water & sanitation

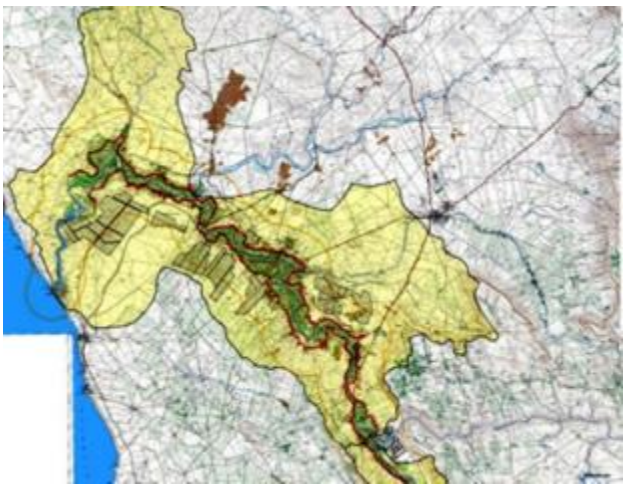
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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

Evaluation of Development Options Sub-Report





April 2019

Department of Water and Sanitation
Directorate: Options Analysis

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

APPROVAL

Title	:	Evaluation of Development Options Sub-Report
Consultants	:	Aurecon South Africa (Pty) Ltd
Report status	:	Final
Date	:	April 2019

STUDY TEAM

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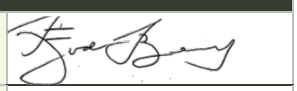
Author signature		Approver signature	
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DEPARTMENT OF WATER AND SANITATION

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

Evaluation of Development Options Sub-Report

April 2019

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

Reports produced as part of this project are indicated below.

Bold type indicates this report.

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

Concise Description of the Content of Study Reports

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

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

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

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

Executive Summary

This report describes the salient features, costs and impacts of identified potential irrigation development options for new irrigation development in the lower Olifants River. The report provides the background and an introduction to the discussions at the Options Screening Workshop that was held on 11 and 12 December 2018 in Cape Town.

The options evaluation process being followed comprises of the following steps:

a) Compilation of a Long List of potential options,
b) First-level screening of the Long List of options,
c) Compilation of a Preliminary Short List of options
d) Qualitative screening of the Preliminary Short List of options
e) Compilation of a Short List of options to be evaluated further,
f) Evaluation of short-listed options,
g) Documentation of evaluated options according to a standard template,
h) Holding an Options Workshop with key stakeholders,
i) Refining options and preparation of the Suitable Areas for Agricultural Development Report (the Options Report) with recommendations for feasibility-level evaluation.

The study area and the associated options have been divided into five regions (also referred to as sub-areas), as follows:

- Region 1: Olifants River catchment upstream of Clanwilliam Dam.
- Region 2: Clanwilliam Dam, Olifants River catchment from Clanwilliam Dam to and including Bulshoek Weir.
- Region 3: Schemes located wholly outside the Olifants River catchment.
- Region 3: Olifants River catchment from Bulshoek Weir to Lutzville.
- Region 5: Olifants River catchment from Klawer to the Coast.

The options have been categorised according to which region they are located or will abstract water from.

The key features of the evaluated, short-listed options are documented in **Table E1** on the following page. The options with bold reference numbers are discussed in this report, while the others were screened out during the initial evaluation process.

Table E1: Summary Options Table

Note that some options that have been screened out have been included in the table. Options relating to "Full" irrigation areas (before reduction resulting from environmental implications) have been included for illustrative purposes only.

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
Zone 2 - Clanwilliam Dam and Canal and Jan Dissels catchment											
1a	Area 23, Abstraction from Clanwilliam Dam	*Full area*	Pumping water directly from the lake of the Clanwilliam Dam. The abstraction point will be affected by the rise/fall of the water level. Full area 716 ha, reduced to 234 ha. Potential for 5 ha plots. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	6.51	6.84	0.33	0.33	55.69	1.41	Sensitivity: **High**: Western half within the CBA1, eastern portion preferred. Eastern half in ESA1 and ESA2. Wetlands cross the site. Mitigation: Avoid CBA1 areas. TheESA1 and ESA2 areas are likely to require an offset. Provide buffer for wetlands on site.	1.5
1b		*Reduced area*		2.11	2.21	0.11	0.11	23.13	1.74		1.5
2	Area 24: Jan Dissels 1	-	Pumping from Clanwilliam Dam. Full area 174 ha, reduced to 31 ha following environmental screening. Potential for 5 ha plots. Land between the Clanwilliam Dam and the Jan Dissels River is municipal property. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	1.57	1.64	0.08	0.08	38.18	2.61	Sensitivity: **High**: Most of the site is located within CBA1 excluding a small portion to the north west and small parts within the site boundary. The northern section of the site is located within ESA1 areas and ESA2 wetlands/watercourse features are scattered across the site. The south eastern boundary of the site falls within a Tankwa Cederberg Roggeveld NPAES. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide buffer for wetlands/watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
3	Areas 25-26: Jan Dissels 2-3	-	Pumping from Clanwilliam Dam. Full area 419 ha, reduced to 0 ha following environmental screening. Potential for 5ha plots. The land belongs to the province/agricultural school. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	3.76	3.95	0.19	0.19	47.55	1.95	Sensitivity: **High**: Most of the sites are located within CBA1 excluding a small portion in the northern section of the sites. ESA1 and ESA2 features transect the site. NFEPA wetlands occur adjacent to the northern and southern sections of the sites. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide buffer for wetlands/watercourses on site.	1.5
4	Areas 24-25-26: Jan Dissels 1-2-3	-	Pumping from Clanwilliam Dam. Full area 593 ha, reduced to 31 ha following environmental screening. Potential for 5 ha plots. State land ownership. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	5.33	5.59	0.27	0.27	43.30	1.42	Sensitivity: **High**: Most of the sites are located within CBA1 excluding a small portion in the northern section of the sites. ESA1 (except for Area 25) and ESA2 features transect the site. Areas of the sites are located within the Tankwa Cederberg Roggeveld NPAES. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
5	Transfer of lower Jan Dissels River scheduled allocations to Olifants River	-	Moving existing allocations of 3 irrigators in the lower Jan Dissels River to the Olifants River, to improve the ecological condition of the lower section of the Jan Dissels River.	1.0	1.0	0	0	0	0	N.A.	1.5
Zone 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir											
6b	Areas # 20(1)-21-22, Pumping from Olifants River	-	Water pumped from the Olifants River. Located 5 km from Clanwilliam town to the east of the N7. Potential for 5 ha plots, considering the proximity of the area to Clanwilliam town and existing markets. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam. The land is privately-owned.	0.59	0.62	0.03	0.03	6.94	1.80	Sensitivity: **High**: EN vegetation type occurs within the eastern section of the site. ESA1 and ESA2 features are located across the site. Mitigation: Avoid areas of EN vegetation type. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.	1.5

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
6c	Areas # 20(2&3), Pumping from Olifants River	-	Water pumped from the Olifants River. Located 7 km from Clanwilliam town to the east of the N7. Potential for 5 ha plots, considering the proximity of the area to Clanwilliam town and existing markets. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam. The land is privately-owned.	0.88	0.92	0.04	0.04	9.63	1.63	Sensitivity: **High**: EN vegetation type occurs within the eastern section of the site. ESA1 and ESA2 features are located across the site. Mitigation: Avoid areas of EN vegetation type. the ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.	1.5
7	Area 19, Pumping from Olifants River	-	Water pumped from the Olifants River. Located between Clanwilliam Dam and Bulshoek Weir to the east of the N7. The land is privately-owned.	0.62	0.65	0.03	0.03	7.98	1.80	Sensitivity: **Moderate**: Most of the south western section of the site falls within ESA1. Mitigation: ESA1 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.	1.5
8	Area 18, Pumping from Olifants River	-	Water pumped from the Olifants River. Located between Clanwilliam Dam and Bulshoek Weir on both sides of the N7. The land is privately-owned.	0.26	0.27	0.01	0.01	2.61	1.41	Sensitivity: **High**: A small section of the site falls within CBA1 towards the north east. ESA1 and ESA2 features occur on site. Mitigation: Avoid CBA1 areas. The ESA1and ESA2 areas are likely to require an offset. Provide buffer for wetlands/watercourses on site.	1.5
9a	Area 17, Pumping from Olifants River	*Full area*	Water pumped from the Olifants River. Located between Clanwilliam Dam and Bulshoek Weir on both sides of the N7. The land is privately-owned.	2.51	2.64	0.13	0.13	21.05	1.38	Sensitivity: **High**: Most of the site is located within a CBA1, which includes EN vegetation types. ESA1 areas occur towards the west and south east boundaries of the site, while ESA2 occurs in the centre of the site and towards the south east. Mitigation: Avoid CBA1 and areas of EN vegetation type. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.	1.5
9b		*Reduced areas 1 & 2*		0.46	0.48	0.02	0.02	8.28	2.37	Sensitivity: **Moderate**: The western section of the northern reduced area is located within ESA1, while the southern reduced area has portions of ESA1 across the site. There are only two small ESA2 areas present on the southern reduced area. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.	1.5
10a	Area 16, Abstraction from Bulshoek Weir	*Full area*	Water pumped from the Olifants River. Located between Bulshoek Weir and the N7. The land is privately-owned.	3.37	3.54	0.17	0.17	31.61	1.59	Sensitivity: **High**: The centre of the site is located within a CBA1. ESA1 and ESA2 areas occur from the centre to the southern section of the site including wetlands and watercourses. EN vegetation occurs on site. Mitigation: Avoid CBA1 and areas of EN vegetation type. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.	1.5
10b		*Reduced area*		0.80	0.84	0.04	0.04	9.88	1.95	Sensitivity: **High**: EN vegetation occurs along the western edges of the site. Mitigation: Avoid EN vegetation types.	1.5
	Zone 3 - Options Located Outside the Olifants River Valley										
11a	Jakkals River Irrigation Scheme (JRIS) & Graafwater	*Inter-basin transfer to Jakkals River for abstraction*	Sandveld Investment & Development Co. Ltd (SANID) Water identified four farms as possible irrigation areas (3 100ha) and a pipeline route. Water is pumped from Clanwilliam Dam and released into and abstracted from the Jakkals River for the JRIS (3 100 ha) and Graafwater. Pumping head of 563 m.	10.27	13.14	2.57	2.87	318.38	5.74	Sensitivity: **High**: The pipeline follows the road much of the route, but the eastern section o includes areas of CBA1. The pipeline also transects ESA1 and ESA2 areas mostly in the west and includes watercourses and wetland areas. Mitigation: Avoid CBA1 area as far as practicable a and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Wetlands/watercourses require site specific mitigation.	2
11b		*Direct pipeline*	Pipeline scheme along the R364. Pumping head of 467 m.	10.27	10.58	0.00	0.31	258.10	4.06	Sensitivity: **Moderate**: The pipeline follows the R364 much of the route and therefore avoids most CBA and ESA area, except on the	2

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
										western end where it leaves the road. Other exceptions include a few wetland/watercourses. Mitigation: Avoid CBA1 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Wetlands/watercourses require site specific mitigation.	
12	Provision of water to coastal towns	-	Supply coastal municipalities (Lamberts Bay and Elands Bay) with water for domestic use. Pumping head of 384 m.	0.37	0.37	0.00	0.01	125.33	32.34	Sensitivity: **High**: The pipeline transects numerous CBA1 areas along the proposed route and transects CBA2 areas in small areas east from Graafwater as well as west towards the coast on route to Lamberts Bay which includes EN and VU vegetation types as well as NFEPA wetlands. ESA1 and ESA2 areas are transect, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a train line. Mitigation: Avoid CBA1 and CBA2 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Consultation with Steenboksfontein Private Nature Reserve is recommended.	1.5
13	Combined JRIS & supply to Graafwater, Lamberts Bay & Elands Bay	-	Pipeline scheme along the R364 and distribution to Graafwater and coastal towns. Pumping head of 474 m.	10.63	10.93	0.00	0.32	328.90	4.36	Sensitivity: **High**: The pipeline transects numerous CBA1 (Terrestrial) and CBA2 areas east from Graafwater as well as west towards the coast on route to Lamberts Bay which includes EN and VU vegetation types as well as NFEPA wetlands. ESA1 and ESA2 areas are transect, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a train line. Mitigation: Avoid CBA1 and CBA2 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Consultation with Steenboksfontein Private Nature Reserve is recommended.	2
	Zone 4 - Olifants River below Bulshoek Weir to Trawal										
14	Release at Bulshoek and pump from river: Area 15, Zypherfontein 1	-	Water pumped from the Olifants River below Bulshoek Weir and the Doring confluence to the scheme on the right bank. The land is privately-owned.	4.76	6.14	1.38	1.38	37.33	1.38	Sensitivity: **Moderate**: CBA1 occurs adjacent to the south western border of the site. VU vegetation occur in the southern section of the site. ESA1 areas, including watercourses, occur across the site. While ESA2 features are found from the centre to the southern sections of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
15	Release at Bulshoek and pump from river: Area 14, Trawal	-	Water pumped from the Olifants River below Bulshoek Weir and the Doring confluence to the scheme on the left bank. The land is privately-owned.	7.18	9.26	2.08	2.08	58.30	1.35	Sensitivity: **Moderate**: Numerous ESA1 features such as watercourses cross the site, with some ESA2 features occurring from the centre and south eastern sections of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
16	Release at Bulshoek and pump from river: Area 13, Zypherfontein 2	-	Water pumped from the Olifants River below Bulshoek Weir and the Doring confluence to the scheme on the right bank. The land is privately-owned.	6.80	8.77	1.97	1.97	60.45	1.41	Sensitivity: **Moderate**: ESA1 features such as watercourses can be found towards the north, east and southern tips of the area. ESA2 features occur near the south eastern boundary of the site, as well as the centre. VU vegetation types occur in the south western section of the site.	1.5

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
										Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	
17	Release at Bulshoek and pump from river: Area 12, Melkboom	-	Water pumped from the Olifants River to the scheme on the right bank, either just after or before the Doring River confluence. The land is privately-owned.	3.45	4.45	1.00	1.00	37.56	1.68	Sensitivity: **Moderate**: ESA1 features such as watercourses transect the site. ESA2 features occur in proximity of the largest watercourse and various smaller watercourses located in the northern section of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
18	Combined Areas # 13-14-15 Zypherfontein 1-2 & Trawal	*Pipeline with branches*	Water supplied by pipeline from Bulshoek Weir to the Zypherfontein 1-2 and Trawal areas.	19.24	20.29	0.96	1.54	445.01	2.74	Refer to applicable Areas above.	2
19	Combined Areas # 12-13-15 Zypherfontein 1-2 & Melkboom	*Raised BH canal, pipeline, high-level canal*	Water supplied from Bulshoek Weir to the Zypherfontein 1-2 and Melkboom areas, via a raised Bulshoek canal, pipeline and syphon crossing the Olifants River, and a new high-level canal supplying these areas under gravity.	16.42	21.18	4.76	5.06	200.64	1.10	Refer to applicable Areas above.	2
	Zone 5 - Olifants River from Klawer to the Coast										
20	Release at Bulshoek and pump from river: Area # 11, Klawer 2	-	Water pumped from the Olifants River **in winter** to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. Option ruled out.	1.78	2.37	0.59	0.59	36.02	2.35	Sensitivity: **High**: The entire site except for a small portion near the northern boundary is located within CBA1. Northern sections of the site have been earmarked as ESA1. ESA2 watercourse and wetland features occur in the southern section of the site. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
22	Release at Bulshoek and pump from river: Area # 9, Klawer	-	Water pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. The land is partially public land with the remainder privately-owned. A 3.15 million m^3 balancing storage dam is needed to fill in winter, to ensure summer supply of acceptable quality.	24.88	35.33	10.45	10.45	305.49	1.93	Sensitivity: **High**: A pocket of CBA1 remains in the centre of the reduced area. Watercourses occurring along the south eastern section of the site have been designated as ESA1. The eastern part of the site falls into the Knersvlakte NPAES. Mitigation: Avoid CBA2 areas. Provide a buffer for watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
23	Release at Bulshoek and pump from river: Area # 8, Aties Karoo	-	Water pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. An 8.6 million m^3 balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality.	41.00	59.46	18.45	18.45	730.90	2.12	Sensitivity: **High**: ESA1 and ESA2 features occur across the site. Smaller sections along the eastern boundary of the site falls into the Knersvlakte NPAES. Mitigation Provide a buffer for watercourses and wetlands on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
24	Release at Bulshoek and pump from river: Area # 7, Coastal 1	-	Water pumped from the Olifants River to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. A 27.6 million m^3 balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality.	20.74	30.08	9.33	9.33	998.45	4.79	Sensitivity: **Moderate**: ESA1 and ESA2 features occur across the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
25	Release at Bulshoek and pump from river: Area # 4, Ebenhaeser New	-	Water pumped from the Olifants River to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. A 17.4 million m^3 balancing storage dam needed to fill	43.76	66.07	22.32	22.32	563.80	1.86	Sensitivity: **High**: A small section the site falls within a CBA1. ESA1 and ESA2 features occur across the site. NFEPA wetlands occur adjacent to the western and north eastern boundary of the site. The south eastern section of the site falls within a NPAES focus area.	1.5

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
			in winter, to ensure summer supply of acceptable quality.							Mitigation: Avoid CBA1 areas. Provide a buffer for watercourses and wetlands on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	
26a	Release at Bulshoek and pump from river: Area # 3, Coastal 2	*Reduced area (1)*	Water pumped from the Olifants River **in winter** to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. Option ruled out.	0.33	0.50	0.17	0.17	8.35	3.08	Sensitivity: **Moderate**: An ESA1 aquatic feature occurs in the centre of the site. While small ESA2 features occur towards the south of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1
26b		*Reduced area (2)*	Water pumped from the Olifants River **in winter** to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. Option ruled out.	0.70	1.05	0.36	0.36	17.50	3.22	Sensitivity: **Moderate**: An ESA1 aquatic feature occurs in the north eastern section of the site and along the border. While small ESA2 features occur towards the south east border of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1
27	Release at Bulshoek and pump from river: Area # 2, Lutzville 2	-	Water pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. A 21.5 million m^3 balancing storage dam is needed to fill in winter, to ensure summer supply of acceptable quality.	39.52	59.67	20.15	20.15	1023.38	2.95	Sensitivity: **Moderate**: ESA1 and ESA2 features occur across the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1.5
28	Release at Bulshoek and pump from river: Area # 1, Lutzville 1	-	Water pumped from the Olifants River **in winter** to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. Scheme ruled out.	1.22	1.84	0.62	0.62	40.35	3.35	Sensitivity: **Moderate**: ESA1 and ESA2 features occur across the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1.5
29	Use of spare capacity in canal sections: Release at Bulshoek Weir and pump into canal sections	*Karoovlakte canal section*	Pump from river into Karoovlakte (zone 5) canal section. Irrigate portion of Area 9 Klawer on the right bank.	42.81	60.79	17.98	17.98	230.42	0.85	See Area 9 Klawer Pipeline outside the site is limited.	1.5
30		*Naaukoes canal section*	Pump from river into Naaukoes (zone 5) canal section. Irrigate full Area 11 Klawer 2 on the left bank. Abstraction water quality too poor and Klawer 2 scheme falls within CBA1 area, which rules scheme out on its own. If combined with option 31 though, the scheme will be feasible.	1.81	2.33	0.52	0.52	22.54	1.80	Sensitivity: **High**: A large part of the pipeline transects CBA1 areas. The pipeline also transects a NFEPA wetland and ESA2 area. Mitigation Avoid CBA 1 areas as far as practicable. The ESA 2 areas are likely to require an offset. Provide a buffer for watercourses/wetlands on site.	1.5
31		*Vredendal canal section*	Pump from river into Naaukoes (zone 5) canal section and abstract from Vredendal canal section. Irrigate portion of Area 7 Coastal 1 on the left bank.	20.74	26.76	6.02	6.02	137.66	1.06	Sensitivity: **Moderate**: The pipeline route crosses ESA1 features. Mitigation: ESA1 likely to require an offset. Provide a buffer for watercourses/wetlands on site.	1.5
	Zones 4 and 5: LORGWS (Bulshoek) Canal										
32	Replace LORGWS Canal with a pipeline with increased capacity	-	Supply existing irrigation plus full new irrigation via a pipeline that fully replaces the existing Bulshoek canal, with increased capacities to accommodate increased use from the Bulshoek main canal and portions of the left bank and right bank canals.	167.63	170.69	3.06	8.09	7,225.1	4.03	Sensitivity: **Moderate**: Pipeline crosses small areas of CBA1 areas, VU & EN ecosystems, PA, and NFEPA wetlands Mitigation: Follow roads / existing canal where possible. Avoid CBA1, EN ecosystems and PA. Avoid threatened plan species. Rehabilitation of footprint	4
33	Increase capacity of LORGWS canal and other betterments	-	Raise the Bulshoek main canal and left bank canal up to the Trawal/Naaukoes connection and supply existing irrigators as well as new irrigation areas.	45.82	48.88	3.06	15.43	384.87	1.34	Sensitivity: **Low**: Assuming existing canals used. Mitigation: Use existing footprint as far as possible Avoid CBA1 areas as far as possible, avoid threatened species. Rehabilitation of footprint. Refer to the applicable areas (Zypherfontein 1 & 2, Trawal, Melkboom, Klawer 2 and Coastal 1).	3

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Acronyms

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

1 Background and Methodology

1.1 Study Objective

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.

1.2 Objective of this Report

This report describes the salient features, costs and impacts of identified potential irrigation development options for new irrigation development. The report provides background and an introduction to the Options Screening Workshop to be held on 11 and 12 December 2018 in Cape Town.

Potential **irrigation development options**, referred to as 'options' in the remainder of this report, is a means of making use of additional water from a raised Clanwilliam Dam, for new irrigation development in an economically sustainable manner. These options are associated with specific conveyance methods and/or infrastructure required for the proposed development.

In all options, the use of additional water for irrigation may comprise one of the following:

- Expansion of irrigated areas on existing commercial farms,
- Establishment of new commercial irrigation areas,
- Allowance for irrigation plots of about 5 ha in size.

1.3 Background to the Project

The study area is shown in **Figure 1.1**. The Clanwilliam Dam is situated in the Olifants River near the town of Clanwilliam in the Olifants/Doorn River Catchment Management Area in the Western Cape. The dam requires remedial work for dam safety reasons, which offers the opportunity to

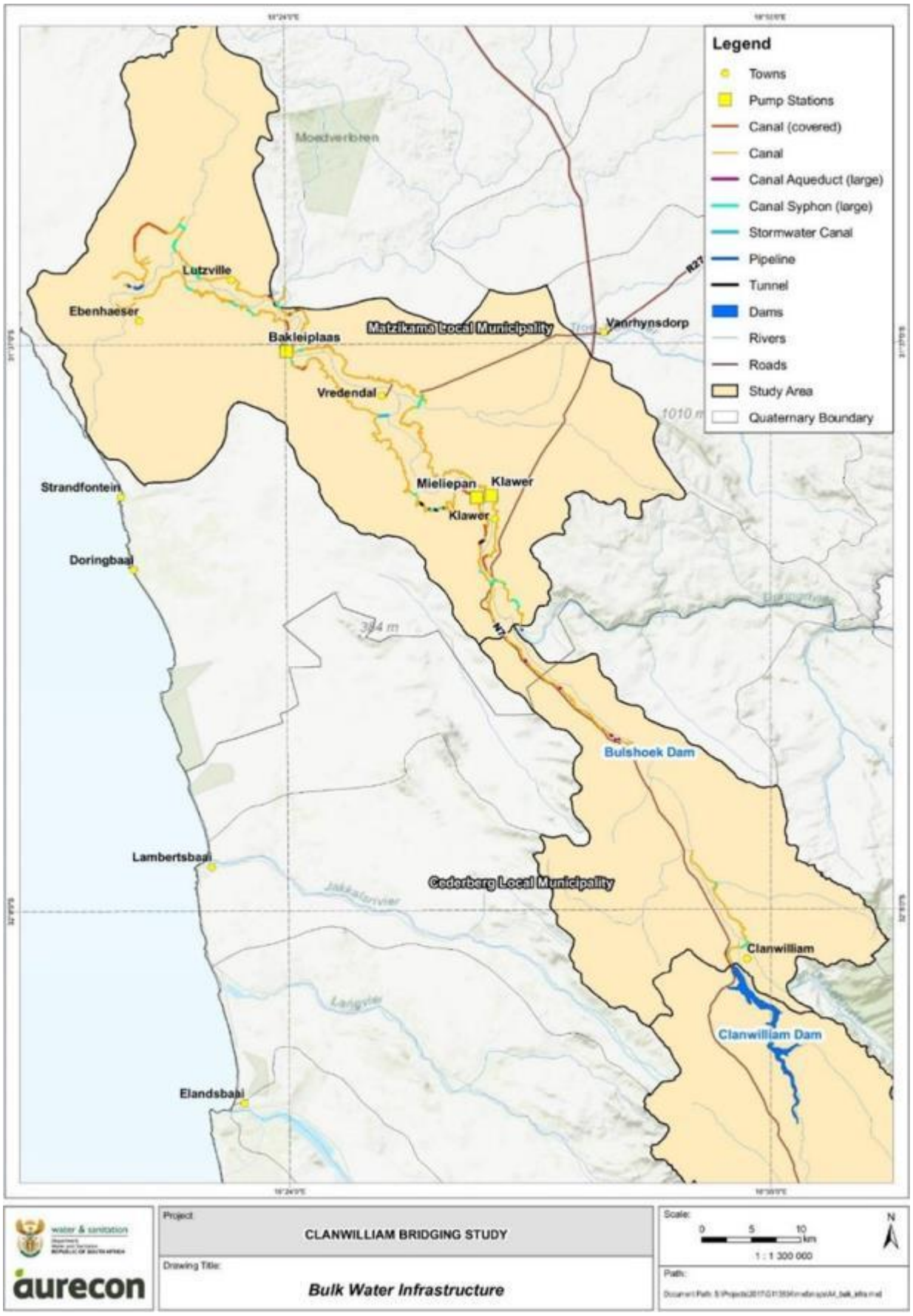

Figure 1.1 │ The Bridging Study Area

increase the yield at the same time by raising the dam and enlarging the storage capacity. Water use in the region is predominantly for irrigated agriculture.

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

The environmental authorisation for the raising of Clanwilliam Dam is effective from February 2010 and the project was approved by the Minister as a government water works in August 2010. The implementation of this project is currently in the construction stage, which commenced in October 2018.

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

Once the various water distribution options and associated bulk water infrastructure have been determined at a higher level of confidence, the feasibility design and costing need to be done, and the project needs to be made implementation-ready.

1.4 Approach and methodology

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

j) Compilation of a Long List of potential options,
k) First-level screening of the Long List of options,
l) Compilation of a Preliminary Short List of options
m) Qualitative screening of the Preliminary Short List of options
n) Compilation of a Short List of options to be evaluated further,
o) Evaluation of short-listed options,
p) Documentation of evaluated options according to a standard template,
q) Discussion of options at an Options Workshop with key stakeholders,
r) Refining options and preparation of the Suitable Areas for Agricultural Development Report (the Options Report), inclusive of updated or new options, and with recommendations for feasibility-level evaluation.

1.4.1 Compilation of the Long List of Options

A significant number of potential irrigation development options were identified from previous and on-going studies, liaison with officials and stakeholders, evaluation of soil-suitability maps and existing land use, as well as formulating new potential options. The list of these initial potential options has been termed the "*Long List*" of options. The Long List describes potential options that could be considered for the study area.

The study area was originally split into three regions for easy reference, during the Clanwilliam Dam Raising Feasibility Study. To be able to distinguish better between the characteristics and identified potential options of the different areas, the study area and the associated options have now been divided into five regions (also referred to as sub-areas), as follows:

- Region 1: Olifants River catchment upstream of Clanwilliam Dam.
- Region 2: Clanwilliam Dam, and Olifants River catchment from Clanwilliam Dam to and including Bulshoek Weir.
- Region 3: Schemes located wholly outside the Olifants River catchment.
- Region 4: Olifants River catchment from Bulshoek Weir to Lutzville.
- Region 5: Olifants River catchment from Klawer to the Coast.

The options have been categorised according to which region they are located or will abstract water from.

1.4.2 Screening of potential options

Potential options in the Long List of options were interrogated by the Study Team to ascertain which of these could be seriously considered for further evaluation. the results of this initial evaluation, with reasons, are documented in a draft Distribution Options Discussion Paper. An Options Brainstorming Workshop was held with key stakeholders on 6 August 2018, to discuss the initial identified potential options, where after the Long List of options was refined, and the Options Discussion Paper updated.

The Options Discussion Paper was then circulated for contributions and review by the Project Steering Committee (PSC) members and discussed with stakeholders at the PSC meeting held on 22 August 2018. The potential options were also discussed during meetings held with the Lower Olifants River Water User Association (LORWUA) and the Clanwilliam Water User Association (WUA) on 20 September 2018.

The outcome of this preliminary screening process was the identification of the options that should be evaluated further (to produce a Preliminary Short List of Options).

The characteristics of these preliminary-identified options were unpacked, and a qualitative assessment of the options characteristics, access to the additional water supply following the raising of Clanwilliam Dam, the order of magnitude of the additional bulk water distribution costs and potential impacts were then done. This initial, more qualitative evaluation reduced the options on *technical* grounds to develop a Short List of Options.

This was followed by quantitative evaluation of the Short List of Options, requiring some iteration as information became available, to identify the "better" development options, from a technical, socio-economic and political perspective.

1.5 Options screened out before the Options Workshop

The following identified options have been screened out during the initial evaluation process:

- Zone 1: Olifants River catchment upstream of Clanwilliam Dam.
- Zones 4 and 5: Reducing losses in the LORGWS canal / refurbishment of the canal system.
- Zones 2, 4 and 5: Changes in crops.

1.5.1 Zone 1: Olifants River catchment upstream of Clanwilliam Dam

It has been decided that prospective irrigators may continue to apply for water use authorisations for the use of water for irrigation in the Olifants River valley upstream of the Clanwilliam Dam. Since there is very little scope for additional irrigation development upstream of Clanwilliam Dam, without creating more on-farm balancing storage, water for new irrigation in this region would likely need be abstracted from the Olifants River in winter and stored in new/enlarged off-channel farm dams. This is expected to be an expensive option. Several dam sites were identified in the Olifants/Doring River Basin Study (DWAF, 1998), and were considered as possible storage dams to supply existing users and allow for possible future development. This option will not be further evaluated in this study, but farmers will not be excluded from applying for water use authorisations according to the standard application process.

1.5.2 Zones 4 and 5: Reducing losses in the LORGWS canal / refurbishment of the canal system

Undertaking of short-term and medium-term canal repairs is essential, as not doing so would negatively impact the functionality of the scheme. This option has the benefit of limiting losses from the canal. Improved water use efficiency, i.e. reducing losses, covering the canal, and other efficiency measures would limit losses and thus increase the supply from the canal. The

overall condition of the canal is however so poor that a significant maintenance programme will take many years and will not improve the condition of the canal sufficiently in a short enough period, to be able to allow further development of irrigation from the canal, based on efficiency savings.

1.5.3 Zones 2, 4 and 5: Changes in crops

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

1.6 Options Screened Out During Qualitative Evaluation

The following identified options have been screened out during the qualitative evaluation of preliminary short-listed options:

- Zone 2: Using the full capacity of the Clanwilliam Canal.
- Zone 2: Increase the capacity of the Clanwilliam Canal.
- Zone 2: Replace Clanwilliam Canal with a pipeline.
- Zone 4: New main canal section from Bulshoek on Right Bank of Olifants River.
- Zones 4-5: Increase abstraction from existing canals.
- Zones 4-5: High volume low head lifting pump stations.
- Zones 4-5: Replace all or sections of LORGWS Canal with increased capacity canal.
- Zones 4-5: Additional farm dams along the canal.
- Zones 4-5: Existing Ebenhaeser Scheme.
- Zone 2: Jan Dissels River schemes.
- Zones 4-5: Klawer 2 Scheme.
- Zones 4-5: Klawer 3 Scheme.
- Zones 4-5: Coastal 2 Scheme.
- Zones 4-5: Lutzville 1 Scheme.
- Zones 4-5: Provision of additional balancing dam/s along the canal.
- Zones 4-5: Increase winter use from existing canals.

1.6.1 Zone 2: Using the full capacity of the Clanwilliam Canal

According to the Clanwilliam WUA the canal is already fully used during 'normal' years and it is not feasible to increase flow for further development. In addition, there are no identified irrigable areas that could be irrigated from the canal.

1.6.2 Zone 2: Increase the capacity of the Clanwilliam Canal

As no additional irrigable area has been identified that can be irrigated from the canal, this option falls away.

1.6.3 Zone 2: Replace Clanwilliam Canal with a pipeline

While this option would reduce losses from 30% to about 3% and free up water, this will be a very costly option. In addition, no additional irrigable area has been identified that can be irrigated from the canal. This is an issue for existing irrigators only.

1.6.4 Zone 4: New main canal section from Bulshoek on Right Bank of Olifants River

This has been considered and has been incorporated in scheme-specific options. Removed because of duplication.

1.6.5 Zones 4-5: Increase abstraction from existing canals

This has been incorporated into a similar option termed 'Increase capacity of LORGWS canal and other betterments'.

1.6.6 Zones 4-5: High volume low head lifting pump stations

Benefit will be achieved for a limited distance only. This will be a very costly option that will also present an operational challenge.

1.6.7 Zones 4-5: Replace all or sections of LORGWS Canal with increased capacity canal

This has been incorporated into a similar option termed 'Increase capacity of LORGWS canal and other betterments'.

1.6.8 Zones 4-5: Additional farm dams along the canal

Although this option could increase the yield from the system, especially for larger farm dams, it is not considered to have much potential, mainly because of limited land availability for farm dams, due to the small farm sizes.

1.6.9 Zones 4-5: Existing Ebenhaeser Scheme

The water-supply challenges being experienced at the existing Ebenhaeser scheme are not due to a shortage of water but are operation-related and should be addressed by other means. The best option is through the planned pressure scheme, which is being implemented. A new Ebenhaeser scheme, adjacent to the existing irrigation, has been evaluated.

1.6.10 Zone 2: Jan Dissels River schemes

Three schemes were identified in the Jan Dissels River, not including the existing irrigated area on land leased out. Following environmental screening, only 31 ha of irrigable land remained, which is deemed too small for economic development.

1.6.11 Zones 4-5: Klawer 2

This option requires a balancing dam to store water to be pumped in winter and then blended with abstracted summer releases of poorer water quality, to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter. The entire site, except for a small portion near the northern boundary, is located within a critical biodiversity area (CBA1), which also rules out the option.

1.6.12 Zones 4-5: Klawer 3

The Klawer 3 scheme is an identified irrigable area located along a tributary of the Troe-Troe River near Vredendal. Following environmental screening, only very small and dispersed irrigable areas remained, which were too small to practically consider further, and were located far away from the Olifants River. This option requires a balancing dam to store water to be pumped in winter and then blended with abstracted summer releases of poorer water quality, to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

1.6.13 Zones 4-5: Coastal 2

The Coastal 2 irrigable area is an area located about halfway between Vredendal and Lutzville, along the left bank of the river. Following environmental screening, only two very small irrigable areas remained, which were too small to practically consider further. This option requires a balancing dam to store water to be pumped in winter and then blended with abstracted summer releases of poorer water quality, to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

1.6.14 Zones 4-5: Lutzville 1

This option requires a balancing dam to store water to be pumped in winter and then blended with abstracted summer releases of poorer water quality, to ensure an acceptable minimum irrigation water quality for the crops (notably grapes). The evaluation showed that the balancing storage required would be so large, that it would be better to abstract all irrigation water in winter.

1.6.15 Zones 4-5: Provision of additional balancing dam/s along the canal

A significant benefit of an additional balancing dam along the canal may be realised during a drought, while it could also augment the yield or irrigate new areas. A careful evaluation of potential balancing dam sites, that would be located near the existing LORWUA canal, led to the identification of two potential balancing dam sites.

The first site is located on the left bank of the Olifants River, in the hills near the confluence of the Olifants and Doring rivers, and Trawal. While it seems like a good dam site, and the Trawal and Zypherfontein schemes could easily be irrigated from it, the dam is located too high. While different dam sizes could be considered, pumping from the canal or river to the dam would need to be at least 130m high or more, which would be extremely expensive, and not viable. The dam would inundate the road leading south from Trawal to Skurfkop Station.

A second dam site has also been identified in the hills near Klawer on the right bank, but the pumping requirement would be even higher, which also rules out this dam site.

1.6.16 Zones 4-5: Increase winter use from existing canals

There is very little scope to release more water through the canals during the peak summer months. A distribution option that can be considered is to put more water through the canals from March to October, i.e. during the winter period. This would require the introduction of

alternative crop types that have a different water requirement, with peak demands at different times to those crops currently grown. This option has a high risk involved in terms of the need for a reliable market to be available for the alternative crops at the right time. This is an option to expand existing summer irrigation, but as an option for new irrigation on its own, this option will not be viable.

1.7 Selected Options for Evaluation (Short List)

The following short-listed options have been selected for further evaluation:

Zone 2 - Clanwilliam Dam and Jan Dissels River:

- Scheme 1: Abstraction from Clanwilliam Dam.
- Scheme 5: Transfer of lower Jan Dissels River scheduled allocations to the Olifants River.

Zone 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir:

- Scheme 6: Pumping from Olifants River.
- Scheme 7: Pumping from Olifants River.
- Scheme 8: Pumping from Olifants River.
- Scheme 9: Pumping from Olifants River.
- Scheme 10: Abstraction from Bulshoek Weir.

Zone 3 - Options Located Outside the Olifants River Valley:

- Scheme 11: Jakkals River Irrigation Scheme (JRIS) and Graafwater.
- Scheme 12: Provision of water to coastal towns.
- Scheme 13: Provision of water to JRIS, Graafwater, Lamberts Bay and Elands Bay.

Zone 4 - Olifants River below Bulshoek Weir to Trawal

- Scheme 14: Release at Bulshoek Weir and pump from river:
- Scheme 14: Zypherfontein 1.
- Scheme 15: Release at Bulshoek Weir and pump from river: Combined Schemes 15-33, Trawal.
- Scheme 16: Release at Bulshoek Weir and pump from river: Scheme 16, Zypherfontein 2.
- Scheme 17: Release at Bulshoek Weir and pump from river: Scheme 17, Melkboom.
- Scheme 18: Release at Bulshoek Weir and pump from river: Combined Schemes 14-16-17.
- Scheme 19: Release at Bulshoek Weir and pump from river: Combined Schemes 14-15-17.

Zone 5 - Olifants River from Klawer to the Coast

- Scheme 22: Klawer
- Scheme 23: Aties-Karoo
- Scheme 24: Coastal 1
- Scheme 25: Ebenhaeser New
- Scheme 27: Lutzville 2
- Scheme 29: Use of spare capacity in the Karoovlakte canal section.
- Scheme 30: Use of spare capacity in the Naaukoes canal section.
- Scheme 31: Use of spare capacity in the Vredendal canal section.

Zones 4 and 5: LORGWS (Bulshoek) Canal

- Scheme 32: Replace all or sections of LORGWS Canal with a pipeline with increased capacity.
- Scheme 33: Increase capacity of LORGWS canal and other betterments.

The scheme locations are shown in **Figure 1.2**, **Figure 1.3**, **Figure 1.4** and **Figure 1.5**.

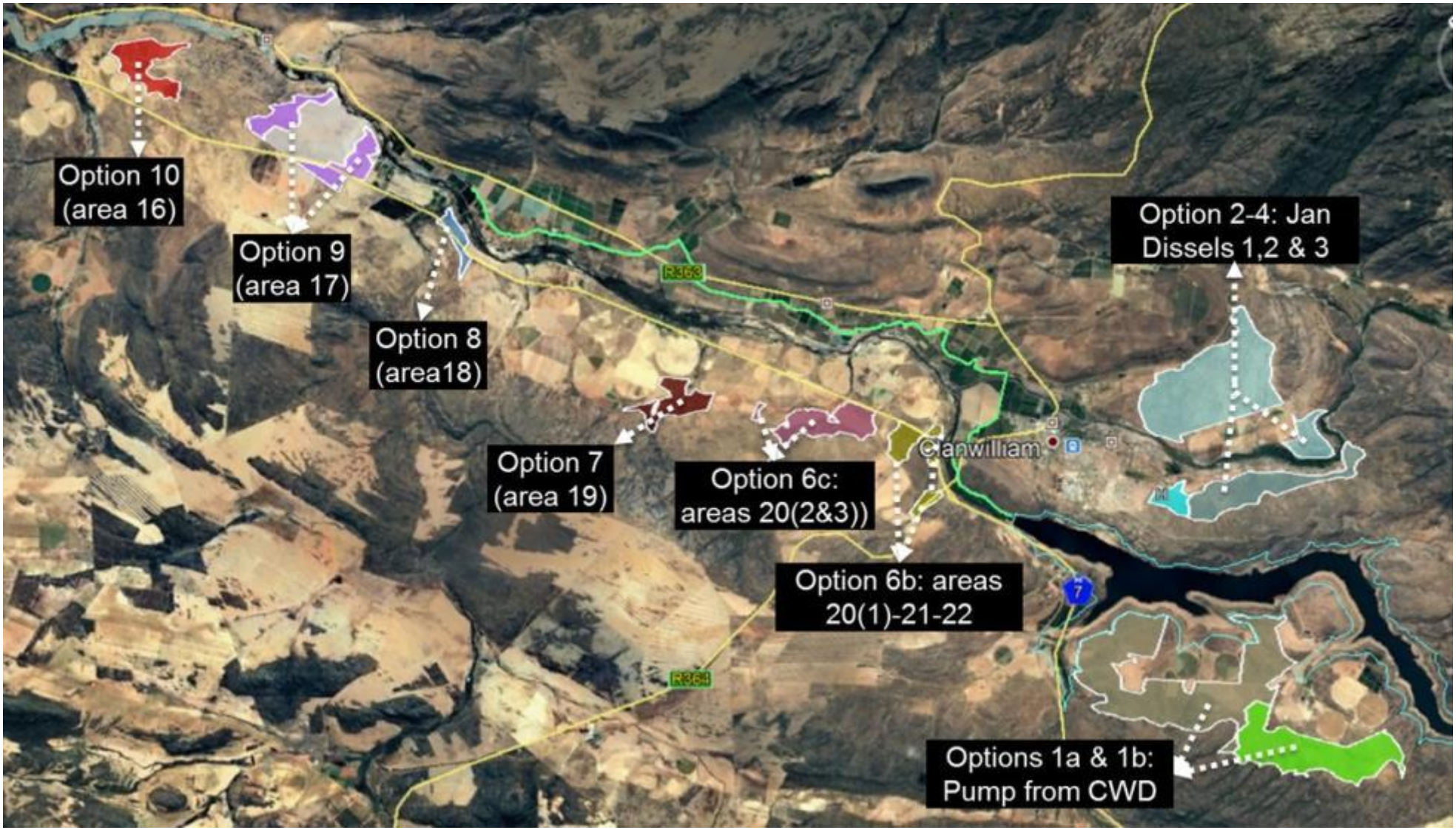

Figure 1.2 | Upper Jan Dissels and Olifants River options

Figure 1.3 │ Supply to JRIS, Graafwater, Lamberts Bay and Elands Bay

Figure 1.4 | Zypherfontein 1 and 2, Trawal and Melkboom options

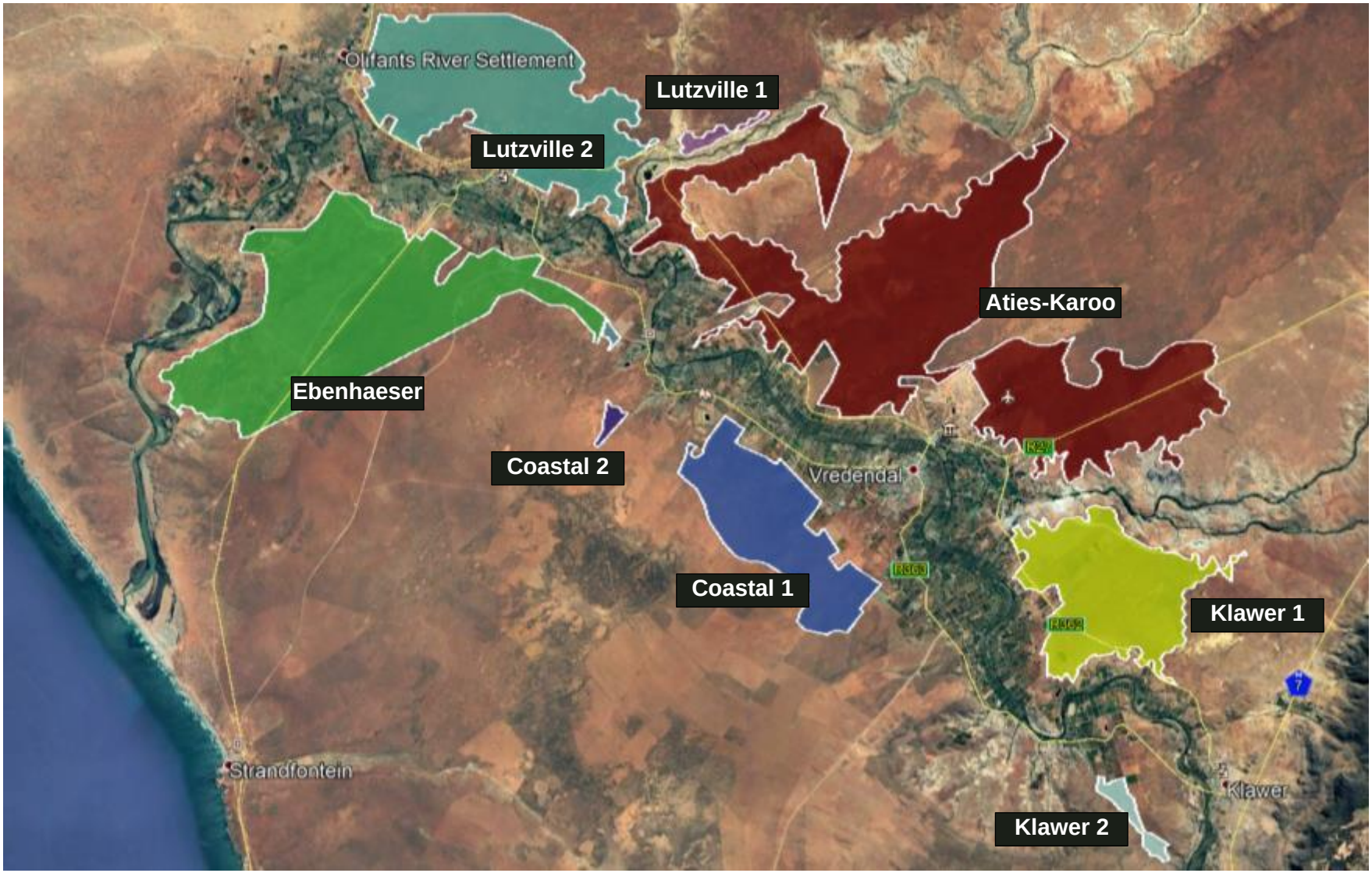

Figure 1.5 | Lower Olifants irrigable areas

1.8 Evaluation of Selected Options

1.8.1 Technical Evaluation

Irrigation water requirements were calculated, considering conveyance losses, average zone crop water requirements, crop rotation, peaking factors, and leaching requirements.

Incremental and total conveyance losses in the Olifants River were estimated by river reach, as indicated in **Table 1-1**.

Table 1-1 | Estimated Conveyance Losses in the Olifants River

River section	% River losses up to abstraction point
Zone 2: Clanwilliam Dam to Bulshoek Weir	5%
Zone 3: Jakkals River	25%
Zone 4: Bulshoek Weir to Verdeling	29%
Zone 5: Verdeling to Klawer	33%
Zone 5: Klawer to Spruitdrift	42%
Zone 5: Spruitdrift to EB de Waal	45%
Zone 5: EB de Waal to Lutzville	51%

Conveyance infrastructure losses were estimated as follows:

- Short pipelines: 0%
- Longer Pipeline: 3%
- Earth canal: 25% not used
- Lined concrete canal: 15%
- Existing Bulshoek Canal: 27%
- Existing Clanwilliam canal: 30%.

The following criteria were used for the technical evaluation:

- Bulk pipelines and pump stations were sized to cater for peak monthly water requirements.
- Dam sizes were based on topography variation (either lined kraal dams or U-shaped dams) and three hours of pumping were allowed for storage from dams or weirs. For pumping from the Olifants River, 24 hours of storage was allowed, and for pumping from canals, 96 hours of storage.

- In-house spreadsheets were developed and used for reconnaissance-level design and costing.
- Run-of-river abstraction rates were determined as a function of the flow regime in the Olifants River below the Doring River confluence. The scheme sizing and size of an off-channel dam, where appropriate.
- Reservoirs were provided between rising main and gravity main pipelines to allow for some operational flexibility.
- Typical costs were developed for the evaluation of canals.
- Certain capital costs were based on costs available from previous studies or costs of similar sized infrastructure.
- Costs were escalated to be representative of the base year costs (2018) 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 the costs were too out-dated.
- Purchasing of privately-owned land was estimated from recent land sales in the study area.

The unit reference value (URV) is a means of comparing different options on an equal basis by calculating a cost per unit (here 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 the scheme 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. An evaluation period of 32 years (2018 to 2045) was selected for all water augmentation schemes, for determination of URV.

URVs were classed in three categories as follows:

- Low: Below R 1.60/m^3
- Medium: Between R 1.60/m^3 and R 2.50/m^3
- High: Greater than R 2.50/m^3.

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.

1.8.2 Ecological and Socio-economic Considerations

A desktop-level assessment of the environmental and socio-economic impacts of each option was carried out. Country-wide 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 are listed in each option's description, as well as their predicted severity and mitigation measures. Specific impacts include:

- Inter-basin transfer of raw water, which has environmental implications (water quality, transfer of biota between catchments, etc.);
- 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.

1.8.3 Water Quality Considerations

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

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. Salinity in Clanwilliam Weir and Bulshoek Weir is low, and the water is in an Ideal category for irrigation.

If the source of 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, then the Electrical Conductivity (ECiw) at the abstraction point needs to be estimated, and the leaching requirement needs to be calculated. The higher the salt concentration

in the irrigation water, the higher estimated water requirement 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 5 years to leach the salts from the soils. Thereafter, the normal leaching requirement needs to be applied as described above. However, the infrastructure should be designed to accommodate the additional water during the initial 5 years. Therefore, for new greenfield irrigation areas, the soil forms in the new area was determined from the 2018 soil surveys, and the recommended leaching requirement for the dominant soil form was looked up.

Storage requirement for good quality water for blending

The canal from Bulshoek Weir is running at almost full capacity. Because of this, 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, currently irrigation return flows during the summer months 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. The return flow salt loads (kg/ha/day) were calculated from existing irrigation areas using historical salt concentrations recorded along the river, and the size of the irrigation area contributing to the loads. The total dissolved solids (TDS) concentration at a specific location was then estimated using a mass balance approach, which considered the average salt load released from Bulshoek Weir (volume and TDS concentration), the average summer salt load from the Doring River, and the salt loads from existing irrigation areas between Bulshoek Weir and the abstraction point. The volume of good quality water that should be stored to blend with the abstracted water to a minimum average TDS concentration of 800 mg/l (Tolerable category) was then calculated.

1.9 Options Workshop

At the Options Workshop held on 11 and 12 December 2018, the background to and findings of the evaluation of options was presented to a group of key stakeholders. The stakeholders provided comment and made suggestions regarding improvements and variations of the potential

options or clarified specific facts. Several options will be refined following the workshop and some newly-identified options will be evaluated.

1.10 Content of this Report

Chapter 1: (this Chapter): Provides an introduction and background, and briefly describes the methodology followed in the reconnaissance-level investigation.

Chapter 2: Zone 2, Clanwilliam Dam and Jan Dissels River: Describes the options relating to abstraction directly from Clanwilliam Dam, and the options in the Jan Dissels catchment.

Chapter 3: Zone 2, Clanwilliam Dam to Bulshoek Weir: Describes the options for abstraction from the Olifants River between Clanwilliam Dam up to and including Bulshoek Weir

Chapter 4: Zone 3, Options Located Outside the Olifants River Valley: Describes the options that are not located in the Olifants River valley.

Chapter 5: Zone 4, Olifants River from Bulshoek Weir to Trawal: Describes the options for abstraction from the Olifants River below Bulshoek Weir up to Trawal.

Chapter 6: Zone 5, Olifants River from Klawer to Coast: Describes the options for abstraction from the Olifants River from Klawer to the Coast.

Chapter 7: Zones 4 and 5, LORGWS (Bulshoek) Canal: Describes options relating to increased irrigation from the LORGWS canal.

2 Zone 2, Clanwilliam Dam and Jan Dissels River

This Chapter describes the options relating to abstraction directly from Clanwilliam Dam and the options in the Jan Dissels River catchment.

2.1 Scheme 1 - Abstraction from Clanwilliam Dam

2.1.1 Option 1b layout

The option layout is shown in **Figure 2.1**.

Figure 2.1 | Option 1b layout

2.1.2 Option 1b description

Irrigators can pump water directly from the lake of the Clanwilliam Dam, although abstraction points will be affected by the rise/fall of the water level. An area of 716 ha west of Clanwilliam

Dam, on the western side of the N7 highway, near the bridge, was identified as irrigable land. This area has been reduced to 234 ha for this option, following environmental screening. The portion of the land near the dam, extending from the bridge to the old Total garage, has been expropriated to make provision for the dam raising.

This option involves the construction of a ±2.7 km long, 315 mm diameter uPVC rising main from the dam. The 340 Kw pump station, located along the dam, with a pumping head of 138 m, will deliver water to a farm dam of 720 m^3 capacity. Abstraction works cost is expected to be minimal and has not been allowed for.

2.1.3 Water Requirements and Losses

The water requirement for the 234 ha development is 2.11 million m^3/a. Minimal conveyance losses are expected (pipeline).

2.1.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

2.1.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT)) are shown in **Table 2.1.** The URV for this option is given in **Table 2.2**.

Table 2-1 | Option 1b Comparative Capital Costs in million Rand

Pipeline	Pump station	Farm dam	Purchase of land	Total Cost
7.00	11.63	0.05	4.45	23.13

Table 2-2 | Option 1b URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	23.13
Annual operating cost (R million/annum)	1.23
NPV Cost (R million)	42.58
Unit Reference Value (R/m^3)	1.74

2.1.6 Ecological Impact

Sensitivity: High: Western half of identified area is within the critical biodiversity area CBA1. The eastern half is preferred, which is within the ecological support areas ESA1 and ESA2. Wetlands cross the site.

Mitigation: Avoid the CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset, which has not been included in the comparative cost estimate. Provide a buffer for the wetlands on site.

2.1.7 Option 1 Summary

The potential area for irrigation development has been significantly reduced by environmental concerns, which remain high. This scheme has a good location and medium unit reference value. There are no water quality concerns and insignificant water losses (pipeline). There is potential for 5 ha plots, as it is located close to Clanwilliam town. A potential power supply could be from a new hydropower plant at the raised Clanwilliam Dam.

2.2 Scheme 5 - Transfer of Lower Jan Dissels River Scheduled Allocations to the Olifants River

2.2.1 Option 5 layout

The option layout is shown in **Figure 2.2**.

Figure 2.2 | Option 5 layout

2.2.2 Option 5 description

The Jan Dissels River Compulsory Licensing Study recommended moving some, or all, the existing allocations of irrigators in the lower Jan Dissels River to either the Olifants River or to the Clanwilliam Canal. This proposal is to improve the ecological condition of the lower section of the Jan Dissels River. This recommendation is also contained in Section 4.2 of the 'Task 5' *Existing Infrastructure and Current Agricultural Development Report* of this study. It is an opportunity for three water users in the lowest stretch of the Jan Dissels River to shift their abstractions to the Olifants River (Clanwilliam Canal fully used), thereby increasing low flows to improve the currently very poor ecological status of the bottom stretch of the Jan Dissels River.

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

2.2.3 Water requirements and Losses

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

There are no conveyance losses.

2.2.4 Water Quality

This option has no water quality implication.

2.2.5 Cost and Unit Reference Value

This option has no cost implication.

2.2.6 Ecological Impact

This option is expected to have appositive ecological impact. It will relieve pressure on the lower Jan Dissels River in summer and thereby contribute to the improvement of the ecological condition of the lower Jan Dissels River.

This transfer of water allocation will need to be made from the unutilised part of the 25% portion of the additional yield from the raised Clanwilliam Dam intended for improving the assurance of supply of existing users.

2.2.7 Option 5 Summary

The transfer of water allocations to the Olifants river will increase the low summer flows and thereby improve the ecological status of the bottom stretch of the Jan Dissels River, which is currently very poor. There are no cost or water quality implications.

3 Zone 2, Clanwilliam Dam to Bulshoek Weir

This Chapter describes the options for abstraction from the Olifants River between Clanwilliam Dam and including Bulshoek Weir.

3.1 Scheme 6b - Pumping from Olifants River

3.1.1 Option 6b layout

The option layout is shown in **Figure 3.1**.

Figure 3.1 | Option 6b layout

3.1.2 Option 6b description

The area is located only about 5 km from Clanwilliam town to the east of the N7. This could possibly be a suitable area for smallholder plots of 5 ha, considering the proximity of the area to

Clanwilliam town and existing markets. Water would be pumped from the Olifants River to a farm dam, with irrigation under gravity.

The total effective farmable area is 66 ha. The land is privately-owned.

This option involves the construction of a ±1.49 km long, 200 mm diameter uPVC rising main from the pump station located at the Olifants River. The pumping head from the rive rot the farm dam is 119 m.

3.1.3 Water Requirements and Losses

The water requirement for the 66 ha is 0.59 million m^3/a.

Limited river losses are expected as the scheme is located very close to the dam. There will be negligible infrastructure conveyance losses (pipeline).

3.1.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.1.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.1** and the URV is given in **Table 3.2**.

Table 3-1 | Option 6b Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
1.39	2.98	0.12	1.78	6.94

Table 3-2 | Option 6b URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	6.94
Annual operating cost (R million/annum)	0.32
NPV Cost (R million)	12.30
Unit Reference Value (R/m^3)	1.80

3.1.6 Ecological Impact

Sensitivity: High: Endangered (EN) vegetation type occurs within the eastern section of the site. ESA1 and ESA2 features are located across the site.

Mitigation: Avoid EN vegetation type areas. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.

3.1.7 Option 6b Summary

The potential area for development has been significantly reduced by environmental concerns, which remain high. The scheme has a good location and medium unit reference value. There are no water quality concerns and insignificant water losses. There is potential for 5 ha plots, as it is located close to Clanwilliam town. A potential power supply could be from a new hydropower plant at the raised Clanwilliam Dam.

3.2 Scheme 6c - Pumping from Olifants River

3.2.1 Option 6c layout

The option layout is shown in **Figure 3.2**.

Figure 3.2 | Option 6c layout

3.2.2 Option 6c description

The identified development area is located only about 7 km from Clanwilliam town to the east of the N7. This could possibly be a suitable area for smallholder plots of 5 ha, considering the proximity of the area to Clanwilliam town and existing markets. Water would be pumped from the Olifants River to a farm dam, with irrigation under gravity.

The total effective farmable area is 94 ha. The land is privately-owned.

This option involves the construction of a ±1.94 km long, 250 mm diameter uPVC rising main from the pump station located at the Olifants River. The pumping head from the river to the farm dam is 109 m.

3.2.3 Water Requirements and Losses

The water requirement for the 94ha development is 0.84 million m^3/a.

The river losses will be limited as the scheme is located very close to the dam. There will be negligible infrastructure conveyance losses (pipeline).

3.2.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.2.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.3**. The unit reference value for this option is given in **Table 3.4**.

Table 3-3 | Option 6c Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
2.07	3.82	0.17	2.65	9.63

Table 3-4 | Option 6c URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	9.63
Annual operating cost (R million/annum)	0.44
NPV Cost (R million)	16.63
Unit Reference Value (R/m^3)	1.63

3.2.6 Ecological Impact

Sensitivity: High: EN vegetation type occurs within the eastern section of the site. ESA1 and ESA2 features are located across the site.

Mitigation: Avoid the EN vegetation type areas. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.

3.2.7 Option 6c Summary

Environmental concerns are high. This scheme has a good location and medium unit reference value. There are no water quality concerns and insignificant water losses. There is potential for 5 ha plots, as it is located close to Clanwilliam town. A potential power supply could be from a new hydropower plant at the raised Clanwilliam Dam.

3.3 Scheme 7 - Pumping from Olifants River

3.3.1 Option 7 layout

The option layout is shown in **Figure 3.3**.

Figure 3.3 | Option 7 layout

3.3.2 Option 7 description

The development area is located about 10 km from Clanwilliam town to the east of the N7. This could possibly be a suitable area for smallholder plots of 5 ha, considering the proximity of the area to Clanwilliam town and existing markets. Water would be pumped from the Olifants River to a farm dam, with irrigation under gravity.

The total effective farmable area is 62 ha. The land is privately-owned.

This option involves the construction of a ±2.4 km long, 200 mm diameter rising main from the pump station located at the Olifants River. The pumping head from the river to the farm dam is 105 m.

3.3.3 Water Requirements and Losses

The water requirement for the 62 ha is 0.62 million m^3/a.

There will be limited river loss of 0.03 million m^3/a (5%) and negligible infrastructure conveyance losses (pipeline).

3.3.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.3.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.5**. The unit reference value for this option is given in **Table 3.6**.

Table 3-5 | Option 7 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
2.21	2.98	0.12	1.8	7.98

Table 3-6 | Option 7 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	7.98
Annual operating cost (R million/annum)	0.33
NPV Cost (R million)	13.33
Unit Reference Value (R/m^3)	1.86

1.1.1 Ecological Impact

Sensitivity: Moderate: Most of the south western section of the site falls within ESA1.

Mitigation: ESA1 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.

3.3.6 Option 7 Summary

Option 7 has moderate environmental concerns. The scheme has a good location and medium unit reference value. There are no water quality concerns and insignificant conveyance water losses.

3.4 Scheme 8 - Pumping from Olifants River

3.4.1 Option 8 layout

The option layout is shown in **Figure 3.4**.

Figure 3.4 | Option 8 layout

3.4.2 Option 8 description

The area identified for development is located about 13 km from Clanwilliam town to the east and west of the N7. Water would be pumped from the Olifants River with irrigation under gravity. The area is located between Clanwilliam Dam and Bulshoek Weir on both sides of the N7.

The total effective farmable area is only 29 ha. The land is privately-owned.

This option involves the construction of a ±0.64 km long, 160 mm diameter uPVC rising main from the pump station located at the Olifants River. There is a pumping head of 44 m between the river and the farm dam.

3.4.3 Water Requirements and Losses

The water requirement for the 29 ha is 0.26 million m^3/a.

Total conveyance losses are 0.01 million m^3/a.

3.4.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.4.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.7**. The unit reference value for this option is given in **Table 3.8**.

Table 3-7 | Option 8 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
0.46	1.09	0.05	0.77	2.61

Table 3-8 | Option 8 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	2.61
Annual operating cost (R million/annum)	0.08
NPV Cost (R million)	4.25
Unit Reference Value (R/m^3)	1.41

3.4.6 Ecological Impact

Sensitivity: High: A small section of the site falls within CBA1 towards the north east. ESA1 and ESA2 features also occur on site.

Mitigation: Avoid the CBA1 areas. ESA1and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.

3.4.7 Option 8 Summary

This option has high environmental concerns. The scheme has a good location and low unit reference value. There are no water quality concerns and insignificant water losses.

3.5 Scheme 9b - Pumping from Olifants River

3.5.1 Option 9b layout

The option layout is shown in **Figure 3.5**.

Figure 3.5 | Option 9b layout

3.5.2 Option 9b description

The identified development area is located about 17 km from Clanwilliam town to the east and west of the N7. Water will need to be pumped from the Olifants River to a farm dam.

The total effective farmable area is 46 ha. The land is privately-owned.

This option involves the construction of a ±1.79 km long, 200 mm diameter uPVC rising main from the pump station located at the pumping point in the river. There is a pumping head of 115 m between the river and the farm dam.

3.5.3 Water Requirements and Losses

The water requirement for the 46 ha is 0.46 million m^3/a.

Total conveyance losses are 0.02 million m^3/a.

3.5.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.5.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.9**. The unit reference value for this option is given in **Table 3.10**.

Table 3-9 | Option 9b Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
3.34	4.89	0.21	1.39	8.28

Table 3-10 | Option 9b URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	8.28
Annual operating cost (R million/annum)	0.28
NPV Cost (R million)	12.61
Unit Reference Value (R/m^3)	2.37

3.5.6 Ecological Impact

Sensitivity: Moderate: The western section of the northern reduced area is located within ESA1, while the southern reduced area has portions of ESA1 across the site. There are only two small ESA2 areas present on the southern reduced area.

Mitigation: ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.

3.5.7 Option 9b Summary

Option 9b has moderate environmental concerns. This scheme has a good location and medium unit reference value. There are no water quality concerns and insignificant water losses.

3.6 Scheme 10a - Abstraction from Bulshoek Weir

3.6.1 Option 10a layout

The option layout is shown in **Figure 3.6**.

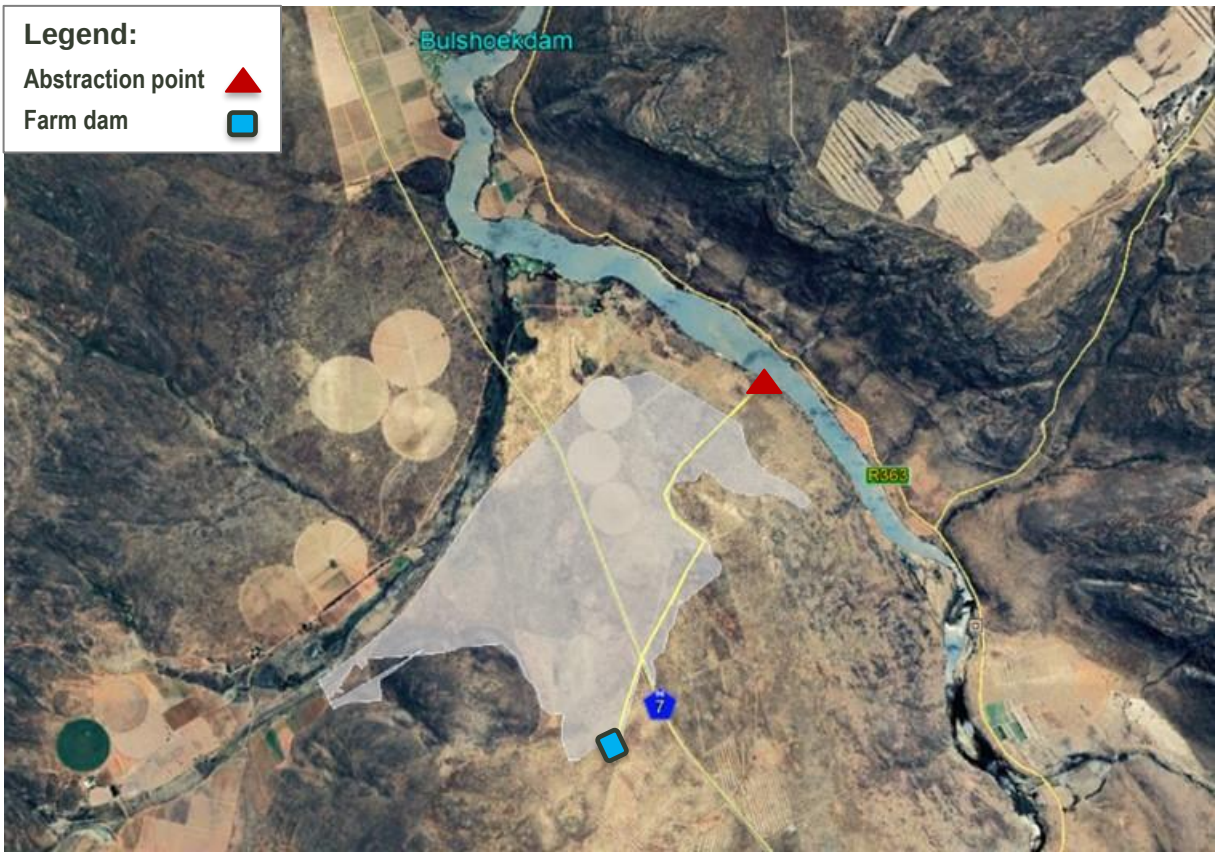

Figure 3.6 | Option 10a layout

3.6.2 Option 10a description

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

The full identified irrigation area before reduction in size due to environmental concerns is 338 ha. The comparison with Scheme 10b illustrates the implications of the reduced irrigable area.

This option involves the construction of a ±3.15 km long, 400 mm diameter steel rising main from the pump station located at the pumping point to the farm dam. This option has a pumping head of 137 m.

3.6.3 Water Requirements and Losses

The water requirement for the 338 ha is 3.37 million m^3/a.

Total conveyance losses are 0.17 million m^3/a.

3.6.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.6.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.11**. The unit reference value for this option is given in **Table 3.12**.

Table 3-11 | Option 10a Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
5.53	15.68	0.08	7.13	31.61

Table 3-12 | Option 10a URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	31.61
Annual operating cost (R million/annum)	1.90
NPV Cost (R million)	61.97
Unit Reference Value (R/m^3)	1.59

3.6.6 Ecological Impact

Sensitivity: High: The centre of the site is located within a CBA1. The ESA1 and ESA2 areas occur from the centre to the southern section of the site, including wetlands and watercourses. EN vegetation also occurs on site.

Mitigation: Avoid CBA1 and EN vegetation type areas. ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.

3.6.7 Option 10a Summary

Option 10a has high environmental concerns. This scheme has a good location and low unit reference value. There are no water quality concerns and insignificant water losses.

3.7 Scheme 10b - Abstraction from Bulshoek Weir

3.7.1 Option 10b layout

The option layout is shown in **Figure 4.7**.

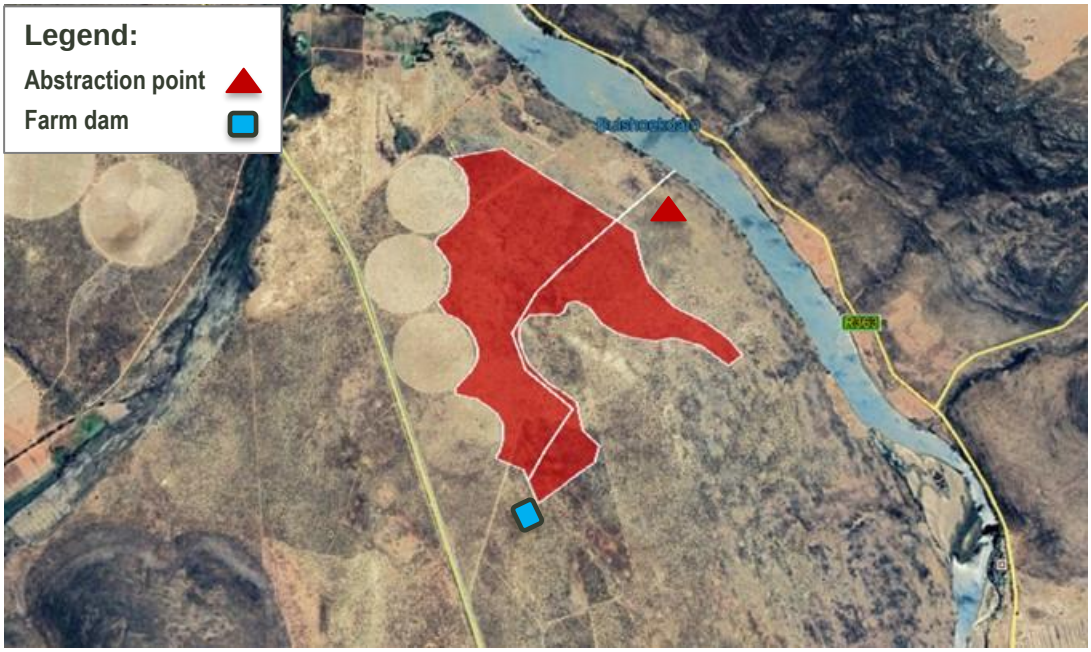

Figure 3.7 | Option 10b layout

3.7.2 Option 10b description

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

The total effective farmable area is 80 ha.

This option involves the construction of a ±1.94 km long, 200 mm diameter uPVC rising main from the pump station located at the pumping point to the farm dam. This option has a pumping head of 144 m.

3.7.3 Water Requirements and Losses

The water requirement for the 80 ha is 0.80 million m^3/a.

Total conveyance losses are 0.04 million m^3/a.

3.7.4 Water Quality

Water quality is good. A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

3.7.5 Cost and Unit Reference Value

The comparative capital costs (2018 prices, excluding VAT) are shown in **Table 3.13**. The unit reference value for this option is given in **Table 3.14**.

Table 3-13 | Option 10b Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
2.05	4.44	0.02	2.4	9.88

Table 3-14 | Option 10b URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	9.88
Annual operating cost (R million/annum)	0.51
NPV Cost (R million)	18.12
Unit Reference Value (R/m^3)	1.95

3.7.6 Ecological Impact

Sensitivity: High: EN vegetation occurs along the western edges of the site.

Mitigation: Avoid EN vegetation types.

3.7.7 Option 10b Summary

Option 10b has high environmental concerns. This scheme has a good location and medium unit reference value. There are no water quality concerns and insignificant water losses.

4 Zone 3, Options Located Outside the Olifants River Valley

Chapter 4 describes the options that are not located in the Olifants River valley. Pumping water to these schemes from a new, enlarged hydropower plant at the raised Clanwilliam Dam is a possible opportunity for the usage of power to be generated by the new hydropower plant.

4.1 Scheme 11a/b - Jakkals River Irrigation Scheme (JRIS) and Graafwater

4.1.1 Option 11a/11b layout

The layout for option 11a and 11b is shown in respectively in **Figure 4.1** and **Figure 4.2**. Two alternative routes have been assessed. The 'Jakkals Vlei' irrigation option was identified by an interest group. A secondary identified objective is to supply Graafwater and coastal municipalities (Lamberts Bay and Elands Bay) with water for domestic use. This option is based on the Jakkals River Irrigation Scheme Project (JRIS), which was identified by the Sandveld Investment & Development Co. Ltd (SANID) Water. SANID Water identified four farms as possible irrigation areas. The four farms have a total effective farmable area of 3,187 ha.

4.1.2 Option 11a description

It is proposed for Option 11a that water will be pumped from the Clanwilliam Dam, released in the Jakkals River, outside of the Olifants River catchment, and abstracted from the Jakkals River, close to the identified irrigation area.

This involves the construction of a ±12 km long, 600 mm diameter steel rising main from the Clanwilliam Dam to a small reservoir. A ±1.7 km long, 500 mm diameter steel gravity pipeline will deliver the transferred water to the Jakkals River. The pipeline passes over a mountain range, with a pumping head of around 570 m.

Option 11b description

It is proposed for Option 11b that water will also be pumped from the Clanwilliam Dam, but the rising main will follow the R364 road to Graafwater. The rising main delivers water to a small reservoir, from where a gravity pipeline will supply a farm dam. A booster pump station may be needed to limit pressure. This option involves the construction of a ±19.87 km long, 500 mm diameter steel rising main from the Clanwilliam Dam. The pipeline passes over a mountain range, with a pumping head of around 467 m.

4.1.3 Water Requirements and Losses

The water requirements for this scheme were calculated using a crop distribution of 100% potatoes, with a 40% rotation factor. Potatoes were considered as they are the dominant crop farmed in the area. Citrus was also considered for this scheme as there is evidence of citrus farming in the area. Citrus was however, regarded as an unlikely option as Citrus is not currently widely planted in the Jakkals Vlei/Graafwater area. The water requirement for the Jakkals Vlei scheme was calculated as 13.14 million m^3/a for Option 11a and 10.58 million m^3/a for Option 11b.

Total conveyance losses are 2.88 million m^3/a for Option 11a and 0.31 million m^3/a for Option 11b.

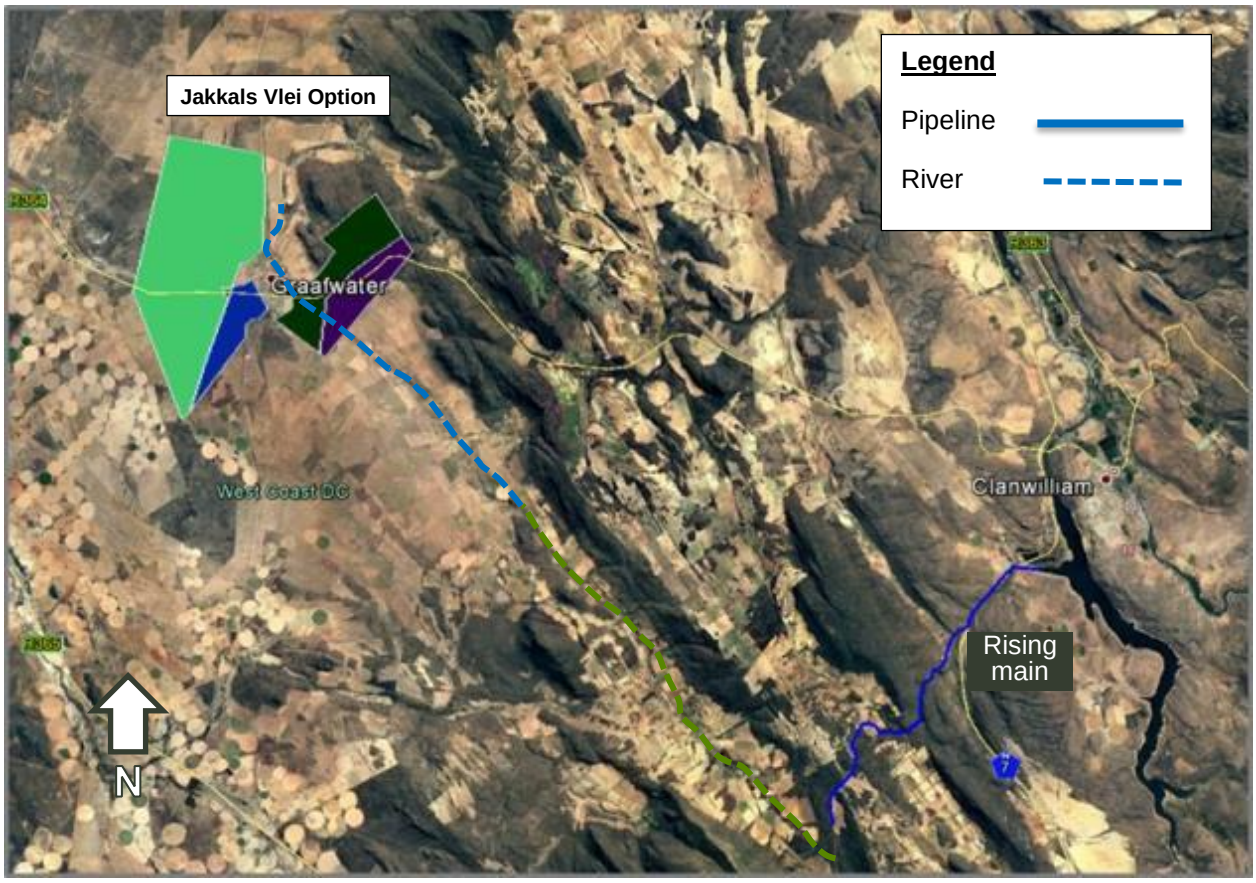

Figure 4.1 | Option 11a Jakkals Vlei option, pumping to the Jakkals River

Figure 4.2 | Option 11b Jakkals Vlei pipeline option

4.1.4 Water Quality

The quality of water abstracted from Clanwilliam Dam is in an Ideal category for irrigation. A leaching requirement of 3% has been added to the estimated irrigation water requirement to leach salts from the soil.

After discharge into the Jakkals River, the salinity of the water transferred from Clanwilliam Dam will probably increase moderately in a downstream direction. Only one water quality sample has been collected in the Jakkals River, and that was in September 2002 at the farm Kleinfontein. This sample indicated that, at the start of the dry season, salinity (50 mS/m) was in an Acceptable category (25-75 mS/m). Land use in the Jakkals River catchment up to Graafwater is dominated by dry-land agriculture, which has less of an impact on dry-season salinity than return flows from irrigated agriculture. It is therefore estimated that salinity of the transferred water may increase moderately between the discharge point and Graafwater, but probably remain within an Acceptable category.

4.1.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 11a is shown in **Table 4.1**. The unit reference value for this option is given in **Table 4.2**.

Table 4-1 | Option 11a Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Reservoir	Farm dam	Purchase of land	Total Cost
74.96	148.85	27.00	0.25	67.28	318.38

Table 4-2 | Option 11a URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	318.38
Annual operating cost (R million/annum)	24.78
NPV Cost (R million)	682.57
Unit Reference Value (R/m^3)	5.74

The comparative cost estimate (2018 prices, excluding VAT) for Option 11b is shown in **Table 4.3**. The unit reference value for this option is given in **Table 4.4**.

Table 4-3 | Option 11b Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Reservoir	Farm dam	Purchase of land	Total Cost
94.58	99.45	23.49	0.25	67.28	285.1

Table 4-4 | Option 11b URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	285.10
Annual operating cost (R million/annum)	13.20
NPV Cost (R million)	482.79
Unit Reference Value (R/m^3)	4.06

4.1.6 Ecological Impact

Sensitivity: High: The pipeline follows the road much of the route, but the eastern section includes areas of CBA1. The pipeline also transects ESA1 and ESA2 areas, mostly in the west, and includes watercourses and wetland areas.

Mitigation: Avoid CBA1 area as far as practicable and apply site specific mitigation if not possible. The affected CBA and ESA areas are likely to require an offset. Wetlands/watercourses require site specific mitigation.

4.1.7 Option 11 Summary

This is a very costly option that will not be economically feasible without significant subsidisation. There are significant environmental concerns relating to the inter-basin transfer of water, which would need to be mitigated. Option 11a should not be considered at all, given the higher cost, negative inter-basin transfer impacts on the Jakkals River, and the high conveyance losses. The pipeline option has moderate environmental impacts and limited conveyance loss. The socio-economic impacts of acquiring the farms with existing irrigation, as identified by SANID, will be high. The prospective scheme has been around for some time and has a level of political acceptability, following the marketing done by SANID Water.

4.2 Scheme 12 - Provision of Water to Coastal Towns

4.2.1 Option 12 layout

The layout of Option 12 is shown in **Figure 4.3**.

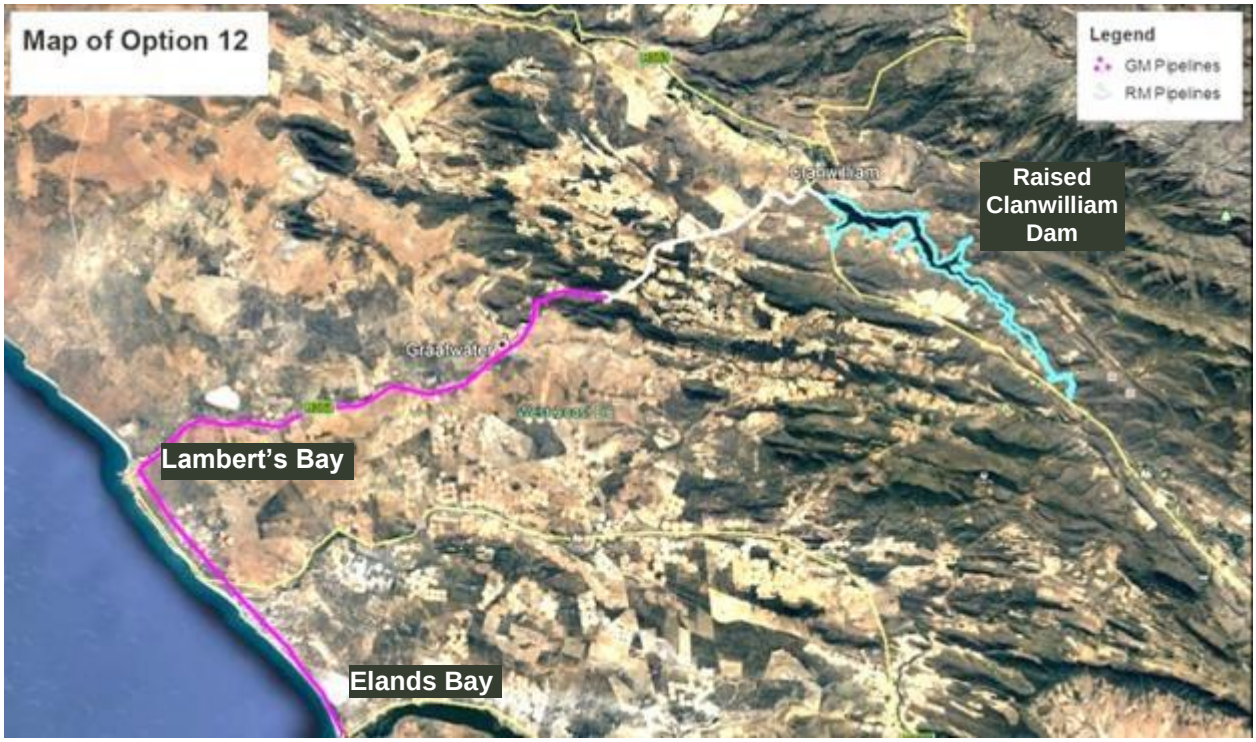

Figure 4.3 | Option 12 layout

4.2.2 Option 12 description

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

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

A 1 700 m³/d reverse-osmosis (RO) seawater desalination plant, upgradeable to 5 000 m³/d, has subsequently been built in Lamberts Bay. The plant should alleviate growing pressure on the region's water system and improve availability of high-quality water for the region's nearly 40 000 residents. This plant is however not operational yet.

The option to supply water from Clanwilliam Dam involves the construction of:

1. A ±19.87 km long, 200 mm diameter rising main from the pump station located at Clanwilliam Dam. This option has a pumping head of 760 m to Lamberts Bay and Elands Bay.
2. A ±8.34 km long, 600 mm diameter gravity main to Graafwater.
3. A ±28.19 km long, 200 mm diameter gravity main from Graafwater to Lamberts Bay.
4. A ±24.44 km long, 200 mm diameter gravity main from Lamberts Bay to Elands Bay.

4.2.3 Water Requirements and Losses

The water requirement is 0.37 million m^3/a.

Total conveyance losses are 0.1 million m^3/a.

4.2.4 Water Quality

Abstracted water quality from Clanwilliam Dam is good.

4.2.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 12 is shown in **Table 4.5**. The unit reference value for this option is given in **Table 4.6**.

Table 4-5 | Option 12 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Reservoir	Farm dam	Purchase of land	Total Cost
93.49	5.41	11.00	0	0	125.33

Table 4-6 | Option 12 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	125.33
Annual operating cost (R million/annum)	1.61
NPV Cost (R million)	136.76
Unit Reference Value (R/m^3)	32.34

4.2.6 Ecological Impact

Sensitivity: High: The pipeline transects numerous CBA1 areas along the proposed route. and the route also transects CBA2 areas in small areas east of Graafwater, as well as west towards the coast enroute to Lamberts Bay. The route includes endangered(EN) and vulnerable (VU) vegetation types as well as National Freshwater Ecosystem Priority Areas (NFEPA) wetlands. ESA1 and ESA2 areas are also transected, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a railway line.

Mitigation: Avoid CBA1 and CBA2 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Consultation with Steenboksfontein Private Nature Reserve is recommended.

4.2.7 Option 12 Summary

This is an exorbitantly costly option that will not be economically feasible without significant subsidisation, even though this is an urban water supply option. The option has high environmental and socio-economic impacts, and limited conveyance loss. The coastal towns likely have better, more cost-effective options for water supply in terms of groundwater.

4.3 Scheme 13 - Provision of Water to JDRIS, Graafwater, Lamberts Bay and Elands Bay

4.3.1 Option 13 layout

The layout of Option 13 is shown in **Figure 4.4**.

Figure 4.4 | Option 13 layout

4.3.2 Option 13 description

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

Many coastal towns in the Cape Province feel the pressure with water demands exceeding supply, especially during peak holiday seasons. An example is Lamberts Bay, a town about 280 kilometers from Cape Town - along the Cape West Coast, in Cederberg LM. To resolve this dilemma, the DWS and the Cederberg Municipality first considered two possibilities: provide additional boreholes; or install a 61-kilometre pipeline from the Clanwilliam Dam. Investigative studies, revealed the pipeline would not guarantee a sustainable water supply and test boreholes

exposed overly excessive iron and manganese content in the water. The DWS and the town's municipality therefore decided to commission a new desalination plant adjacent to the town's existing water purification plant.

A 1 700 m³/d reverse-osmosis (RO) seawater desalination plant, upgradeable to 5 000 m³/d, has subsequently been built in Lamberts Bay. The plant should alleviate growing pressure on the region's water system and improve availability of high-quality water for the region's nearly 40 000 residents. This plant is however not operational yet.

The total effective farmable area for the proposed Jakkals River Irrigation Scheme is 3 187 ha.

The option to supply water from Clanwilliam Dam involves the construction of:

1. A ±19.87 km long, 500 mm diameter rising main from the pump station located at Clanwilliam Dam. This option has a pumping head of 760 m to Lamberts Bay and Elands Bay.
2. A ±8.34 km long, 500 mm diameter gravity main to Graafwater.
3. A ±28.19 km long, 200 mm diameter gravity main from Graafwater to Lamberts Bay.
4. A ±24.44 km long, 200 mm diameter gravity main from Lamberts Bay to Elands Bay.
5. A ±4.78 km long, 600 mm diameter rising main on-farm pipeline, pumping a head of 68 m.
6. A ±0.52 km long, 500 mm diameter gravity main on-farm pipeline.

This option involves the construction of a ±19.87 km long, 500 mm diameter rising main from the pump station located at Clanwilliam Dam. There is a pumping head of 474 m.

4.3.3 Water Requirements and Losses

The water requirement for irrigation and domestic water supply is 10.63 million m^3/a.

Total conveyance losses are 0.32 million m^3/a. A leaching requirement of 3% has been added to the estimated irrigation water requirement to leach salts from the soil for the first 5 years after establishment.

4.3.4 Water Quality

Abstracted water quality from Clanwilliam Dam is good.

4.3.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 13 is shown in **Table 4.7**. The unit reference value for this option is given in **Table 4.8**.

Table 4-7 | Option 13 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Reservoir	Farm dam	Purchase of land	Total Cost
133.38	104.37	23.56	0.26	67.28	328.90

Table 4-8 | Option 13 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	328.90
Annual operating cost (R million/annum)	14.16
NPV Cost (R million)	537.53
Unit Reference Value (R/m^3)	4.36

4.3.6 Ecological Impact

Sensitivity: High: The pipeline route transects numerous CBA1 (Terrestrial) and CBA2 areas east of Graafwater as well as west towards the coast enroute to Lamberts Bay. The route includes EN and VU vegetation types as well as NFEPA wetlands. ESA1 and ESA2 areas are transected, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a railway line.

Mitigation: Avoid CBA1 and CBA2 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Consultation with Steenboksfontein Private Nature Reserve is recommended.

4.3.7 Option 13 Summary

This is a very costly option that will not be economically feasible without significant subsidisation. The option has high environmental and socio-economic impacts and limited conveyance loss. The prospective scheme has been around for some time and has a level of political acceptability, following the marketing done by SANID Water. The coastal towns likely have better, more cost-effective options for water supply in terms of groundwater.

5 Zone 4, Olifants River from Bulshoek Weir to Trawal

Chapter 5 describes the options for abstraction from the Olifants River below Bulshoek Weir up to Trawal.

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

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

Water can also be released from the Bulshoek Weir down the Olifants River and be pumped either directly for irrigation, or to farm dams.

5.1 Scheme 14 - Zypherfontein 1: Release at Bulshoek and pump from river

5.1.1 Option 14 layout

The layout of Option 14 is shown in **Figure 5.1**.

Figure 5.1 | Option 14 layout

5.1.2 Option 14 description

The Zypherfontein 1 Scheme, and the other irrigation options located in close vicinity, together provides an option for a large new development downstream of Bulshoek Weir, but above the confluence with the Doring River, which avoids the influence of poorer water quality below the confluence. While additional irrigation development may be phased in over time, the options together provide an opportunity for a much faster uptake of water. The Lower Olifants River Water User Association (LORWUA) has indicated that it would strongly support such a scheme. Because it is a large scheme, with much of the irrigation scheme located further away from the

river, costs are expected to be slightly higher than for small schemes located closer to the river. There are however advantages of scale, due to the size of the project.

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

- Pumping from the Olifants River.
- New canal system from Bulshoek Weir (addressed in Scheme 19).

The total effective farmable area is 505 ha.

The option to pump from the river involves the construction of a ±13.6 km long, 500 mm diameter rising main from the pump station to a farm dam. There is a pumping head between the river and the dam of 115 m.

5.1.3 Water Requirements and Losses

The water requirement for 505 ha is 4.76 million m^3/a.

Total conveyance losses are 1.38 million m^3/a.

5.1.4 Water Quality

Water quality is good. A leaching requirement of 21% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

5.1.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 14 is shown in **Table 5.1**. The unit reference value for this option is given in **Table 5.2**.

Table 5-1 | Option 14 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
3.61	20.04	0.47	**9.60**	**37.33**

Table 5-2 | Option 14 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	37.33
Annual operating cost (R million/annum)	2.41
NPV Cost (R million)	76.21
Unit Reference Value (R/m^3)	1.38

5.1.6 Ecological Impact

Sensitivity: Moderate: CBA1 occurs adjacent to the south western border of the site. VU vegetation occurs in the southern section of the site. ESA1 areas, including watercourses, occur across the site. While ESA2 features are found from the centre to the southern sections of the site.

Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.

5.1.7 Option 14 Summary

Option 14 has moderate environmental concerns. The scheme has a good location and low unit reference value. There are no water quality concerns and moderate water losses.

5.2 Scheme 15 - Trawal: Release at Bulshoek and pump from river

5.2.1 Option 15 layout

The layout of Option 15 is shown in **Figure 5.2**.

Figure 5.2 | Option 15 layout

5.2.2 Option 15 description

Water is released from Bulshoek Weir and pumped from the Olifants River below the Doring confluence, to the scheme on the left bank.

The total effective farmable area is 695 ha. The land is privately-owned.

This option involves the construction of a ±2.5 km long, 600 mm diameter steel rising main from the pump station at the river to a farm dam. There is a pumping head of 107 m.

5.2.3 Water Requirements and Losses

The water requirement for the 695 ha is 7.18 million m^3/a.

Total conveyance losses are 2.08 million m^3/a.

5.2.4 Water Quality

Water quality is good. A leaching requirement of 19% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

5.2.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 15 is shown in **Table 5.3**. The unit reference value for this option is given in **Table 5.4**.

Table 5-3 | Option 15 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
9.55	27.91	0.46	14.68	58.30

Table 5-4 | Option 15 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	58.30
Annual operating cost (R million/annum)	3.43
NPV Cost (R million)	112.63
Unit Reference Value (R/m^3)	1.35

5.2.6 Ecological Impact

Sensitivity: Moderate: Numerous ESA1 features such as watercourses cross the site, with some ESA2 features occurring from the centre and in the south eastern sections of the site.

Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.

5.2.7 Option 15 Summary

Option 15 has moderate environmental concerns. This scheme has a good location and low unit reference value. There are no water quality concerns and moderate water losses.

5.3 Scheme 16 - Zypherfontein 2: Release at Bulshoek and pump from river

5.3.1 Option 16 layout

The layout of Option 16 is shown in **Figure 5.3**.

Figure 5.3 | Option 16 layout

5.3.2 Option 16 description

Water is released from Bulshoek Weir and pumped from the Olifants River below the Doring confluence to the scheme on the right bank.

The total effective farmable area is 658 ha. The land is privately-owned.

This option involves the construction of a ±3.62 km long, 600 mm diameter steel rising main from the pump station at the river to a farm dam. There is a pumping head of 106 m.

5.3.3 Water Requirements and Losses

The water requirement for the 658 ha is 6.80 million m^3/a.

Total conveyance losses are 1.97 million m^3/a.

5.3.4 Water Quality

Water quality is good. A leaching requirement of 19% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

5.3.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 16 is shown in **Table 5.5**. The unit reference value for this option is given in **Table 5.6**.

Table 5-5 | Option 16 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
13.85	26.19	0.44	13.89	60.45

Table 5-6 | Option 16 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	60.45
Annual operating cost (R million/annum)	3.27
NPV Cost (R million)	111.45
Unit Reference Value (R/m^3)	1.41

5.3.6 Ecological Impact

Sensitivity: Moderate: ESA1 features such as watercourses can be found towards the north, east and southern tips of the area. ESA2 features occur near the south eastern boundary of the site, as well as the centre. VU vegetation types occur in the south western section of the site.

Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.

5.3.7 Option 16 Summary

Option 16 has moderate environmental concerns. This scheme has a good location and low unit reference value. There are no water quality concerns and moderate water losses.

5.4 Scheme 17 - Melkboom: Release at Bulshoek and pump from river

5.4.1 Option 17 layout

The layout of Option 17 is shown in **Figure 5.4**.

Figure 5.4 | Option 17 layout

5.4.2 Option 17 description

Like the Zypherfontein Scheme proposal, the Melkboom option provides for a large new development on the right bank of the Olifants River downstream of the Doring River confluence.

The potential irrigation area of 500 ha is located just east of the Olifants/Doring Rivers' confluence. Two water supply options could be considered, i.e.: (1) canal system or (2) pump water to several properties via a distribution network. The current owners are not farming.

The total effective farmable area is 333 ha.

This option involves the construction of a ±4.12 km long, 500 mm diameter steel rising main from the pump station at the river to a farm dam. There is a pumping head of 120 m.

5.4.3 Water Requirements and Losses

The water requirement for the 500 ha is 3.45 million m^3/a.

Total conveyance losses are 1.00 million m^3/a.

5.4.4 Water Quality

Even though the abstraction point is located just below the confluence of the Doring River and the Olifants River, the abstracted water quality will be good. A leaching requirement of 19% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

5.4.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 17 is shown in **Table 5.7**. The unit reference value for this option is given in **Table 5.9**.

Table 5-7 | Option 17 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
10.95	15.27	0.34	7.02	37.56

Table 5-8 | Option 17 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	37.56
Annual operating cost (R million/annum)	1.90
NPV Cost (R million)	67.18
Unit Reference Value (R/m^3)	1.68

5.4.6 Ecological Impact

Sensitivity: Moderate: ESA1 features such as watercourses transect the site. ESA2 features occur in proximity of the largest watercourse and various smaller watercourses located in the northern section of the site.

Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.

5.4.7 Option 17 Summary

Option 17 has moderate environmental concerns. This scheme has a good location and low unit reference value. There are no water quality concerns and moderate water losses.

5.5 Scheme 18 - Water supplied by pipeline from Bulshoek Weir

5.5.1 Option 18 layout

The layout of Option 18 is shown in **Figure 5.5**.

Figure 5.5 | Option 18 layout

5.5.2 Option 18 description

Option 18 is a combination of three schemes; Zypherfontein 1 (Option 14), Zypherfontein 2 (Option 16) and Trawal (Option 15). Water will be supplied via a gravity pipeline from Bulshoek Weir, instead of being pumped from the Olifants River.

The total combined effective farmable area is 1 808 ha.

This option involves the construction of a ±14.87 km long, 1 300 mm diameter gravity main pipeline from Bulshoek Weir. The gravity pipeline supplies water to the pump stations for the three schemes, from where it is pumped to the farm dams as follows:

- The Zypherfontein 2 scheme requires the construction of a ±3.6 km long, 600 mm diameter rising main from the pump station to the farm dam, with a pumping head of 106 m.
- The Trawal scheme requires the construction of a ±2.5 km long, 600 mm diameter rising main from the pump station to the farm dam, with a pumping head of 107 m.
- The Zypherfontein 1 scheme requires the construction of a ±1.4 km long, 500 mm diameter rising main from the pump station to the farm dam, with a pumping head of 115 m.

5.5.3 Water Requirements and Losses

The water requirement for the combined 1 808 ha is 19.24 million m^3/a.

The total conveyance losses for this option (pipelines) are 1.54 million m^3/a. The combined losses for the individual schemes, where water is abstracted from the Olifants River, is 5.43 million m^3/a (3.5 times more).

5.5.4 Water Quality

Water quality is good. A leaching requirement of 19% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

5.5.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 18 is shown in **Table 5.9**. The unit reference value for this option is given in **Table 5.10**.

Table 5-9 | Option 18 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
276.05	82.10	1.36	**38.17**	**445.07**

Table 5-10 | Option 18 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	445.07
Annual operating cost (R million/annum)	12.69
NPV Cost (R million)	610.72
Unit Reference Value (R/m^3)	**2.74**

5.5.6 Ecological Impact

Sensitivity: Moderate, as per the ecological descriptions of Schemes 14, 15 and 16.

Mitigation: As per the mitigation measures for Schemes 14, 15 and 16.

5.5.7 Option 18 Summary

Option 18 has moderate environmental concerns. This scheme has a good location but high unit reference value. There are no water quality concerns and low water losses.

5.6 Scheme 19 - Water supplied from Bulshoek Weir via raised canal and pipelines

5.6.1 Option 19 layout

The layout of Option 19 is shown in **Figure 5.6**.

Figure 5.6 | Option 19 layout

5.6.2 Option 19 description

Option 19 is a combination of three schemes; Zypherfontein 1 (Option 14), Zypherfontein 2 (Option 16) and Melkboom (Option 17). Water will be supplied by raising the canal from Bulshoek Weir, instead of being pumped directly from the Olifants River.

The total combined effective farmable area is 1 445 ha.

This option involves the raising of the first 8km of the Trawal Canal section by 0.125 m and the construction of a small canal on the right bank with a capacity of 1.5m^3/s to supply the three schemes. Three balancing dams will be located along the canal route.

5.6.3 Water Requirements and Losses

The water requirement for the combined 1 445 ha is 16.42 million m^3/a.

Total conveyance losses are 4.76 million m^3/a.

5.6.4 Water Quality

Water quality is good. A leaching requirement of 19% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

5.6.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 19 is shown in **Table 5.11**. The unit reference value for this option is given in **Table 5.12**.

Table 5-11 │ Option 19 Comparative Capital Costs in million Rand

Pipeline / Canal	River abstraction works & pump station	Farm dam	Purchase of land	Total Cost
15.82	53.05	1.24	**30.51**	**200.64**

Table 5-12 │ Option 19 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	200.64
Annual operating cost (R million/annum)	6.86
NPV Cost (R million)	190.87
Unit Reference Value (R/m^3)	**1.10**

5.6.6 Ecological Impact

Sensitivity: Moderate, as per the ecological descriptions of Schemes 14, 16 and 17.

Mitigation: As per the mitigation measures for Schemes 14, 16 and 17.

5.6.7 Option 19 Summary

Option 19 has moderate environmental concerns. This scheme has a good location but high unit reference value. There are no water quality concerns and low water losses.

6 Zone 5, Olifants River from Klawer to Coast

Chapter 6 describes the options for abstraction from the Olifants River from Trawal to the Coast. Water can be released from the Bulshoek Weir down the Olifants River and be pumped either directly for irrigation, or to farm dams. The poorer quality water from the Doring River tributary will influence the extent to which water could be abstracted for irrigation below the confluence of the Olifants and Doring rivers. Below the extent where abstracted river water could be used directly for irrigation, irrigation will get more expensive, due to the need to provide conveyance infrastructure (canal / pipeline) or alternatively to improve water quality through treatment/low-pressure desalination.

6.1 Scheme 22 - Klawer

6.1.1 Option 22 layout

The layout of Option 22 is shown in **Figure 6.1**.

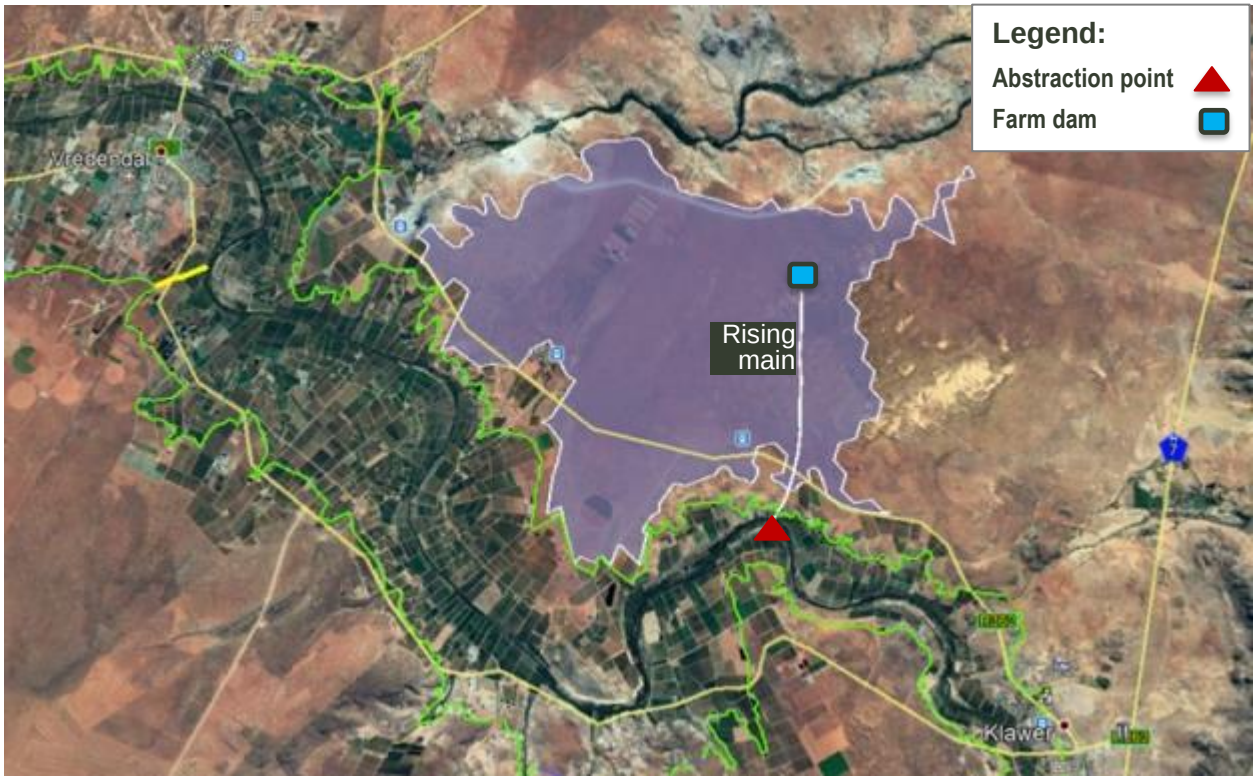

Figure 6.1 | Option 22 layout

6.1.2 Option 22 description

The proposed Klawer irrigation area of 2 645 ha is located just north-west of Klawer, between the National Road N7 and the R362 regional road (Klawer to Vredendal), and south of the Biedouw River. The water required for this option will be released down the Olifants River from Bulshoek Weir. The water will then be abstracted directly from the Olifants River and conveyed to the central on-farm dam.

This option involves the construction of a ±3.5km, 1000mm dia. steel diameter rising main pipeline from the pump station located at the pumping point at the Olifants River, with a pumping head of 124m. Balancing dam storage of 3.15 million m^3/a is required.

6.1.3 Water Requirements and Losses

The water requirement for the farmable area of 2 645 ha is 24.88 million m^3/a.

Total conveyance losses are 10.45 million m^3/a. River losses are high.

6.1.4 Water Quality

A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst) on average for the seven (7) summer months of irrigation, a balancing dam of 3.5 million m^3 is required, in addition to the farm dam used for emergency storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

6.1.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 22 is shown in **Table 6.1**. The unit reference value for this option is given in **Table 6.2**.

Table 6-1 | Option 22 Comparative Capital Costs in million Rand

Pipeline	Pump station	Balancing Dam	Farm dam	Purchase of land	Total Cost
32.54	105.36	36.78	2.16	55.84	306.95

Table 6-2 | Option 22 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	306.95
Annual operating cost (R million/annum)	13.74
NPV Cost (R million)	557.77
Unit Reference Value (R/m^3)	1.94

6.1.6 Ecological Impact

Sensitivity: High: A pocket of CBA1 remains in the centre of the reduced area. Watercourses occurring along the south eastern section of the site have been designated as ESA1. The eastern part of the site falls into the Knersvlakte National Protected Area Expansion Strategy (NPAES).

Mitigation: Avoid CBA2 areas. Provide a buffer for watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).

6.1.7 Option 22 Summary

Option 22 has high environmental concerns and a medium unit reference value. This option has very high water losses of over 40%, because of losses in the lower Olifants River below Bulshoek Weir. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Klawer scheme is to be considered. This scheme possibly holds potential for 5 ha plots, given its location between Klawer and Vredendal.

6.2 Scheme 23 - Aties-Karoo

6.2.1 Option 23 layout

The layout of Option 23 is shown in **Figure 6.2**.

Figure 6.2 | Option 23 layout

6.2.2 Option 23 description

The Aties-Karoo area is the block of land bordered roughly by the National Road N7, the Hol/Vars Rivers, and the R27 regional road between Vredendal and Vanrhynsdorp. Based on the WODRIS botanical investigation (PGWC, 2003g), more than 90% of the proposed irrigation area was identified as a 'red flag' area. However, with the implementation of mitigation, an area of 1 963 ha on the south-western fringe of the Aties-Karoo has been identified for development. Any envisaged irrigation development in this area would be subject to a detailed environmental impact assessment (EIA). Distribution of water according to Scheme 22, and/or an enlarged LORGWS canal, or supply pumped from the lower Olifants River. This area falls within State owned land.

The total effective farmable area is 4 500 ha. A larger area of 14 500 ha in the Aties-Karoo area was identified, but this area was reduced due to the available allocation of water from the raised Clanwilliam Dam.

Balancing Dam Storage of 8.60 million m^3/a is required.

This option involves the construction of a ±8.88 km long, 1 300 mm diameter rising main from the pump station at the river to a farm dam. There is a pumping head of 139 m.

6.2.3 Water Requirements and Losses

The water requirement for the farmable area of 4 500 ha is 41.00 million m^3/a.

Total conveyance losses are 18.45 million m^3/a.

6.2.4 Water Quality

A leaching requirement of 8% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst) on average for the seven (7) summer months of irrigation, a balancing dam of 8.6 million m^3 is required, in addition to the farm dam used for emergency storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

6.2.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 23 is shown in **Table 6.3**. The unit reference value for this option is given in **Table 6.4**.

Table 6-3 | Option 23 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Dam	Farm dam	Purchase of land	Total Cost
143.04	195.25	243.25	3.18	95.00	730.90

Table 6-4 | Option 23 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	730.90
Annual operating cost (R million/annum)	26.85
NPV Cost (R million)	1005.61
Unit Reference Value (R/m^3)	2.12

6.2.6 Ecological Impact

Sensitivity: High: ESA1 and ESA2 features occur across the site. Smaller sections along the eastern boundary of the site fall into the Knersvlakte NPAES.

Mitigation: Provide a buffer for watercourses and wetlands on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).

6.2.7 Option 23 Summary

Option 23 has high environmental concerns and a medium unit reference value. This option has very high water losses of 45%, because of losses in the lower Olifants River below Bulshoek Weir. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Aties-Karoo scheme is to be considered. This scheme holds potential for 5 ha plots, given its relative closeness to Vredendal.

6.3 Scheme 24 - Coastal 1

6.3.1 Option 24 layout

The layout of Option 24 is shown in **Figure 6.3**.

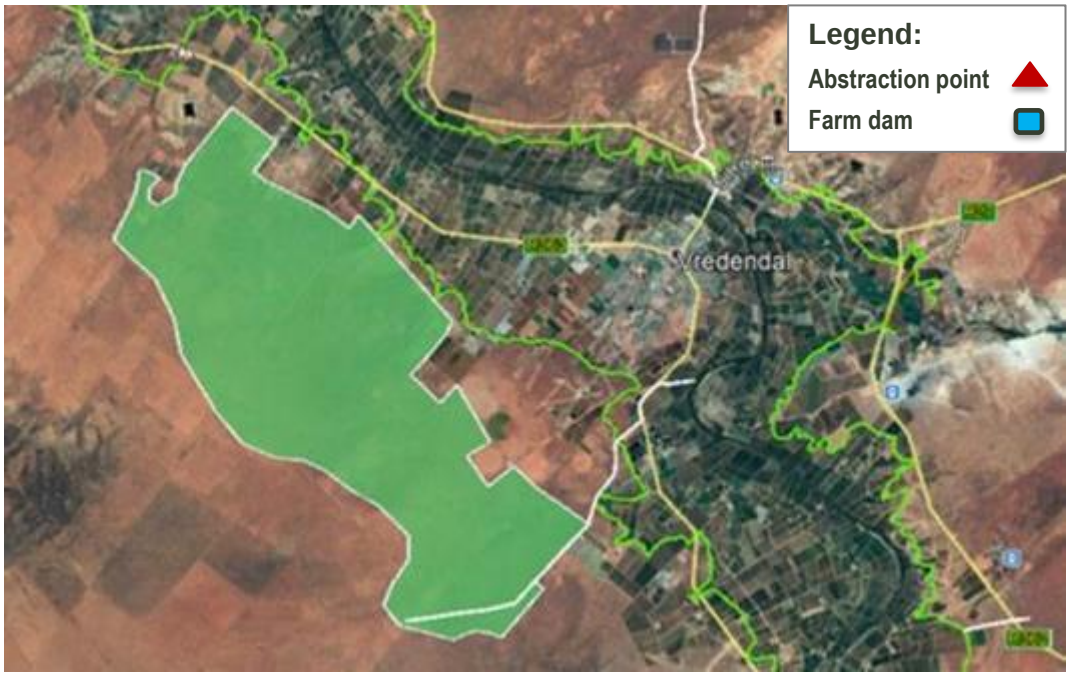

Figure 6.3 | Option 24 layout

6.3.2 Option 24 description

The proposed Coastal Region irrigation area is located on the mildly undulating coastal plain, west of the Olifants River to the Atlantic Coast, north of Doring Bay to as far as Ebenhaeser. It stretches from Ebenhaeser in the north-west to Tweelingkop south-west of Vredendal in the east. Distribution of water will be by releasing more water through the canal from March to October, i.e. during the winter period, and/or via an enlarged LORGWS River canal, or pump water released from Bulshoek Weir from the lower Olifants River. This area falls within State owned land.

The total effective farmable area is 2 235 ha.

Balancing Dam Storage of 27.60 million m^3/a is required.

This scheme involves the construction of a ±6.72 km long, 1 000 mm diameter steel rising main from the pump station located at the canal to a farm dam. There is a pumping head of 121 m.

6.3.3 Water Requirements and Losses

The water requirement for the farmable area of 2 235 ha is 20.74 million m^3/a.

Total conveyance losses are 9.33 million m^3/a.

6.3.4 Water Quality

A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst) on average for the seven (7) summer months of irrigation, a balancing dam of 27.6 million m^3 is required, in addition to the farm dam used for emergency storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

6.3.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 24 is shown in **Table 6.5**. The unit reference value for this option is given in **Table 6.6**.

Table 6-5 | Option 24 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Dam	Farm dam	Purchase of land	Total Cost
62.52	85.77	778.60	1.85	47.19	998.45

Table 6-6 | Option 24 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	998.45
Annual operating cost (R million/annum)	16.83
NPV Cost (R million)	1149.95
Unit Reference Value (R/m^3)	4.79

6.3.6 Ecological Impact

Sensitivity: Moderate: ESA1 and ESA2 features occur across the site.

Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.

6.3.7 Option 24 Summary

Option 24 has moderate environmental concerns and high unit reference value. This option has very high water losses of 45%, because of losses in the lower Olifants River below Bulshoek Weir. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Coastal 1 scheme is to be considered. This scheme holds potential for 5 ha plots, given its relative closeness to Vredendal.

6.4 Scheme 25 - Ebenhaeser New

6.4.1 Option 25 layout

The layout of Option 25 is shown in **Figure 6.4**.

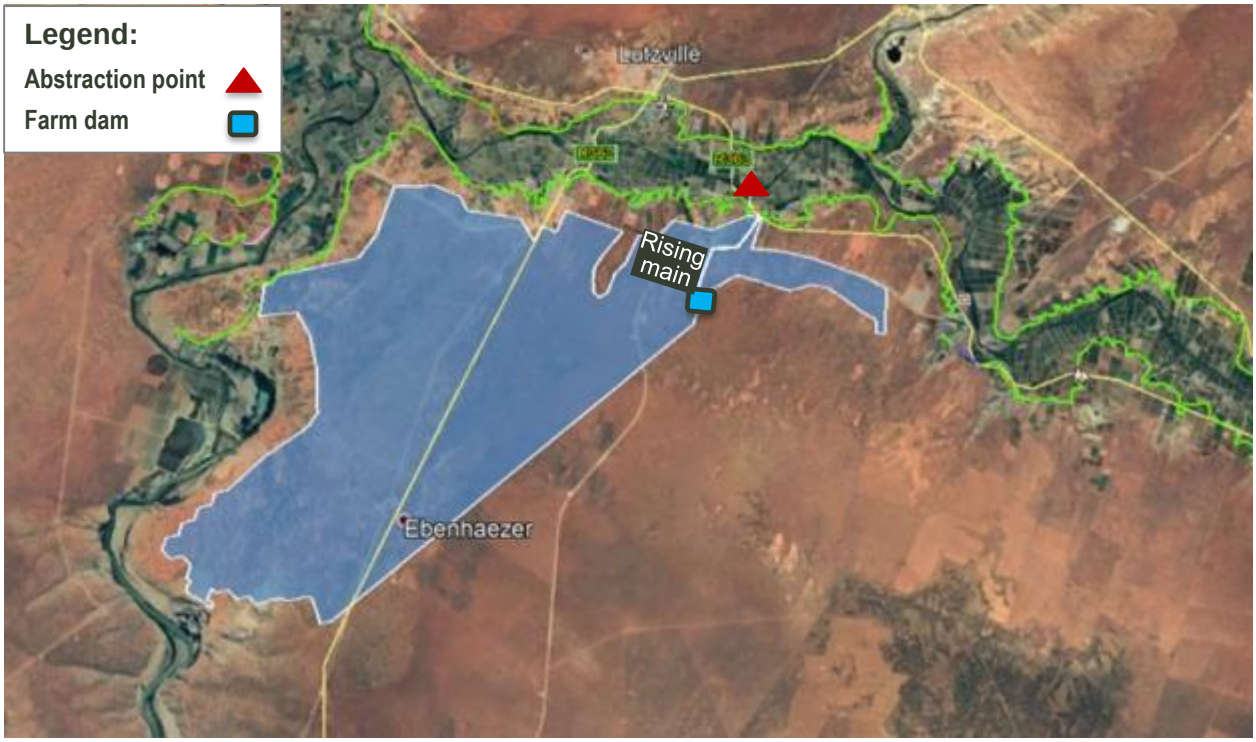

Figure 6.4 | Option 25 layout

6.4.2 Option 25 description

The proposed irrigation area is located in Ebenhaeser. Distribution of water will be by releasing more water through the canal from March to October, i.e. during the winter period, and/or via an enlarged LORGWS River canal, or pump water released from Bulshoek Weir from the lower Olifants River. This area falls within State owned land.

The total effective farmable area is 4 500 ha. A larger area of 6 620 ha in the Ebenhaeser area was identified, but this area was reduced due to the available allocation of water from the raised Clanwilliam Dam.

Balancing Dam Storage of 17.40 million m^3/a is required.

This option involves the construction of a ±3.35 km long, 1 300 mm diameter steel rising main from the pump station to a farm dam. There is a pumping head of 129 m.

6.4.3 Water Requirements and Losses

The water requirement for the farmable area of 4 500 ha is 43.76 million m^3/a.

Total conveyance losses are 22.32 million m^3/a.

6.4.4 Water Quality

A leaching requirement of 15% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst) on average for the seven (7) summer months of irrigation, a balancing dam of 17.4 million m^3 is required, in addition to the farm dam used for emergency storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

6.4.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 25 is shown in **Table 6.7**. The unit reference value for this option is given in **Table 6.8**.

Table 6-7 | Option 25 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Dam	Farm dam	Purchase of land	Total Cost
54.03	193.02	180.87	3.33	95.00	563.80

Table 6-8 | Option 25 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	563.80
Annual operating cost (R million/annum)	25.25
NPV Cost (R million)	938.61
Unit Reference Value (R/m^3)	1.86

6.4.6 Ecological Impact

Sensitivity: High: A small section of the site falls within a CBA1. ESA1 and ESA2 features occur across the site. NFEPA wetlands occur adjacent to the western and north eastern boundary of the site. The south eastern section of the site falls within a NPAES focus area.

Mitigation: Avoid CBA1 areas. Provide a buffer for watercourses and wetlands on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).

6.4.7 Option 25 Summary

Option 25 has high environmental concerns and a medium unit reference value. This option has very high water losses of over 50%, because of losses in the lower Olifants River below Bulshoek Weir. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Ebenhaeser scheme is to be considered. This scheme may hold potential for 5 ha plots, given its relative closeness to Lutzville.

6.5 Scheme 27 - Lutzville 2

6.5.1 Option 27 layout

The layout of Option 27 is shown in **Figure 6.5**.

Figure 6.5 | Option 27 layout

6.5.2 Option 27 description

For this option water will be pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. A balancing storage dam is needed to be filled in winter, to ensure summer supply of acceptable quality.

The total effective farmable area is 4 145 ha. The identified irrigation area is partially public land and the remainder is privately-owned.

Balancing Dam Storage of 21.50 million m^3/a is required.

This option involves the construction of a ±7.1 km long, 1 300 mm diameter steel rising main from the pump station to a farm dam. There is a pumping head of 129 m.

6.5.3 Water Requirements and Losses

The water requirement for the farmable area of 4 145 ha is 39.52 million m^3/a.

Total conveyance losses are 20.15 million m^3/a.

6.5.4 Water Quality

A leaching requirement of 13% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

To keep the water quality for irrigation below 800 mg/ℓ (at worst) on average for the seven (7) summer months of irrigation, a balancing dam of 21.5 million m^3 is required, in addition to the farm dam used for emergency storage. The balancing dam will be filled in winter and the water used to blend with the water abstracted from the Olifants River in summer, to achieve the desired water quality.

6.5.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 27 is shown in **Table 6.9**. The unit reference value for this option is given in **Table 6.10**.

Table 6-9 | Option 27 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Dam	Farm dam	Purchase of land	Total Cost
114.18	174.60	601.80	3.10	87.52	1023.83

Table 6-10 | Option 27 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	1023.38
Annual operating cost (R million/annum)	26.65
NPV Cost (R million)	1352.14
Unit Reference Value (R/m^3)	2.95

6.5.6 Ecological Impact

Sensitivity: Moderate: ESA1 and ESA2 features occur across the site.

Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.

6.5.7 Option 27 Summary

Option 27 has moderate environmental concerns and a high unit reference value. This option has very high water losses of over 50%, because of losses in the lower Olifants River below Bulshoek Weir. The need for large balancing storage to store winter water and blend with poorer quality water in summer significantly influences the cost of water, especially if a smaller sized Lutzville 1 scheme is to be considered. This scheme may hold potential for 5 ha plots, given its relative closeness to Lutzville.

6.6 Scheme 29 - Use of Spare Capacity in the Karoovlakte Canal Section

6.6.1 Option 29 layout

The layout of Option 29 is shown in **Figure 6.6**.

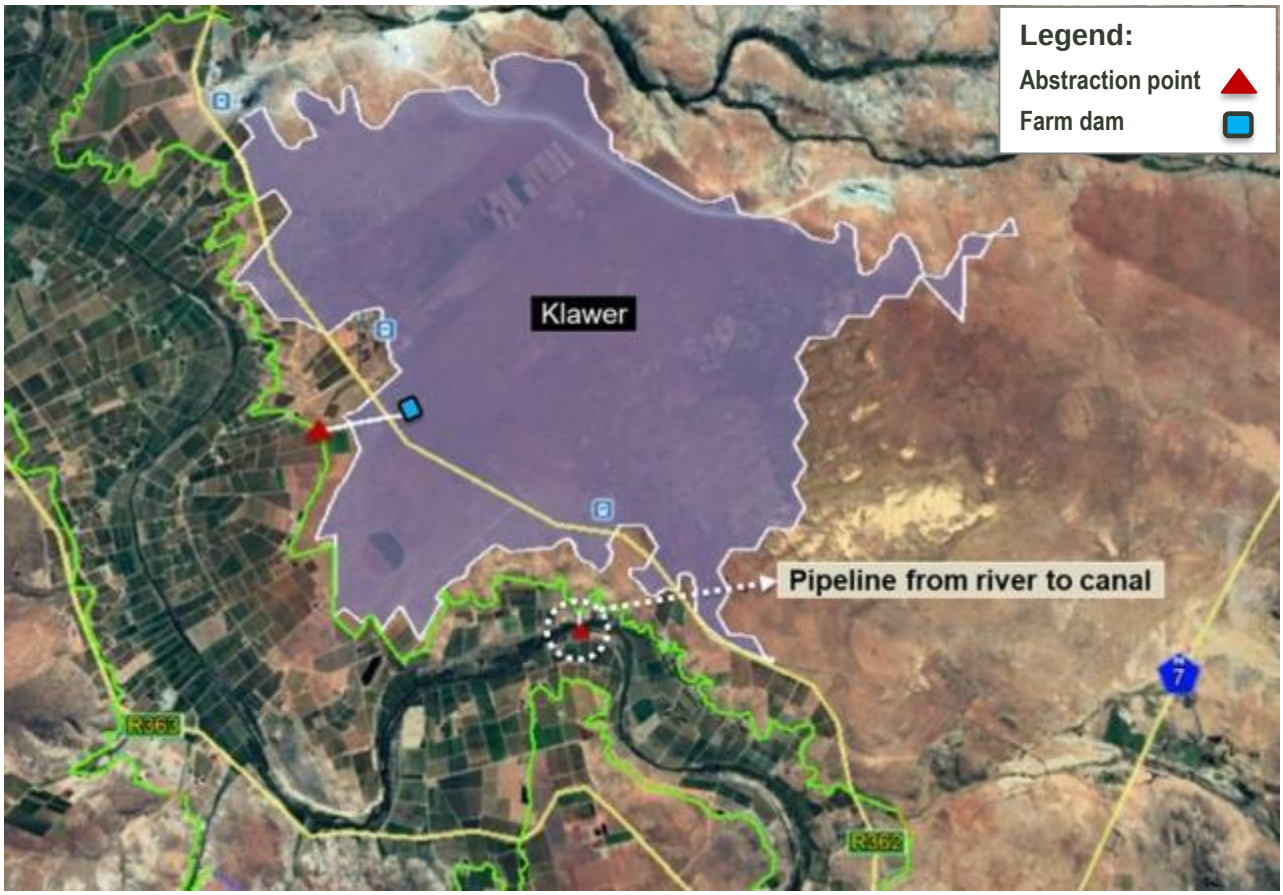

Figure 6.6 | Option 29 layout

6.6.2 Option 29 description

Certain canal sections still have some spare capacity, even during the dry season, because of the way that the canal has been constructed. Water can be released from the Bulshoek Weir down the Olifants River and be pumped into these identified canal sections with spare capacity, to be used via existing canal infrastructure. The various canal sections are shown in **Figure** 6.7. The spare capacity in these canal sections can be used, either to expand current irrigation or potentially to supply water for new irrigation.

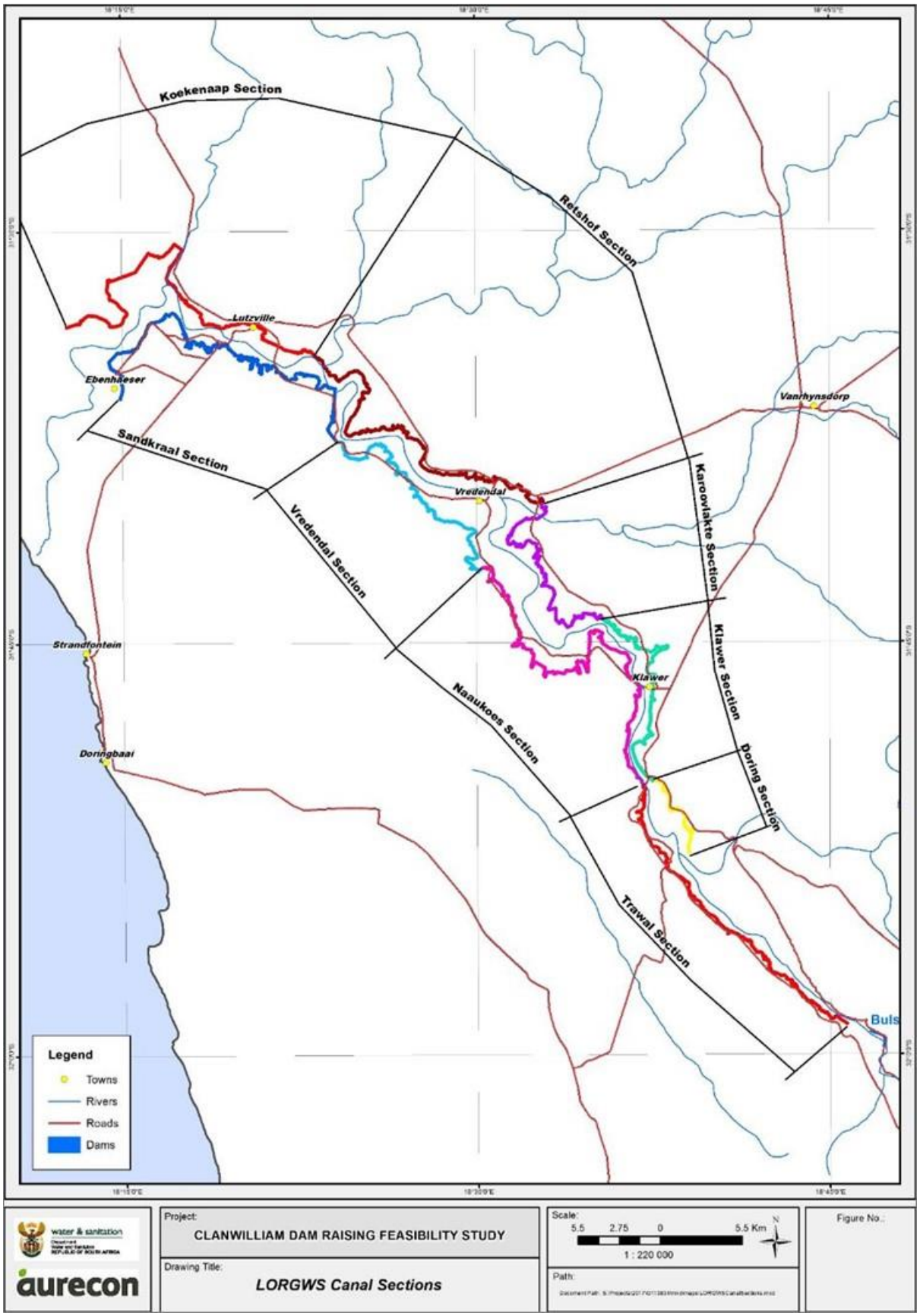

Figure 6.7 | Canal Sections of the Lower Olifants Canal

A disadvantage of this option will be the poorer water quality, because of mixing the Olifants River water with the more saline Doring River water, compared to current water quality. There is significant spare capacity in especially the Naauwkoes section canal on the East Bank and the Karoovlakte section canal on the West Bank during January. There is limited spare capacity in a few other canal sections.

The monthly values for flow in the various canal sections are given in **Table 6-11** below.

Table 6-11 | Estimated average monthly flow in the canal system per section

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

The values for each canal section, for the month of January, have been plotted in **Figure 6.8** to show what spare capacity is available (Irrigation Development and Water Distribution Options Report, Clanwilliam Dam Raising Feasibility Study, Section 4.4.4).

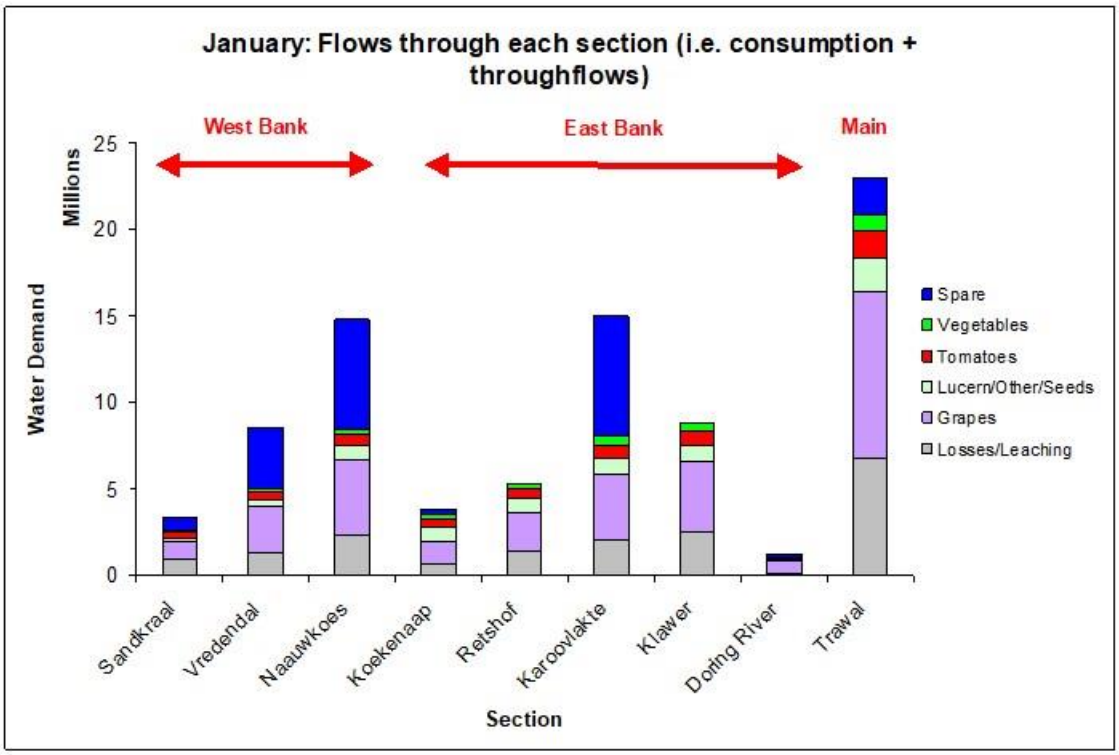

Figure 6.8 │ Spare capacity in canal sections

The abstraction flow rates for Option 29 were based on the estimates of spare canal capacity in the summer months, while keeping the annual requirements of the schemes below 10 million m^3/a. These water volumes were used to estimate the potential areas that could be irrigated, by making use of the spare capacity in the canal sections.

Excluding transmission losses (river and canal) the resulting potential irrigation area is 4 767 ha with the existing spare capacity. It has been assumed that the full Klawer scheme is irrigated from the spare capacity, although portions of the Aties-Karoo scheme could potentially also be irrigated. The total effective farmable area is 2 939 ha, that can be irrigated from the Karoovlakte section of the canal.

This scheme requires water to be pumped from the river to the canal, which involves the construction of a ±0.16 km long, 1 000 mm diameter steel rising main from the pump station, with a pumping head of 33 m.

To transfer water from the canal to the farm dam involves the construction of a ±1.1 km long, 1 300 mm diameter steel rising main from the pump station, with a pumping head of 49 m.

6.6.3 Water Requirements and Losses

The water requirement for the farmable area of 2 939 ha is 42.81 million m^3/a.

Total conveyance losses are 17.98 million m^3/a.

6.6.4 Water Quality

A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

A disadvantage of this option will be the poorer water quality at the abstraction site, compared to current water quality, because of mixing good quality water from Bulshoek Weir with the more saline Doring River water, as well as saline irrigation return flows. During the high flow winter months, salinity at the abstraction point would probably be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l), but with the onset of the dry season, salinity at the abstraction point would probably increase to a Tolerable category (EC 75 – 225 mS/m, TDS 480 – 1440 mg/l). The implications for domestic users from the canal would also need to be considered because the household water would have a saltier taste and corrosion of household pipes and appliances would be accelerated.

This option will need further evaluation regarding blending of the poor-quality water abstracted from the river with the water of the canal.

6.6.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 29 is shown in **Table 6.12**. The unit reference value for this option is given in **Table 6.13**.

Table 6-12 │ Option 29 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
18.47	95.39	2.96	96.08	230.42

Table 6-13 │ Option 29 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	230.42
Annual operating cost (R million/annum)	11.91
NPV Cost (R million)	414.23
Unit Reference Value (R/m^3)	0.85

6.6.6 Ecological Impact

For the Klawer irrigable area:

Sensitivity: High: A pocket of CBA1 remains in the centre of the reduced area. Watercourses occurring along the south eastern section of the site have been designated as ESA1. The eastern part of the site falls into the Knersvlakte NPAES.

Mitigation: Avoid CBA1 areas. Provide a buffer for watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).

6.6.7 Option 29 Summary

Option 29 has high environmental concerns and a low unit reference value. This option has very high water losses of over 40%, because of losses in the lower Olifants River below Bulshoek Weir. In terms of water quality, the implications for domestic users from the canal would also need to be considered because of the introduction of poorer quality water that will be pumped into the canal. This scheme may hold potential for 5 ha plots, given its location between Klawer and Vredendal.

6.7 Scheme 30 - Use of Spare Capacity in the Naaukoes Canal Section

6.7.1 Option 30 layout

The layout of Option 30 is shown in **Figure 6.9**.

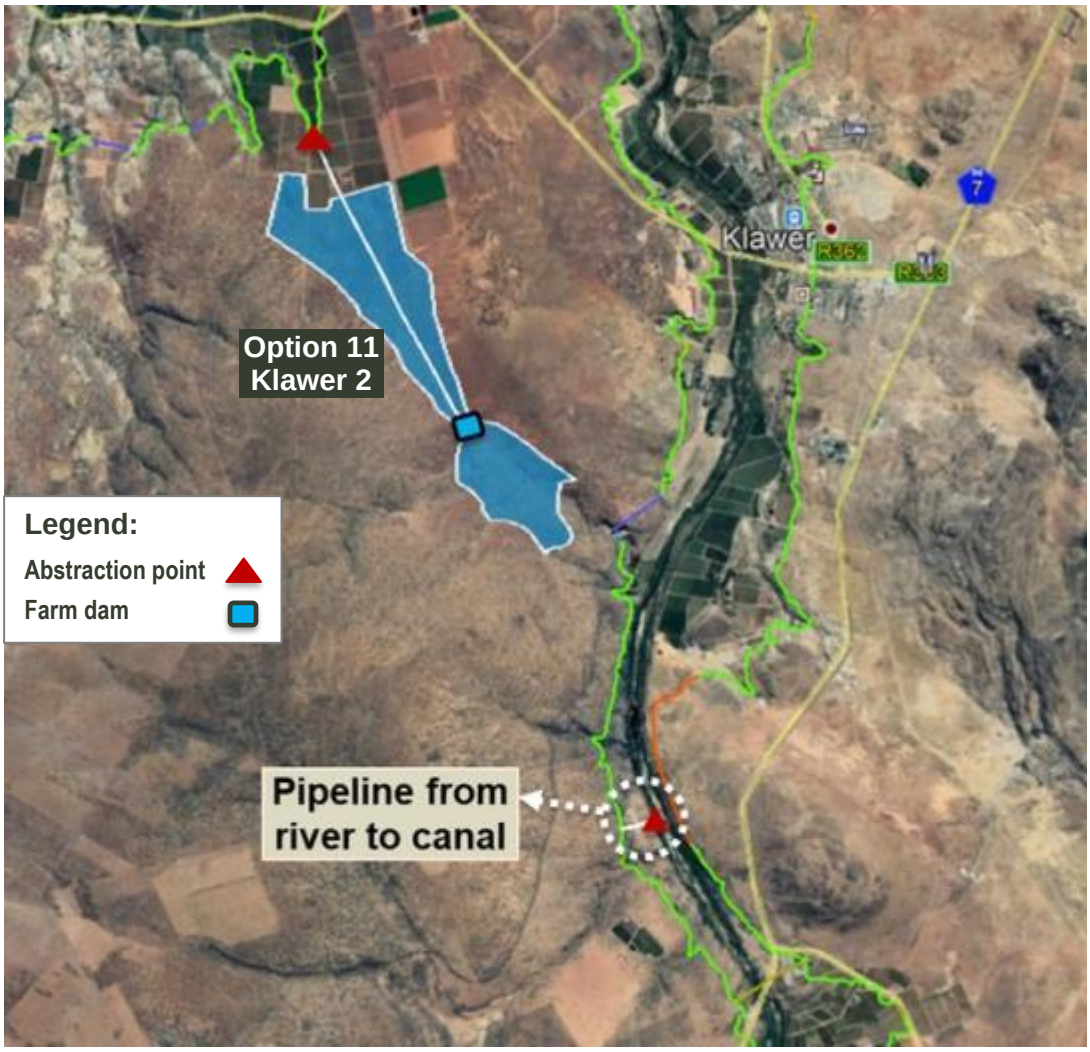

Figure 6.9 | Option 30 layout

6.7.2 Option 30 description

Certain canal sections still have some spare capacity, even during the dry season, because of the way that the canal has been constructed. Water can be released from the Bulshoek Weir down the Olifants River and be pumped into these identified canal sections with spare capacity, to be used via existing canal infrastructure. Figure 6.8 indicates the various canal sections associated with spare capacity. The spare capacity in these canal sections can be used, either to expand current irrigation or potentially to supply water for new irrigation. There is significant spare

capacity in especially the Naauwkoes section on the East Bank and the Karoovlakte section on the West Bank during January. There is limited spare capacity in a few other canal sections.

The total effective farmable area with the conveyed water, using spare capacity, is 192 ha, being the full irrigable area of the Klawer 2 option. The Klawer 2 option has however been ruled out because of environmental impacts.

If this option could be implemented it would require pumping water from the river to the canal. This involves the construction of a ±0.38 km long, 250 mm diameter uPVC rising main from the pump station, with a pumping head of 45 m.

Transferring water from the canal to the farm dam involves the construction of a ±2.90 km long, 355 mm diameter uPVC rising main from the pump station, with a pumping head of 88 m.

6.7.3 Water Requirements and Losses

The water requirement for the farmable area of 192 ha is 1.81 million m^3/a.

Total conveyance losses are 0.52 million m^3/a.

6.7.4 Water Quality

A leaching requirement of 12% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

A disadvantage of this option will be the slightly poorer water quality at the abstraction site, compared to current water quality, because of mixing good quality water from Bulshoek Weir with the more saline Doring River water, as well as saline irrigation return flows between Bulshoek Dam and the abstraction site. During the high flow winter months, salinity at the abstraction point would probably be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l), but with the onset of the dry season, salinity at the abstraction point would probably deteriorate slightly to an Acceptable category (EC 25 - 75 mS/m, TDS 160 - 480 mg/l). The impacts on domestic users that take water directly from would probably be minimal. As the abstraction point from the river is located not that far downstream of the Doring River confluence, the impacts on salinity would be limited to the last few weeks of the dry season when the Doring River becomes moderately saline.

This option is ruled out for development on its own. However, combined with Option 31, this holds potential as an option to consider.

This option will need further evaluation with regarding blending of the poor-quality water abstracted from the river with the water of the canal.

6.7.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 30 is shown in **Table 6.14**. The unit reference value for this option is given in **Table 6.15**.

Table 6-14 | Option 30 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
7.53	8.19	0.36	2.41	22.54

Table 6-15 | Option 30 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	22.54
Annual operating cost (R million/annum)	0.96
NPV Cost (R million)	37.70
Unit Reference Value (R/m^3)	1.80

6.7.6 Ecological Impact

Sensitivity: High: A large part of the pipeline transects CBA1 areas. The pipeline also transects a NFEPA wetland and ESA2 area.

Mitigation Avoid CBA1 areas as far as practicable. The ESA 2 areas are likely to require an offset. Provide a buffer for watercourses/wetlands on site.

6.7.7 Option 30 Summary

Option 30 has high environmental concerns and a high unit reference value. As the entire site, except for a small portion near the northern boundary, is located within CBA1, this rules out the option for development on its own. However, combined with Option 31, this holds potential as an option to consider.

6.8 Scheme 31 - Use of Spare Capacity in the Vredendal Canal Section

6.8.1 Option 31 layout

The layout of Option 31 is shown in **Figure 6.10**.

Figure 6.10 | Option 31 layout

6.8.2 Option 31 description

Certain canal sections still have some spare capacity, even during the dry season, because of the way that the canal has been constructed. Water can be released from the Bulshoek Weir down the Olifants River and be pumped into these identified canal sections with spare capacity, to be used via existing canal infrastructure. Figure 6.8 indicates the spare capacity associated with the various canal sections. The spare capacity in canal sections can be used, either to expand current irrigation or potentially for new irrigation. A disadvantage of this option, located below the confluence, will be the poorer water quality, because of mixing Olifants River water with the more saline Doring River water, compared to current water quality. There is significant spare capacity in especially the Naauwkoes section canal on the East Bank and the Karoovlakte section canal on the West Bank during January. There is limited spare capacity in a few other canal sections.

The total effective farmable area is 2 235 ha, being the full irrigable area of the Coastal 1 option.

Water needs to be pumped from the canal to the farm dam. This involves the construction of a ±1.38 km long, 1 000 mm diameter steel rising main from the pump station, with a pumping head of 56 m.

Water also needs to be pumped from the river to the canal. This involves the construction of a ±0.38 km long, 700 mm diameter steel rising main from the pump station, with a pumping head of 45 m.

6.8.3 Water Requirements and Losses

The water requirement for the farmable area of 2 235 ha is 20.74 million m^3/a.

Total conveyance losses are 6.02 million m^3/a.

6.8.4 Water Quality

A leaching requirement of 10% has been added to the estimated water requirement to leach salts from the greenfield soils for the first 5 years after establishment. After that a leaching requirement of 3% should be applied by irrigation farmers, or as determined by the salinity of the water used for irrigation.

A disadvantage of this option will be the slightly poorer water quality at the abstraction site, compared to current water quality, because of mixing good quality water from Bulshoek Dam with the more saline Doring River water, as well as saline irrigation return flows between Bulshoek Dam and the abstraction site. During the high flow winter months, salinity at the abstraction point would probably be in an Ideal category (EC < 25 mS/m, TDS < 160 mg/l), but with the onset of the dry season, salinity at the abstraction point would probably deteriorate slightly to an Acceptable category (EC 25 - 75 mS/m, TDS 160 - 480 mg/l). The impacts on domestic users that take water directly from the canal would probably be minimal. As the abstraction point from the river is located not that far downstream of the Doring River confluence, the impacts on salinity would be limited to the last few weeks of the dry season when the Doring River becomes moderately saline.

This option will need further evaluation regarding blending of the poor-quality water abstracted from the river with the water of the canal.

6.8.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 31 is shown in **Table 6.16**. The unit reference value for this option is given in **Table 6.17**.

Table 6-16 | Option 31 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dam	Purchase of land	Total Cost
14.76	60.70	3.21	47.19	137.66

Table 6-17 | Option 31 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	137.66
Annual operating cost (R million/annum)	7.51
NPV Cost (R million)	254.95
Unit Reference Value (R/m^3)	1.06

6.8.6 Ecological Impact

Sensitivity: Moderate: The pipeline route crosses ESA1 features.

Mitigation: The ESA1 is likely to require an offset. Provide a buffer for watercourses/wetlands on site.

6.8.7 Option 31 Summary

Option 31 has moderate environmental concerns and a low unit reference value. This option has poor water quality concerns and significant river water losses of around 30%. There are concerns with increasing the amount of water released into the existing canal without refurbishment, as the canal infrastructure is currently in a poor condition.

7 Zones 4 and 5, LORGWS (Bulshoek) Canal

This Chapter describes options relating to increased irrigation from the LORGWS canal.

7.1 Scheme 32 - Replace All or Sections of LORGWS Canal with a Pipeline with Increased Capacity

7.1.1 Option 32 layout

The layout of Option 32 is shown in **Figure 7.1**.

Figure 7.1 | Option 32 layout

7.1.2 Option 32 description

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

The total effective farmable area is 6 490 ha.

This option comprises a pipeline from Bulshoek Weir on the left bank to replace the existing canal. It involves the construction of a ±91.7 km long, 3 000 mm diameter steel gravity pipe system from Bulshoek weir.

A distribution pipeline on the right bank from the Bulshoek main pipeline involves the construction of a ±109.1 km long, 3 000 mm diameter steel gravity pipe system.

A further pipeline on the right bank will convey water (upstream) to the confluence of the Olifants and Doring rivers, from the Bulshoek main pipeline. It involves the construction of a ±33.5 km long, 3 000 mm diameter steel gravity pipe system.

The water requirement for this option is 167.63 million m^3/a. Total conveyance losses are 8.09 million m^3/a.

7.1.3 Water Quality

Water quality is good as abstraction is from Bulshoek Weir. A leaching requirement of 13% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

7.1.4 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 32 is shown in **Table 7.1**. The unit reference value for this option is given in **Table 7.2**.

Table 7-1 | Option 32 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Balancing Reservoir	Farm dams	Purchase of land	Total Cost
6538.70	173.53	393.00	3.73	96.43	7225.10

Table 7-2 | Option 32 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	7225.10
Annual operating cost (R million/annum)	86.63
NPV Cost (R million)	7229.64
Unit Reference Value (R/m^3)	4.03

7.1.5 Ecological Impact

Sensitivity: Moderate: Pipeline crosses small areas of CBA1, VU and EN ecosystems, PA, and NFEPA wetlands.

Mitigation: Follow roads / existing canal where possible. Avoid CBA1, EN ecosystems and PA. Avoid threatened plant species. Ensure proper rehabilitation of areas disturbed during construction.

7.1.6 Option 32 Summary

Option 32 has moderate environmental concerns and a very high unit reference value. The total comparative cost of this option is significantly higher than any of the other identified options.

7.2 Scheme 33 - Increase Capacity of LORGWS Canal and Other Betterments

7.2.1 Option 33 layout

The layout of Option 33 is shown in **Figure 7.2**.

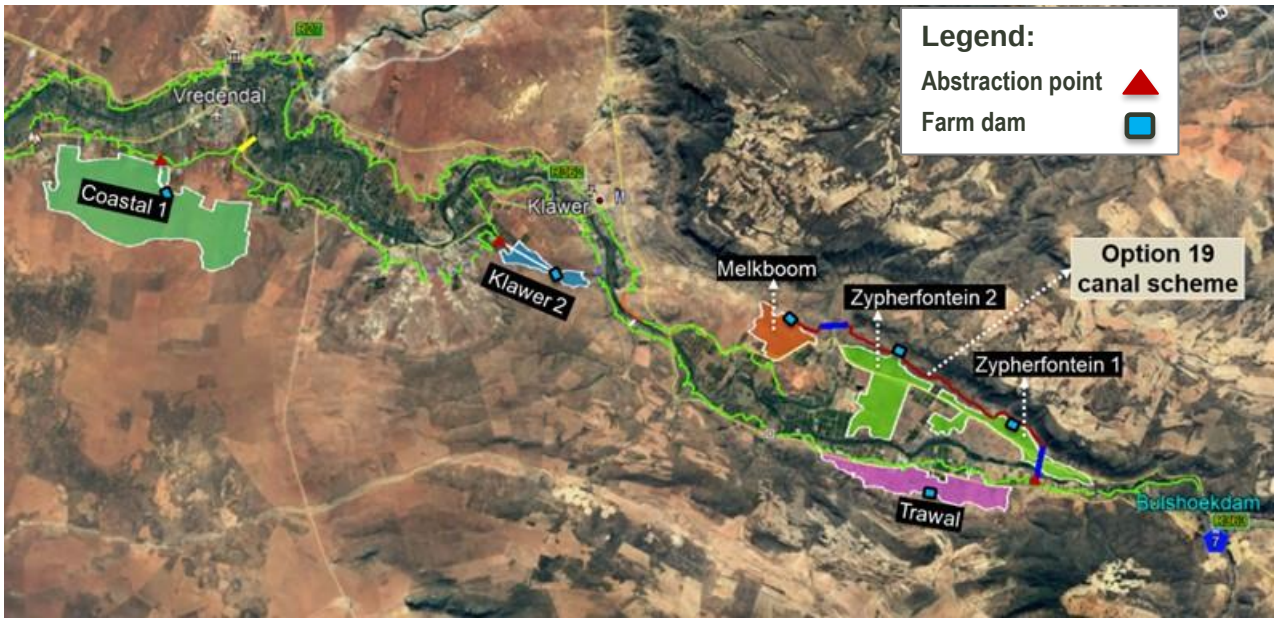

Figure 7.2 | Option 33 layout

7.2.2 Option 33 description

This option involves increasing the capacity of the canal system by raising the canal or increasing its profile. If the canal had a larger carrying capacity, more water could be made available for

irrigation downstream of the Bulshoek Weir, especially since the bulk of suitable irrigation areas are located very low down in the Olifants River catchment. The Feasibility Study (DWS, 2008) recommended that the canal profile should not be increased to increase its capacity.

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

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

The total effective farmable area for this option is 4 124 ha.

7.2.3 Water Requirements and Losses

The water requirement for the farmable area of 4 124 ha is 45.82 million m^3/a.

Total conveyance losses are 3.06 million m^3/a.

7.2.4 Water Quality

Water quality is good as water is abstracted at Bulshoek Weir. A leaching requirement of 13% has been added to the estimated water requirement to leach salts from the soil for the first 5 years after establishment.

7.2.5 Cost and Unit Reference Value

The comparative cost estimate (2018 prices, excluding VAT) for Option 33 is shown in **Table 7.3**. The unit reference value for this option is given in **Table 7.4**.

Table 7-3 | Option 33 Comparative Capital Costs in million Rand

Pipeline / Canal	Pump station	Farm dams	Purchase of land	Total Cost
91.47	173.53	7.45	96.43	384.87

Table 7-4 | Option 33 URV in R/m^3

Item	Discount Rate 8%
Total comparative capital cost (R million)	384.87
Annual operating cost (R million/annum)	14.93
NPV Cost (R million)	624.26
Unit Reference Value (R/m^3)	1.34

7.2.6 Ecological Impact

Sensitivity: Low: Assuming existing canals are used.

Mitigation: Use existing footprint as far as possible. Avoid CBA1 areas as far as possible and avoid threatened species. Ensure proper rehabilitation of areas disturbed during construction. Refer to the applicable areas in this report (Zypherfontein 1 & 2, Trawal, Melkboom, Klawer 2 and Coastal 1).

7.2.7 Option 33 Summary

Option 33 has low environmental concerns and a low unit reference value. There are concerns with increasing the amount of water released into the existing canal without refurbishment (only raising), as the canal infrastructure is currently in a poor condition.

8 Summary of Options

The key features of the evaluated, short-listed options are documented in **Table 8-1**. Note that some options that have been screened out have been included in the table. Options relating to "Full" irrigation areas have been included for illustrative purposes only.

Table 8-1 | Summary Options Table

Note that some options that have been screened out have been included in the table. Options relating to "Full" irrigation areas (before reduction resulting from environmental implications) have been included for illustrative purposes only.

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
Zone 2 - Clanwilliam Dam and Canal and Jan Dissels catchment											
1a	Area 23, Abstraction from Clanwilliam Dam	*Full area*	Pumping water directly from the lake of the Clanwilliam Dam. The abstraction point will be affected by the rise/fall of the water level. Full area 716 ha, reduced to 234 ha. Potential for 5 ha plots. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	6.51	6.84	0.33	0.33	55.69	1.41	Sensitivity: **High**: Western half within the CBA1, eastern portion preferred. Eastern half in ESA1 and ESA2. Wetlands cross the site. Mitigation: Avoid CBA1 areas. TheESA1 and ESA2 areas are likely to require an offset. Provide buffer for wetlands on site.	1.5
1b		*Reduced area*		2.11	2.21	0.11	0.11	23.13	1.74		1.5
2	Area 24: Jan Dissels 1	-	Pumping from Clanwilliam Dam. Full area 174 ha, reduced to 31 ha following environmental screening. Potential for 5 ha plots. Land between the Clanwilliam Dam and the Jan Dissels River is municipal property. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	1.57	1.64	0.08	0.08	38.18	2.61	Sensitivity: **High**: Most of the site is located within CBA1 excluding a small portion to the north west and small parts within the site boundary. The northern section of the site is located within ESA1 areas and ESA2 wetlands/watercourse features are scattered across the site. The south eastern boundary of the site falls within a Tankwa Cederberg Roggeveld NPAES. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide buffer for wetlands/watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
3	Areas 25-26: Jan Dissels 2-3	-	Pumping from Clanwilliam Dam. Full area 419 ha, reduced to 0 ha following environmental screening. Potential for 5ha plots. The land belongs to the province/agricultural school. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam.	3.76	3.95	0.19	0.19	47.55	1.95	Sensitivity: **High**: Most of the sites are located within CBA1 excluding a small portion in the northern section of the sites. ESA1 and ESA2 features transect the site. NFEPA wetlands occur adjacent to the northern and southern sections of the sites. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide buffer for wetlands/watercourses on site.	1.5
4	Areas 24-25-26: Jan Dissels 1-2-3	-	Pumping from Clanwilliam Dam. Full area 593 ha, reduced to 31 ha following environmental screening. Potential for 5 ha plots. Sate land ownership. Potential power supply from a new hydropower plant at the raised Clabwilliam Dam.	5.33	5.59	0.27	0.27	43.30	1.42	Sensitivity: **High**: Most of the sites are located within CBA1 excluding a small portion in the northern section of the sites. ESA1 (except for Area 25) and ESA2 features transect the site. Areas of the sites are located within the Tankwa Cederberg Roggeveld NPAES. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
5	Transfer of lower Jan Dissels River scheduled allocations to Olifants River	-	Moving existing allocations of 3 irrigators in the lower Jan Dissels River to the Olifants River, to improve the ecological condition of the lower section of the Jan Dissels River.	1.0	1.0	0	0	0	0	N.A.	1.5
Zone 2 - Olifants River from Clanwilliam Dam to and including Bulshoek Weir											
6b	Areas # 20(1)-21-22, Pumping from Olifants River	-	Water pumped from the Olifants River. Located 5 km from Clanwilliam town to the east of the N7. Potential for 5 ha plots, considering the proximity of the area to Clanwilliam town and existing markets. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam. The land is privately-owned.	0.59	0.62	0.03	0.03	6.94	1.80	Sensitivity: **High**: EN vegetation type occurs within the eastern section of the site. ESA1 and ESA2 features are located across the site. Mitigation: Avoid areas of EN vegetation type. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.	1.5

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
6c	Areas # 20(2&3), Pumping from Olifants River	-	Water pumped from the Olifants River. Located 7 km from Clanwilliam town to the east of the N7. Potential for 5 ha plots, considering the proximity of the area to Clanwilliam town and existing markets. Potential power supply from a new hydropower plant at the raised Clanwilliam Dam. The land is privately-owned.	0.88	0.92	0.04	0.04	9.63	1.63	Sensitivity: **High**: EN vegetation type occurs within the eastern section of the site. ESA1 and ESA2 features are located across the site. Mitigation: Avoid areas of EN vegetation type. the ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.	1.5
7	Area 19, Pumping from Olifants River	-	Water pumped from the Olifants River. Located between Clanwilliam Dam and Bulshoek Weir to the east of the N7. The land is privately-owned.	0.62	0.65	0.03	0.03	7.98	1.80	Sensitivity: **Moderate**: Most of the south western section of the site falls within ESA1. Mitigation: ESA1 areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site.	1.5
8	Area 18, Pumping from Olifants River	-	Water pumped from the Olifants River. Located between Clanwilliam Dam and Bulshoek Weir on both sides of the N7. The land is privately-owned.	0.26	0.27	0.01	0.01	2.61	1.41	Sensitivity: **High**: A small section of the site falls within CBA1 towards the north east. ESA1 and ESA2 features occur on site. Mitigation: Avoid CBA1 areas. The ESA1and ESA2 areas are likely to require an offset. Provide buffer for wetlands/watercourses on site.	1.5
9a	Area 17, Pumping from Olifants River	*Full area*	Water pumped from the Olifants River. Located between Clanwilliam Dam and Bulshoek Weir on both sides of the N7. The land is privately-owned.	2.51	2.64	0.13	0.13	21.05	1.38	Sensitivity: **High**: Most of the site is located within a CBA1, which includes EN vegetation types. ESA1 areas occur towards the west and south east boundaries of the site, while ESA2 occurs in the centre of the site and towards the south east. Mitigation: Avoid CBA1 and areas of EN vegetation type. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.	1.5
9b		*Reduced areas 1 & 2*		0.46	0.48	0.02	0.02	8.28	2.37	Sensitivity: **Moderate**: The western section of the northern reduced area is located within ESA1, while the southern reduced area has portions of ESA1 across the site. There are only two small ESA2 areas present on the southern reduced area. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.	1.5
10a	Area 16, Abstraction from Bulshoek Weir	*Full area*	Water pumped from the Olifants River. Located between Bulshoek Weir and the N7. The land is privately-owned.	3.37	3.54	0.17	0.17	31.61	1.59	Sensitivity: **High**: The centre of the site is located within a CBA1. ESA1 and ESA2 areas occur from the centre to the southern section of the site including wetlands and watercourses. EN vegetation occurs on site. Mitigation: Avoid CBA1 and areas of EN vegetation type. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands/ watercourses on site.	1.5
10b		*Reduced area*		0.80	0.84	0.04	0.04	9.88	1.95	Sensitivity: **High**: EN vegetation occurs along the western edges of the site. Mitigation: Avoid EN vegetation types.	1.5
	Zone 3 - Options Located Outside the Olifants River Valley										
11a	Jakkals River Irrigation Scheme (JRIS) & Graafwater	*Inter-basin transfer to Jakkals River for abstraction*	Sandveld Investment & Development Co. Ltd (SANID) Water identified four farms as possible irrigation areas (3 100ha) and a pipeline route. Water is pumped from Clanwilliam Dam and released into and abstracted from the Jakkals River for the JRIS (3 100 ha) and Graafwater. Pumping head of 563 m.	10.27	13.14	2.57	2.87	318.38	5.74	Sensitivity: **High**: The pipeline follows the road much of the route, but the eastern section o includes areas of CBA1. The pipeline also transects ESA1 and ESA2 areas mostly in the west and includes watercourses and wetland areas. Mitigation: Avoid CBA1 area as far as practicable a and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Wetlands/watercourses require site specific mitigation.	2
11b		*Direct pipeline*	Pipeline scheme along the R364. Pumping head of 467 m.	10.27	10.58	0.00	0.31	258.10	4.06	Sensitivity: **Moderate**: The pipeline follows the R364 much of the route and therefore avoids most CBA and ESA area, except on the	2

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
										western end where it leaves the road. Other exceptions include a few wetland/watercourses. Mitigation: Avoid CBA1 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Wetlands/watercourses require site specific mitigation.	
12	Provision of water to coastal towns	-	Supply coastal municipalities (Lamberts Bay and Elands Bay) with water for domestic use. Pumping head of 384 m.	0.37	0.37	0.00	0.01	125.33	32.34	Sensitivity: **High**: The pipeline transects numerous CBA1 areas along the proposed route and transects CBA2 areas in small areas east from Graafwater as well as west towards the coast on route to Lamberts Bay which includes EN and VU vegetation types as well as NFEPA wetlands. ESA1 and ESA2 areas are transect, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a train line. Mitigation: Avoid CBA1 and CBA2 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Consultation with Steenboksfontein Private Nature Reserve is recommended.	1.5
13	Combined JRIS & supply to Graafwater, Lamberts Bay & Elands Bay	-	Pipeline scheme along the R364 and distribution to Graafwater and coastal towns. Pumping head of 474 m.	10.63	10.93	0.00	0.32	328.90	4.36	Sensitivity: **High**: The pipeline transects numerous CBA1 (Terrestrial) and CBA2 areas east from Graafwater as well as west towards the coast on route to Lamberts Bay which includes EN and VU vegetation types as well as NFEPA wetlands. ESA1 and ESA2 areas are transect, including watercourses. In most places the road reserve is excluded from the CBA / ESA areas. The pipeline route also crosses through a Protected Area (Steenboksfontein Private Nature Reserve) but follows a train line. Mitigation: Avoid CBA1 and CBA2 areas as far as practicable and apply site specific mitigation if not possible. The CBA and ESA areas are likely to require an offset. Provide a buffer for wetlands/watercourses on site. Consultation with Steenboksfontein Private Nature Reserve is recommended.	2
Zone 4 - Olifants River below Bulshoek Weir to Trawal											
14	Release at Bulshoek and pump from river: Area 15, Zypherfontein 1	-	Water pumped from the Olifants River below Bulshoek Weir and the Doring confluence to the scheme on the right bank. The land is privately-owned.	4.76	6.14	1.38	1.38	37.33	1.38	Sensitivity: **Moderate**: CBA1 occurs adjacent to the south western border of the site. VU vegetation occur in the southern section of the site. ESA1 areas, including watercourses, occur across the site. While ESA2 features are found from the centre to the southern sections of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
15	Release at Bulshoek and pump from river: Area 14, Trawal	-	Water pumped from the Olifants River below Bulshoek Weir and the Doring confluence to the scheme on the left bank. The land is privately-owned.	7.18	9.26	2.08	2.08	58.30	1.35	Sensitivity: **Moderate**: Numerous ESA1 features such as watercourses cross the site, with some ESA2 features occurring from the centre and south eastern sections of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
16	Release at Bulshoek and pump from river: Area 13, Zypherfontein 2	-	Water pumped from the Olifants River below Bulshoek Weir and the Doring confluence to the scheme on the right bank. The land is privately-owned.	6.80	8.77	1.97	1.97	60.45	1.41	Sensitivity: **Moderate**: ESA1 features such as watercourses can be found towards the north, east and southern tips of the area. ESA2 features occur near the south eastern boundary of the site, as well as the centre. VU vegetation types occur in the south western section of the site.	1.5

#	Option	Variation	Brief description of option	Water require-ment (Mm^3/a)	Total require-ment (Mm^3/a	River losses (Mm^3/a	Total losses (Mm^3/a)	Capital cost (R million)	URV (8%)	Environmental impacts	Programme (years)
										Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	
17	Release at Bulshoek and pump from river: Area 12, Melkboom	-	Water pumped from the Olifants River to the scheme on the right bank, either just after or before the Doring River confluence. The land is privately-owned.	3.45	4.45	1.00	1.00	37.56	1.68	Sensitivity: **Moderate**: ESA1 features such as watercourses transect the site. ESA2 features occur in proximity of the largest watercourse and various smaller watercourses located in the northern section of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
18	Combined Areas # 13-14-15 Zypherfontein 1-2 & Trawal	*Pipeline with branches*	Water supplied by pipeline from Bulshoek Weir to the Zypherfontein 1-2 and Trawal areas.	19.24	20.29	0.96	1.54	445.01	2.74	Refer to applicable Areas above.	2
19	Combined Areas # 12-13-15 Zypherfontein 1-2 & Melkboom	*Raised BH canal, pipeline, high-level canal*	Water supplied from Bulshoek Weir to the Zypherfontein 1-2 and Melkboom areas, via a raised Bulshoek canal, pipeline and syphon crossing the Olifants River, and a new high-level canal supplying these areas under gravity.	16.42	21.18	4.76	5.06	200.64	1.10	Refer to applicable Areas above.	2
	Zone 5 - Olifants River from Klawer to the Coast										
20	Release at Bulshoek and pump from river: Area # 11, Klawer 2	-	Water pumped from the Olifants River **in winter** to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. Option ruled out.	1.78	2.37	0.59	0.59	36.02	2.35	Sensitivity: **High**: The entire site except for a small portion near the northern boundary is located within CBA1. Northern sections of the site have been earmarked as ESA1. ESA2 watercourse and wetland features occur in the southern section of the site. Mitigation: Avoid CBA1 areas. The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
22	Release at Bulshoek and pump from river: Area # 9, Klawer	-	Water pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. The land is partially public land with the remainder privately-owned. A 3.15 million m^3 balancing storage dam is needed to fill in winter, to ensure summer supply of acceptable quality.	24.88	35.33	10.45	10.45	305.49	1.93	Sensitivity: **High**: A pocket of CBA1 remains in the centre of the reduced area. Watercourses occurring along the south eastern section of the site have been designated as ESA1. The eastern part of the site falls into the Knersvlakte NPAES. Mitigation: Avoid CBA2 areas. Provide a buffer for watercourses on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
23	Release at Bulshoek and pump from river: Area # 8, Aties Karoo	-	Water pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. An 8.6 million m^3 balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality.	41.00	59.46	18.45	18.45	730.90	2.12	Sensitivity: **High**: ESA1 and ESA2 features occur across the site. Smaller sections along the eastern boundary of the site falls into the Knersvlakte NPAES. Mitigation Provide a buffer for watercourses and wetlands on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	1.5
24	Release at Bulshoek and pump from river: Area # 7, Coastal 1	-	Water pumped from the Olifants River to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. A 27.6 million m^3 balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality.	20.74	30.08	9.33	9.33	998.45	4.79	Sensitivity: **Moderate**: ESA1 and ESA2 features occur across the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for wetlands and watercourses on site.	1.5
25	Release at Bulshoek and pump from river: Area # 4, Ebenhaeser New	-	Water pumped from the Olifants River to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. A 17.4 million m^3 balancing storage dam needed to fill in winter, to ensure summer supply of acceptable quality.	43.76	66.07	22.32	22.32	563.80	1.86	Sensitivity: **High**: A small section the site falls within a CBA1. ESA1 and ESA2 features occur across the site. NFEPA wetlands occur adjacent to the western and north eastern boundary of the site. The south eastern section of the site falls within a NPAES focus area.	1.5

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										Mitigation: Avoid CBA1 areas. Provide a buffer for watercourses and wetlands on site. Avoid NPAES areas (subject to consultation with Cape Nature on what is planned for these areas).	
26a	Release at Bulshoek and pump from river: Area # 3, Coastal 2	*Reduced area (1)*	Water pumped from the Olifants River **in winter** to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. Option ruled out.	0.33	0.50	0.17	0.17	8.35	3.08	Sensitivity: **Moderate**: An ESA1 aquatic feature occurs in the centre of the site. While small ESA2 features occur towards the south of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1
26b		*Reduced area (2)*	Water pumped from the Olifants River **in winter** to the scheme on the left bank, below the Doring River confluence. The land is privately-owned. Option ruled out.	0.70	1.05	0.36	0.36	17.50	3.22	Sensitivity: **Moderate**: An ESA1 aquatic feature occurs in the north eastern section of the site and along the border. While small ESA2 features occur towards the south east border of the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1
27	Release at Bulshoek and pump from river: Area # 2, Lutzville 2	-	Water pumped from the Olifants River to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. A 21.5 million m^3 balancing storage dam is needed to fill in winter, to ensure summer supply of acceptable quality.	39.52	59.67	20.15	20.15	1023.38	2.95	Sensitivity: **Moderate**: ESA1 and ESA2 features occur across the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1.5
28	Release at Bulshoek and pump from river: Area # 1, Lutzville 1	-	Water pumped from the Olifants River **in winter** to the scheme on the right bank, below the Doring River confluence. The land is privately-owned. Scheme ruled out.	1.22	1.84	0.62	0.62	40.35	3.35	Sensitivity: **Moderate**: ESA1 and ESA2 features occur across the site. Mitigation: The ESA1 and ESA2 areas are likely to require an offset. Provide a buffer for watercourses and wetlands on site.	1.5
29	Use of spare capacity in canal sections: Release at Bulshoek Weir and pump into canal sections	*Karoovlakte canal section*	Pump from river into Karoovlakte (zone 5) canal section. Irrigate portion of Area 9 Klawer on the right bank.	42.81	60.79	17.98	17.98	230.42	0.85	See Area 9 Klawer Pipeline outside the site is limited.	1.5
30		*Naaukoes canal section*	Pump from river into Naaukoes (zone 5) canal section. Irrigate full Area 11 Klawer 2 on the left bank. Abstraction water quality too poor and Klawer 2 scheme falls within CBA1 area, which rules scheme out on its own. If combined with option 31 though, the scheme will be feasible.	1.81	2.33	0.52	0.52	22.54	1.80	Sensitivity: **High**: A large part of the pipeline transects CBA1 areas. The pipeline also transects a NFEPA wetland and ESA2 area. Mitigation Avoid CBA 1 areas as far as practicable. The ESA 2 areas are likely to require an offset. Provide a buffer for watercourses/wetlands on site.	1.5
31		*Vredendal canal section*	Pump from river into Naaukoes (zone 5) canal section and abstract from Vredendal canal section. Irrigate portion of Area 7 Coastal 1 on the left bank.	20.74	26.76	6.02	6.02	137.66	1.06	Sensitivity: **Moderate**: The pipeline route crosses ESA1 features. Mitigation: ESA1 likely to require an offset. Provide a buffer for watercourses/wetlands on site.	1.5
	Zones 4 and 5: LORGWS (Bulshoek) Canal										
32	Replace LORGWS Canal with a pipeline with increased capacity	-	Supply existing irrigation plus full new irrigation via a pipeline that fully replaces the existing Bulshoek canal, with increased capacities to accommodate increased use from the Bulshoek main canal and portions of the left bank and right bank canals.	167.63	170.69	3.06	8.09	7,225.1	4.03	Sensitivity: **Moderate**: Pipeline crosses small areas of CBA1 areas, VU & EN ecosystems, PA, and NFEPA wetlands Mitigation: Follow roads / existing canal where possible. Avoid CBA1, EN ecosystems and PA. Avoid threatened plan species. Rehabilitation of footprint	4
33	Increase capacity of LORGWS canal and other betterments	-	Raise the Bulshoek main canal and left bank canal up to the Trawal/Naaukoes connection and supply existing irrigators as well as new irrigation areas.	45.82	48.88	3.06	15.43	384.87	1.34	Sensitivity: **Low**: Assuming existing canals used. Mitigation: Use existing footprint as far as possible Avoid CBA1 areas as far as possible, avoid threatened species. Rehabilitation of footprint. Refer to the applicable areas (Zypherfontein 1 & 2, Trawal, Melkboom, Klawer 2 and Coastal 1).	3

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