 m^3/s) and using a DN 500 HDPE pipe.

It is evident from **Figure 14-** that a residual pressure of approximately 18 m would be available at the inlet to the sump. The DN 500 HDPE pipe will result in a velocity of 1.94 m/s at a flow of 25.5 Mℓ/d. This high velocity is preferred to ensure that sediment remains in suspension in the syphon underneath the Olifants River.

Figure 14- shows the hydraulic gradient line of the Vredendal Canal Diversion Gravity Main for a flow of 30.80 Mℓ/d (0.36 m^3/s) and using a DN 560 HDPE pipe.

It is evident from **Figure 14-** that the residual head at the inlet to the sump would be approximately 25 m. The DN 560 HDPE pipe will result in a velocity of 1.89 m/s at a flow of 30.8 Mℓ/d.

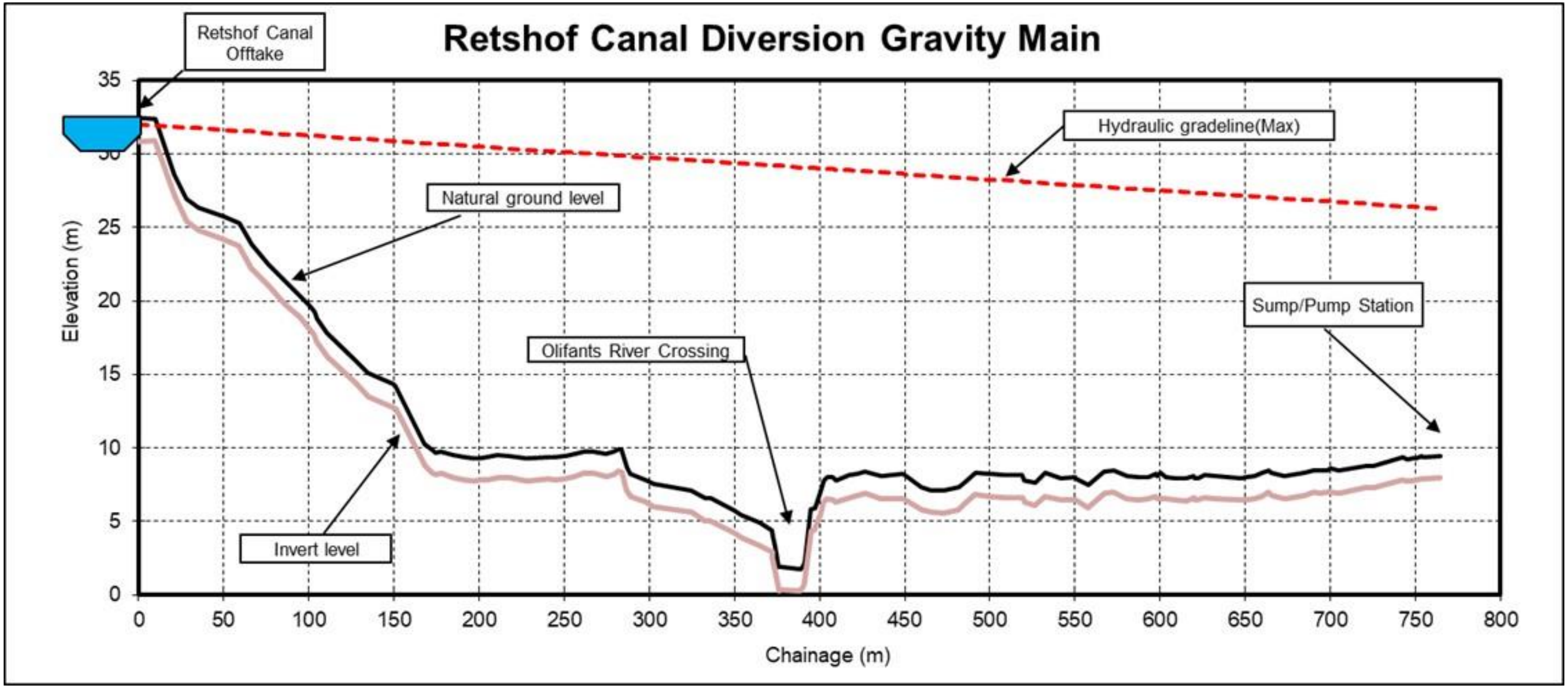

Figure 14-7: Retshof Canal Diversion Gravity Main: HGL for 25.5 Mℓ/d in aged DN 500 pipeline

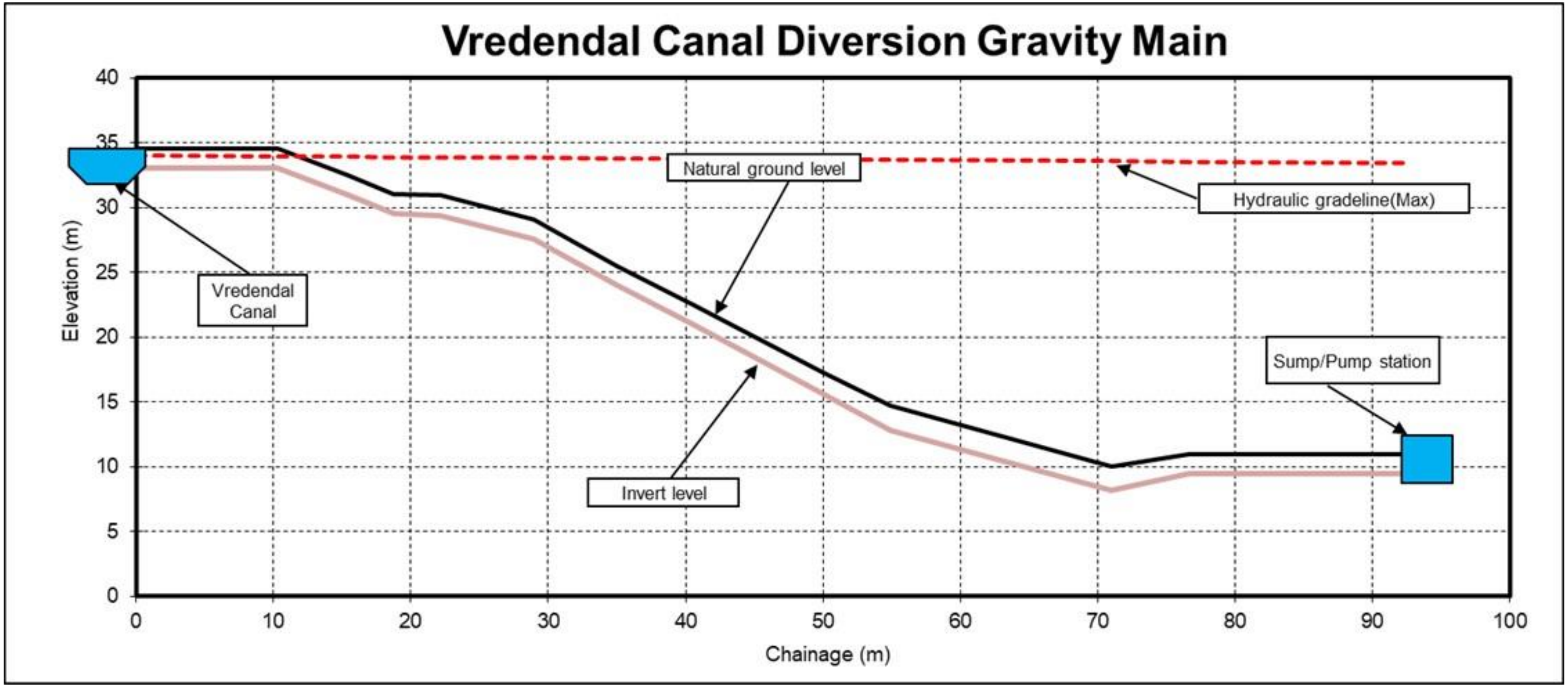

Figure 14-8: Vredendal Canal Diversion Gravity Main: HGL for 30.80 Mℓ/d in aged DN 560 pipelines

14.5.2 Olifants River Crossing

A syphon would be required on the diversion gravity main from the Retshof canal to cross the Olifants River. The crossing is located approximately 380 m from the right bank canal offtake point, and the length across the river is approximately 37 m. It is recommended that a below ground syphon crossing be implemented using a DN 500 stainless steel pipe encased in concrete.

14.6 Diversion Pump Station and Sump

The diversion sump will collect water from the Retshof and Vredendal canal diversion gravity mains. The pump station will pump the water via the diversion rising main to the Ebenhaeser Balancing Dam.

14.6.1 Pump Duties

A pump configuration of two (2) duty pumps and one (1) standby pump is proposed for the Diversion Pump Station.

Figure 14- shows the characteristic and pump curves for the diversion pump station.

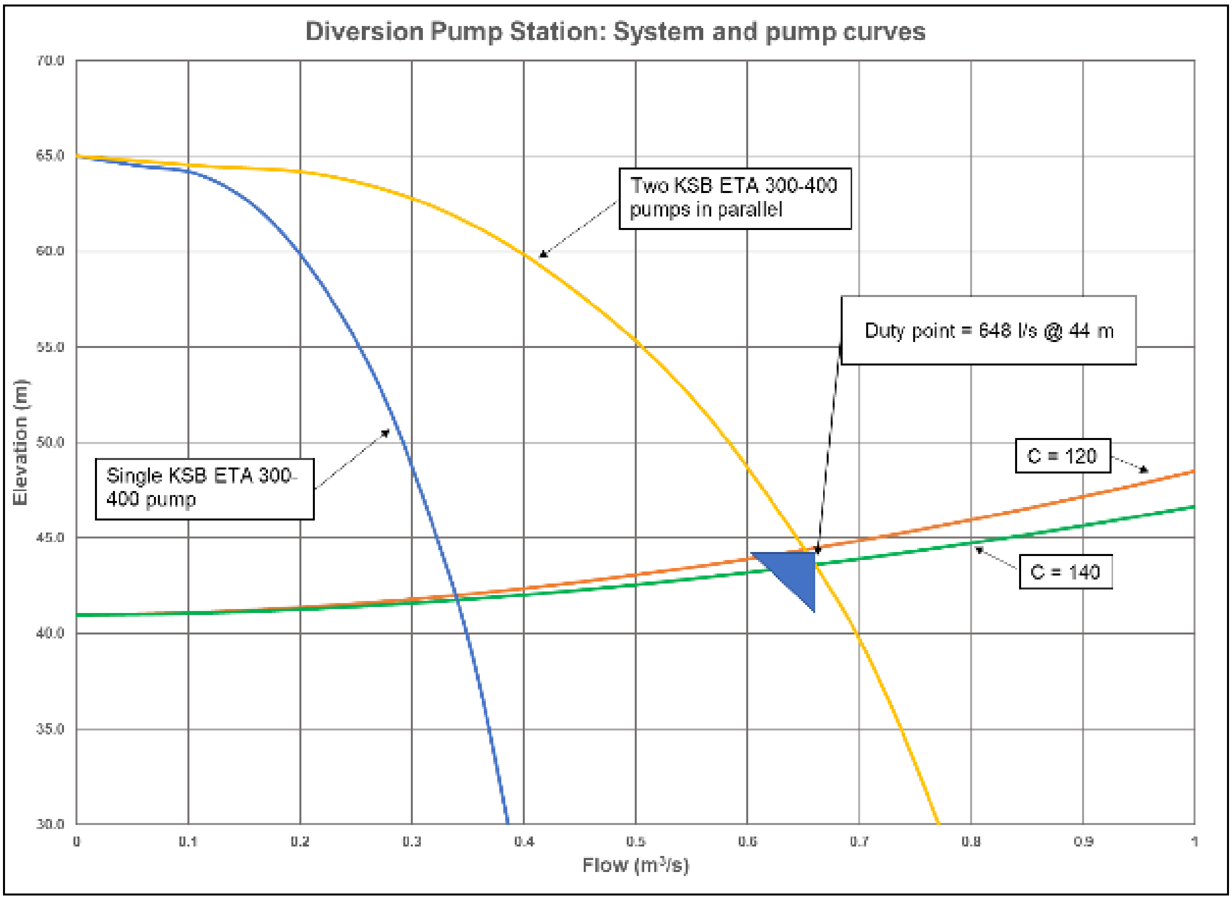

Figure 14-9: Characteristic and pump curve for diversion pump station

It is evident from **Figure 14-** that the diversion pump station has a duty point of 56 Mℓ/d (0.65 m^3/s) at a total pumping head of approximately 44 m. It is proposed that variable speed drives (VSDs) be installed so that the pump station can match the inflow from the two canal off-takes, which will vary on a daily and weekly basis. The VSDs will require a smaller diversion sump and will reduce the number of stops and starts required.

14.6.2 Diversion sump

The diversion sump is designed to store the flow from the right and left bank canals pumped over a one (1) hour period, i.e. 292 ℓ/s + 356 ℓ/s = 648 ℓ/s pumped over a one hour period, which equates to an active sump capacity of 2 300 m^3 (2.3 Mℓ). It is proposed that a 2 500 m^3 (2.5 Mℓ) sump or reservoir be provided. The sump's minimum operating level is 8.5 masl and the full supply level is 13.5 masl. The existing power supply is about 130 m from the proposed pump station location. The existing overhead line would need to be extended to the pump station. The layout of the diversion pump station and sump is shown in **Figure** 14-.

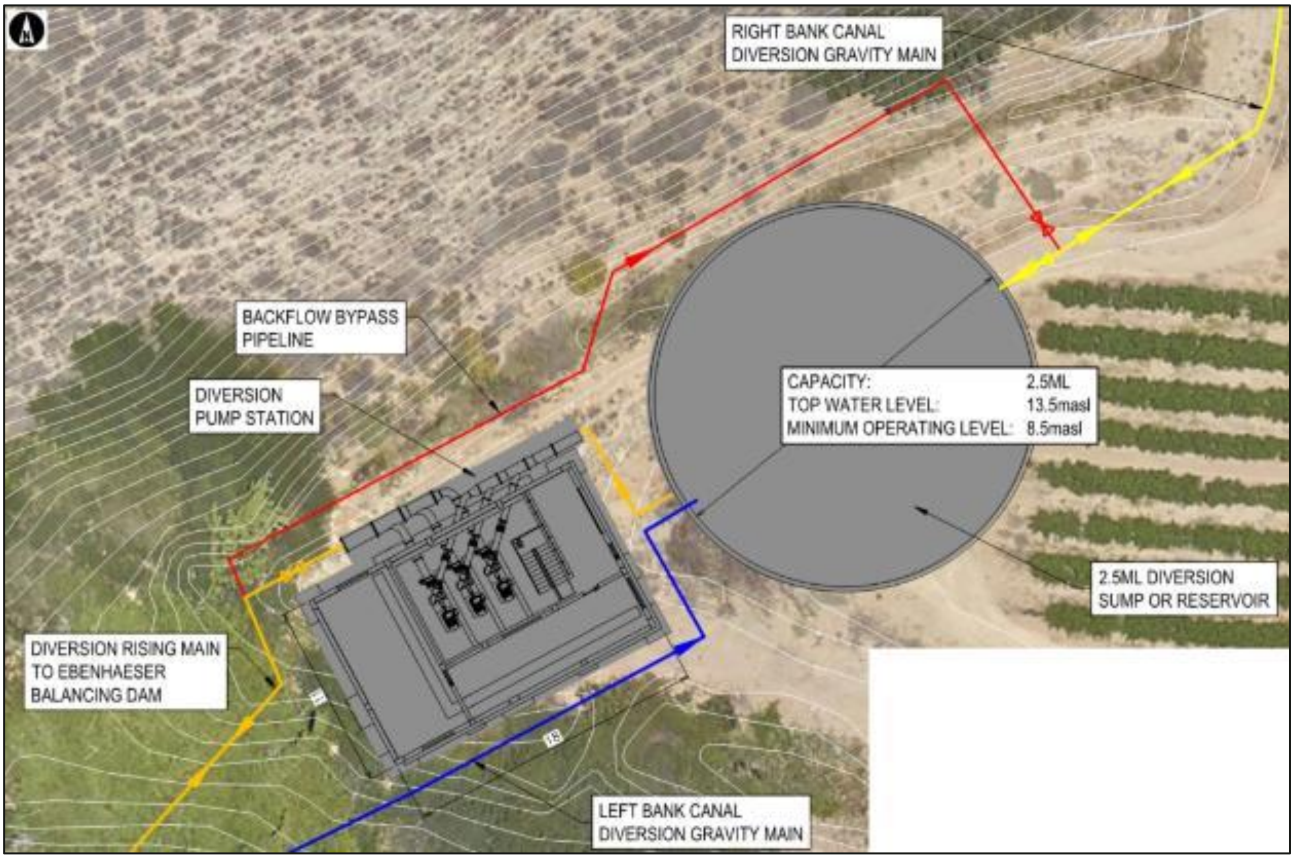

Figure 14-10: Plan View of Diversion Pump Station and Sump

14.7 Diversion Rising Main

The proposed diversion rising main will convey water from the Diversion Pump Station to the Ebenhaeser Balancing Dam. The design flow for the 520 m long rising main is 0.65 m^3/s. It is proposed that a DN 710 HDPE pipe be used, which will result in a velocity of 2.08 m/s. The higher velocity has a minimal impact on the pumping head due to the short length of the rising main. **Figure** 14- shows the hydraulic gradient line of the Diversion Rising Main for a flow of 56 Mℓ/d (0.65 m^3/s).

14.8 Ebenhaeser Balancing Dam return flow to canals

The diversion rising mains are designed to allow water from the Ebenhaeser balancing dam to be supplied back under gravity to the Vredendal canal and the Retshof canal when needed. LORWUA has requested a total return flow of 24 Mℓ/d (0.278 m^3/s), i.e. 12 Mℓ/d (0.139 m^3/s) to be supplied to each of the canals. Water will be fed under gravity from the Ebenhaeser Balancing Dam along the diversion rising main, with a bypass provided at the diversion pump station to discharge water to the Retshof canal. Provision will be made for an additional offtake from the diversion rising main to discharge water into the Vredendal canal.

Figure 14- shows the hydraulic gradient line of the return flow from the Ebenhaeser Balancing Dam Pump Station to the Retshof Canal offtake location for a flow of 24.0 Mℓ/d.

It is evident from **Figure 14-** that the residual heads at the Vredendal and Retshof canals would be approximately 18 m and 19 m, respectively. This is sufficient head to install a diaphragm flow control valve to limit the flow to each canal to 12 Mℓ/d.

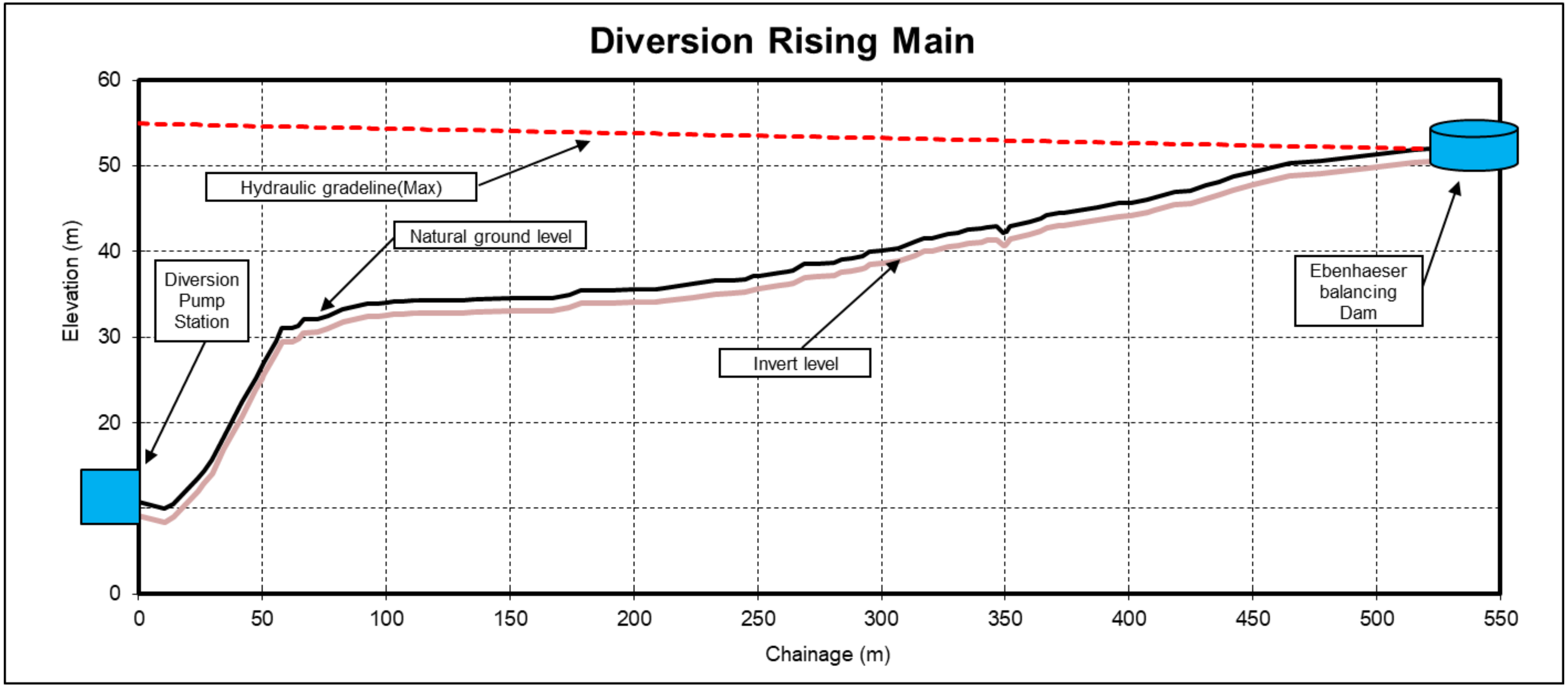

Figure 14-11: Diversion Rising Main: HGL for 56 Mℓ/d in aged DN 710 pipeline

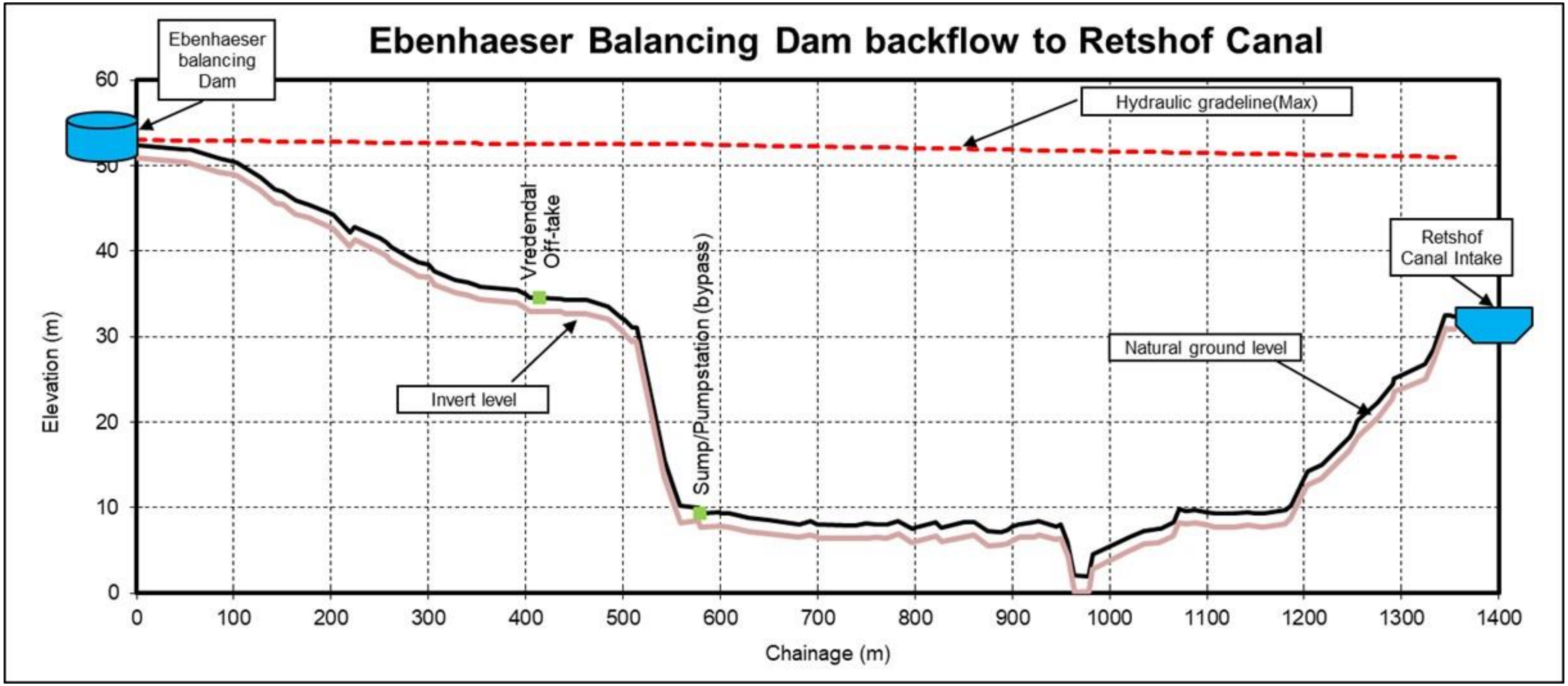

Figure 14-12: Retshof Canal Diversion Gravity Main (return flow): HGL for 24 Mℓ/d

14.9 Ebenhaeser Balancing Dam

14.9.1 Salient features of the proposed dam design

The salient features of the proposed Ebenhaeser Balancing Dam are presented in **Table 14-1**.

Table 14-1: Main details of the Ebenhaeser Balancing Dam

Parameter	Value
Classification	
Size	Medium
Hazard potential	Significant
Classification	Category 2
Dam Site	
Location (coordinates)	31°37'43.63"S 18°23'57.73"E
River	Off channel
Closest town	Lutzville
Distance	10 km
Property description	Bakleiplaas A182: T58032/2000 (Privately owned)
Catchment and flood parameters	
Catchment area	0.9 km^2
Recommended Design Flood (RDF) magnitude	Incoming 3.6 m^3/s Outgoing 0.3 m^3/s
Water surface elevation at RDF discharge	70.45 masl
Safety Evaluation Flood (SEF) magnitude	Incoming 24.0 m^3/s Outgoing 0.9 m^3/s
Water surface elevation at SEF discharge	70.60 masl
Probable Maximum Flood (PMF)	34.3 m^3/s
Dam statistics	
Dam type	Lined homogeneous earthfill embankment
Total crest length	1371 m
Maximum height above riverbed level	19.2 m
Embankment Non-overspill crest (NOC)	72.2 masl
Full supply level (FSL)	70.4 masl
Gross storage capacity at FSL	2.32 million m^3
Surface area of water at FSL	26.3 ha
Minimum Operating Level (MOL)	55.0 masl

Parameter	Value
Base width of dam at maximum cross section	100 m
Embankment Fill	639,000 m^3
Crest width	5 m
Upstream slope	1V:3H
Downstream slope	1V:2H
Riverbed level at downstream toe	53.0 masl
Spillway	
Spillway type	Uncontrolled trapezoidal by-wash with concrete sill on the right flank discharging into partially lined channel.
Crest level	70.4 masl
Crest length	3 m
Freeboard	1.8 m
Energy dissipation	None
Outlet details	
Inlet and outlet pipes	The dam will have two pipes of 700 mm dia each which serve as the inlet and outlet pipes. The pipes will be encased in reinforced concrete through the embankment. At the downstream end, each of the pipes will have an arrangement to control the inlet and outlet flows. At the upstream end the outlet pipe will connect to an upstream sieve inlet.

14.9.2 Site overview

The proposed location of the Ebenhaeser Balancing Dam (**Figure** 14-) is about 100 m west of a bend in the R363 road, some 11 km north west of Vredendal on the privately owned Bakleiplaas A182 property. The proposed offtake from the Vredendal canal is situated some 200 m from the proposed embankment.

A gross storage capacity of 2.32 million m^3 is required to divert 3.65 million m^3/a water from the Vredendal and Retshof canals, including 0.15 million m^3 for return flow into the canals for operational purposes.

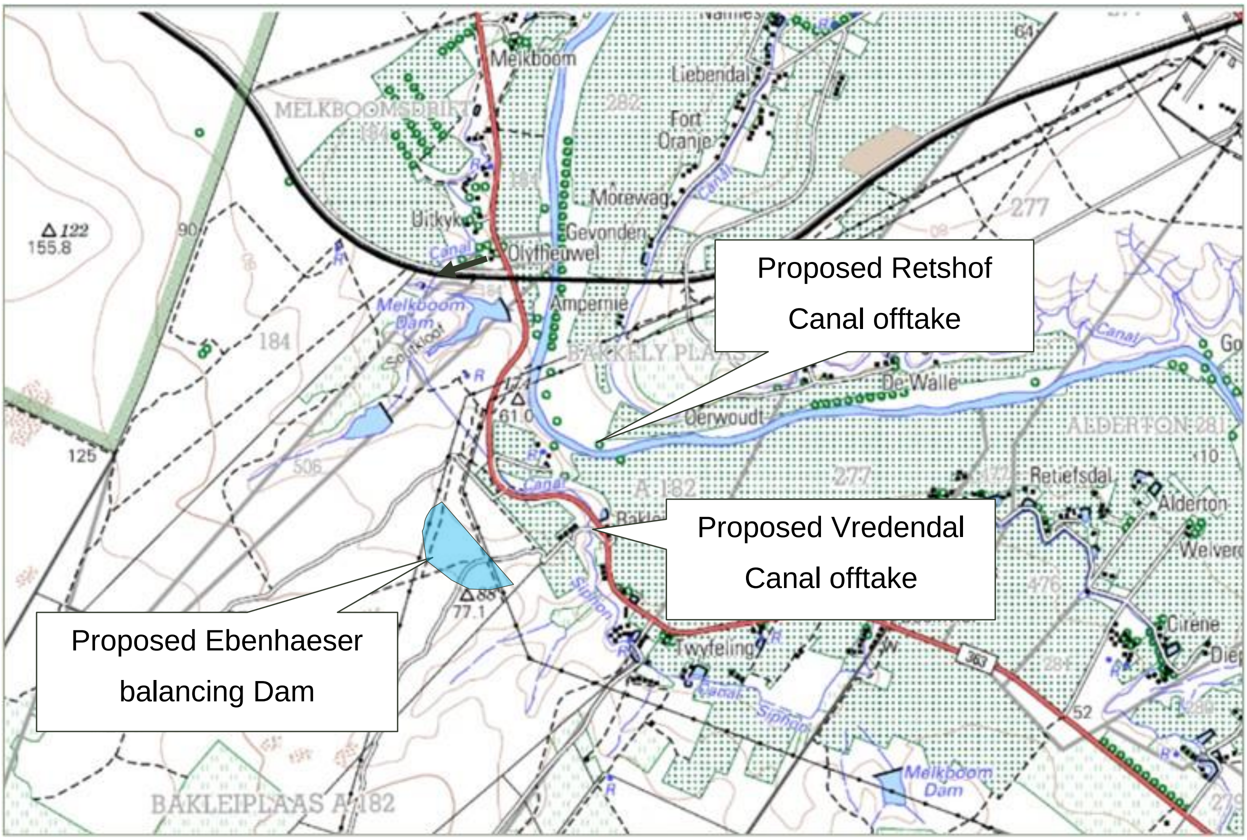

Figure 14-13: Layout plan of the proposed Ebenhaeser Balancing Dam

A Storage vs. Depth curve and a Surface Area vs. Depth curve for the dam basin were generated from the topographical surveys at the proposed dam wall position. These curves are presented in **Figure** 14- below.

The storage volume includes the volume of material excavated from the basin for use as fill material in the embankment.

14.9.3 Dam safety classification

The dam will be classified as a Category II dam due to the wall height and potential risk. This classification is further used in the determination of the freeboard requirements, as well as for the recurrence intervals of the design floods.

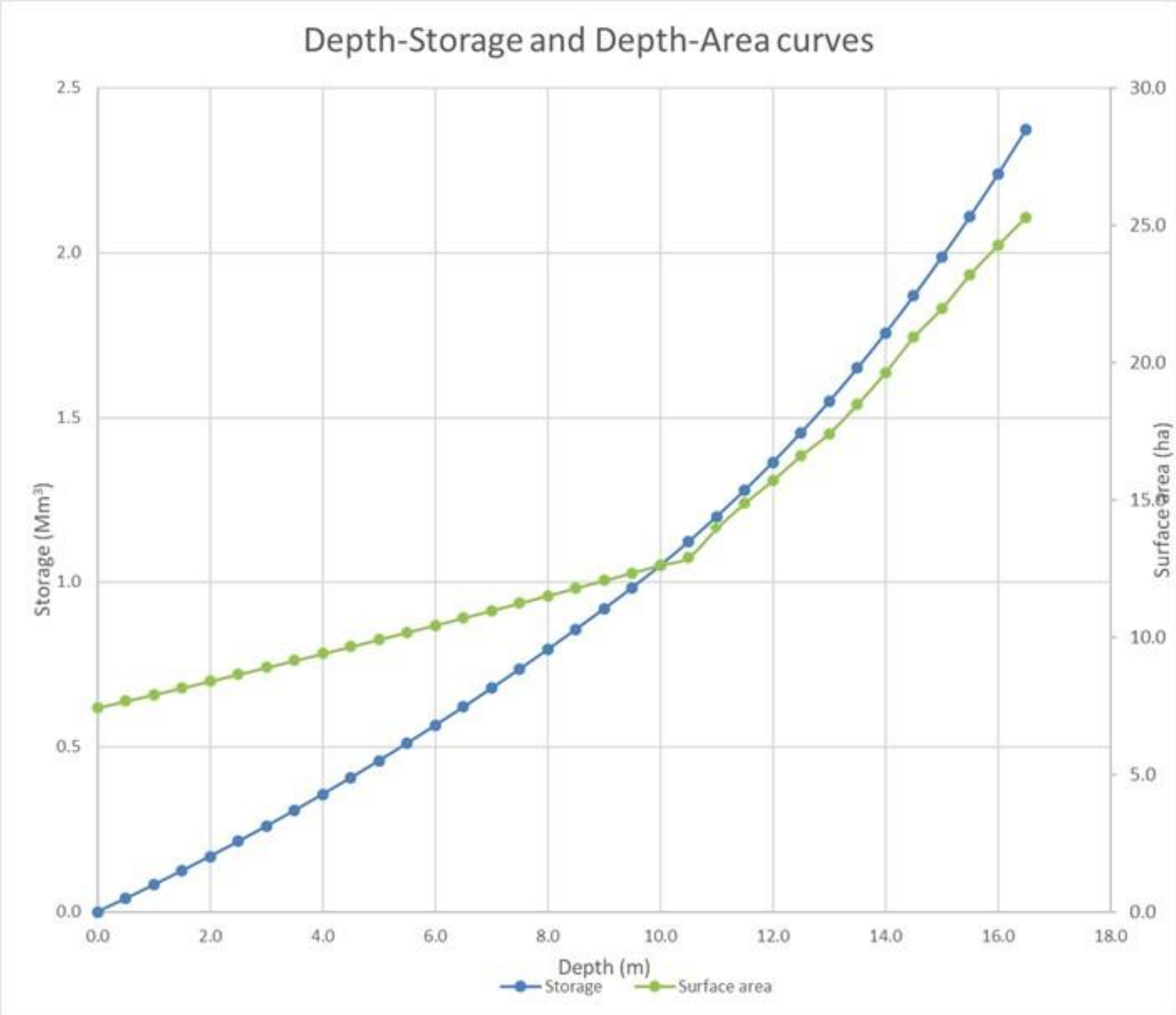

Figure 14-14: Depth-Storage and Depth-Area curves for Ebenhaeser Balancing Dam

14.9.4 Flood hydrology

Based on the small size of the catchment area (0.9 km^2) and its drainage path, it was decided to follow two deterministic approaches for the estimation of the design floods, namely the SCS and Rational Methods.

The two methods resulted in a 1:100 year recurrence interval (1.0 % annual exceedance probability) flood peak of 3.2 m^3/s and a Probable Maximum Flood (PMF) peak of 34.2 m^3/s

For a Category 2 dam, the SANCOLD Guidelines in Relation to Floods (SANCOLD, 1991) recommend that:

a) The Recommended Design Flood (RDF) is equal to the 1:100 year recurrence interval (1.0 % AEP) flood peak of 3.2 m^3/s; and

b) The Safety Evaluation Flood (SEF) is equal to 70% of the PMF, namely 24.0 m^3/s.

Both these floods will be highly attenuated by the large area of the dam in relation to the small flood inflows.

14.9.5 Embankment and Lining Design

14.9.5.1 Dam type selection

Geotechnical investigations show that the materials in the basin are sandy, have very little clay and are very permeable, and thus the dam needs to be lined.

It is proposed that the embankment dam, comprising a homogenous fill zone, should be lined with a HDPE membrane. A 150 mm thick layer of geocell (such as Hyson cell) filled with a sand and cement mixture (soilcrete) will be used to protect the HDPE liner on the upstream slopes from long term UV damage, mechanical damage and possible vandalism.

On the flatter floor portion of the dam the HDPE lining will be covered with a 300 mm thick compacted layer of general fill.

14.9.5.2 Embankment layout and detail

The embankment layout is typically U-shaped to account for the topography, which is more of a gentle incline than a broad valley. It is proposed that the embankment will be constructed with material excavated from the dam basin. The embankment cross-section (**Figure** 14-) has typical slopes of 1V:3H on its upstream side and 1V:2H on its downstream side. The crest is approximately 1 371 m long and 5 m wide with a 2% cross-fall toward the upstream side for surface drainage.

The lowest level at the valley bottom is 53.0 masl and the embankment has a required NOC level of 72.2 masl, which results in a maximum wall height of 19.2 m.

The upstream face is protected by an HDPE lining covered by a sand-cement (soilcrete) layer 150 mm thick (perpendicular thickness). The downstream face is protected by a 250 mm thick layer of crushed stone.

The internal zoning of the homogenous embankment consists of general fill excavated from the dam basin. The upstream slope and dam basin are lined with HDPE to prevent seepage. The lining on the upstream embankment slope and slopes around the dam is protected with a sand-cement (soilcrete) layer. The underdrainage system can consist of an underdrain running all along the upstream toe of the embankment leading to an underdrainage pipe that daylights below the downstream toe.

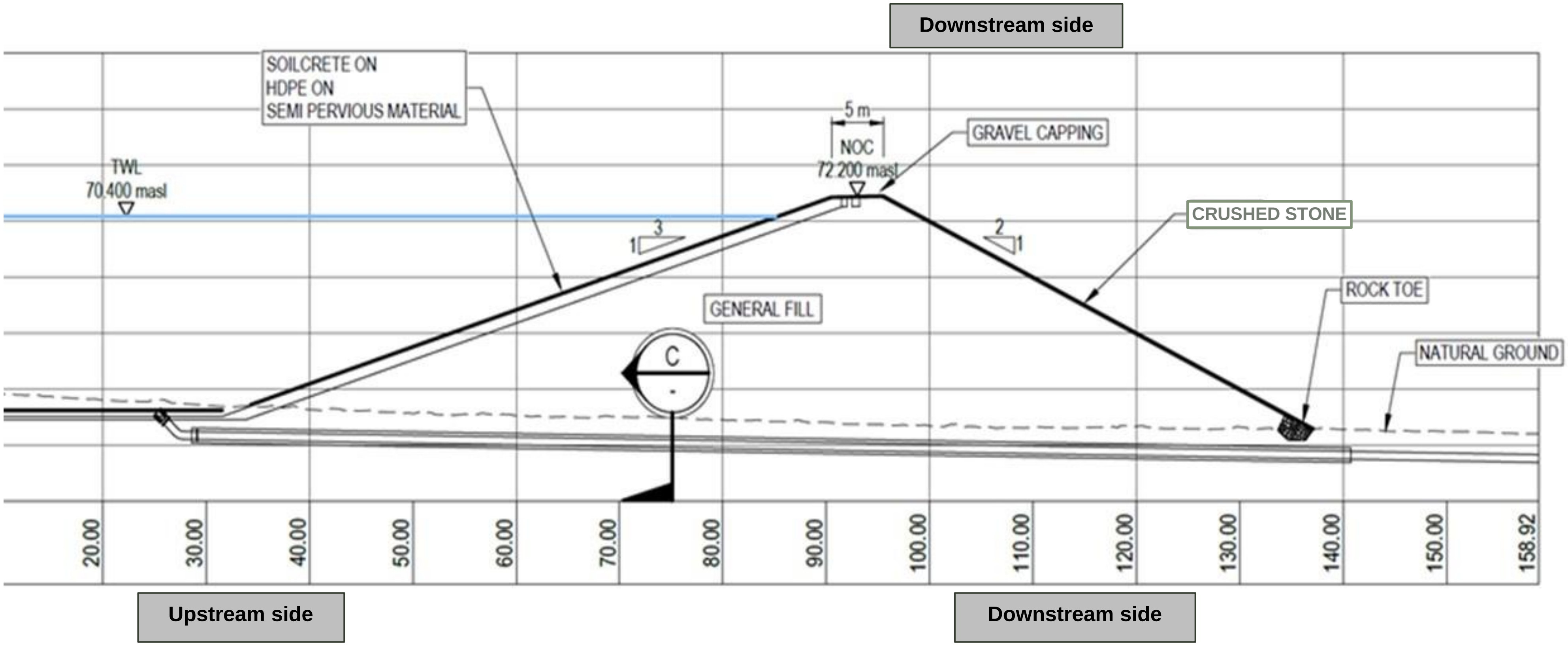

Figure 14-15: Illustrative cross-section through the proposed balancing dam embankment

14.9.5.3 Lining detail

The 1.5 mm HDPE liner will cover the entire basin up to the NOC contour and be anchored in the embankment crest. On all the embankment and basin slopes that are steeper than 1V:4H or above approximately 60 masl, the lining will be double textured (rough on both sides to increase friction at contact with material layers) and covered with a layer of sand-cement (soilcrete). The rest of the basin, below approximately 60 masl, will be lined with a smooth 1.5 mm HDPE liner and covered with 300 mm thick compacted general fill layer.

14.9.6 Spillway

14.9.6.1 Spillway design

The spillway will be located on the right abutment so that it can drain into the nearby natural drainage course. The spillway and embankment layout are shown in **Figure 14-**.

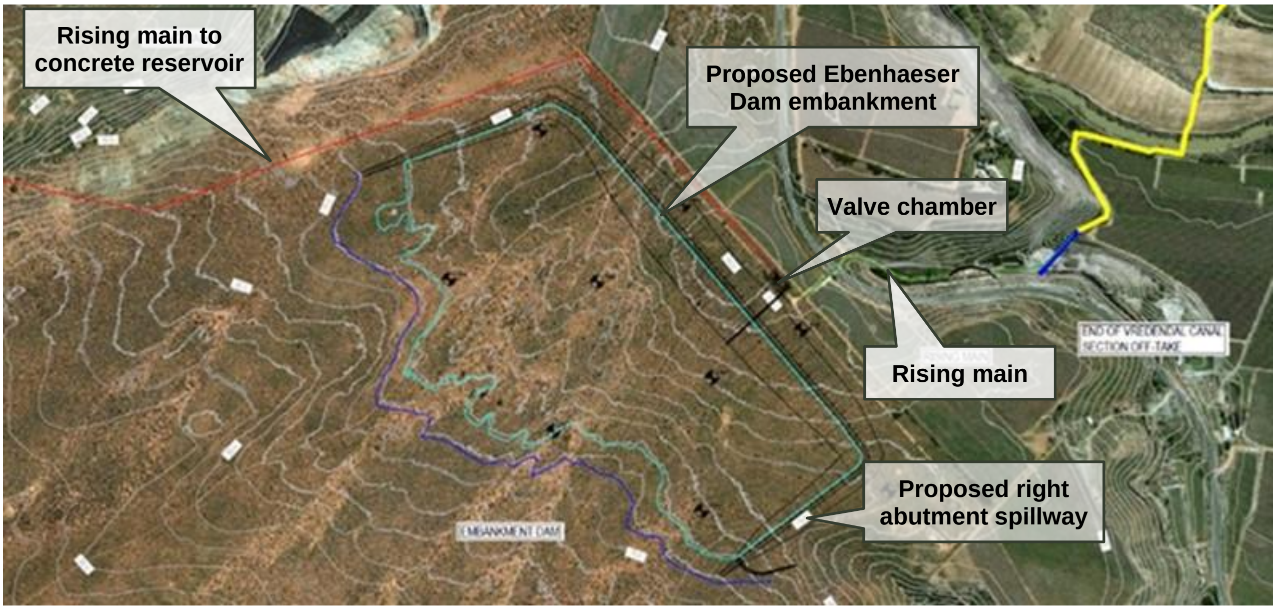

Figure 14-16: Plan view of the embankment showing proposed spillway location

14.9.6.2 Discharge channel

The 1.8 m freeboard is primarily to accommodate wave action and not to accommodate flood events. The discharge channel will only be used for continuous flow should the pumps be left on when the dam is full or during an SEF event, which means that achieving a rock foundation is not critical. The first 35 m of the discharge channel should be lined with armorflex or gabions. The rest of the channel can remain unlined.

The channel is trapezoidal, has side slopes of 1V:1H and extends for 100 m. The base width narrows from 3.0 m to a nominal 1.0 m and has a longitudinal slope of 0.063 m/m (1:15).

14.9.6.3 Flood routing

The outcomes of the flood determination, embankment design and spillway design were used in a level pool flood routing exercise. The hydrographs from the SCS flood determination method were used for the flood routing. The incoming flood peaks were attenuated by 97%.

14.9.7 Freeboard

The required Freeboard for the embankment (height between FSL and NOC) was calculated to be 1.8 m, mainly due to allowance for wave action.

14.9.8 Outlet works

14.9.8.1 Inlet/Outlet works configuration

The outlet works consist of a chamber at the downstream toe of the main embankment. There are two 700 mm diameter outlet pipes, encased in concrete, under the embankment, which daylight in the chamber. One of the pipes is a dedicated gravity outlet pipe. The other pipe connects to the rising main from the canal offtake. The encased pipework through the embankment should be made of stainless steel.

The layout of the balancing dam and outlet works is shown in **Figure 14-**.

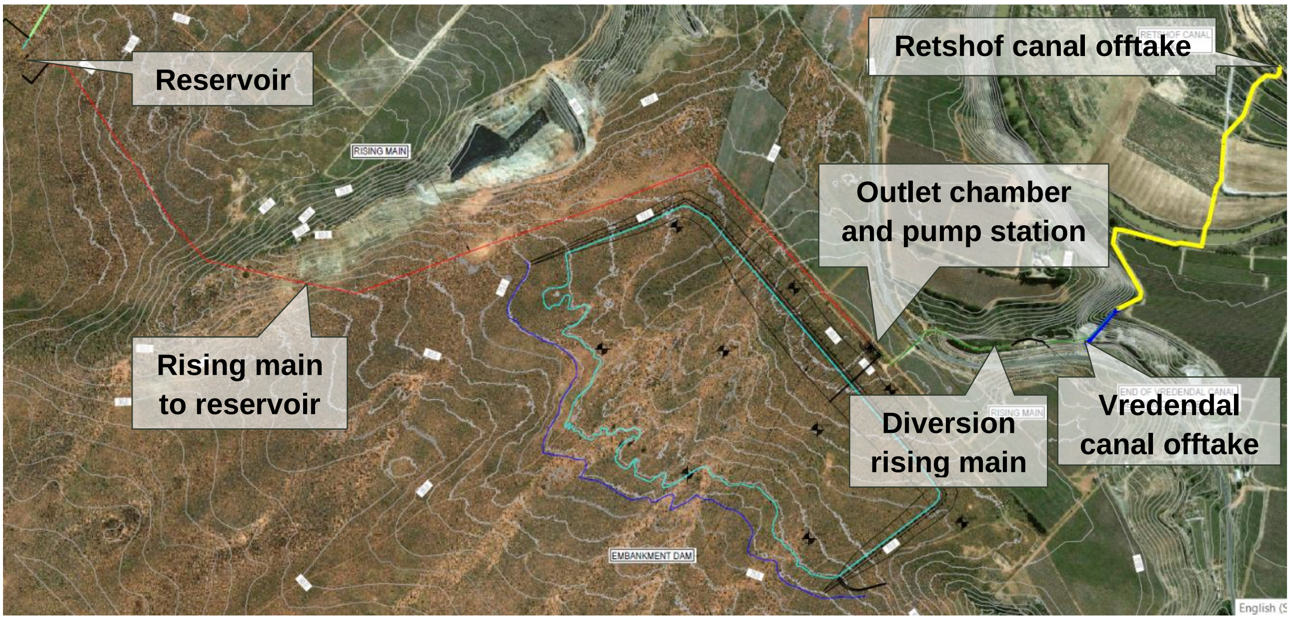

Figure 14-17: Ebenhaeser Dam and supply/connection pipe layout

The two 700 mm diameter inlet/outlet pipes will be encased in reinforced concrete through the embankment. The concrete pipe encasement will have battered slopes to improve the compaction and contact between backfill and the encasement.

It is proposed that a scour outlet be connected to the main outlet pipe to the booster pump station, such that it will discharge into a small trench, with an option to eventually return to the nearby Vredendal canal.

14.9.9 Associated infrastructure

14.9.9.1 Instrumentation

A row of settlement beacons should be installed on the downstream edge of the crest of the embankment at 50 m intervals, along with reference beacons.

Monitoring of water depth can be done either with a set of water depth markers located on the upstream slope near to the outlet works or by installing an electronic water depth gauge (e.g. vibrating wire piezometer), which would enable remote water level monitoring of the proposed Ebenhaeser Balancing Dam.

The proposed dam design may include an underdrain system. The main perforated drains collect at points along the toe and daylight through concrete drainage outlets. This will enable the visual and volumetric monitoring of the seepage through the embankment at various points along the downstream toe.

14.9.9.2 Storm water diversion

Due to the very small catchment and the fact that the dam is off-channel, only limited river diversion works will be required during construction. A perimeter drain should be installed just beyond the NOC contour of the basin to divert any storm water away from the dam so as not to contaminate the quality of the pumped water. This drain could also serve as storm water diversion during construction.

14.10 Ebenhaeser Balancing Dam Inlet/Outlet Chamber

The proposed dam will be supplied from the DN 710 diversion rising main, which will also be used to transfer water back to the canals when needed. Water from the balancing dam will also be pumped via a DN 560 rising main to a concrete balancing reservoir located to the west of the proposed balancing dam.

The outlet works consist of a chamber below the right flank of the downstream toe of the embankment. Two DN 700 inlet and outlet pipes encased in concrete will daylight in the chamber.

The proposed pipework configuration is shown in **Figure 14-**.

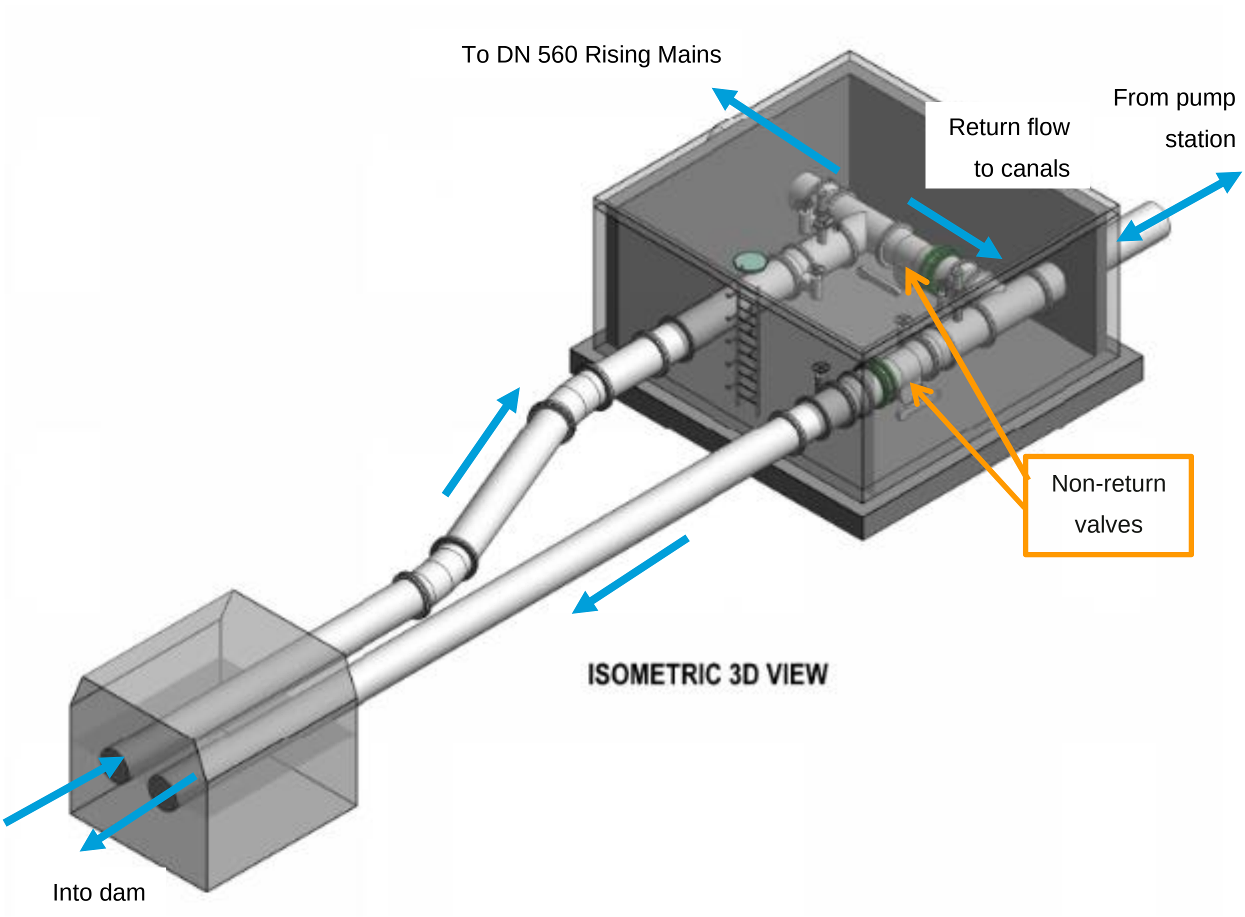

Figure 14-18: Isometric view of Ebenhaeser Balancing Dam Inlet/Outlet Chamber

14.11 Ebenhaeser Balancing Dam Pump Station

The Ebenhaeser Balancing Dam Pump Station will pump water from the Ebenhaeser balancing dam via a DN 560 rising main to a concrete balancing reservoir.

Figure 14- shows the characteristic and pump curves for the pump station.

It is evident from **Figure 14-** that the pump station has a duty point of 20.9 Mℓ/d (0.242 m^3/s) at a total pumping head of approximately 57 m.

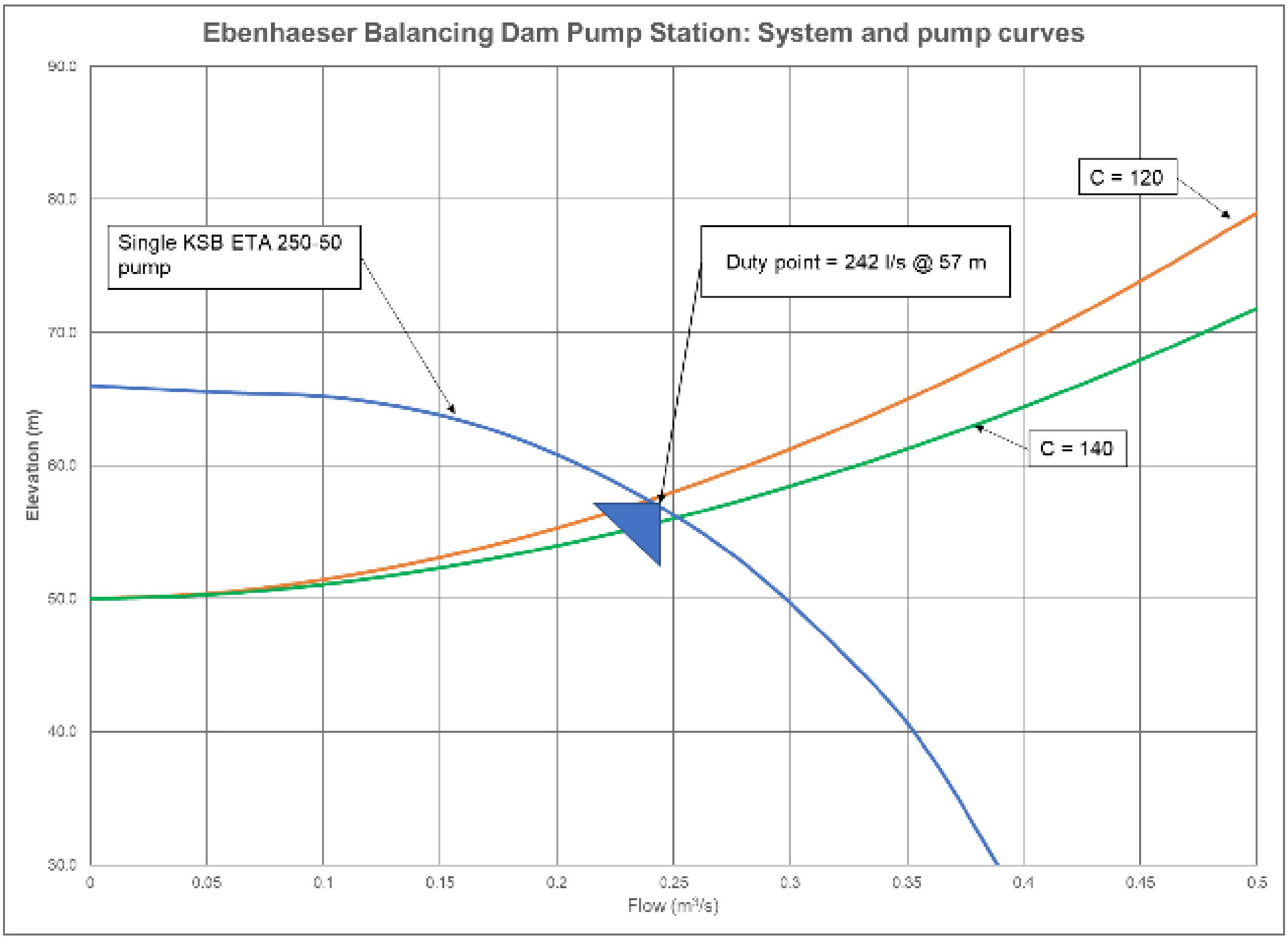

Figure 14-19: Characteristic and pump curve for Ebenhaeser Balancing Dam Pump Station

Figure 14- shows a plan view of the Ebenhaeser Balancing Dam Pump Station.

14.12 Rising Main to Concrete Balancing Reservoir

14.12.1 Description of pipeline

The proposed rising main (1 975 m in length) will convey water from the Ebenhaeser Balancing Dam to the Concrete Balancing Reservoir. The design flow of the rising main is 0.242 m³/s. It is proposed that a DN 560 HDPE pipe be used, which will result in a velocity of 1.28 m/s.

Figure 14- shows the hydraulic gradient line of the rising main to the concrete balancing reservoir for a flow of 20.9 Mℓ/d (0.242 m³/s).

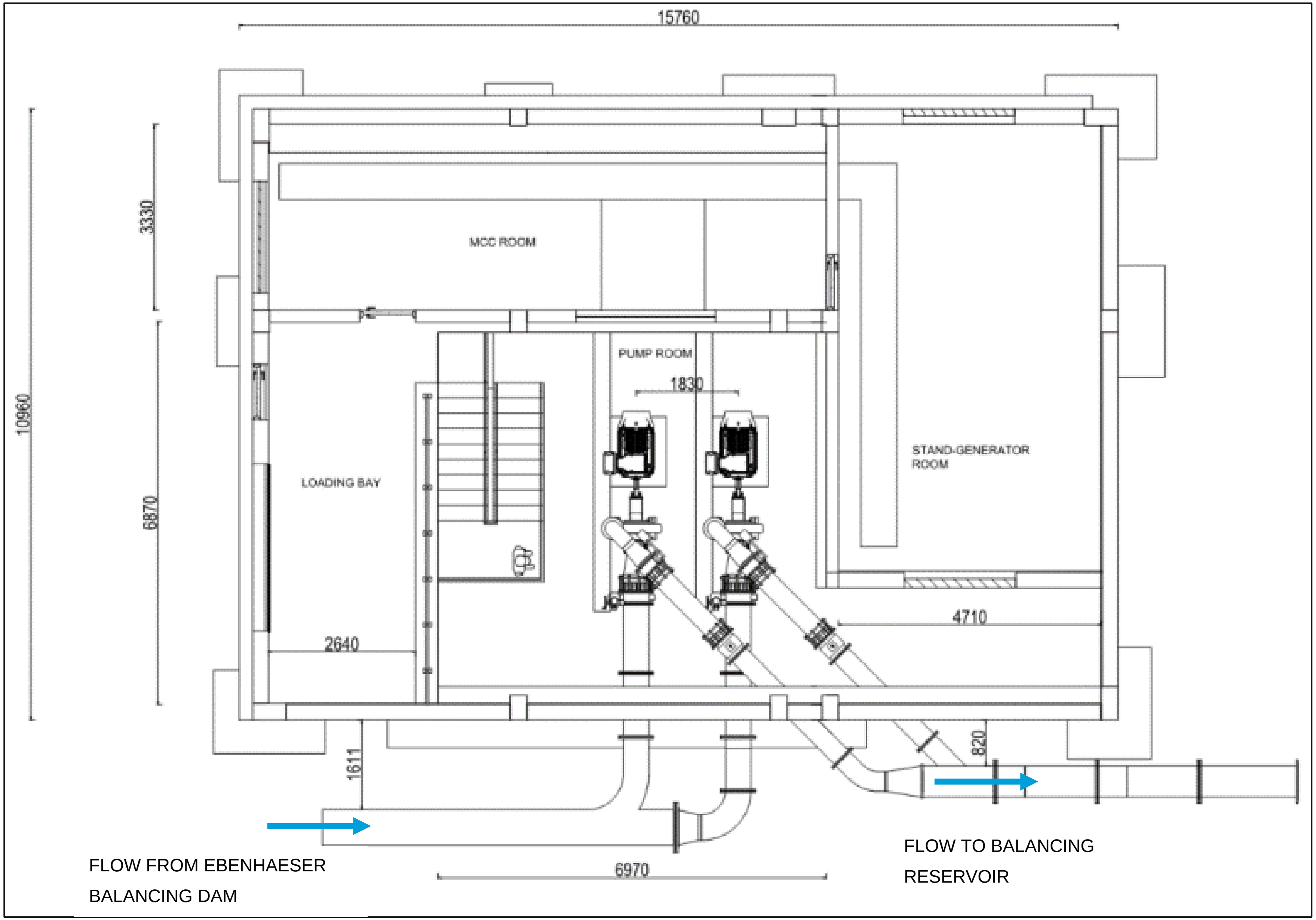

Figure 14-20: Plan view of Ebenhaeser Balancing Dam Pump Station

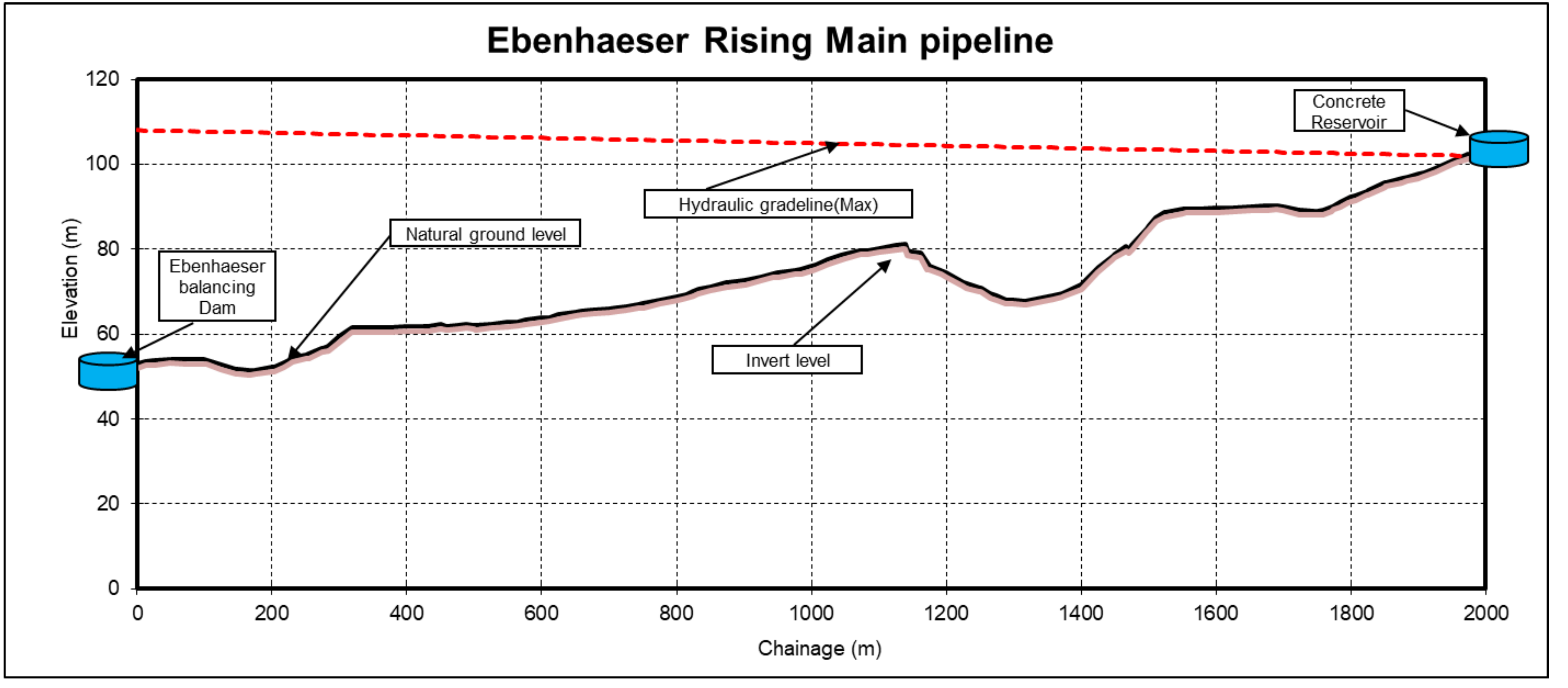

Figure 14-21: Rising Main to Concrete Reservoir: HGL for 20.9 Mℓ/d in aged DN 560 pipeline

14.13 Concrete Balancing Reservoir

The concrete balancing reservoir is designed to store the flow of 242 ℓ/s pumped over 12 hours, which equates to a reservoir with an active capacity of 10 450 m^3 (10.45 Mℓ). It is proposed that an 11 000 m^3 (11 Mℓ) reinforced concrete reservoir be provided. The reservoir's minimum operating level is 99.5 masl and full supply level is 105.5 masl. These levels are based on an assumption that the reservoir will be sunken half depth.

A new access road will have to be constructed to the reservoir.

14.14 Gravity Pipeline and Distribution Mains

14.14.1 Gravity Pipeline to Five Clusters

14.14.1.1 Description of the pipelines

The proposed gravity pipeline will convey water from the concrete balancing reservoir to the five water requirement clusters along the route (a total length of 17 700 m). Pipeline diameters were optimised to ensure sufficient residual head at each cluster off-take. The design flow rates and proposed pipeline diameters are shown in **Table 14-2**.

Table 14-2: Gravity Pipeline to Five Clusters: Design flows and diameters

Gravity pipeline	Design flow (m^3/s)	Diameter (mm)
Section 1: Reservoir to Cluster 1	0.242	630
Section 2: Cluster 1 to Cluster 2	0.195	560
Section 3: Cluster 2 to Cluster 3	0.168	500
Section 4: Cluster 3 to Cluster 4	0.106	400
Section 5: Cluster 4 to Cluster 5	0.048	355

Figure 14- shows the hydraulic gradient line of the gravity pipeline to the five clusters for the flow rates and pipe diameters shown in **Table 14-2**.

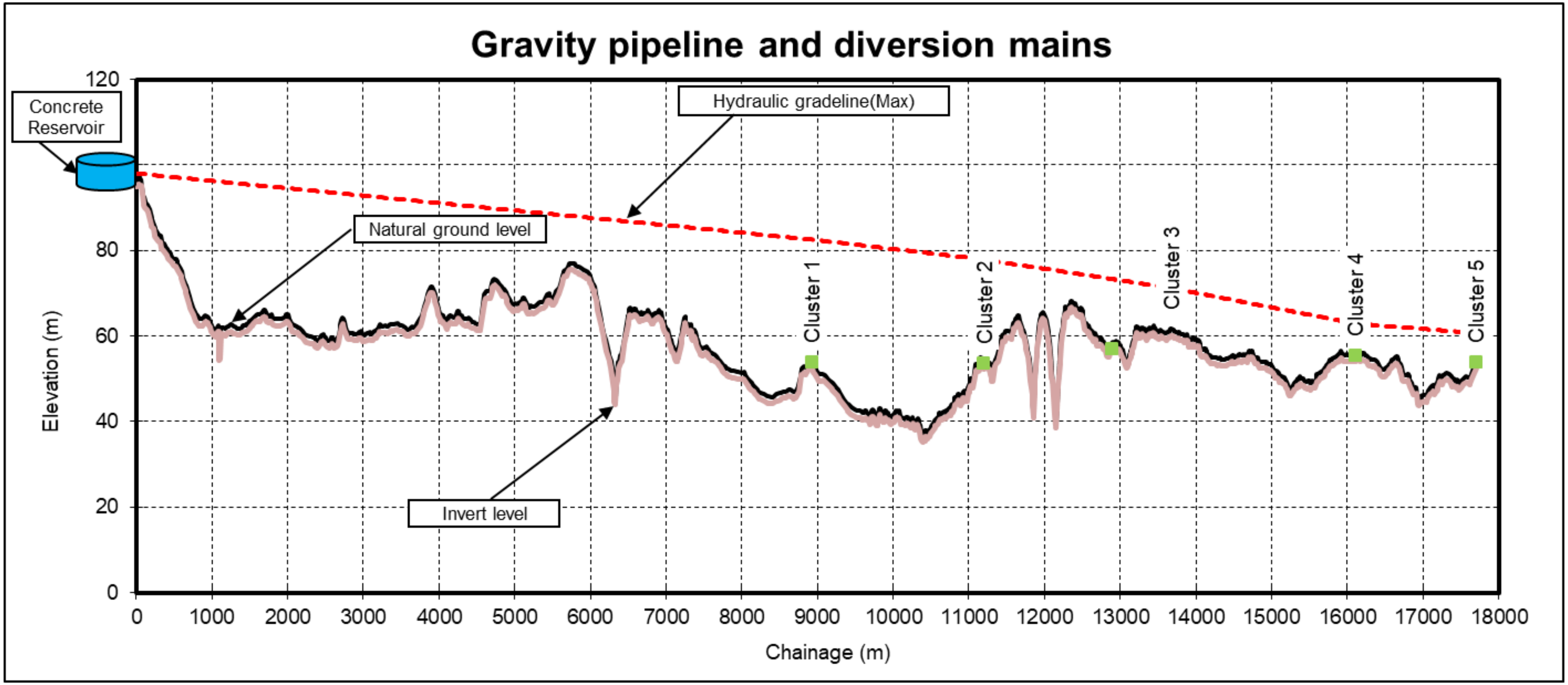

Figure 14-22: Gravity pipeline and diversion main offtakes at clusters: Hydraulic gradient line

14.14.1.2 Railway Crossing

The gravity pipeline will have to cross a railway line approximately 1 250 m downstream of the concrete balancing reservoir. It is proposed to cross the railway line with a concrete sleeve pipe installed by means of pipe jacking.

14.14.1.3 Culvert Crossing near Railway Line

Approximately 6 500 m downstream of the concrete balancing reservoir there is an existing culvert underneath the road adjacent to the railway line.

It is proposed that the gravity pipeline be laid adjacent to the road on top of the existing culvert. Note that the culvert might need to be extended. The length of the span and the details of the crossing will be determined during the detailed design phase of the project, upon receiving more site-specific survey information of the existing culvert.

14.14.1.4 Road Crossing

It is proposed that concrete pipe sleeves be installed where major roads are crossed, and that minor road crossings be performed by open trench excavation. The major road crossings are to be done by pipe jacking or micro-tunnelling.

14.14.2 Distribution Mains for Clusters

Water will be conveyed to the edge (high point) of the water requirement clusters from where the water will be distributed to the irrigators via distribution mains in future (designed by others).

A tee will be provided on the gravity pipeline at each cluster offtake position leading into a chamber. Each chamber will have a flow control valve and a flow meter, with isolation valves upstream and downstream, in order to service the flow control valve. A blank flange will be fitted on the downstream side, outside the chamber, ready for the distribution mains to be connected in the future.

14.15 Cost Estimates

14.15.1 Capital Cost

Table 14-3 provides a summary of the capital cost estimates for the various scheme components and types of work (excluding the balancing dam).

Table 14-3: Capital Cost estimate for Pipelines, Pump Stations and Canals (excl. VAT)

No	Description	Ebenhaeser Scheme (R million)	LOWRUA Betterment cost (R million)	Combined Cost (R million)
1	Pipelines	139.654		139.654
2	Canal Diversion Structures	2.531		2.531
3	Diversion Pump Station and Sump	8.490		8.490
4	Ebenhaeser Balancing Dam Return flow to canals		1.736	1.736
5	Ebenhaeser Balancing Dam Inlet/Outlet Chamber	2.274		2.274
6	Ebenhaeser Balancing Dam Pump Station	6.900		6.900
7	Balancing Reservoir	13.200		13.200
8	Distribution Mains Offtake Chambers	1.188		1.188
Sub-total: October 2020 prices		**174.238**	**1.736**	**175.974**

A capital cost estimate for the balancing dam was conducted based on the geotechnical information and detailed topographical survey data. This cost estimate is summarised in **Table** 14-4, excluding an allowance for Preliminary & General and Contingency costs. The 'LORWUA Betterment Cost' is the cost of an additional 150 000 m^3 balancing dam storage and required conveyance and other infrastructure.

Table 14-4: Capital Cost Estimate for the Balancing Dam (excl. VAT)

No	Description	Ebenhaeser Dam (2.17 Mm^3) (R million)	LORWUA Betterment Cost (0.15 Mm^3) (R million)	Combined Cost (2.32 Mm^3) (R million)
1	Earthworks	62.863	4.963	67.826
2	HDPE lining	23.791	1.878	25.669
3	Concrete works	1.815	0.143	1.958
4	Mechanical and other	1.373	0.108	1.481
	Sub-total October 2020 prices	**89.841**	**7.093**	**96.934**

14.15.2 Total Project Cost Estimate

Table 14-5 shows a summary of the total project cost estimate, inclusive of other miscellaneous scheme costs.

Table 14-5: Ebenhaeser Scheme Project Cost Estimate

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Cost (R million)
Pipelines, pumps and canals	174.238	1.736	175.974
Balancing dam	89.841	7.093	96.934
Total Capital Cost	**264.079**	**8.829**	**272.908**
Preliminary & General Items (40%)	105.632	3.532	109.163
Subtotal 1	**369.711**	**12.361**	**382.071**
Contingencies (25%)	92.428	3.090	95.518
Subtotal 2	**462.138**	**15.451**	**477.589**
Access roads	2.220	0.020	2.240
Electrical supply	1.040	0	1.040
Sub-Total: Construction Costs	**465.398**	**15.471**	**480.869**
Professional fees (10%)	46.540	1.547	48.087
Value Added Tax (15%)	69.810	2.321	72.130
Land acquisition	0.930	0.041	0.971
TOTAL (October 2020 prices)	**582.678**	**19.380**	**601.086**

To determine the project cost estimate at the date of project commencement, an escalation of 6.5% per year can be applied from the base date of October 2020.

14.15.3 Operation and maintenance costs

The total annual operation and maintenance costs of R 1.429 million, for the various Ebenhaeser Scheme components have been included as an annual cost based on a percentage of the construction value. The components are divided into three sections, as follows:

- Civil works: R 865 000/a;
- Mechanical and electrical works: R 115 000/a; and
- Balancing Dam: R 449 000/a.

14.15.4 Comparative Capital Costs (NPV and URV)

The Development and Betterment capital costs (October 2020 prices, excluding VAT) of the Ebenhaeser Scheme are shown in **Table 14-6**. The NPV and URV value for the Development portion of the scheme are given in **Table 14-7**.

Table 14-6: Ebenhaeser Scheme Comparative Capital Costs in million Rand (2020 prices, excl. VAT)

Cost distribution	Canal & Bal Dam Structures	Balancing dams	Pump stations	Pipelines & syphon	Reser-voir	Purchase of land	Prof. design & support	Roads & Elec supply	Total Cost
Development	8.41	157.22	26.93	246.47	23.10	0.93	46.55	**3.33**	**512.94**
Betterment	3.04	12.42	-	-	-	0.04	1.54	**0.02**	**17.06**
Total	**11.45**	**169.64**	**26.93**	**246.47**	**23.10**	**0.97**	**48.09**	**3.35**	**530.00**

Table 14-7: Development NPV (R million) and URV (R/m^3)

Cost Item	Cost (R million, excl. VAT)	Value (R/m^3)
Total NPV Cost	R 536.71	
URV at 8% discount rate		R 12.77

14.16 Further Investigations for Detailed Design

Recommendations applicable to the detailed design and construction phases of the Ebenhaeser Scheme have been made regarding the following aspects:

a) A ground centreline survey along the final chosen pipeline routes, and site-specific surveys for the railway and existing culvert crossings on the Ebenhaeser gravity pipeline;

b) Volume of suitable pipeline bedding material and suitable sources;

c) Confirmation of the pipeline routes and infrastructure locations, following consultation with affected landowners and authorities.

d) Consideration of findings from the core drilling of the syphon route through the Olifants River for the right bank gravity pipeline syphon;

e) Independent quality control inspections of the pipes, and the choice of pipe material;

f) Engaging with Eskom regarding electrical supplies to the pump stations;

g) Selection of pump types;

h) Reconsidering the sizing of the concrete balancing reservoir;

i) Submission of the proposed railway and road crossing details to the relevant authorities for their approval;

j) Confirming assumptions relating to the desired balancing dam storage volume, embankment zoning and dimensions, and lining;

k) The relocation of three power lines affected by the position of the balancing dam; and

l) Reconsidering the energy costs used in the cost calculations, optimising it for Eskom's Time of Use, to achieve savings in energy cost over the life cycle.

15 Financial Viability of Irrigation Farming

This chapter describes the evaluation of the financial viability of irrigation farming for various commercial-scale options and smallholders.

15.1 Introduction

The need to provide clarity on the proposed farming models related to the uptake of additional irrigation water was identified. In terms of the principle of water allocation reform (WAR), preference should be given to HDIs when allocation of water is considered. The farming models were developed with this principle in mind. Furthermore, a needs analysis of HDI farmers was done, focusing on the agricultural value chain. Case studies of both land restitution cases and successful commercial JV projects were evaluated. A balance needs to be found between commercial sustainability on the one hand, and the needs of HDIs and destitute communities on the other. Both objectives need to be addressed to obtain the buy-in from all relevant Government Departments and ultimately to motivate for the funding and financing of the scheme.

An institutional and funding assessment was done. Various options for financing public water infrastructure were investigated, and a summary of available grants for financing scheme infrastructure is provided.

Refer to the *Financial Viability of Irrigation Farming Sub-Report* (DWS, 2018) for the evaluation undertaken.

15.2 Selection of Crops

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

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

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

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

15.2.1 Table Grapes

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

15.2.2 Citrus

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

15.2.3 Wine Grapes

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

15.2.4 Raisins

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

15.2.5 Potatoes

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

15.2.6 Crop Types and Crop Water Use Requirements

Refer to **Table 15-1** for crop types recommended for each region.

Table 15-1: Identified Irrigation Zones and Suitable Crops (DWS, 2018)

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

A summary of proposed crop water use requirements for each geographical area is shown below in **Table 15-2**. The table includes the irrigation efficiency factor for each crop type. It is recommended to make use of the most recent Validation & Verification (V&V) information for the planning of bulk infrastructure options. (DWS, 2018).

Table 15-2: Summary of crop water use requirements per geographical area

Zone	Crop	Water use (m³/ha/a)			Proposed volume (m³/ha/a)
		Source	Efficiency factor	Volume	
1 – Citrusdal	Citrus	2004 Feasibility	90%	13 280	10 000
		V&V	90%	10 000	
		DOA	90%	14 310	
		DWS	90%	13 002	
2 – Clanwilliam	Citrus	2004 Feasibility	90%	14 100	11 000
		Jan Dissels study	90%	8000 (micro)	
		V&V	90%	11 000	
		DWS	90%	14 901	
	Table grapes	Jan Dissels study	90%	9000 (micro)	11 340
		V&V	90%	11 340	
		DWS	90%	12 417	
	Potatoes	2004 Feasibility	85%	5490	10 080
		DWS	80%	7440 / 10 811	
		V&V	80%	10 080	
3 – Jakkalsvlei / Graafwater	Potatoes	V&V	80%	10 080	10 080 Note that the value for Clanwilliam will also be used apply to the Jakkalsvlei / Graafwater area)
4 – Bulshoek to Trawal (quat E10K)	Table grapes	V&V	90%	11 340	11 340
	Wine grapes / raisins	V&V	90%	9500	9500
	Tomatoes	No data	-	-	It is recommended to use the V&V figure of 9281, which is the generic quota for vegetables
	Vegetables (general)	V&V	80%	9281	9281
	Brassica	No data	-	-	Recommended to use Zone 5 figures of either 5030 or 2080, depending on season (as available from the DOA data)

Zone	Crop	Water use (m³/ha/a)			Proposed volume (m³/ha/a)
		Source	Efficiency factor	Volume	
5 – Klawer to Coast (quats E33G and E33H)	Table grapes	V&V	90%	12 390 (Vredendal)	12 390
		DOA	90%	4560 (Vredendal)	
			90%	5320 (Lutzville)	
		DWS	90%	12 128 (Klawer)	
			90%	11 959 (Lutzville)	
	Wine grapes / raisins	2004 feasibility	95%	9650 (Klawer)	9500
			95%	9080 (Lutzville)	
		V&V	90%	9500	
		DOA	90%	7110 (Lutzville)	
			90%	5960 (Vredendal)	
		DWS	90%	10 669 (Klawer)	
			90%	10 551 (Lutzville)	
	Tomatoes (processing)	2004 feasibility	95%	6930 (Klawer, Dec)	Recommended V&V value of 9281 for vegetables
			95%	6340 (Lutzville, Dec)	
	Tomatoes (table)	2004 feasibility	95%	8410 (Klawer, Dec)	
			95%	9340 (Klawer, Sep)	
			95%	7740 (Lutzville, Dec)	
			95%	8760 (Lutzville, Sep)	
	Tomatoes (unspecified)	DOA	80%	2830 (Vredendal, Mar)	
			80%	4710 (Vredendal, Jun)	
			80%	8800 (Vredendal, Sep)	
			80%	8180 (Vredendal, Nov)	
			80%	3700 (Lutzville, Mar)	
			80%	6110 (Lutzville, Jun)	
			80%	10 390 (Lutzville, Sep)	
			80%	9980 (Lutzville, Nov)	
		DWS	80%	11 276 (Lutzville, Sep)	
	Vegetables	V&V	80%	9281	9281

Zone	Crop	Water use (m³/ha/a)			Proposed volume (m³/ha/a)
		Source	Efficiency factor	Volume	
	Brassica	DOA	80%	4000 (Vredendal, Feb)	Recommended to use maximum volumes – either 5030 or 2080, depending on season
			80%	2080 (Vredendal, Apr)	
			80%	5030 (Lutzville, Feb)	
			80%	2660 (Lutzville, Apr)	

15.3 Minimum Viable Farm Sizes

The minimum viable farm sizes resulting from the financial evaluations done are presented in **Table 15-3**, according to the identified commodities. The minimum viable farm size for an existing farm was calculated, as well as the minimum viable farm size for a new black-owned farm, where the land was obtained at no cost.

Table 15-3: Minimum Viable Farm Sizes

Crop	Existing Commercial (ha)	New Black Owned (ha)
Citrus	22	90 (@IRR 8%)[1)]
Table Grapes	16	46 (@IRR >9.25%)
Wine Grapes	Not currently viable	Not currently viable
Raisins	68/12[2)]	26 (@IRR >9.25%)
Tomatoes/Brassica seed - commercial	27	41 (@IRR >9.25%)
Tomatoes/Brassica seed - small scale production	6	6 (@IRR >9.25%)

1) Note that the IRR for new black-owned farms is 8% instead of > 9.25% to keep the farm size reasonable, reducing the 5% risk factor.
2) For raisins, the 68 ha minimum viable size relates to the current average study group yield of 22 tons/ha and the 12 ha minimum viable size is calculated at a potential yield of 50 tons/ha based on top varieties and best practice.

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

15.3.1 Financial Viability of Irrigation Farming

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

It is therefore important to note that the expansion of existing irrigation farms will in general be financially more viable than the development of new irrigation farms. The main reasons for this are the cost effectiveness of the improved utilisation of infrastructure on existing farms relative to the costly nature of the development of new farms. For expansion of existing farms, citrus and table grapes currently appear to be profitable, followed by the other crops under certain circumstances. Based on the financial evaluations, the following deductions have been made, which are to be considered when evaluating options:

1. Irrigation farming is capital intensive and costly due to, *inter-alia*, the following:
    - High-potential irrigation land is relatively scarce and is therefore expensive;
    - The upgrading of medium-low and medium potential irrigation soil is a relatively expensive activity;
    - The upgrading and development of bulk water infrastructure for irrigation is capital-intensive and is therefore costly;
    - On-farm water infrastructure is also costly; and
    - The establishment costs for new orchards/vineyards are high.
2. To produce a high income and offset the high capital- and other costs, high-value crops are produced, predominantly for export markets. These high-value crops however require a high level of technological and managerial inputs, making it difficult for new market entrants. For instance, the financial viability models for new black-owned farms and small-scale commercial farms is based on the yields that commercial growers achieve, but it cannot be assumed that all new black-owned farms will achieve these yields.

15.3.2 Economic Empowerment of HDIs

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

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

From a smallholder farming perspective, it was found that a 6 ha agricultural unit in Ebenhaeser could potentially provide the farmer with an income of over R 8 000 per month, if irrigation infrastructure and implements are covered by grants and the growers possess the inputs, skills and expertise to produce commercial-grade yields. It has been assumed that these farmers will only be liable for a very small portion of the total water levy. This finding could also be extrapolated to other areas that may be able to receive new water use allocations, e.g. municipal commonage schemes or other peri-urban or subsistence farming operations, should they similarly be exempt of paying full levies.

16 Economic Implications

The chapter provides an overview of the socio-economic impact analysis undertaken to measure the nature and magnitude of the socio-economic impacts emanating from the distribution and use of additional water from a raised Clanwilliam Dam.

16.1 Objective and Methodology

An analysis was undertaken to evaluate the relevant impacts that could emerge as a result of the irrigation development. The socio-economic impact was separately undertaken for the construction and operational periods.

Partial general equilibrium analysis[2] has been used to quantify the socio-economic impact of the development. The Social Accounting Matrix (SAM) provides the basis for this partial general economic equilibrium analysis. In general, apart from information on the interdependence between the different sectors taken up in the Input-Output Table, the SAM differs from the traditional Input-Output Table in one important aspect, in that it includes detailed information on the income and spending patterns of households. For the purposes of conducting the partial general socio-economic equilibrium analysis, the SAM has been converted into a user-friendly model. This is a detailed econometric model that is generally used for purposes of measuring the socio-economic impacts resulting from a specific project.

The socio-economic impact model used to calculate the impact of the project on the South African economy uses the South African National SAM as its database. The South African SAM was originally compiled by Statistics South Africa and has been adapted and updated to reflect the most recent socio- and macro-economic representation of the South African economy in a monetary value format.

[2] **Partial equilibrium** is a condition of economic equilibrium which takes into consideration only a part of the market to attain equilibrium.

The largest impact comes from the additional water supplied by the proposed project (baseline plus buffer water). To calculate the socio-economic impact, unit volumes are converted into potential production capacity using water use/production coefficients (Rand / million m^3).

The calculations and findings have been documented in the *Socio-economic Impact Analysis Sub-Report* of this study.

16.2 Data

Several guidelines were taken into consideration in the decision of identifying a specific crop allocation for a specific area. The following provides a summary of the guidelines used:

- Is the proposed crop already produced in the area and is packing and marketing infrastructure available? This specifically applies to available support structures like pack houses and management, as the availability of the structures will lower production costs.
- What is the medium to long term price structure outlook for the specific product? This applies specifically to wine grapes as the long-term outlook is not very positive.
- The export of citrus appears very positive and as such provision is made for oranges, lime and lemon, and soft citrus varieties in Zone 2, Clanwilliam Dam to Bulshoek Weir.
- The export of raisins is currently very positive and the medium to long term outlook is positive.
- Significant allowance has been made for table grapes, because of the very negative outlook of wine grapes, but this may change in future.
- Marketing infrastructure for tomatoes is available.
- The potato and wheat in rotation is used as the preference crop in a very specific area, according to recommendations relating to soils.
- The ‘other fruit’ group has the possibility for the expansion of the sub-tropical or deciduous groups that are produced in the area.
- In the baseline scenario, the long term projected tonnage per hectare was determined for water provided at an 80% assurance of supply at 2018 prices, to determine an income per crop. The individual budgets for the orchard crops make provision for establishment in year one, up to full production in the appropriate year, with an estimated lifetime of 30 years.
- **Table 16-1** presents the estimated number of hectares per crop, for each study zone, based on the preliminary hectares of new irrigation that can be developed when Clanwilliam Dam has been raised. Although this area was later refined, it changed little (by 3% from 6 062 ha to an estimated 5 874 ha).
- The long term projected tonnage per hectare was determined for water provision at an 80% assurance of supply, at 2018 prices to determine an income per crop. The individual budgets

for the orchard crops make provision for the establishment in year one up to full production in the appropriate year, with an estimated lifetime of 30 years.

Table 16-1: Estimated crop areas by zone

Crop Type	Zone 2	Zone 4	Zone 5	Totals	Percentage
Citrus	1 370	0	0	1 370	23%
Table Grapes	822	2 144	116	3 082	51%
Wine Grapes	0	0	162	162	3%
Dry Grapes (Raisins)	0	658	46	704	12%
Potato/Wheat in Rotation	466	0	0	466	8%
Tomato	0	0	134	134	2%
Other Fruit	82	57	5	144	2%
Total hectares	**2 739**	**2 859**	**463**	**6 062**	**100%**

16.3 Construction Phase Results

The following is observed during the construction period of the proposed Right Bank Canal when comparing the proposed baseline option with the option where the 'Betterment' component is added:

- The GDP increased from R 328 million to R 618 million for the period.
- Capital formation increased from R 1 425 million to R 2 702 million.
- Employment opportunities improve from 975 to 1 836, which also increases the affected people in the different households from 4 000 to 7 200, if it is accepted that one employment opportunity in rural situation supports four people.
- Salaries and wages increase from R 261 million to R 491 million per annum for the construction period.
- The only negative value is the increased negative impact on the Balance of Payments from R 108 million to R 204 million.

It is therefore possible to conclude that the possible decision to include the 'Betterment' option will have a very positive impact during the construction period. On a more practical level, it will improve the delivery of the water, as the losses from the new Right Bank Canal Scheme will significantly reduce when compared with losses from the existing left bank main canal.

16.4 Operational Phase Results – New Irrigation Area

The total GDP for the new irrigation areas is estimated to be R 2 674 million per annum (expressed in 2018 prices). The direct component of this projected GDP is estimated at R 1 072 million, the indirect component at R687 million and the induced component at R 915 million.

The operational activities will also create new capital, which is an important driver of economic growth. The following estimated capital is created per annum in the different segments:

- Direct: R 365 million.
- Indirect: R 1 892 million.
- Induced: R 2 637.
- This amounts to a total of R 4 894 million annually.

In total an estimated 15 031 job opportunities can be created and supported per annum of which 10 924 in the direct category will be in the area and on the farms. It can also be accepted that a percentage of indirect and induced categories will also be in the feeder area. Of the jobs created, 1 665 will be in the skilled category, 5 923 semi-skilled and 7 723 unskilled.

One of the crucial aspects of any socio-economic impact assessment is poverty alleviation. The extent to which poverty alleviation is achieved is measured by the impact on household income, specifically the extent to which low-income households will be affected by the additional water following the raising of Clanwilliam Dam. In total, the annual impact of the expected wages to be paid to the households is an estimated total of R 2 131 million annually, expressed in 2018 prices, of which 14% is to low income households, at an average income of R 3 500 per month.

Government income (taxes, etc.) will increase, on average, by R 766 million per annum. If this amount is translated into social services, by using the social expenditure portion of the current budget, it produces the following increases in social services:

- Additional educators: 194.
- Additional hospital beds serviced: 42.
- Additional doctors: 9.
- Additional low-cost houses built: 64 per annum, which accumulates to over 1 270 over a 20-year period.

When undertaking projections of this kind, it is important to realise that the total cost to government, to for example employ one teacher, must be taken into account - that is, not only the educator's remuneration package, but also all of the other costs related to supporting the educator standing in front of a class (i.e. furniture, school buildings, administrative support, etc.). Thus, total government expenditure on education is divided between the total numbers of educators employed. The figures reflected above thus make provision for all direct and indirect costs associated with each of the social indicators investigated.

A second issue to highlight is that the estimated investment for the baseline option is R 725.04 million and for the added "betterment" option R 1 239.05 million expressed in 2018 prices, but the projected taxes that will be paid to the Fiscus is estimated at R 766 million per annum, for the duration of the production period expressed in 2018 prices.

16.5 Operational Phase Results – Existing Area with Improved Assurance of Supply

The benefits to the Provincial and National Government from the increased assurance of water supply to the present producers are:

- Total average GDP increase: R 601 million per annum.
- Number of jobs secured: 4 611. These are people that will have a higher job security.
- Average Increase in Household Income: R 650 million per annum.
- Fiscal Impact: R 171 million per annum.
- Average annual stabilising impact of the increase in Balance of Payments is R 328 million.

The additional benefits to be attained for the existing irrigation per annum (R million, 2018 prices) are presented in **Table 16-2**.

Table 16-2: Annual benefits of the Operational Phase for an improved assurance of supply

Criterium	Direct Impact	Indirect Impact	Induced Impact	Total Impact
Impact on GDP (R million)	R 245	R 150	R 206	**R 601**
Impact on employment [number of job opportunities]	3 635	457	519	**4 611**
Impact on Households (R million)				**R 650**
Fiscal Impact (R million)				**R 171**
Impact on the Balance of Payments (R million)				**R 328**

Thus, an increased assurance of water supply provides the farmer more security for sustainable farming. This higher assurance level provides the farmer the opportunity to optimise his farming operations. It does not only provide a higher annual yield, but also results in the retention of the temporary labour force that is included in the number of job opportunities.

16.6 Conclusion

The analysis undertaken indicates that the availability of the additional water from the raised Clanwilliam Dam, inclusive of the increased assurance of supply, will have a substantial positive impact on the social and economic conditions prevailing in the area, and that there will be substantial poverty alleviation in the area.

17 Right Bank Canal Scheme Cost Analysis

This Chapter describes the economic modelling exercise that quantified the risk of failure of the existing left bank main canal up to Verdeling, and the determination of the economic viability of the proposed new right bank canal, to reduce the risk of failure, as described in the *Right Bank Canal Cost Analysis Sub-Report*.

17.1 Objective and Approach

This socio-economic evaluation aimed to quantify the risk and implications of failure of the existing left bank main canal, from the Bulshoek Weir to Verdeling where the canal bifurcates (Trawal section of the LORGWS), to provide additional motivation for the Betterment cost component of the Right Bank Canal Scheme.

The Right Bank Canal Scheme and associated costs have been described in Chapter 13.

17.2 Risks and Challenges

There is a big difference in engineering standards to which the existing left bank main canal was built, as opposed to current accepted standards. Construction standards were not up to today's standards and lining of the canal e.g., mostly consisted of hessian cloth plastered over by hand. The age of the infrastructure, plus the inadequate standards (e.g., lack of service roads and cross-drainage) are reasons why revamping/replacing of the infrastructure is significantly overdue.

After more than 90 years of usage, the concrete lining of the canal has become frail and prone to damage, which results in canal breaks occurring frequently. The frequency and severity of these breakages seems to be worsening. The canal systems have been in use for significantly longer than its design life. Design standards typically note the useful economic "life" of canals as 45 years - the canals are now twice that age.

The very poor state of canal infrastructure poses a high risk to the regional community and economy, due to the disruption, periods of non-supply (including supply to towns, industries and mines), and associated commercial and cost implications. The largest break happened in January

2015 (**Figure 17-**) with a repair cost of R11.5 million, which cost the agriculture sector an estimated R100 million (Creamer Media, 2017).

The LORWUA reported (J Matthee 2018, personal communication) that it spends approximately R 4.2 million per annum on normal maintenance with its own teams, and contracts out approximately R 5.8 million per annum on more serious repairs. Breakages on the current main canal poses the biggest risk, as all downstream water users, which represents most scheme users, are affected.

Figure 17-1: Lower Olifants Canal break in 2015

There is excessive conveyance water losses and leakage from the existing canals, estimated by DWS to be up to 30%, compared to less than 10% for a new canal. The flow capacity of the existing canals is also restrictive and often cannot meet the peak demand, especially during the very hot, peak summer period.

17.3 Betterment Infrastructure Works

Betterment implies an improvement of existing (hard) water resource infrastructure, resulting in an increased functional performance and/or increased capital value thereof. A distinction is made between types of expenditure on existing works during their working lives, namely maintenance, refurbishment, betterment, etc.. This also determines how certain charges will be levied, and who will take responsibility for its undertaking. Betterment works for the scheme have long been planned for by the owner of the scheme, DWS, as well as the operator, LORWUA. Financial constraints have significantly delayed the implementation of the more significant betterment works that are needed.

17.4 Methodology

The approach used is to quantify the macro- and micro-economic impact associated with the mitigation of the risk of failure of the existing main canal (Trawal section) of the LORGWS by constructing a right bank canal (the Right Bank Canal Scheme) to replace the existing main canal from Bulshoek Weir to Verdeling.

The proposed construction consists of the following two development scenarios, to be compared following financial and economic viability evaluation:

- **Scenario 1: Right Bank Canal:** Construction of a Right Bank Canal to serve the four recommended Trawal irrigation areas, existing allocations and other future water users.
- **Scenario 2: Alternative - Left Bank Canal:** Construction of two small bulk water supply schemes to serve the four recommended Trawal irrigation areas, existing and future water users and refurbishment of the remainder of the existing left bank main canal.

A Cost Benefit Analysis (CBAn) approach is used to calculate the micro-economic feasibility of the project by comparing the costs versus the benefits, and thereby establishing the financial and economic feasibility of the development scenario.

The CBAn consists of two separate analyses:

- Firstly, the analysis of the possible schemes and betterment works that can supply the four identified irrigation areas at Trawal, to determine the financial and economic feasibility of the system for the scenarios.
- Secondly, the financial and economic feasibility of the two scenarios is compared to support a recommendation in terms of financial and economic terms.

A SAM-based econometric model was applied to estimate the social and macro-economic impacts of the Trawal irrigation development as well as the impact on a local, regional, and national level.

17.5 Costs and Implementation Programmes

Table 17-1 presents the estimated costs of the two small schemes to supply water to the four Trawal identified areas, which forms part of Scenario 2.

Table 17-1: Costs of two small schemes

Capital Cost Components	Costs (R million)
New high-level canal	122.7
Pump stations	153.04
Pipelines and syphon	83.86
Farm Dams	27.42
Canal raising: 8km of existing main canal	3.92
Cost of lining: 8km of existing main canal	45.61
Land purchase cost	66.32
Consulting fees	70.29
Total cost	**R 573.16**

The estimated capital construction cost to develop the two small bulk water development schemes to provide water to the Trawal irrigation areas is R 573.16 million, expressed in 2020 prices.

The development and betterment costs for the two scenarios are presented in **Table 17-2**.

Table 17-2: Development and Betterment costs of the two development scenarios

Main canal long-term alternative	Development Component	Betterment Component	Total Cost	Construction Period
Two small schemes and upgrading of left bank main canal	R 573.16	R 1 436.41	R 2 009.57	18 years
Right Bank Canal Scheme	R 573.16	R 1 421.50	R 1 994.66	4 Years

It is estimated that the right bank canal will be constructed over a 4-year period. The two small supply schemes will be constructed over 3 years and the betterment of the remainder of the main left bank canal will be implemented thereafter, over a 15-year period. On the basis of an economic 8% p.a. discount rate, the Present Value comparison of the "betterment components" of the two development scenarios is as shown in **Table 17-3**.

Table 17-3: Present Values of Comparative Costs (R million, 2020 prices)

Main canal long-term alternative	Present Value
Right Bank Canal Scheme	R 1 177.05
2 small schemes and upgrading remainder of left bank main canal	R 819.66
Difference	**R 357.39**

The incremental present value cost of implementing the Right Bank Canal Scheme is R 357.4 million. Note that this calculation did not take into consideration additional maintenance costs over the additional 14-year construction period for the left bank main canal.

From the differential present cost value, it appears that the Alternate Left Bank Scenario is the preferable scenario, however this does not take the contribution of the possible significant benefits and the extended negative impact of the canal breaks and water supply restrictions into consideration. Also, the additional water available from the raised Clanwilliam Dam will only be properly utilised after 18 to 20 years for the Alternate Left Bank Scenario compared to the 8 to 10 year period for the Right Bank Canal Scenario.

17.6 Impact of Restricted Water Supply and Canal Breaks

An analysis was done of the current crops produced in the lower Olifants River valley and the production budgets, expressed in 2020 prices. An analysis is also provided of the impact of the water restriction during the latest drought period, as well as the estimated losses suffered during canal breaks. **Table 17-4** provides the estimated losses suffered during the recent drought period for grape-based products. This provides an estimation of the financial impact on the producers, as well as the farm labour and even the impact on the urban areas.

Table 17-4: Losses by producers during recent drought period

Crops	Baseline	Drought Year		Post Drought			
	2016/17	2017/18		2018/19		2019/20	
	Yield	Yield	% Change	Yield	% Change	Yield	% Change
Wine grapes (t/ha)	22,6	19,8	-12%	17,2	-24%	23,7	5%
Raisins (total tonnes)	7 800	5 800	-26%	6 500	-17%	11 000	41%
Table grapes (total 4,5kg export ctns)	3 968 073	2 802 436	-29%	2 366 503	-40%	3 319 516	-16%

Table 17-5 presents the estimated percentage loss suffered by producers, for different periods of breaks in water supply.

Table 17-5: Losses by producers during different breaks in water supply

Duration of break	Wine Grapes & Raisins		Table Grapes	
	Year 1 loss	Year 2 loss	Year 1 loss	Year 2 loss
30-day water break	50%	20%	55%	25%
3-month water break	60%	40%	65%	45%

From **Table 17-4** and **Table 17-5** it is obvious that the drought restriction has a very negative impact on the grape-based crop production, not only in terms of physical yields but also financially. As all three crops are also exported on a large scale, the country also suffers because of a drop in the balance of payments.

The impact on summer and winter vegetable production has also been addressed.

17.7 Social and Economic Conditions in the Local Municipalities

A detailed analysis is provided of the current social and economic conditions in the two local municipalities. The latest available data show the dependence of these two local municipalities on irrigated agriculture. In the case of the Cederberg Local Municipality 42.6% of the people employed are active in the agricultural sector and 39.7% for the Matzikama Local Municipality.

Both municipalities have large numbers of indigent households, and unemployment is relatively high with large numbers of part-time employees.

The main deduction from the analysis is that the future growth of the economy of the two municipalities will depend on increased irrigation development.

17.8 Financial and Economic Viability and Macro-Economic Impact

To determine the financial and economic feasibility of the development (termed 'the project'), a comprehensive CBAn econometric modelling approach was used, with the following three models being developed:

- Constant Price Financial CBAn Model with an 8% discount rate – constant prices;
- Current Price Financial CBAn Model with an 11.28% discount rate – nominal prices at 4.5% annual inflation; and
- Constant Price Economic CBAn Model with an 8% discount rate – market (shadow) prices.

The three indicators used are:

- Net Present Value (NPV) >0;
- Internal Rate of Return (IRR) > Discount Rate; and
- Benefit Cost Ratio (BCR) >1.

A project must satisfy all three indicators to be recommended for implementation.

The macro-economic impacts were determined with a partial equilibrium model, based on the Western Cape Provincial SAM, to estimate the macro-economic impact contribution of a specific scenario.

17.9 Current Production and Future Assumptions

A detailed analysis was performed to identify the current crops being produced, the profitability of these crops, and the future outlook for a selection of specific representative crops. All of the crops currently produced require intensive management and have high input costs. The availability of effective marketing channels also plays an important role in the selection of the specific crops.

Table 17-6 presents the existing production, but keep in mind that the situation is very dynamic and continuous changes are taking place. According to information received from SAWIS, the area under wine grapes declines by about 130 hectares per annum and is mostly replaced by table grapes and raisin varieties.

Table 17-6: Production below Bulshoek Weir by Crop Type

Crop type	Sub-Area 4 and 5- Bulshoek Weir to Lutzville (hectares)	Percentage
Peaches	100	0.80%
Table grapes	880	7.04%
Wine grapes	8 389	67.11%
Dry Grapes (Raisins)	1 300	10.40%
Summer Vegetables	811	6.49%
Tomatoes Industrial	350	2.80%
Tomatoes Fresh	186	1.49%
Winter Vegetables	485	3.88%
Total	**12 501**	**100.00%**

Some changes in the crop composition were assumed, based on the current and future price structures, and after considering the different scenarios. **Table 17-7** presents the existing crop structure and the adapted percentages used in the analysis.

Table 17-7: Existing crops vs. crops analysed

Crop type	Current Percentage	Adapted Percentage Used
Peaches	0.80%	0.00%
Table grapes	7.04%	11.17%
Wine grapes	67.11%	44.66%
Dry Grapes (Raisins)	10.40%	20.10%
Summer Vegetables	6.49%	6.70%
Tomatoes Industrial	2.80%	8.04%
Tomatoes Fresh	1.49%	6.70%
Winter Vegetables	3.88%	2.64%
Total	**100.00%**	**100%**

Peaches were removed and wine grapes reduced in line with the current financial and marketing problems. The percentage of table grapes, raisins and tomatoes were increased, as the market for all three products appears to be strong in the coming years.

17.10 Financial and Economic Viability of the Proposed Trawal Irrigation

The four identified potential irrigation areas were analysed against the background that the 2 339 hectares is reserved for the establishment of historically disadvantaged farmers. A second issue analysed is the fact that these farmers will need additional financial and other support, which an existing commercial farmer will not require.

The development construction period is estimated at four years, with the development of the first irrigation area during the second year of construction.

The latest projections are that, if construction starts in Year 1, the following areas can become available for the Right Bank Canal Scenario:

- Year 2: Zypherfontein 1 - 669 hectares;
- Year 3: Zypherfontein 2 - 661 hectares;
- Year 5: Trawal - 554 hectares; and
- Year 5: Melkboom - 455 hectares.

Farm establishment costs were estimated in the: *Financial Viability of Irrigation Farming Sub-Report* together with the *Mechanization Guide 2020* published by JP and ME le Roux and the building costs from the *2020 Building Cost AECOM* publication.

Table 17-8 presents the total estimated farm development costs for the proposed Trawal irrigation area.

Table 17-8: Trawal Irrigation Area - Farm Unit establishment costs (R million, excl. VAT)

Year	2	3	4	5	Total
Sheds	12.36	10.75	5.81	12.20	41.13
Raisin slabs	0.15	0.15	0.15	0.15	0.60
Pack houses	6.00	6.00	6.00	6.00	24.00
Irrigation and bulk water	95.07	82.73	44.69	93.89	316.38
Tractors/ implements, etc.	41.49	36.11	19.50	40.98	138.08
Total	**R 155.07**	**R 135.74**	**R 76.15**	**R 153.22**	**R 520.18**

The operational costs were calculated in line with 'Budgets'. Crop Budget is a term used by the Department of Agriculture and all producer organisations like Grain SA, SAWIS, SATI, etc. The main objective of compiling a crop budget for a specific crop is to use them as the basis of determining Net Income for a representative farm or specific crop. This variable is an important parameter in determining the value of irrigated land as well as the economic value of irrigation water.

Table 17-9 presents the results of the three CBAn models as discussed in Section 17.8.

Table 17-9: Results from the three CBAn Models

Model	Constant Price - Financial	Current Price - Financial	Economic Price
Discount Rate	**8%**	**11,28%**	**8%**
Present Value Benefits (R million)	R 6 169.1	R 7 599.6	R 6 169.1
Present Value – Costs (R million)	R 4 665,1	R 5 518.2	R 4 592.5
Net Present Value (NPV) (R million)	R 1 504.02	R 2 081.46	R 1 576.67
Benefit Cost Ratio (BCR)	1.32	1.38	1.34
Internal Rate of Return (IRR)	16.8%	22.2%	17.34%

Table 17-9 shows positive, financially viable results for all three baseline models. A detailed risk analysis was performed making provision for the following:

- Capital costs that can increase up to 40%, for both the canal system and the farm development costs;
- A 20% annual increase for electricity costs; and
- A 10% annual wage increase.

For all three models, the analysis results remain positive and it is deducted that this section of the project is financially viable.

The macro-economic analysis shows that in total, 2 705 jobs will be directly created, mostly on the farms, of which 84 will be skilled, 281 semi-skilled, and 2 899 unskilled. A large percentage of the unskilled "direct" labour will be part-time, while the skilled and semi-skilled labour will be permanent employees.

The indirect employment created is estimated at a total of 234, and the induced employment at a total of 444.

The total annual amount paid to households is estimated at R 417 million, expressed in 2020 prices. The low-income household share is R 44 million, which is 10.1%, per annum, expressed in 2020 prices.

The total annual taxes paid are estimated at R 154 million, with R 108 million paid to National Government.

The annual estimated impact on the balance of payment is R 259 million, expressed in 2020 prices. It is mostly made up of the exports of table grapes and raisins, with a percentage contribution from wine production.

From the above analysis it is deduced that the Trawal irrigation proposal is financially and economically viable and can be recommended for implementation.

17.11 Comparison of the Financial and Economic Viability of the Right Bank Canal scenario to the Alternative Left Bank scenario

The data used in the different models to determine the financial and economic feasibility of the two scenarios are presented below.

The total new area that can be developed for irrigation below Bulshoek Weir for the Right Bank Canal Scenario is 3 639 hectares, consisting of the 2 339 hectares in Trawal and an additional 1 300 hectares, consisting of:

- Klawer Phase 1: 412 hectares.
- Klawer Phase 2: 438 hectares.
- Coastal flow-restricted: 89 hectares.
- Ebenhaeser: 361 hectares.

If the Alternate Left Bank Canal Scenario is implemented, the Klawer Phase 2 Scheme might not be developed, due to the lack of canal flow capacity, and the additional area is reduced to 888 hectares, if it is assumed that the extent of canal losses remains at 20%. However, as the canal is lined, the losses will decrease, eventually to the extent that adequate flow capacity can potentially be available to also implement the Klawer Phase 2 Scheme, although this would not be advisable.

The Klawer Phase 2 Scheme can also be developed as the last phased scheme, for the Right Bank Canal Scenario, and additional funds become available for an upgrade or replacement of the Klawer canal section, to service the new irrigation area and other water users.

The following presents the estimated development area per year for the Right Bank Canal Scenario, for all new schemes below Bulshoek Weir:

- Year 2 - Zypherfontein 1: 669 hectares.
- Year 2 - Klawer Phase 1: 412 hectares.
- Year 3 - Zypherfontein 2: 661 hectares.
- Year 3 - Ebenhaeser Restitution and CPA augmentation: 361 hectares.
- Year 5 - Trawal: 554 hectares.
- Year 5 - Melkboom: 455 hectares.
- Year 5 - Coastal 1 flow restricted: 89 hectares.
- Year 7 - Klawer Phase 23: 438 hectares.

For the Alternate Left Bank Canal Scenario, the following development area was estimated and populated in the model:

- Year 2 - Zypherfontein 1: 669 hectares.
- Year 2 - Klawer Phase 1: 412 hectares.
- Year 2 - Trawal: 554 hectares.
- Year 3 - Zypherfontein 2: 661 hectares.
- Year 3 - Ebenhaeser: 361 hectares.
- Year 4 - Melkboom: 455 hectares.
- Year 5 - Coastal 1 flow-restricted: 89 hectares.
- Year 13 - Klawer[4] Phase 2: 438 hectares.

The farm development costs were also calculated for the settlement of historically disadvantaged farmers and for application in the CBAn models, as presented below.

The farm developmental costs are presented in **Table 17-10**.

Table 17-10: Right Bank Production Unit Development Costs (R million, eccl. VAT, 2020 prices)

Year	2	3	4	5	6	7	Total
Hectares developed per year	1081	1022	0	1098	0	438	3639
Percentage per annum	29.7%	28.1%	0.0%	30.2%	0.0%	12.0%	100.0%
Sheds, etc.	31.80	30.06	0.00	32.30	0.00	12.88	107.05
Irrigation and bulk water	229.08	216.57	0.00	232.68	0.00	92.82	771.15
Tractors/ implements, etc.	128.43	121.42	0.00	130.45	0.00	52.04	432.34
Total	**R 389.31**	**R 368.06**	**R 0.00**	**R 395.43**	**R 0.00**	**R 157.74**	**R 1 310.53**

[3] This will be soonest that Klawer Phase 2 could be implemented.
[4] This will only be possible once the left bank canal has been refurbished

The total farm development cost of R 1 310.53 million, expressed in 2020 prices, are the same for both scenarios, but the application of the funds is phased in the relevant CBAn models, according to the two different area development programmes.

The production costs are based on the budgets and phased according to the proposed area development. The same applies for the income generated by the development of the new irrigation areas and phased in accordingly. **Table 17-11** presents the CBAn results of the Right Bank Canal Scenario.

Table 17-11: CBAn results of the Right Bank Canal scenario

Parameters	FCBA[5] Constant Price	FCBA Current Price 4.5% Annual Inflation	ECBA Constant Price
Discount Rate	8%	11.28%	8%
Benefit - Present Values (R million)	R 8 597.85	R 12 418.23	R 8 142.66
Total Costs – Present Values (R million)	R 8 316.36	R 9 998.77	R 5 396.88
Net Present Value (NPV) (R million)	R 281.49	R 2 419.46	R 2 745.78
Benefit Cost Ratio (BCR)	1.03	1.24	1.51
Internal Rate of Return (IRR)	8.8%	13.71%	16.2%

The results of the baseline model present a very positive financially viable result. A sensitivity analysis was performed to show the results, if no additional benefits are realised from the existing producers, as well as different production levels, should the new farmers experience problems to reach expected production levels in the first seven years. The sensitivity analysis also shows a very positive set of results (**Table 17-12**).

Table 17-12: Right Bank Canal Scenario Sensitivity Analysis results

Parameters	No Additional Benefits from Existing Area	New Production 10% Short	New Production 15% Short	New Production 20% Short
NPV (R mil.)	R 2 055.59	R 2 390.8	R 1 788.3	R - 476,65
BCR	1.26	1.24	1.18	0.98
IRR	12.2%	11.3%	9.9%	6.52%

[5] FCBA – Financial Cost Benefit Analysis

It is deducted that the Right Bank Canal Scenario is financially viable for the first two risk analyses done, but not if the production yields are more than 15% short.

Table 17-13 presents the results for the Alternate Left Bank Scenario.

Table 17-13: CBAn results of the Alternate Left Bank Canal scenario – Klawer Phase 2 Included

Parameters	FCBA[6] Constant Price	FCBA Current Price 4.5% Annual Inflation	ECBA Constant Price
Discount Rate	8%	11.28%	8%
Benefits – Present Value (R million)	R 7 973.00	R 10 118.06	R 7 973.00
Total Costs – Present Value (R million)	R 7 949.32	R 9 380.47	R 7 848.45
Net Present Value (NPV) (R million)	R 23.68	R 737.59	R 124.55
Benefit Cost Ratio (BCR)	1.01	1.08	1.03
Internal Rate of Return (IRR)	8.1%	14.0%	8.4%

The results indicate a financially viable scenario. In **Table 17-14**, the sensitivity results of the Alternate Left Bank Canal Scenario are presented.

Table 17-14: Alternate Left Bank Canal Scenario Sensitivity Analysis results

Parameters	No Additional Benefits from Existing Area	New Production 5%short	New Production 10% short
NPV (R mil.)	R 482.00	R 244.47	R - 248.65
BCR	1,05	1,03	0.97
IRR	13.2%	12.2%	10.3%

The results for the Alternate Left Bank Canal Scenario show much more sensitivity than the results for the Right Bank Canal Scenario.

The results show that both scenarios are financially viable in terms of the CBAn results, with the Right Bank Canal Scenario providing much stronger results.

The sensitivity analysis also does not support the Alternate Left Bank Canal Scenario in terms of the different risk factors relating to possible construction cost increases and not reaching maximum production levels, or possible product prices not keeping up with the cost of production inflation.

[6] FCBA – Financial Cost Benefit Analysis

Table 17-15 shows a comparison of the baseline results from the financial and economic CBAn models for both scenarios, indicating the stronger Scenario 1.

Table 17-15: Result Comparison of the Right Bank and Left Bank Scenarios

Parameters	FCBA Current Price 4.5% Annual Inflation	FCBA Current Price 4.5% Annual Inflation	Economic CBAn Constant Market Prices	Economic CBAn Constant Market
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Discount Rate	11,28%	11,28%	8%	8%
Benefit - Present Values (R mil.)	R 13 590.76	R 10 118.06	R 8 142.66	R 7 973.00
Total Costs - Present Values (R mil.)	R 9 998.76	R 9 380.46	R 5 396.88	R 7 848.44
Net Present Value (NPV) (R mil.)	R 3 592.00	R 737.60	R 2 745.78	R 124.56
Benefit Cost Ratio (BCR)	1.36	1.08	1.51	1.01
Internal Rate of Return (IRR)	16.2%	14.0%	16.2%	8.4%

The macro-economic impact analysis shows that, in total 7 686 job opportunities can be created and supported, of which 6 160 are in the direct category and will be in the area and on the farms. It can also be accepted that a percentage of the other two categories will occur in the feeder area.

At least 6 160 jobs will be created in the Cederberg and Matzikama Local Municipality service areas, where social conditions are currently not very encouraging and irrigation activities can add to the improvement of the situation.

Table 17-16 shows the number of jobs that can be created and supported at different skill levels by the proposed new irrigation development of the Right Bank Canal Scenario.

Table 17-16: Jobs created by the Right Bank Canal Scenario

Impact on employment	Numbers
Skilled	484
Semi-skilled	1 257
Unskilled	5 945
Total	7 686

It is evident from **Table 17-16** that 484 of the employment opportunities to be created will be in the skilled category, with 1 257 in the semi-skilled category and 5 945 in the unskilled category.

One of the crucial aspects of any socio-economic impact assessment is poverty alleviation. The extent to which poverty alleviation is achieved is measured by the impact on household income, specifically, the extent to which low-income households will be affected by the successful execution of the project. **Table 17-17** shows the total annual impact of the expected wages to be paid to households, with a total of R 818 million annually, expressed in 2020 prices.

Table 17-17: Impact on expected household wages

Impact on Households	Total Impact (Rand million)
Low Income	103
Medium Income	253
High Income	623
Total	979

As a large percentage of the table grapes, raisins and wine grape products are exported, a very positive impact is realised on the balance of payments of Treasury, namely R 584 million annually, expressed in 2020 prices.

17.12 Do-Nothing Scenario

The two development scenarios have been evaluated against the 'Do Nothing' scenario which is the following:

- After the Clanwilliam Dam wall has been raised and the additional water is available, only the new irrigation schemes that make use of the existing spare canal flow capacity can be developed. This means that the right bank canal or alternatively the two small bulk water supply schemes are not constructed. The following schemes are developed for the 'Do Nothing' scenario:
  - Year 2: Klawer Phase 1 – 412 hectares;
  - Year 3: Ebenhaeser Restitution and CPA augmentation – 361 hectares; and
  - Year 7: Coastal flow-restricted – 89 hectares.
- Attempt to maintain the current canal system with all its weaknesses, leakages and canal breaks.

The results of the 'Do Nothing' scenario would then be:

- Restricted economic development in the lower Olifants River valley as the current left bank canal will not be able to accommodate the new water volumes.
- The available additional water is not properly used.

- Only at schemes that make use of the spare capacity in the existing canals would historical disadvantaged farmers be established and the opportunity to establish or support them on the other areas will not take place.
- Very limited opportunity for poverty alleviation in the area due to restricted development of new irrigation areas.

17.13 Analysis of the Trawal Irrigation Areas

The financial and economic feasibility of developing the four recommended Trawal irrigation areas were established separately. The financial feasibility was established by applying the CBAn approach. A Cash Flow Model was used to determine if farmers will be able to repay any production and farm development loans. The economic feasibility was determined by using a Macroeconomic Impact Model (MEIA).

A detailed investigation was performed to identify the current crops produced, the profitability of these crops, and the future outlook of specific crops. Based on this analysis, a specific crop composition was used in the analysis.

The future income of the new areas was phased in the modelling exercise. The capital costs, as well as the production costs were phased in the models.

The results are positive for the CBAn analysis as well as the Cash Flow, in which it is estimated that newly established historically disadvantaged farmers should be able to repay their loans within a period of 10 years. The MEIA also shows very positive results and the construction of the Right Bank Canal Scheme will make a very positive contribution to the economic growth of the two local municipalities.

Table 17-18 presents the results of the CBAn results, indicating financial viability.

Table 17-18: CBAn Results for the Trawal Area

Model	Constant Price - Financial	Current Price - Financial	Economic Price
Discount Rate	**8%**	**11,28%**	**8%**
Present Value Benefits (R million)	R 6 169.1	R 7 599,6	R 6 169.1
Present Value – Costs (R million)	R 4 665.1	R 5 518,2	R 4 592.5
Net Present Value (NPV) (R million)	R 1 504.02	R 2 081,46	R 1 576.67
Benefit Cost Ratio (BCR)	1.32	1.38	1.34
Internal Rate of Return (IRR)	16.8%	22.2%	17.34%

The results indicate a very positive set of results. The sensitivity analysis undertaken supports the very positive results.

17.14 Comparison of the Two Canal Scenarios

The following presents a summary of the CBAn results for the current price and market price models of the two canal development scenarios:

- Scenario 1: Right Bank Canal Scheme.
- Scenario 2: Alternate Left Bank Canal Scheme.

Table 17-19 shows that Scenario 1 is preferable in terms of the baseline CBAn results, although both show viable results.

Table 17-19: Comparative CBAn results for the canal development scenarios

Parameters	FCBA Current Price 4.5% Annual Inflation	FCBA Current Price 4.5% Annual Inflation	Economic CBAn Constant Market Prices	Economic CBAn Constant Market
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Discount Rate	11.28%	11.28%	8%	8%
Benefit - Present Values (R million)	R 13 590.76	R 10 118.06	R 8 142.66	R 7 973.00
Total Costs – Present Values (R million)	R 9 998.76	R 9 380.46	R 5 396.88	R 7 848.44
Net Present Value (NPV) (R million)	R 3 592.00	R 737.60	R 2 745.78	R124.56
Benefit Cost Ratio (BCR)	1.36	1.08	1.51	1.01
Internal Rate of Return (IRR)	16.2%	14.0%	16.2%	8.4%

The findings included in **Table 17-19** show that Scenario 1 presents the stronger financial and economic results, especially in the case of the Economic CBAn.

A detailed risk and sensitivity analysis was also performed, with evaluation of some of the cost items that might increase faster than the projected inflation rate, as well as the possibility that projected income levels may not be attained. The comparison of the sensitivity analysis for the two scenarios is shown in **Table 17-20**.

Table 17-20: Sensitivity Analysis scenarios comparison

Scenarios	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Parameters	**No Additional Production Existing Areas**	**No Additional Production Existing Areas**	**Production 10% Short**	**Production 10% Short**
NPV (R million)	R 2 055.59	R 482.00	R 2 390.8	R - 248.65
BCR	1.26	1.05	1.24	0.97
IRR	12.2%	13.2%	11.3%	10.3%

The results in **Table 17-20** show that both scenarios provided positive answers, if no impact of the existing areas are taken into consideration, but the benefits of Scenario 2 are considerably lower than the benefits from Scenario 1 (Right Bank Canal Scheme).

The second comparison set shows that, if the financial benefits are lower than 15% of the expected results, then Scenario 2 is not viable.

The macro-economic impact analysis shows that the implementation of the Right Bank Canal Scheme will introduce considerable positive results in terms of the growth potential of the economy of the lower Olifants River valley, which is an area where economic growth is currently very low. It will also make a large contribution to poverty alleviation in the region, by the number of new jobs created and salary payments to households.

Scenario 1 will also produce economic impacts in the lower Olifants region after 8 to 9 years, while Scenario 2 will probably reach the same level of positive impacts after 18 to 20 years.

17.15 Recommendation

The financial and economic viability analysis undertaken demonstrates that the Right Bank Canal Scenario is recommended as the preferred scenario.

The benefits of implementing the Right Bank Canal Scheme, in comparison with the implementation of the alternative two small water supply schemes and upgrading of the existing left bank canal, are as follows:

a) The Right Bank Canal will be built to current construction standards, with proper freeboard and additional capacity that allows for intra-month flexibility to meet water requirements and therefore improve production. While this, at first, will only be of immediate benefit for water users up to Verdeling, this presents the opportunity for the rest of the system to benefit later when the secondary canals are upgraded.

b) The Right Bank Canal will be more secure against failure than the re-lined left bank canal. In addition, this security will be achieved earlier.
c) The Right Bank Canal will present an opportunity for a subsequent upgrade of the system downstream, extending the benefit of greater flexibility and additional capacity. This in turn, along with the slightly increased capacity, will allow irrigators to plant a higher percentage of permanent crops, especially during the high summer period, with associated socio-economic benefits.
d) There is greater confidence in the estimation of the Right Bank Canal's construction costs and programme. For the upgrading of the left bank canal, the requirement to keep water flowing while construction takes place makes it a complex exercise, beset with operational difficulties and unforeseen issues that can increase costs and are likely to cause delays.
e) The Right Bank Canal Scheme makes provision to meet the future water requirements such as towns, industries and mines (initially only up to Verdeling, until further canals are upgraded). Upgrading the existing left bank canal does not make provision to meet the future water requirements, especially the potential to eventually increase the supply capacity up to Vredendal.
f) Should the left bank canal be re-lined, new irrigation schemes that rely on the construction of the Right Bank Canal cannot be developed, such as the Klawer Scheme Phase 2, which can be done if the Right Bank Canal Scheme is implemented.
g) There will be significant water savings due to reduced losses, should the Right Bank Canal be constructed, compared to re-lining the entire left bank main canal. Considering that the value of the water is between R 30/m^3 and R 45/m^3, the value of the losses is significant. The integrity of the Right Bank Canal will also be better than that of a re-lined left bank canal.

While it is not possible to directly compare all the incremental benefits with the incremental costs, a strong argument can be made for implementing the Right Bank Canal Scheme. The replacement of the current left-bank main canal with a proposed right bank canal of increased capacity is an opportunity to significantly reduce the risk of canal breakage and supply interruptions to water users, to lower water losses, to lower the risk of damage to the regional economy and plan for future water provision.

The Right Bank Canal Scheme provides a unique opportunity to combine long-delayed betterment works more cost-effectively with new development infrastructure. The opportunity to piggy-back on to the scheme is a once-off. If missed, that opportunity will be gone forever.

18 Legislative Compliance

This chapter describes water use licensing and dam safety legislation and the need for compliance, as well as the environmental requirements and processes that are required to make the schemes implementation ready.

18.1 Water Use Licensing

The proposed schemes will require separate WULAs in terms of Section 21 of the NWA.

Water uses that need to be included in the WULA (as relevant for each scheme) are:

i. Taking water from a water resource (development of irrigation areas) - Section 21(a);
ii. Storing water (dam) - Section 21(b);
iii. Impeding or diverting the flow of water in a watercourse (dam and associated conveyance infrastructure) - Section 21(c); and
iv. Altering the bed, banks, course or characteristics of a watercourse (conveyance infrastructure and balancing dam) - Section 21(i).

18.1.1 Jan Dissels Scheme

The need for water use licensing for the Jan Dissels Scheme is not envisioned as part of the implementation of the scheme. If the pipeline does however cross any rivulets, a WULA would be required in terms of Section 21(i) of the NWA.

The prospective water users would be responsible for undertaking WULA processes for Section 21(a) and 21(b) water uses (for irrigation development), which would be separate from the process for the implementation of the scheme.

18.1.2 Right Bank Canal Scheme

Water use licensing for the Right Bank Canal Scheme will be required as part of the implementation of the scheme. WULAs in terms of Section 21(c) and 21(i) of the NWA will be required for crossing the Olifants and Doring rivers, and other streams and drainage lines.

The prospective water users would be responsible for undertaking WULA processes for Section 21(a) and 21(b) water uses (for irrigation development), which would be separate from the process for the implementation of the scheme. The WULA process and deliverables will comply with GN R267/2017.

18.1.3 Ebenhaeser Scheme

The volume of water to be stored in the balancing dam exceeds the maximum volume generally authorised under GN 538 (2016 with effect from March 2017) Appendix A. The dam will thus require a WULA in terms of Section 21(b) of the NWA.

The syphon that will be constructed through the Olifants River for the Retshof canal diversion will require Section 21(c) and 21(i) WULAs to be undertaken. The WULA process and deliverables will comply with GN R267/2017.

As the balancing dam and some of the proposed schemes routes and sites are located within minor drainage lines, Section 21(c) and 21(i) applications for these may also be required.

The prospective water users would be responsible for undertaking WULA processes for Section 21(a) and 21(b) water uses (for irrigation development), which would be separate from the process for the implementation of the scheme.

18.2 WULA Process

The implementation of the proposed conveyance infrastructure and balancing dam will, where relevant trigger the requirement for a combined water use licence in accordance with Section 21 of the NWA for each scheme.

The WULAs will be submitted via the DWS online eWULAAS platform. The relevant Water Management Area is *Catchment E - Berg-Olifants*, which means that the application will be processed by the Bellville DWS office.

The issuing of a water use licence is based on an evaluation of the proposed activity in terms of the impact on the resource as well as the potential social, economic and environmental impacts of the proposed use. Supporting documentation and studies are required to show:

- The extent to which the proposed water use will impact on the resource;
- The steps that will be undertaken to mitigate this impact;
- The extent to which the proposed water use will contribute to the local and national economy; and
- The social benefits in terms of job creation and income generation in the area.

A strong emphasis is given to water use that supports water allocation reform, the re-dress of previous inequitable allocation of water use licences and the equitable use of the natural resource.

Because it is proposed that the embankment of the Ebenhaeser balancing dam will be constructed with material excavated from the dam basin, the **disposal of inert waste** is unlikely to require a Section 21 (g) application and is therefore currently excluded from the authorisations/licences/permits required.

18.3 Dam Safety Licence Requirements

The following legal requirements apply to new dams, alterations to existing dams or repair of dams that failed, as issued by the Dam Safety Office:

1) Apply for classification of the dam with the Dam Safety Office (DSO) (part of the Department of Water and Sanitation). The Ebenhaeser balancing dam is expected to be classified as a Category II dam. This requires the services of an Approved Professional Person (APP).
2) The APP will be responsible for the design work as well as submitting an application to the DSO for a Licence to Construct, which comprises an application form, design report, engineering drawings and construction specifications.
3) During construction, the APP must submit quarterly reports to the DSO on progress of the construction of the dam.
4) Before the construction completion and impoundment is set to commence, the APP must apply to the DSO for a Licence to Impound. This involves the compilation and submission of an operation and maintenance manual and emergency preparedness plan.
5) A Water Use Licence or written authorisation must be obtained from the Regional Director of the relevant region before a Licence to Impound can be issued
6) After completion of all construction work, the APP must register the dam, submit a completion report, completion drawings and a completion certificate stating that the work has been completed according to his/her specifications.

18.4 Application for Licence for Borrow Area

At this stage it is anticipated that a borrow area(s) may be required to source construction material, which could trigger listed activities under GN R983 and R985. Provision should therefore be made for a separate application to be submitted to DMRE for the authorisation of these listed activities.

18.5 Ecological Water Requirement

In accordance with the NWA, any new or raised dam is required to make EWR releases in order to sustain the downstream riparian environment. It is unlikely that there will be any required releases from the Ebenhaeser balancing dam as it is off-channel and will have a perimeter trench diverting any runoff around the dam. No allowance for the EWR has thus been made in the design.

18.6 Environmental Impact Assessment

18.6.1 Introduction

Following the completion of the Clanwilliam Bridging Study, DWS will undertake separate EIA processes for the Jan Dissels, Right Bank Canal and Ebenhaeser Schemes, in terms of all applicable environmental legislation, in a combined EIA study with separate components. A detailed scope of services has been prepared to invite proposals from professional service providers, which includes the need to prepare and submit a WULA for the schemes in terms of Section 21 and Section 22(3) of the NWA.

In terms of NEMA, and Environmental Impact Assessment Regulations, as amended on 4 December 2014, and any later amendments, an Environmental Authorisation for the three proposed schemes will be required from DEFF, who is the Competent Authority. The procedural requirements for the EIA process are set out in GN R983 of 2014 (as amended). Of greatest importance is the multi-staged approach to public participation and stakeholder engagement stipulated by these regulations.

Impact mitigation measures and environmental management are to be set out in an Environmental Management Programme (EMPr) and must address the life-cycle of the project. The EMPr must be compiled during the EIA process and submitted as part of the final EIA report to the competent authority.

18.6.2 Specialist studies

Various specialist studies will be required, as part of the EIA process, to quantify and assess social and environmental impacts of the proposed schemes and identify suitable mitigation measures. Specialist studies that are envisaged for these schemes include:

- A terrestrial ecology and botanical study;
- An aquatic ecology and wetland assessment;
- A Phase 1 heritage impact and paleontological assessment; and
- A social impact assessment.

18.6.3 Applicable Legislation

The legislation applicable to the EIA process includes the following:

18.6.3.1 National Environmental Management Act (No. 107 of 1998, as amended)

The three schemes will require a Scoping-EIA process in terms of NEMA, as it will trigger *inter alia* activities 15 and 16 of GN R984 (2014, as amended). The schemes will also trigger various listed activities under GN R983 and R985 (2014, as amended).

18.6.3.2 Mineral and Petroleum Resources Development Act (No. 28 of 2002, as amended)

The schemes may require specific construction material to be sourced elsewhere if suitable material is not available from commercial sources. This will result in the need for a borrow pit close to the construction site(s). DWS has been exempted from the provisions of Sections 16, 20, 22 and 27 of the Mineral and Petroleum Resources Development Act (MPRDA), in terms of Section 106 of the Act. While the amended GN R983 and R984 now exclude Section 106 (mining activities), auxiliary activities such as vegetation clearance or access roads are not excluded.

At this stage it is therefore anticipated that borrow (mining) areas might trigger listed activities under GN R983 and R985. Appendices 1 of GN R983 to R985 specify that the Minister of Mineral Resources is the CA for listed activities that are directly related to the extraction or primary processing of a mineral. A separate application will thus be required to be submitted to the DMRE for the authorisation of any listed activities, which will be triggered as a direct result of the mining activities (borrow pit).

18.6.3.3 National Environmental Management: Biodiversity Act (No. 10 of 2004, as amended)

Based on the Post Feasibility Bridging study the study area encompasses a total of 28 threatened ecosystems with two categorised as Endangered, namely the Leipoldtville Sand Fynbos and Citrusdal Shale Renosterveld. There are a few areas mapped as CBAn 2, in the study area. It is anticipated that the National Environmental Management: Biodiversity Act (NEMBA) will have to be consulted.

18.6.3.4 National Water Act (No. 36 of 1998, as amended)

The volume of water to be stored in the Ebenhaeser balancing dam is 2.3 million m^3. The dam will thus require a Water Use Licence Application in terms of Section 21 (b) of the NWA. Section 21(c) and 21(i) applications will most likely also be required for the balancing dam and conveyance infrastructure, such as syphons, diversion works and pipelines.

18.6.3.5 National Forests Act (No. 84 of 1998, as amended)

The Ebenhaeser balancing dam site is located within an ‘Endangered’ ecosystem, which is in a near natural state. It is therefore anticipated that a permit might be required for the destruction of any tree species that are protected under the National Forests Act (NFA). It may however be possible to relocate some of the protected species.

18.6.3.6 Nature and Environmental Conservation Ordinance (No. 19 of 1974)

The Ebenhaeser balancing dam site is located within an 'Endangered' ecosystem, which is in a near natural state. It is therefore anticipated that a permit might be required for the relocation, damage or destruction of species that are protected under the Nature and Environmental Conservation Ordinance.

18.6.3.7 National Heritage Resources Act (No. 25 of 1999)

The proposed project requires notification of Heritage Western Cape (HWC), in terms of Section 38(1)(b) and 38(c) of the NHRA. In the event of a heritage object and/or site being identified during the Phase 1 Archaeological and Paleontological study, an application for a permit for destruction or relocation will be required.

18.6.4 Competent Authority

Note that in terms of Section 24C (2)(d)(i) of NEMA and Section 43 (1)(c)(i), DEFF will be the Competent Authority for all listed activities under GN R983 to R985. They could potentially select to delegate responsibility to the Provincial Authority, which is DEA&DP.

19 Implementation Arrangements

This chapter identifies the various legislative considerations required for effective implementation, identifies affected land, land acquisition and wayleaves, discusses operation and maintenance requirements, and institutional arrangements.

19.1 Affected Land, Land Acquisition and Wayleaves

19.1.1 Jan Dissels Scheme

Landowners will need to be consulted regarding the pipeline routes and associated infrastructure over their properties. It is recommended that a 9 m wide servitude be registered along the proposed pipeline routes and that the proposed pipeline be positioned in the centre of the servitude. During the construction phase, it is proposed that provision be made for a 25 m wide working width (temporary servitude) along the proposed pipeline routes.

19.1.1.1 Rising Main from the Raised Dam Wall

The surface area required for the 3 740 m long pipeline, including a 9 m wide servitude, is 3.37 ha. The surface area required for the reservoir is 0.17 ha.

The land required for the Rising Main pump station at the dam wall will not have to be acquired, as this falls within the Clanwilliam Dam area, which is owned by DWS.

The Rising Main route will cross two surfaced roads, namely the Deon Burger Road and the entrance/exit roads to the Clanwilliam Dam Resort. Approval will be required from the provincial roads department for the road crossings and possible construction works in the road reserve.

The route will transect the Ramskop Nature Reserve, which is managed by the Cederberg Municipality. There are indications that existing pipelines are present in this area and that the construction of the pipeline could potentially be approved by the Management Authority, which would be the Municipality in this case. This route does however include the removal of indigenous vegetation and would probably require temporary and permanent access tracks to be constructed.

19.1.1.2 Clanwilliam Dam

As DWS is the owner of Clanwilliam Dam and is also expected to be the owner of the scheme, no issues are foreseen with abstraction from the raised dam.

19.1.1.3 Access Road from the 'Ou Kaapse' Road or township

An access road to the proposed concrete reservoir must be constructed from the "Ou Kaapse" Road or the township development located close by. There is an existing gravel road to the proposed site. It is uncertain whether this road would require upgrading.

19.1.1.4 Jan Dissels River Syphon

Environmental implications of the syphon through the Jan Dissels River will be considered as part of the on-farm irrigation conveyance infrastructure, and is not part of the implementation of the bulk water scheme.

19.1.1.5 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 for the proposed development 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.

19.1.1.6 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 to provide additional income, which is needed to support the increasing number of learners that are applying for exemption of school fees and thereby 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 WCDoA has arranged for 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.

19.1.2 Right Bank Canal Scheme

Figure 19- shows the existing infrastructure that will be affected by the canal alignment, which includes the major components described below.

19.1.2.1 Canal Access Road

A 4.0 m wide canal service road next to the canal is planned. This gravel road will link to existing roads at locations where the canal crosses these roads. It is envisaged that the service road will be used as access road during the construction of the canal.

19.1.2.2 Existing Left Bank Canal Road

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

19.1.2.3 R363 Provincial Road and Farm Roads

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

The proposed canal crosses the R363 a total of four (4) times and it crosses major farm roads a total of 11 times. A bridge needs to be provided at each of these crossings.

The locations of the crossings are shown in **Figure 19-**.

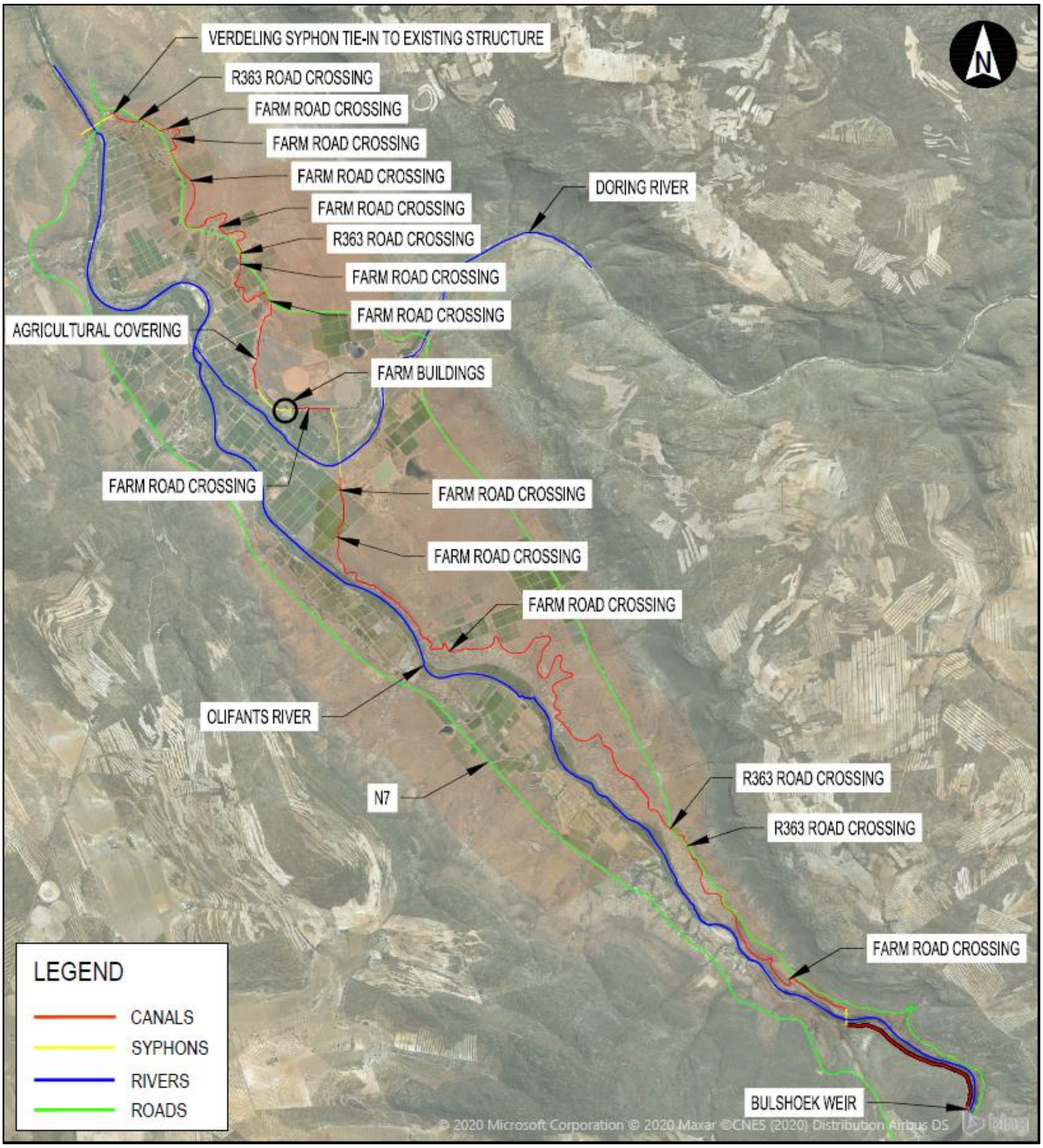

Figure 19-1: Existing infrastructure affected by the Right Bank Canal route

19.1.2.4 Farm Owners

The horizontal alignment for the proposed Right Bank Canal runs through privately owned farms. These landowners will need to be consulted regarding the canal route and associated infrastructure over their properties. Land and servitudes for the canal will need to be acquired from these landowners. Compensation for the land acquired will include infrastructure affected by the project.

19.1.2.5 Existing Syphon at Verdeling

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

19.1.2.6 Syphons

Both the Olifants and Doring River syphons, as well as the syphon along the steep section near the Doring River syphon are located on privately owned farms. These landowners will need to be consulted regarding the canal route and associated infrastructure over their properties. Land and servitudes for the canal will need to be acquired from these landowners. Compensation for the land acquired will include infrastructure affected by the project.

19.1.3 Ebenhaeser Scheme

19.1.3.1 Landowners

The scheme will traverse several farms, owned by various landowners. These landowners will need to be consulted regarding the pipeline routes and associated infrastructure over their properties. The portion of land upon which the Ebenhaeser Balancing dam is to be located is known as Bakleiplaas 182 and is privately owned.

It is recommended that a 9 m wide servitude be registered along the proposed pipeline routes and that the proposed pipeline be positioned in the centre of the servitude.

During the construction phase, it is proposed that provision be made for a 25 m wide working width (temporary servitude) along the proposed pipeline routes.

The surface area required for the 3 720 m long pipelines (portion of the gravity main and rising main) on undeveloped private land, including a 9 m wide servitude, is 3.35 ha. The surface area required for the reservoir is 0.21 ha.

The surface area required for the 1 360 m long diversion pipelines on developed private land, including a 9 m wide servitude, is 1.22 ha. The surface area required for the pump stations and balancing tank is 0.14 ha.

Most of the remaining Financial Assistance Land Administration (‘FALA’) land of DALRRD is located near the existing Ebenhaeser Community Scheme, and will be traversed by a significant portion of the gravity pipeline. The diversion infrastructure, rising main pipelines, balancing dam and reservoir will be located on private land, which either needs to be acquired or servitudes need to be registered.

19.1.3.2 R362 & R363 Provincial Roads

The proposed diversion rising main (from the diversion pump station to the Ebenhaeser Balancing Dam) will cross the R363 road. The gravity pipeline (from the concrete balancing reservoir to the irrigation clusters) will cross the R362 road. Both roads are owned by 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.

19.1.3.3 Railway line

The proposed gravity pipeline from the concrete balancing reservoir to the irrigation clusters) will cross the railway line once at an existing bridge. The railway line belongs to Transnet and forms part of the Transnet Freight Rail. Approval will be required from Transnet for the railway crossing and possible construction works in the railway reserve.

19.1.3.4 Existing Left Bank and Right Bank Canal

No issues are expected with obtaining permission from DWS and LORWUA for construction of offtakes on the existing left and right bank canals to provide water to the Ebenhaeser Scheme.

19.1.3.5 Olifants River Syphon

The syphon through the Olifants River will be located on a privately owned farm. The landowner will need to be consulted regarding the canal route and associated infrastructure over the property. Land and servitudes for the canal will need to be acquired from the landowner. Compensation for the land acquired will include infrastructure affected by the project.

19.1.4 Wayleaves

Wayleave applications will need to be submitted to all the relevant service authorities to (a) obtain information on the location of their existing services, (b) comment on the proposed pipeline alignments, and (c) to obtain their requirements that must be adhered to during construction.

This process should be undertaken during the detailed design phase of the project.

19.2 Operation and Maintenance Requirements

19.2.1 Jan Dissels Scheme

DWS will be the owner of the scheme. It is anticipated that DWS will also be responsible for the operation of the scheme, but this still needs to be confirmed.

The West Coast District Municipality is the water service authority and Cederberg Municipality is the water service provider. Because this scheme will provide bulk raw water supply it falls outside the mandate of Cederberg Municipality. An alternate operator to consider would therefore be the West Coast District Municipality.

19.2.2 Right Bank Canal Scheme

Once the proposed Right Bank Canal has been completed, it is proposed that the existing main left bank canal (Trawal canal section), continues to supply the existing allocations and proposed additional irrigators on the left bank of the Olifants River, between Bulshoek Weir and Verdeling, as an interim measure. Following the significantly reduced flow in this canal section, the maintenance may be adjusted to focus on the bottom section of the canal profile.

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. All new irrigation (from additional allocations following the raising of Clanwilliam Dam) downstream of Bulshoek Weir will be supplied via the Right Bank Canal, except for additional irrigation to be located on the left bank.

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 downstream of Bulshoek Weir.

Syphons will need to be regularly drained via the lined channels provided to the natural water courses.

19.2.3 Ebenhaeser Scheme

19.2.3.1 Releases from Bulshoek Weir

During weeks when there is identified spare flow capacity in the Vredendal and Retshof canal sections, and when the balancing dam is not full, additional flow 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 rule should be revisited should the Klawer Phase 1 Scheme be implemented, to accommodate the flow required by the Klawer Phase 1 Scheme. This may entail requesting weekly requirements for the Ebenhaeser Scheme according to a pre-planned annual schedule and monitoring whether planned diversion volumes are being met.

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.

19.2.3.2 Scheme Operation

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

The balancing dam should be operated to 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.

From the balancing dam, water will be pumped to the concrete reservoir, and gravitated for irrigation as needed.

Additional balancing storage will be provided in the balancing dam for operational purposes to stabilise the operation of the lower sections of the right and left bank canals. The scheme will divert water back from the balancing dam, which can be discharged into the right and left bank canals at times of low flow in these canal sections.

19.3 Institutional Arrangements

19.3.1 Introduction

The implementation arrangements for the infrastructure of the three proposed bulk water supply schemes are described below. It is a possibility that the funding model of one or more of the schemes may influence the implementation and operation of such scheme/s, but further information on funding is not currently available.

The ‘on-farm’ components of the schemes will be separately implemented.

It is recommended that the construction of the three schemes be undertaken via an open tender competitive bidding process.

19.3.2 Jan Dissels Scheme

It is expected that DWS will be the owner of the scheme. It is not yet evident who will operate the scheme, but it is likely that DWS will operate it, as the scheme will receive water from the adjacent Clanwilliam Dam.

The West Coast District Municipality is the water service authority and Cederberg Municipality is the water service provider. Because this scheme is a bulk raw water supply it falls outside the mandate of Cederberg Municipality. An alternate operator to consider would therefore be the West Coast District Municipality.

19.3.3 Right Bank Canal Scheme

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

19.3.4 Ebenhaeser Scheme

DWS will be the owner of the scheme. It is recommended that the scheme be operated by LORWUA, as the operational releases from Bulshoek Weir and the management of the balancing dam need to be carefully integrated with releases for existing allocations or canal augmentation flows.

There are indications that the Ebenhaeser community and restitution farmers may object to the operation of the scheme by LORWUA. They may prefer a private operator, even if only for a portion of the scheme, potentially for the conveyance from the balancing dam to the irrigation clusters.

20 Project Implementation

This chapter provides information on the recommended implementation process, as well as the possible timeframe and milestone dates.

20.1 Implementation process

The recommended steps for the implementation of the recommended schemes (also referred to as 'the project') are discussed under the relevant headings below. The various actions are provided in chronological order, although some actions can be undertaken in parallel.

20.1.1 Record of Implementation Decisions

The Record of Implementation Decisions (RID) is the official internal DWS document to hand over the project for implementation, and has been compiled as part of this study. The RID describes the components of the project, design aspects, further investigations to be undertaken, institutional and funding arrangements, operational aspects and other pertinent information for implementation of the project.

The RID will be issued to DWS Chief Directorate Infrastructure Development for the implementation of the project after the Environmental Authorisation has been received.

20.1.2 Environmental Authorisation

DWS is required to undertake a comprehensive EIA process in accordance with NEMA and the 2014 EIA Regulations (GN R982 – 985, as amended). The EIA process is a legal requirement to obtain Environmental Authorisation from DEFF for implementation of the three schemes.

20.1.3 Funding Arrangements

The proposed Jan Dissels Scheme will be located on State-owned land. The Right Bank Canal Scheme and the Ebenhaeser Scheme will form part of the LORGWS. It is expected that all three schemes will be implemented as Government Waterworks and funded by National Treasury.

Funding from National Treasury will need to be secured. This will enable the project to be implemented as soon as the detailed design and tender documentation are ready, and environmental authorisation has been received.

Alternative funding and associated implementation arrangements can however not be excluded, especially in a post-Covid-19 situation.

20.1.4 Detailed Design

DWS Chief Directorate Engineering Services can be requested to undertake the detailed design of the proposed Right Bank Canal Scheme and potentially the Jan Dissels and Ebenhaeser Schemes. It is however recommended that a PSP should rather be appointed to undertake the detailed design and construction supervision of the Right Bank Canal, the Jan Dissels and Ebenhaeser schemes. The Chief Directorate Engineering Services would then provide the required management and guidance of the PSP and contractors.

Detailed design will commence once the EIA has been concluded, and an Environmental Authorisation has been issued for each of the three schemes respectively.

20.1.5 Water use licences

The WULAs for storing water and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), National Water Act, 1998) is included in the scope of work for the EIA study.

The raising of Clanwilliam Dam and associated availability of additional water will determine when the licensing process for irrigation development (Section 21(a)) can get underway. This will be determined by DWS during implementation of the project.

20.1.6 Dam safety regulation requirements

Applications for licences to comply with the dam safety regulations will need to be completed as part of the detailed design and construction of the Ebenhaeser balancing dam. The requirements in terms of dam safety regulations are discussed in Chapter 18.3 of this report.

20.1.7 Borrow area regulation requirements

The use of a borrow area(s) to source construction material could trigger listed activities under GN R983 and R985. Before a borrow area is developed, authorisation must be obtained from DMRE for the listed activities.

20.2 Programme and Milestones

The implementation programmes for each of the three schemes have been included in Appendix D of the *Feasibility Design Report* of this study. The total duration for implementation, which includes institutional arrangements, funding, detailed design, tender processes, construction and commissioning, have been estimated as follows:

- Jan Dissels Scheme: 6 years;
- Right Bank Canal Scheme: 10 years; and
- Ebenhaeser Scheme: 8 years.

The implementation of the Jan Dissels and Ebenhaeser schemes is reliant on the availability of additional water, which will only be available when the raising of Clanwilliam Dam has been completed.

The Right Bank Canal Scheme is a Betterment Works and can be implemented after environmental authorisation has been issued and funding is made available, as it is not dependent on the progress with the raising of Clanwilliam Dam.

21 Conclusions

This chapter summarises the conclusions of the feasibility study.

Based on the findings, conclusions are drawn in terms of the following:

21.1 Requirements and Purpose of the Scheme

21.1.1 The Clanwilliam Dam on the Olifants River will be raised by 13 m, making an additional 82 million m3/a available for use, at a 91% assurance of supply. The raising of the dam is currently in the construction phase.

21.1.2 The additional water will be used for new irrigation areas to establish HDI farmers, improve the assurance of supply to the existing scheduled irrigation area, augment the water supply to towns, industries and mines, as well as supply other local water users, inclusive of water losses.

21.2 Water Distribution Options

21.2.1 The development will promote the equitable access to water, redress the results of past racial and gender discrimination, promote the efficient, sustainable and beneficial use of water in the public interest, and facilitate social and economic development.

21.2.2 Water availability is based on an assurance of supply of 91% for irrigation and 98% for municipalities and industries.

21.2.3 An additional available yield, after raising of the dam, is 82.0 million m3/a.

21.2.4 Development planning was done for 61.1 million m3 to be supplied to new HDI farmer development (75% of incremental yield for irrigation use), 15.2 million m3/a to increase the reliability to existing users, and 0.6 million m3/a to supply future domestic, industrial and mining water requirements, after the EWR has been met. A volume of 5.1 million m3/a was identified (for the short-term to medium-term) to account for hydrological and other uncertainties such as climate change.

21.2.5 An independent HDI Farmers Specialist undertook an assessment of current and prospective HDI farmers, and supporting legislation, mechanisms and tools, in support of the uptake of the additional water by HDIs.

21.2.6 A database of existing and prospective HDI water users, and potential land for new irrigation, has been compiled.

21.3 Soil Survey

21.3.1 The extension of the soil survey previously undertaken entailed identification of the soil types, soil suitability, amelioration measures and integrated mapping of the additional area with the existing soil survey, covering about 10 300 ha of land lying between 60 m to 100 m above river level, between Clanwilliam Dam and Klawer.

21.3.2 Five soils classes were identified for annual tuberous crops, annual non-tuberous crops and perennial crops, ranging from Low to High soil potential.

21.3.3 The soil survey is based on field investigations, and interpretation and interpolation at a regional level.

21.4 Options Analysis

21.4.1 A detailed methodology was developed to determine the water requirements of potential irrigation development options, inclusive of aggregate crop water requirements per study zone, crop rotation, water quality considerations such as leaching and the need for water blending, and water losses.

21.4.2 The future water requirements of domestic, industrial and mining water users have been determined.

21.4.3 Potential areas for new irrigation were identified, considering soil classes, existing land use, environmental sensitive areas and practical considerations.

21.4.4 A comprehensive process was followed to identify, screen and recommend irrigation development options.

21.4.5 A preferred suite of proposed irrigation schemes has been identified, as well as the prioritisation and phasing of the uptake of water.

21.4.6 The Jan Dissels Scheme, Right Bank Canal Scheme and Ebenhaeser Scheme have been identified for feasibility level design as new irrigation development GWSs.

21.4.7 Seven other schemes have been recommended for private development, although the possibility of developing some of these schemes as one or more GWSs, has been considered.

21.5 Way Forward for Other Irrigation Developments

21.5.1 Potential 'best approach' farm implementation models for private irrigation development have been evaluated, and the commercial JV model with a shared ownership has been found to be the most feasible option.

21.5.2 Issues relating to the development of 7.5 ha smallholder plots has been considered, either as part of GWSs to be developed, or as smallholder plots as part of private development, to find a balance between commercial JV projects and smaller agricultural units.

21.5.3 The implementation process for private development has been described at a high level.

21.6 Topographical Survey

21.6.1 A LIDAR topographical survey was completed by Southern Mapping for the three schemes designed at feasibility level.

21.6.2 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.

21.6.3 The accuracy of the available survey data is considered adequate to undertake the detailed design of the proposed infrastructure.

21.7 Geological, Geotechnical and Materials Investigations

21.7.1 Geological, geotechnical and materials investigations were done for the Jan Dissels Scheme, Right Bank Canal Scheme and Ebenhaeser Scheme respectively.

21.7.2 Geotechnical field investigations undertaken, including geophysical surveys, test pitting and in-situ field testing, for the preliminary conveyance infrastructure routes, informed the selection of the preferred pipeline routes and infrastructure positions.

21.7.3 Core drilling of three syphons for the Right Bank Canal Scheme and one syphon for the Ebenhaeser Scheme will provide information for the detailed design of the syphons.

21.8 Environmental Screening and Scheme Assessments

21.8.1 Environmental screening of the potential irrigation development areas and conveyance routes, conducted at reconnaissance level, supported the identification of the best ecological options and the minimisation of impacts on the natural environment. The screening also identified opportunities and constraints, and potential ecological risks and impacts.

21.8.2 More detailed environmental scheme assessments of the Jan Dissels, Right Bank Canal and Ebenhaeser schemes identified specific environmental sensitive areas affected by potential scheme bulk water infrastructure and mitigation measures of potential impacts. This was done in support of the feasibility design of the three schemes and the required authorisations during implementation.

21.8.3 Meetings held with environmental authorities provided greater clarity on the environmental approval process of the proposed suite of irrigation schemes.

21.9 Jan Dissels Scheme Feasibility Design

21.9.1 An assessment of two sub-options for the scheme was undertaken, either pumping from the Clanwilliam Dam basin (Rising Main Route 1), or pumping from below the Clanwilliam Dam wall (Rising Main Route 2) to a reservoir situated on the ridge, to supply the irrigation area situated on both sides of the Jan Dissels River.

21.9.2 The water requirement for the estimated 462 ha of irrigable land is 4.26 million m3/a.

21.9.3 The main features of the scheme include the final abstraction point and conveyance route, reservoir site and design flow. The features of the scheme are indicated on scheme layout maps.

21.9.4 The hydraulic calculations for both options are based on a design capacity of 23.2 Mℓ (0.269 m3/s) and the raised Clanwilliam Dam water levels.

21.9.5 A 500 mm HDPE pipe will be suitable for both rising main options.

21.9.6 For Rising Main Route 1, submersible pumps will be suitable for the low-lift pump station and either end-suction centrifugal or horizontal split casing pumps for the high-lift pump station.

21.9.7 For Rising Main Route 2, multi-stage or horizontal split-casing pumps are suitable pump types, with horizontal split-casing pumps being preferred for raw water applications, due to their better solids handling capabilities and ease of undertaking maintenance.

21.9.8 A 12 000 m3 (12 Mℓ) reinforced concrete reservoir will provide a 12 hour storage capacity.

21.9.9 A new access road will have to be constructed to the reservoir and a new power supply provided.

21.9.10 A comparison of the two sub-options found that the NPVs and URVs were the same. Other factors were therefore considered in order to choose the best option.

21.9.11 Rising Main Route 2 is recommended due to its pump installation, which is more secure, easily accessible and will require less maintenance than Rising Main Route 1.

21.9.12 The scheme is favourable from a cost and locality perspective (very close to Clanwilliam town), with very low water losses, but there may be environmental opposition to the development of the scheme.

21.9.13 The estimated total capital cost for the recommended scheme (Rising Main Route 2) is R 95.7 million (incl. VAT) at October 2020 prices.

21.9.14 Recommendations have been made for further investigations in support of detailed design of the scheme.

21.10 Right Bank Canal Scheme Feasibility Design

21.10.1 The Right Bank Canal Scheme is designed to replace the existing main left bank canal with a new canal on the right bank of the Olifants River, transporting water from the existing Bulshoek Weir to the existing 2.0 m diameter syphon at Verdeling, where the canal bifurcates. The features of the scheme are indicated on scheme layout maps.

21.10.2 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, and includes a pipe bridge over the Olifants River and a syphon through the Doring River.

21.10.3 The scheme will supply the four significant new irrigation areas in the Trawal area, namely the Zypherfontein 1 and 2, Trawal and Melkboom irrigation areas, and other downstream users, with a combined irrigable area of 2 339 ha.

21.10.4 The canal routing, syphon types and infrastructure sizing were investigated and designed at feasibility level. The feasibility-level design is based on a design flow rate of 11.40 m/s.

21.10.5 A memorandum on alternative, increased canal design flow rates to consider, which would provide greater benefits to existing allocations, has been provided. A significant constraint to increasing the flow rate has been identified, namely increasing the Bulshoek Weir outlet capacity.

21.10.6 Bulk distribution and storage infrastructure to the four irrigation areas was designed and costed at reconnaissance level.

21.10.7 The estimated total capital cost for the proposed scheme is R 1 994.7 million (excluding VAT, October 2020 prices) of which R 573.2 million is the ‘Development’ cost component and R 1 421.5 is the ‘Betterment’ cost component.

21.10.8 The scheme has quite similar capital costs to the alternative of refurbishing the lining of the left bank main canal, but with different implementation programmes. There are however significant additional benefits to the implementation of this scheme in comparison to refurbishing the left bank main canal.

21.10.9 Recommendations have been made for further investigations in support of detailed design of the scheme.

21.11 Ebenhaeser Scheme Feasibility Design

21.11.1 The Ebenhaeser Scheme is designed to supply water to additional smallholders of the Ebenhaeser community (20% of the volume), and restitution farms without adequate water allocations (80% of the volume).

21.11.2 The water availability (excluding water losses) for the scheme was determined as 3.65 million m3/a, which will be used to irrigate 361 ha.

21.11.3 An assessment of the release and abstraction points, conveyance routes, balancing dam and reservoir sites was undertaken, and design flows were determined. The features of the scheme are indicated on scheme layout maps.

21.11.4 The infrastructure location, routing and sizing were investigated and designed at feasibility level.

21.11.5 Canal diversion structures at the Retshof right bank and Vredendal left bank canals will create off-take points. Canal flows will be diverted from the diversion structures during weeks with surplus flow and will gravitate to a balancing sump. From the sump, water will be pumped via the “diversion” rising main to the 2.32 million m3 Ebenhaeser balancing dam. From the Ebenhaeser balancing dam, water will be pumped via a rising main to a 11 Mℓ concrete balancing reservoir, from where water will gravitate to the edge of the water requirement clusters via the 17.7 km gravity pipeline.

21.11.6 The balancing dam will be an HDPE lined earthfill dam, with a Category II dam safety classification and a maximum wall height of 19.2 m.

21.11.7 There is approximately sufficient “soft excavation” material in the basin to be used for the embankment, although some hard excavation may be needed to supplement this. The aeolian sand that is in plentiful supply will act well as the drainage layer under the HDPE lining.

21.11.8 The balancing dam includes a volume of 150 000 m3 that has been reserved for operational purposes, to divert 24 Mℓ/d (0.278 m3/s) from the balancing dam, to be discharged into the right bank (12 Mℓ/d) and/or left bank (12 Mℓ/d) canals respectively, as required, at times of low flow in the canals.

21.11.9 The estimated total capital cost for the proposed scheme (pipelines, pump stations, canal structures and balancing dam) is R 601.1 million (incl. VAT) at October 2020 prices, of which R 19.4 million is a ‘Betterment’ cost for operational purposes. This is comparatively a very expensive scheme.

21.11.10 Recommendations have been made for further investigations in support of detailed design of the scheme.

21.12 Financial Viability of Irrigation Farming

21.12.1 The feasibility of water uses and financial viability of existing irrigation farming, expansion of existing farms, new farms in the area, new black-owned farms in the area, and smallholder farms, is provided for different study zones and suitable crop combinations.

21.12.2 The expansion of existing irrigation farms will in general be financially more viable than the development of new irrigation farms.

21.12.3 For expansion of existing farms, citrus and table grapes appear to be profitable. The other crops that were investigated are only deemed profitable in certain circumstances.

21.12.4 It is anticipated that contributions to the capital cost of raising the Clanwilliam Dam and the bulk distribution infrastructure, through raised water tariffs, may impact the financial viability of farming operations.

21.12.5 Economic viable farm sizes for different crops are indicated.

21.12.6 Group operations on communal land can encounter many pitfalls and have a lesser chance of success. The main reason for unsuccessful projects is conflict within the group. The bigger the group, the lower the success rate is expected to be.

21.12.7 It was found that smaller agricultural units do not possess the economy of scale to compete commercially (especially if located on land owned by Government). A vegetable growing unit of 7.5 ha could provide a family with an income of approximately R96 000 per year.

21.12.8 The needs analysis of HD farmers that was undertaken, which focused on the agricultural value chain, determined that a smallholder farmer would need assistance throughout the value chain for its operations to become commercially competitive.

21.12.9 The case studies that were evaluated, which included land restitution cases and successful commercial Joint Venture (JV) projects, identified several 'success factors' to take into consideration.

21.12.10 The most ideal project structure, based on examination of case studies, would be a JV company with at least 51% black ownership, which either owns the land and the business or just the business.

21.12.11 The Jan Dissels Scheme and augmentation of supply to the Ebenhaeser community, to be implemented as GWSs, will provide significant opportunities for smallholders. Smallholder farms can also be highly viably if they are incorporated in the proposed development on privately-owned land.

21.12.12 A balance needs to be found between commercial sustainability on the one hand, and the needs of HDIs and destitute communities on the other. Both objectives need to be addressed to obtain the buy-in from all relevant Government Departments and ultimately to motivate the funding and financing of the scheme.

21.13 Socio-economic Impact Assessment

21.13.1 A separate socio-economic impact analysis was undertaken for the construction and operational periods (in comparison with the baseline scenario), to evaluate the nature and magnitude of the socio-economic impacts emanating from the distribution and use of additional water from a raised Clanwilliam Dam, based on 2018 reconnaissance-level evaluation costs of new irrigation schemes.

21.13.2 A partial general equilibrium analysis was used to quantify the socio-economic impact of the development, with the South African national SAM providing the basis for this analysis.

21.13.3 Construction Phase results indicate that the development will have a very positive impact. The GDP will increase by R 290 million and capital formation will increase by R 1 277 million. Employment opportunities will increase by 861, and salaries and wages will increase by R 230 million per annum over the construction period. The only negative is the balance of payments that will increase by R 96 million.

21.13.4 Operational Phase results for new irrigation areas indicate that the total GDP for the new irrigation areas is estimated to be R 2 674 million per annum (expressed in 2018 prices). In total an estimated 15 031 job opportunities can be created. The annual impact of the expected wages to be paid to the households is an estimated total of R 2 131 million annually, expressed in 2018 prices, of which 14% is to low income households, at an average income of R 3 500 per month. Government income (taxes, etc.) will increase, on average, by R 766 million per annum.

21.13.5 Operational Phase Results for the existing irrigation areas, and producers with an improved assurance of supply, is estimated to be a total average GDP increase of R 601 million per annum. A total of 4 611 additional jobs will be secured, i.e. people that will have a higher job security, and an average increase in household income of R 650 million per annum. There will be a fiscal impact of R 171 million and an average annual stabilising impact of the increase in balance of payments of R 328 million.

21.13.6 The analysis undertaken indicates that the availability of the additional water from the raised Clanwilliam Dam, inclusive of the increased assurance of supply, will have a substantial positive impact on the social and economic conditions prevailing in the area, and that there will be substantial poverty alleviation in the area.

21.14 Right Bank Canal Scheme Cost Analysis

21.14.1 From a capital cost point of view, the two development scenarios compared (Right Bank Canal vs. Left Bank Canal Alternative) are effectively the same, although the implementation of production areas would differ.

21.14.2 It is estimated that the total loss of income at farm level over two years, resulting from a break in the existing main canal could be in the region of R1.2 billion for a 30-day water cut and R1.5 billion for a 3-month water cut. At earnings before interest, tax, depreciations and amortisation, the losses are estimated at R 674 million and R 865 million respectively.

21.14.3 It is estimated that the right bank canal will be constructed over a 4-year period, that the alternative two small supply schemes will be constructed over 3 years and that the betterment of the remainder of the left bank main canal will be implemented over a 15-year period thereafter.

21.14.4 The evaluation of social and economic conditions in the Cederberg and Matzikama Local Municipalities indicates that the future growth of the economy of the two municipalities will depend on increased irrigation.

21.14.5 The comparative evaluation of the two development scenarios indicates that the Right Bank Canal Scenario is preferable in terms of the baseline cost benefit analysis results, although both show viable results. The Right Bank Canal Scenario presents the stronger financial and economic results.

21.14.6 The detailed risk and sensitivity analysis performed show that both scenarios provided positive answers if no impact of the existing areas are taken into consideration, but the results of the Alternate Left Bank Scenario are considerably lower than the results from the Right Bank Canal Scenario. The second sensitivity comparison indicates that, if the financial results are lower than 15% of the expected results, then the Alternate Left Bank Canal Scenario is not viable.

21.14.7 The financial and economic viability analysis undertaken supports the recommendation that the Right Bank Canal is the preferred scenario, which is further supported by the significant benefits that have been identified for the construction of the Right Bank Canal Scheme vs. the alternative.

21.14.8 It is concluded that the recommended decision to include a 'Betterment' cost component for the Right Bank Canal Scheme will have a positive socio-economic impact on the area.

21.15 Legislative Compliance

21.15.1 The applications for water use licences that will need to be submitted in terms of Section 21(b), 21(c) and 21(i) of the NWA has been described for the implementation of the three GWSs.

21.15.2 The applications for water use licences that will need to be submitted by the prospective water users in terms of Section 21(a) and 21(b) of the NWA, has been described for the implementation of private schemes, which would be separate from the processes for the implementation of the GWSs.

21.15.3 The need has been identified, if applicable, to submit separate applications to DMRE for the authorisation of borrow areas that may be required to source construction material.

21.15.4 It is unlikely that there will be any required ecological releases, as the Ebenhaeser balancing dam is off-channel and will have a perimeter trench diverting any runoff around the dam. No allowance for an EWR has been made in the design.

21.15.5 DWS is required to undertake the EIA process for the proposed Jan Dissels, Right Bank Canal and Ebenhaeser schemes, in terms of all applicable environmental legislation. The EIA study is expected to start in 2022. Separate environmental authorisations will be obtained for the three schemes. DEFF will be the Competent Authority for all listed activities, but could potentially select to delegate responsibility to the provincial authority, which is DEA&DP.

21.16 Implementation Arrangements

21.16.1 Land that would be affected by the development of the three GWSs has been identified, including land (or servitudes) that would need to be acquired and land owners to be engaged with.

21.16.2 Environmental sensitive areas that would be impacted by conveyance or other bulk water infrastructure have been identified, as well as the need for access roads and road and rail crossings.

21.16.3 Wayleave applications will need to be submitted to all the relevant service authorities during the detailed design phase of the scheme.

21.16.4 Notable operation and maintenance requirements for the three GWSs were identified.

21.16.5 Institutional arrangements with respect to the ownership and operation of the three GWSs were identified.

21.17 Project Financing

21.17.1 An institutional and funding assessment of various structures available to finance capital bulk water infrastructure projects, and relevant application procedures and base qualifying criteria is provided. This includes Government funding, grants, tariffs, water markets, capital markets and private sector markets.

21.17.2 The strategic nature of South Africa's water resources infrastructure, and the typically long payback periods associated with these investments, imply that a predominantly public sector institutional arrangement is the most appropriate financing vehicle, with money coming from the National Revenue Fund.

21.18 Project Implementation

21.18.1 The RID is the official internal DWS document to hand over the schemes for implementation. The RID describes the components of the project, design aspects, further investigations to be undertaken, institutional and funding arrangements, operational aspects and other pertinent information for implementation of the project. The RID will be issued to DWS Chief Directorate Infrastructure Development for the implementation of the schemes after the Environmental Authorisation has been received.

21.18.2 DWS will undertake a comprehensive EIA process in accordance with NEMA and the 2014 EIA Regulations (GN R982 – 985, as amended). The EIA process is a legal requirement to obtain Environmental Authorisation from DEFF for implementation of each of the three schemes.

21.18.3 The proposed Jan Dissels Scheme will be located on State-owned land. The Right Bank Canal Scheme and the Ebenhaeser Scheme will form part of the LORGWS. It is expected that all three schemes will be implemented as Government Waterworks and funded by National Treasury. This will enable each scheme to be implemented as soon as the detailed design and tender documentation are ready, and environmental authorisation has been received. Alternative funding and associated implementation arrangements can however not be excluded, especially in a post-Covid-19 situation.

21.18.4 The implementation of the Jan Dissels and Ebenhaeser schemes is dependent on when additional water will be available after the Clanwilliam Dam has been raised. The Right Bank Canal Scheme is a Betterment Works and can be implemented as soon as Environmental Authorisation has been issued and funding is available, as it is not dependent on the progress with the raising of Clanwilliam Dam.

21.18.5 The implementation of the Klawer Phase 2 Scheme is dependent on the completion of the Right Bank Canal Scheme. This scheme would be a Betterment Works.

21.18.6 Given the significant challenges and delays being experienced with the DWS in-house implementation of projects, due to Supply Chain and other issues, an alternative tried-and-tested implementation model should be considered.

21.18.7 The WULAs for storing water and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), National Water Act, 1998) is included in the scope of work for the EIA study.

21.18.8 Progress with the raising of Clanwilliam Dam and associated availability of additional water will determine when the licensing process for irrigation development (Section 21(a)) can get underway. This will be determined by DWS during implementation of the project.

21.18.9 Applications for licences to comply with the dam safety regulations will need to be completed as part of the detailed design and construction of the Ebenhaeser balancing dam.

21.18.10 The use of a borrow area(s) to source construction material could trigger listed activities under GN R983 and R985. Before a borrow area is developed, authorisation must be obtained from DMRE for the listed activities.

22 Recommendations

This chapter lists the recommendations emanating from the feasibility study.

The study recommendations for implementation of the project are the following:

22.1 Incremental Water Availability and Proposed Use

22.1.1 The development should promote equitable access to water, redress the results of past racial and gender discrimination, promote the efficient, sustainable and beneficial use of water in the public interest, and facilitate social and economic development.

22.1.2 The incremental yield of the raised Clanwilliam Dam should be used to provide water for new irrigation areas to establish HDI farmers, improve the assurance of supply to the existing scheduled irrigation area, augment the water supply to towns, industries and mines, as well as supply other local water users, inclusive of water losses.

22.1.3 The proposed development project will address the following national development objectives:

- *Economy and Employment* - economic growth, rural job creation, increased income, broader ownership of HDIs, and increased capital formation;
- *Economic Infrastructure* - providing water for agricultural growth, investment for water resource development in irrigated agriculture, and food security;
- *Environmental Sustainability and Resilience* - development of adaptation strategies for the protection of rural livelihoods, expansion of commercial agriculture and support services for small-scale and rural farmers;
- *Inclusive Rural Economy* - the creation of additional direct jobs and indirect jobs in the agriculture, agroprocessing and related sectors, activation of the rural economy through improved infrastructure, substantially increase investment in irrigation infrastructure, and creating tenure security for HDI and communal farmers, especially women and youth.

22.1.4 Based on an assurance of supply of 91% for irrigation and 98% for municipalities and industries, the additional available yield, after raising of the dam, is 82.0 million m3/a.

22.1.5 Distribute 61.1 million m3 to new HDI farmer development (75% of the incremental yield for irrigation use), 15.2 million m3/a to increase the reliability to existing users (up to 25% of the incremental yield for irrigation use), and 0.6 million m3/a to supply future domestic, industrial and mining water requirements, after the EWR has been met.

22.1.6 Keep 5.1 million m3/a in reserve for the short-term to medium-term, to first account for hydrological and other uncertainties, at least until the hydrology of the Olifants River catchment has been recalibrated and updated, to avoid over-allocation.

22.1.7 Supported by the HD Farmers Committee, use the Mechanism for the Identification of HDI Farmers tool to aid the selection between different applicants for water licences, taking special cognisance of percentage of water to be allocated to women, the youth and the disabled, attaching weighting of the criteria in a logical and practical manner. The database of existing and prospective HDI water users, and potential land for new irrigation that has been compiled by the HDI Farmers Specialist, should be used as reference where applicable.

22.2 Soil Survey Variations

22.2.1 Take into account that the findings from soil surveys undertaken at a more localised level may vary from the soil classes that were determined during the feasibility study, from the regional-level soil survey that was undertaken.

22.2.2 It is therefore possible that potential irrigation areas identified from more localised investigations could differ from the recommended irrigation areas.

22.3 New Irrigation Schemes

22.3.1 The Jan Dissels Scheme, Right Bank Canal Scheme and Ebenhaeser Scheme have been identified for implementation as GWSs.

22.3.2 Seven other irrigation schemes are recommended for private development, potentially via commercial JV models with a shared ownership or other farm implementation models. The development of some of these schemes as one or more GWSs has however not been excluded.

22.3.3 The development of the Trawal and Klawer irrigation areas should be investigated further following the raising of Clanwilliam Dam, either as JV developments or a GWS, or a combination of both.

22.3.4 The canal and directly associated bulk infrastructure of the Klawer Phase 2 Scheme should be implemented as a GWS, following further evaluation and other implementation measures.

22.3.5 The required extent of smallholder plots should be clarified and, where applicable, included as a condition in the relevant water use licences to be issued, both for the development of GWSs and private development. It is important to ensure a balance between commercial JV projects and smaller agricultural units.

22.3.6 Implement the schemes according to the proposed prioritisation and phasing of the uptake of water.

22.4 Topographical Survey

22.4.1 The LIDAR topographical survey was completed at a standard that is suitable to use for detailed design of the three schemes.

22.4.2 Undertake a ground centreline survey along the final chosen canal and pipeline routes, prior to construction commencing. This will serve as a final check on the canal and pipelines' vertical alignment and verification of the survey data.

22.4.3 A more site-specific survey is required for the railway and existing culvert crossings on the Ebenhaeser gravity pipeline.

22.5 Geotechnical and Materials Investigations

22.5.1 Conduct follow-up geotechnical investigations for the Jan Dissels Scheme, specifically where insufficient data was obtained for the recommended pump station site.

22.5.2 Conduct additional chemical testing to confirm the corrosiveness of the soils.

22.5.3 For the Right Bank Canal and Ebenhaeser Schemes, take into account findings from the core drilling that was undertaken along the syphon routes.

22.6 Jan Dissels Scheme Feasibility Design

22.6.1 It is recommended that the Rising Main Route 2 option be implemented for the Jan Dissels Scheme , i.e. from below the raised dam wall.

22.6.2 An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.

22.6.3 Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

22.6.4 Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.

22.6.5 Confirm the choice of pipe material during the detailed design phase of the project, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.

22.6.6 Eskom should be engaged regarding electrical supplies to the pump stations.

22.6.7 Refine the selection of pump types.

22.6.8 Submit the proposed road crossing details to the relevant road authority during the EIA stage.

22.7 Right Bank Canal Scheme Feasibility Design

22.7.1 If the required design flow capacity is revised, the scheme routing and sizing of infrastructure should be amended during the detailed design stage.

22.7.2 Conduct a more detailed analysis and survey of the existing Bulshoek Weir Outlet to verify the outlet capacity. This could influence the decision regarding an increase of the required canal design flow capacity.

22.7.3 Confirm the canal routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

22.8 Ebenhaeser Scheme Feasibility Design

22.8.1 An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.

22.8.2 Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

22.8.3 Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.

22.8.4 Confirm the choice of pipe material, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.

22.8.5 Eskom should be engaged regarding electrical supplies to the pump stations.

22.8.6 Refine the selection of pump types.

22.8.7 Submit the proposed railway crossing details on the Ebenhaeser gravity main to the relevant railway authority for their approval during the EIA stage.

22.8.8 Submit the proposed road crossing details to the relevant road authority for their approval during the EIA stage.

22.8.9 The assumptions made in the determination of the desired dam storage volume (e.g. siltation from the canal and infiltration losses) should be checked and refined.

22.8.10 The dam embankment zoning and dimensions are based on typical values for embankment dams of this size using similar materials. The zoning dimensions must thus be designed based on the actual material properties and design constraints for the particular zones, which are used as input into a slope stability analysis.

22.8.11 Further investigation into the required thickness and other properties of the lining for the balancing dam will be needed. Specifications for the stone size and protrusions of the materials layers above and below the liner must also be investigated to prevent damage during construction.

22.9 Financial Viability of Irrigation Farming

22.9.1 Refer to the Financial Viability of Irrigation Farming Sub-report for recommendations to inform and support the evaluation of water licence applications for new irrigation development, proposed irrigable areas, crop types for the different zones, farm sizes, and farm implementation models.

22.9.2 A balance between commercial JV projects and smaller agricultural units is required.

22.9.3 The Augsburg facility in Clanwilliam, which was formerly an agricultural school and is now used by the Department of Education as offices, could be used for the training of new HD farmers.

22.9.4 Selected beneficiaries should already be in training when construction of the bulk conveyance infrastructure starts.

22.10 Socio-economic Implications

22.10.1 The socio-economic impact analysis, undertaken for the use of incremental water availability from a raised Clanwilliam Dam, supports the recommended development schemes as they will have a substantial positive impact on the social and economic conditions prevailing in the area, and significantly alleviate poverty in the area.

22.10.2 The extent of the lost opportunities, for every year that the Clanwilliam Dam raising project is delayed will be significant, because the benefits as described in Section 21.13 points 3), 4) and 5) will not materialise.

22.10.3 The Right Bank Canal Scheme provides a unique opportunity to combine long-delayed betterment works more cost-effectively with new development infrastructure. The opportunity to piggy-back on to the new development is a once-off. If missed, that opportunity will be gone forever. The scheme will significantly reduce the risk of canal breakage and supply interruptions to water users, lower water losses, lower the risk of damage to the regional economy, provide opportunity for improved irrigation to existing users and allow for future water provision.

22.11 Legislative Compliance

22.11.1 The water use licence applications for storing water, and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), NWA), as relevant for the three schemes, are included in the scope of work for the EIA study, as well as the application to DMRE for a Licence for Borrow Areas.

22.11.2 The Ebenhaeser Balancing Dam safety regulation requirements are as follows:

- Applications for licences for complying with the dam safety regulations will need to be completed before certain tasks may commence or continue.
- A licence to construct must be issued by the Dam Safety Office (DSO) before any construction may commence.
- Before the bottom outlets of the dam are closed, thereby commencing the impounding of water, the licence to impound must be obtained from the DSO.

22.11.3 DWS is required to undertake a comprehensive EIA process for each of the schemes, in accordance with NEMA and the 2014 EIA Regulations (GN R982 – 985, as amended). The EIA process is a legal requirement to obtain Environmental Authorisation from DEFF for implementation of the project.

22.12 Project Implementation Arrangements

22.12.1 Careful planning and coordination is required for the new irrigation developments and the implementation of the schemes, by following an integrated approach, involving all the other relevant Government departments.

22.12.2 Further investigations for detailed design should be undertaken, inclusive of topographical surveys, geotechnical investigations, construction materials, electrical power supply, and road and railway crossings.

22.12.3 Obtain environmental authorisations for the schemes.

22.12.4 Finalise scheme layouts and sizing of components, and undertake detailed design.

22.12.5 Obtain the necessary licences for implementation of the schemes.

22.12.6 Undertake land acquisition and obtain servitudes, as required for the schemes, including compensation for affected land and infrastructure.

22.12.7 Obtain wayleaves from the relevant authorities for road and railway crossings.

22.12.8 Finalise institutional agreements for implementation of the schemes.

22.12.9 The agreements that are in place between DWS and LORWUA should be reviewed and updated, and should take into consideration the operation of the Right Bank Canal and Ebenhaeser schemes, and the joint use of water from the Ebenhaeser balancing dam.

22.12.10 The RID should be finalised, after the Environmental Authorisation has been received, and issued to DWS Infrastructure Development to formalise the implementation of the schemes.

22.12.11 Funding needs to be secured from National Treasury to enable construction of the project to commence as soon as the detail design is complete and Environmental Authorisation has been received.

22.12.12 A range of infrastructure financing and cost-recovery sources is available for private irrigation schemes, but unless the influence of the cost of water can be clarified, the evaluation of and likely uptake of water for private development cannot proceed with confidence.

22.12.13 While the cost of the water is expected to be high, the water should be affordable to new HDI irrigators, else the uptake of the new irrigation may not materialise. The final tariff will have to be determined according to the approved Water Pricing Strategy, but some form of subsidy may need to be considered to enable the project to be implemented.

22.12.14 In accordance with the Water Pricing Strategy, the price of water must be negotiated with LORWUA, before the Right Bank Canal refurbishment is done, as they must know how much it will cost them.

22.12.15 Professional service providers, appointed via open tender processes, are recommended to undertake the detailed design and construction supervision of the schemes, with contractors also appointed via open tender processes. Chief Directorate Engineering Services would then provide the required management and guidance of the PSPs and contractors.

22.12.16 Water Resource Development Planning should however consider and evaluate all the available implementation possibilities, and then confirm the recommended implementation process for detailed design and construction, or make any other necessary recommendation.

22.12.17 DWS needs to create a platform for communication with other key government departments, to raise awareness regarding this project and its priorities, long before construction commences, as it is usually a lengthy process to implement large projects.

22.13 Further issues to address

Further issues to address are the following:

22.13.1 The principles for 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.

22.13.2 Clarify the uncertainty regarding the cost of water from the LORGWS, following the raising of Clanwilliam Dam, so that the potential for a Trawal Government Water Scheme can be assessed with more confidence.

22.13.3 Clarify the legal obligations on DWS to ensure that the LORGWS infrastructure remains functional.

22.13.4 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.

22.13.5 Receive authorisation for the proposed new irrigation development areas. The majority of these areas are privately owned, and it is expected that the majority of such development will be via joint venture agreements.

22.13.6 To obtain greater clarity on funding options, it is suggested that DWS provide a comprehensive and strong motivation to National Treasury to explain implementation approaches, broader economics and cost recovery aspects, which make it clear that the investment is in the national interest. DWS should request confirmation of National Treasury's view on this, as well as any concerns that they may have and the 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 indicate the risks for the economy and labour of potential canal failures if betterments are not undertaken.

23 References

AECOM. 2020. *Building Costs*.

AgriSETA, 2006. *Learner Guide - Agricultural Input.* Department of Agriculture. Accessed online: https://www.agriseta.co.za/downloads/LearningMaterial/116321_LG.pdf (4 November 2019).

Advisory Panel on Land Reform and Agriculture, 2019. *Final Report of the Presidential Advisory Panel on Land Reform and Agriculture.* Accessed online: https://www.gov.za/sites/default/files/gcis_document/201907/panelreportlandreform_0.pdf (31 October 2019).

Brink, A.B.A. (1983). *Engineering Geology of Southern Africa: Volume 3*. Pretoria: Building Publications Pretoria.

Cederberg Local Municipality Annual Report. 2018-2019.

Chadwick, A; Morfett, J & Borthwick M. 2013. *Hydraulics in Civil and Environmental Engineering.* 5th Edition. Taylor & Francis Group. Boca Raton, FL.

Citrus Growers' Association (CGA), 2017. *Annual Report.* Accessed online: 25 February 2018.

Communal Property Associations Act, South Africa, Act 28 of 1996.

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

Constitution of the Republic of South Africa, 1996.

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

Department of Agriculture, Forestry and Fisheries. 2019. Abstract of *Agricultural Statistics*.

Department of Rural Development and Land Reform, 2016. *Agri-Park Master Plan for the West Coast District Municipality*. Accessed online:

http://www.ruraldevelopment.gov.za/phocadownload/Agri-parks/Cammisa/15-04-2016-Agri-Park-Master-Plan-West-Coast-DM.pdf (6 November 2019).

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

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

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

Department of Water Affairs and Forestry. 2004. *Financial Assistance to Resource-Poor Irrigation Farmers.* Accessed online: http://www.dwa.gov.za/Documents/Policies/rpf/RPFAssistanceSep04.pdf (5 November 2019).

Department of Water Affairs and Forestry, *National Water Resource Strategy 1* (NWRS1), 2005, First edition.

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

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

Department of Water Affairs and Forestry, South Africa, Resource Directed Measures. 2008. *Approved Reserve and Recommended Conditions for the Protection of the Aquatic Ecosystem of the Olifants Doring River System*, prepared by Southern Waters.

Department of Water Affairs and Forestry, South Africa. 2008. *Clanwilliam Dam Raising Feasibility Study* prepared by Ninham Shand.

Department of Water Affairs and Forestry, South Africa. 2009. Water for Growth and Development. Version 7.

Department of Water and Sanitation, Resource Directed Measures. 2012. *The Classification of Significant Water Resources in the Olifants-Doorn Water Management Area* (WMA 17), prepared by Blue Science.

Department of Water Affairs and Forestry, *National Water Resource Strategy 2* (NWRS2), 2013, Second Edition.

Department of Water and Sanitation, Directorate: Water Resource Planning Systems. 2015. *Clanwilliam Regional Water Supply Scheme Operations Analysis*.

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

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

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

Department of Water and Sanitation, 2017. *Validation and verification of existing lawful water uses within the Berg Olifants WMA*. Prepared by Aurecon. Unnumbered report.

Department of Water and Sanitation, South Africa. 2019. *Water Requirements Assessment.* Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/4.

Department of Water and Sanitation, South Africa. 2019. *Distribution of Additional Available Water*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/5.

Department of Water and Sanitation, South Africa. 2019. *Existing conveyance infrastructure and irrigated land.* Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/6.

Department of Water and Sanitation, South Africa. 2019. *Suitable Areas for Agricultural Development Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/10.

Department of Water and Sanitation, South Africa. 2019. *Topographical Survey Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/7.

Department of Water and Sanitation, South Africa. 2020. *Post Feasibility Bridging Study for the Proposed Bulk Conveyance in Infrastructure from the Raised Clanwilliam Dam: Geotechnical Investigations Report. Vol I, II and III*, Report No. P WMA 09/E10/00/0417/8, 2020.

Department of Water and Sanitation, South Africa. 2020. *Post Feasibility Bridging Study for the Proposed Bulk Conveyance in Infrastructure from the Raised Clanwilliam Dam: Topographical Surveys Report* No. P WMA 09/E10/00/0417/7, 2020.

Department of Water and Sanitation, South Africa. 2020. *Conceptual Design Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered.

Department of Water and Sanitation, South Africa. 2020. *Environmental Screening Sub-Report*. Prepared by Zutari (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered

Department of Water and Sanitation, South Africa. 2021. *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post

Department of Water and Sanitation, South Africa. 2021. *Right Bank Canal Design Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered.

Design of Small Dams, 1987. United States Department of the Interior, Bureau of Reclamation.

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

History of Successes and Challenges of SA: Community Trust. Accessed online: https://sawea.org.za/wp-content/uploads/2016/05/Community-Trust-in-South-Africa-SAWEA-SAPVIA-23-MAY-2016.pdf (14 January 2020).

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

Lahiff, Dacis and Manenzhe, 2012. *Joint Ventures in Agriculture: Lessons from Land Reform Projects in South Africa.* International Institute for Environment and Development.

Le Roux JP, ME and CF. *Mechanization Guide*. 2020.

LORWUA. Estimation of water use (pump abstractions from the river bed) downstream of Bulshoek Weir from the Olifants River.

LORWUA, 2004. *Investigation into the rehabilitation of the canal downstream of Bulshoek Dam*, prepared by Element Consulting Engineers.

LORWUA. Estimation of water use (pump abstractions from the riverbed) downstream of Bulshoek Weir from the Olifants River.

Maccsand v City of Cape Town (709/10 & 746/10). 23 September 2011.

Matzikama Local Municipality Annual Report. 2018-2019.

Meiningers Wine Business International, 2017. *Bulk Wine Market to be Hit Hard by 2017 Harvest*. Accessed online: 25 February 2018.

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

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

Pegasys. 2013. *Project to Revise the Pricing Strategy for Water User Charges and Develop a Funding Model for Water Infrastructure Development and Use and a Model for the Establishment of an Economic Regulator, Assessment of Institutional Options for Infrastructure Financing: Concept Note – Version 2.2.* Published by the Department of Water and Sanitation. Accessed online: www.dwa.gov.za.

Pegasys. 2014. *Task 3a: Note on Institutional Arrangements and Structures.* Strategic Water Partners Network.

Personal Communication. 2017. Johan Matthee, LORWUA CEO.

Provision of Land and Assistance Act, Act 126 of 1993.

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

Ruiters. 2011. *Funding models for financing water infrastructure in South Africa: Framework and critical analysis of alternatives*. UNISA Graduate School of Business: Pretoria.

SANCOLD, 1990. Interim Guidelines on Freeboard for Dams, South African National Committee on Large Dams, Report No 3, August 1990.

SANCOLD, 1991. Guidelines on Safety in Relation to Floods, South African Committee on Large Dams, Report No 4, December 1991.

SATI. 2019. *Statistics of Table Grapes in South Africa*.

SAWIS. 2019. *SA Wine Industry 2019 Statistics*, NR 44.

Soil Classification Working Group. 1991. *Soil Classification: A Taxonomic System for South Africa.* Mem Natural Agric. Resources for S.A. No. 15.

Subdivision of Agricultural Land Act, Act 70 of 1970.

Sys, C; Van Ranst, E; Debaveye, J & Beernaert, F. 1993. *Land Evaluation, Part III, Crop Requirements.* Agricultural Publications No 7. University of Ghent, Belgium.

Swaziland Water and Agricultural Development Enterprise Ltd (SWADE). 2015. *Main Conveyance System Final Design Review Report.* Prepared by Aurecon South Africa in association with Bosch Stemele and Bicon Consulting Engineers as part of the Lower Usuthu II Extension Downstream Development. Aurecon Report No. 10288.

Tekie, A. 2016. *A Precarious Success: Land Reform and Governance of the Commons at the Amangcolosi Community Trust.* MA Development Studies Research Report. University of the Witwatersrand.

United States Department of Agriculture Foreign Agricultural Service, 2017. *Global Raisin Production to Slip*. Accessed online: 25 February 2018.

Water Research Commission and Department of Agriculture, Fisheries and Forestry. 2018. *Wide-scale modelling of water use and availability with earth observation/ satellite imagery*, undertaken by Stellenbosch University.

Water Research Commission. *A Manual for Cost Benefit Analysis in South Africa with Specific Reference to Water Resource Development*, Third Edition.

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

Western Cape Provincial Department of Agriculture, 2008. *Western Cape Olifants/Doorn River Irrigation Study,* 2006, prepared by Arcus Gibb.

Western Cape Provincial Department of Agriculture, 2013. *Mapping of agricultural activities, crop types and irrigation areas in the Western Cape Province.*

Western Cape Provincial Department of Agriculture. 2013. *Natural Resources Development Report.* Prepared by Aurecon South Africa (Pty) Ltd as part of the Clanwilliam Dam Raising: Utilisation of Additional Water Study.

Western Cape Provincial Government. August 2018. *Lower Olifants River: Economic Impact Assessment of the 2017/2018 Drought*.

Western Cape Provincial Government. 2020. *Social Economic Profile of Matzikama Local Municipality*.

Western Cape Provincial Government. 2020. *Social Economic Profile of Cederberg Local Municipality*.

Western Cape Department of Agriculture. 2017. *Status of Agricultural Economy Lower Olifants River*.

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

Western Cape Provincial Department of Agriculture, ongoing. Water quality measurements undertaken in the lower Olifants River.

Weinert, H.H. (1980). *The natural road construction materials of southern Africa*, Publisher: National Book Printers, Cape Town, South Africa.

Appendices

Appendix A: PSC Members and Represented Organisations

Contact Person	Organisation	Telephone	Cell	Email	SCM	Cc
DWS NATIONAL OFFICE						
Menard Mugumo	D: Options Analyses, CE: South	012 336 6838	082 804 5162	mugumom@dws.gov.za menardmugumo@gmail.com	✓	
Tony Moore	D: Options Analyses, Chief Engineer	012 336 8528	082 884 5540	mooret@dws.gov.za moore.fontein@gmail.com	✓	
Tendayi Makombe	National Water Resource Planning (NWRP)	012 336 8503	083 662 1414	makombet@dws.gov.za		✓
Beason Mwaka	Director: Water Resource Planning Systems	012 336 8188	082 807 6621	mwakab@dws.gov.za		✓
Mirandah Raborife	-	012 336 8490	082 803 2620	raborifem@dws.gov.za		✓
DWS WESTERN CAPE						
Rassie Nieuwoudt	Chief Engineer, Water Resource Management – Berg/Olifants	027 482 2233	060 5446 665	NieuwoudtR@dws.gov.za	✓	
Karin van Aardt	Chief Engineer: Construction – Project Manager, Clanwilliam PMO	027 482 1072	082 885 0117	vanaardtK@dws.gov.za	✓	
Bertrand van Zyl	NNRI SO, Bellville	021 941 6019	082 807 3541	vanzylb@dws.gov.za	✓	
Thembisa Torch	Institutional Establishment	021 941 6236	083 233 9337	torcht@dws.gov.za	✓	
Leon Nomjila	Water Resource Management (IE)	021 941 6123	082 373 0782	nomjilal@dws.gov.za	✓	
DEPARTMENT OF AGRICULTURE, WESTERN CAPE						
Peter Keuck	Chief Engineer, Sustainable Resource Management	021 808 5340	082 315 3834	peterk@elsenburg.com	✓	
Ashia Petersen	D: Sustainable Resource Management	021 808 5010	082 320 8228	ashia@elsenburg.com	✓	
DEPARTMENT OF AGRICULTURE, LAND REFORM AND RURAL DEVELOPMENT, NATIONAL OFFICE						
Mary Jean Gabriel	Water Use and Irrigation Development (WUID)	012 846 8567	082 555 8064	maryjeang@daff.gov.za	✓	
Nomvuzo Mjadu	WUID	012 846 8597	083 777 4649	patriciamj@daff.gov.za	✓	
Ernest Malatsi	WUID	012 846 8500	073 634 2804	ernestmal@daff.gov.za	✓	
Jacques Pheiffer	-	-	-	Jacques.pheiffer@drdlr.gov.za		✓
Andrey Booysen	District Director for Cape Metro/West Coast	-	-	Andrey.Booysen@drdlr.gov.za		✓
Letitia Matthews	-	-	-	Letitia.mattheus@drdlr.gov.za		✓
WESTERN CAPE DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND DEVELOPMENTAL PLANNING						
Wilna Kloppers	Western Cape DEA&DP Director: Pollution and Chemicals Management	021 483 4656	082 807 6191	Wilna.kloppers@westerncape.gov.za	✓	

Contact Person	Organisation	Telephone	Cell	Email	SCM	Cc
Liza Petersen	Western Cape DEA&DP Control Environmental Officer	021 483 4247	082 040 4193	Liza.Petersen@westerncape.gov.za	✓	
Paul Hardcastle	Western Cape DEA&DP Director: Planning and Policy Coordination	021 483 5687	082 889 9065	Paul.Hardcastle@westerncape.gov.za	✓	
Eldon van Boom	Western Cape DEA&DP Control Environmental Officer	021 483 2877 /3185	-	Eldon.vanBoom@westerncape.gov.za	✓	
DEFF						
Vusi Skosana	Director	012-399 9326	-	vskosana@environment.gov.za		✓
LOCAL MUNICIPALITIES						
Louis Volschenk	Cederberg Municipality, Municipal Manager	-	-	louisv@cederbergmun.gov.za		✓
Lionel Phillips	Matzikama Municipality, Director Economic Development & Community Services	027-201 3350	074 887 1132	lionelp@matzikama.gov.za		✓
PSP STUDY TEAM						
Erik van der Berg	Study Leader	021 526 5790	082 553 5795	Erik.vanderberg@zutari.com	✓	
Alice Chang	Design Engineer	021 526 5775	083 789 4466	Alice.Chang@zutari.com		✓
Jeanne-Louise Wiese	Environmental Practitioner	-	073 163 6409	Jeanne-Louise.Wiese@zutari.com		✓
Martie Wahl	Design Engineer	021 526 5748	083 509 0729	Martie.wahl@zutari.com		✓
Gary Davis	Senior Engineering Geologist	012 427 2342	082 803 6311	Gary.davis@zutari.com		✓
Dulce Lazana	Study Support Engineer	021 5266016	084 874 5806	Dulce.lazana@zutari.com	✓	
Frans van Wyk	Task Leader: Agricultural & Financial (Agrifusion)	023 346 5702	082 774 2536	frans@agrifusion.co.za		✓
Gerhard Nel	Legal Advisor (Agrifusion)	021 882 9922	084 730 6222	gerhard@agrifusion.co.za		✓
Johannes Brand	Agricultural Economist (Agrifusion)	-	071 688 1888	johannes@agrifusion.co.za		✓
William Mullins	Economist (Conningarth Economists)	012 349 1915	083 448 2882	wjmullins@worldonline.co.za		✓
EXTERNAL REVIEWER / HDI FARMERS SPECIALIST						
Sharron Marco-Thyse	HDI Farmers Specialist Consultant	-	082 490 3675	sharron@crls.org.za	✓	
Peter van Niekerk	Technical Reviewer (Water Resource Appraisal Services)	028 316 1968	082 807 4981	waterappraisal@gmail.com	✓	

Zutari (Pty) Ltd
1977/003711/07
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@zutari.com
W zutari.com