DWS Report No. P WMA 09/E10/00/0417/14

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: WATER RESOURCE DEVELOPMENT PLANNING

Record of Implementation Decisions






June 2021

Signature Page

Project Name:	Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam
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DEPARTMENT OF WATER AND SANITATION

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Study Reports

The **Record of Implementation Decisions** forms one of the suite of reports that make-up the *Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam*. The full list of reports is as follows.

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
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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
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14		Jan Dissels and Ebenhaeser Schemes Design Sub-Report
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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.

Report Reference

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa. 2021. *Record of Implementation Decisions, RID Report No. P WMA 09/E10/00/0417/14*. Prepared by Zutari (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam.

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Abbreviations and Acronyms

AEP	Annual Exceedance Probability
APP	Approved Professional Person
CA	Competent authority
DALRRD	Department of Agriculture, Land Reform and Rural Development
DCP	Dynamic cone penetration
DEA&DP	Western Cape Provincial Department of Environmental Affairs and Development Planning
DEFF	Department of Environment, Forestry and Fisheries
DMRE	Department of Mineral Resources and Energy
DN	Nominal diameter
DTM	Digital terrain model
DSO	Dam Safety Office
DWS	Department of Water and Sanitation
EIA	Environmental impact assessment
EMPr	Environmental Management Programme
ESRI	Environmental Systems Research Institute
EWR	Ecological water requirement
FALA	Financial Assistance Land Administration
FSL	Full supply level
GIS	Geographical information system
GN	Government notice
GWS	Government water scheme
Ha	Hectare
HDI	Historically disadvantaged individual
HDPE	High density polyethylene
HFY	Historic firm yield
ID	Infrastructure Development
IWRP	Integrated Water Resources Planning
JV	Joint venture
LIDAR	Light detection and ranging

LORGWS	Lower Olifants River Government Water Scheme
LORWUA	Lower Olifants River Water User Association
MOL	Minimum operating level
NEMA	National Environmental Management Act
NOC	Non overspill crest
NPV	Net present value
NWRI	National Water Resources Infrastructure branch of DWS
NWA	National Water Act
RID	Record of Implementation Decisions
RM	Rising main pipeline
SANRAL	South African National Roads Agency
SANS	South African National Standards
SDF	Spatial development framework
SEF	Safety evaluation flood
TLB	Tractor-loader-backhoe
URV	Unit reference value
VAT	Value added tax
VSD	Variable speed drive
WCDoA	Western Cape Provincial Department of Agriculture
WUA	Water user association
WULA	Water use licence application

Units

kℓ	kilolitre
kW	kilowatt
ℓ/s	litres per second
m	metre
m^3	cubic metre
m^3/a	cubic metre per annum
m^3/s	cubic metre per second
masl	metres above sea level
Mℓ	megalitre
Mℓ/d	megalitre per day
Mm^3/a	million cubic meter per annum
mS/m	milli Siemens per meter
pH	Scale used to specify the acidity or basicity of an aqueous solution

1 Introduction

1.1 Background to the Project

The Clanwilliam Dam is situated in the Olifants River near the town of Clanwilliam in the Olifants/Doorn River Catchment Management Area in the Western Cape in a winter rainfall area. The dam requires remedial work for dam safety reasons, which offers the opportunity to increase the yield at the same time by raising the dam and enlarging the storage capacity. Water use in the region is predominantly for irrigated agriculture.

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, and to provide additional water for new irrigation areas to establish historically-disadvantaged farmers, as well as to supply other local water users.

The *Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam*, which was completed in 2021 was undertaken to provide recommendations on the bulk conveyance infrastructure options (new developments, upgrading or rehabilitation) required for the equitable distribution of the existing and additional water from the raised Clanwilliam Dam, after investigation of:

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

The study area, existing bulk water storage and conveyance infrastructure and the proposed three schemes are shown in **Figure 1-1**.

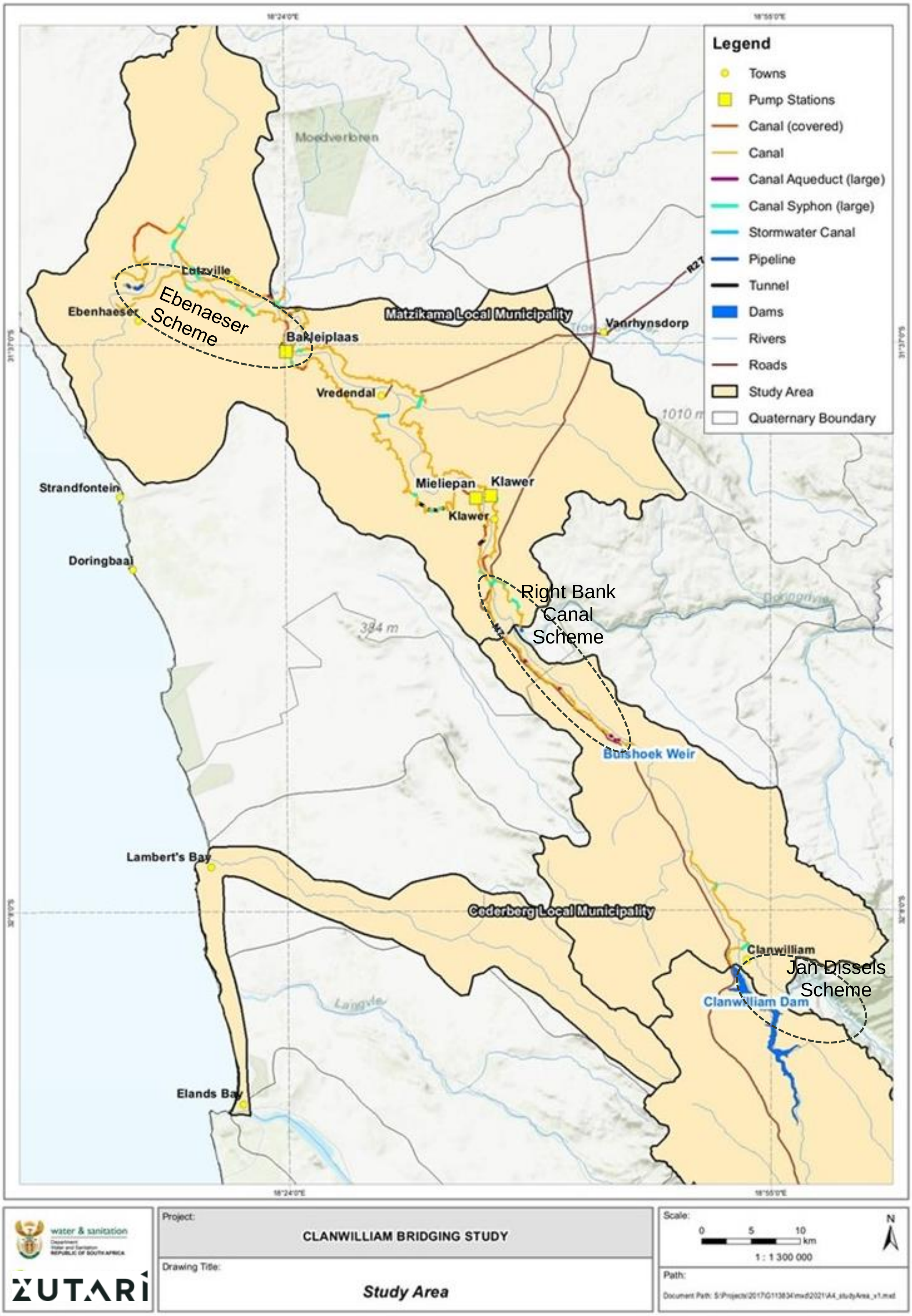


Figure 1-1: Study Area, Existing Bulk Water Infrastructure and Proposed Schemes

The study area mainly includes the Olifants River valley around and downstream of Clanwilliam Dam, up to a level of 100 m above either the river level or above existing distribution canals. The study area outside of the Olifants River valley included the Jakkals River and small coastal towns.

The environmental authorisation for the raising of Clanwilliam Dam is effective from February 2010 and the project was approved by the then Minister of Water and Environmental Affairs as a Government Water Works in August 2010.

The implementation of this project is currently in the construction stage, which commenced in October 2018, after a significant delay.

The beneficiaries of the scheme will form part of the Lower Olifants River Government Water Scheme (LORGWS).

1.2 Overview of the LORGWS

Apart from the extensive irrigation, about 40 000 people in the various towns in the supply area are dependent on the LORGWS, as well as many industries and mining. Without the development of the scheme, the towns, significant irrigation development and associated industries in this very dry region would not exist.

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

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

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

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

1.3 General description of the Project

The following schemes are recommended for implementation:

- **Jan Dissels Scheme** located near Clanwilliam Town. Water from an outlet of the raised Clanwilliam Dam will be pumped to a concrete reservoir on the ridge above the dam on the divide between the Olifants and Jan Dissels River valleys.
- **Right Bank Canal Scheme**, consisting of the construction of a new main canal section on the right bank of the Olifants River, to replace the existing main (Trawal) canal section on the left bank, up to the bifurcation of the existing left bank main canal (at the 'Verdeling' syphon). This scheme will overcome the current flow restriction of the left bank main canal and significantly reduce the risk of supply failure.
- **Ebenhaeser Scheme**, which will use spare flow capacity in the existing right bank and left bank canal sections. Water will be gravitated to a sump from the Vredendal left bank and Retshof right bank canal sections and pumped to a new off-channel balancing dam, from where it will be pumped to a concrete reservoir and gravitated to irrigators.

The implementation of the Jan Dissels and Ebenhaeser schemes is dependent on when additional water will be available after the Clanwilliam Dam has been raised. These schemes are recommended for implementation to align with the availability of additional yield from a raised Clanwilliam Dam.

The Right Bank Canal Scheme is a Betterment Works and can be implemented as soon as Environmental Authorisation has been issued and funding is available.

1.4 Purpose of the Project

The project should promote equitable access to water, redress the results of past racial and gender discrimination, promote the efficient, sustainable and beneficial use of water in the public interest and facilitate social and economic development. The development of the recommended irrigation schemes will:

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

Water will be supplied to the new irrigation schemes as described below.

Jan Dissels Scheme: The scheme will supply the new Jan Dissels irrigation area to be located just South-East of Clanwilliam Town in the Jan Dissels River valley (**Figure 1-2**).

Figure 1-2: Jan Dissels irrigation area

Right Bank Canal Scheme: The scheme (**Figure 1-3**) will supply existing irrigators below Bulshoek Weir, the proposed four new irrigation development areas to be located in the vicinity of Trawal, namely the Zypherfontein1, Trawal, Zypherfontein 2 and Melkboom irrigation areas, as well as new future downstream irrigation development and other future water uses.

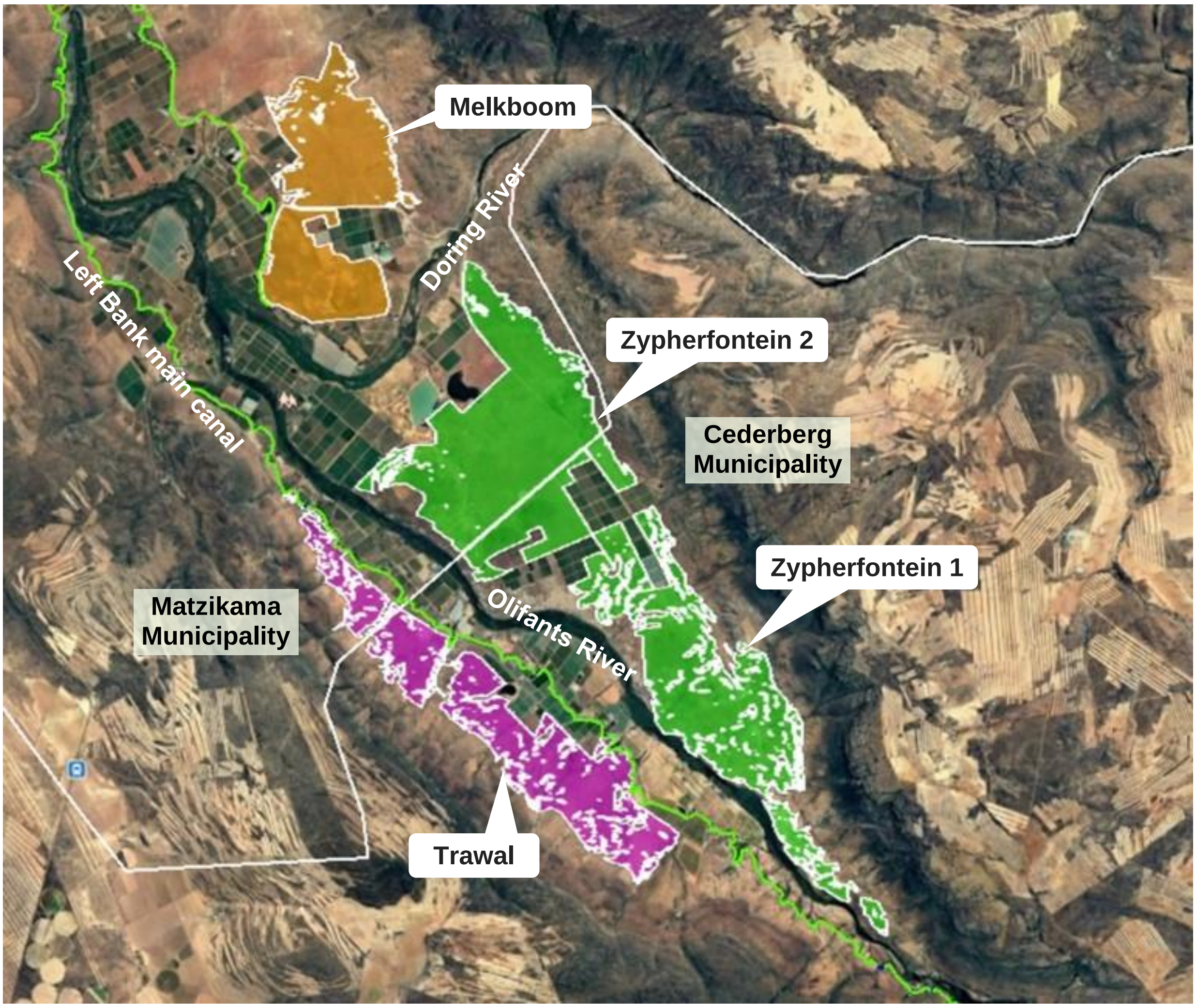


Figure 1-3: Four Trawal irrigation areas

Ebenhaeser Scheme: The scheme will augment the existing inadequate water supply to restitution farms located between Lutzville and Ebenhaeser and allow for the development of additional smallholder plots of the Ebenhaeser Community Property Association, for the existing HDI community at Ebenhaeser. Five water requirement clusters have been identified (**Figure** 1-4).

An increased assurance of supply will be provided for existing water users in the LORGWS, to mitigate the negative socio-economic impacts of severe droughts.

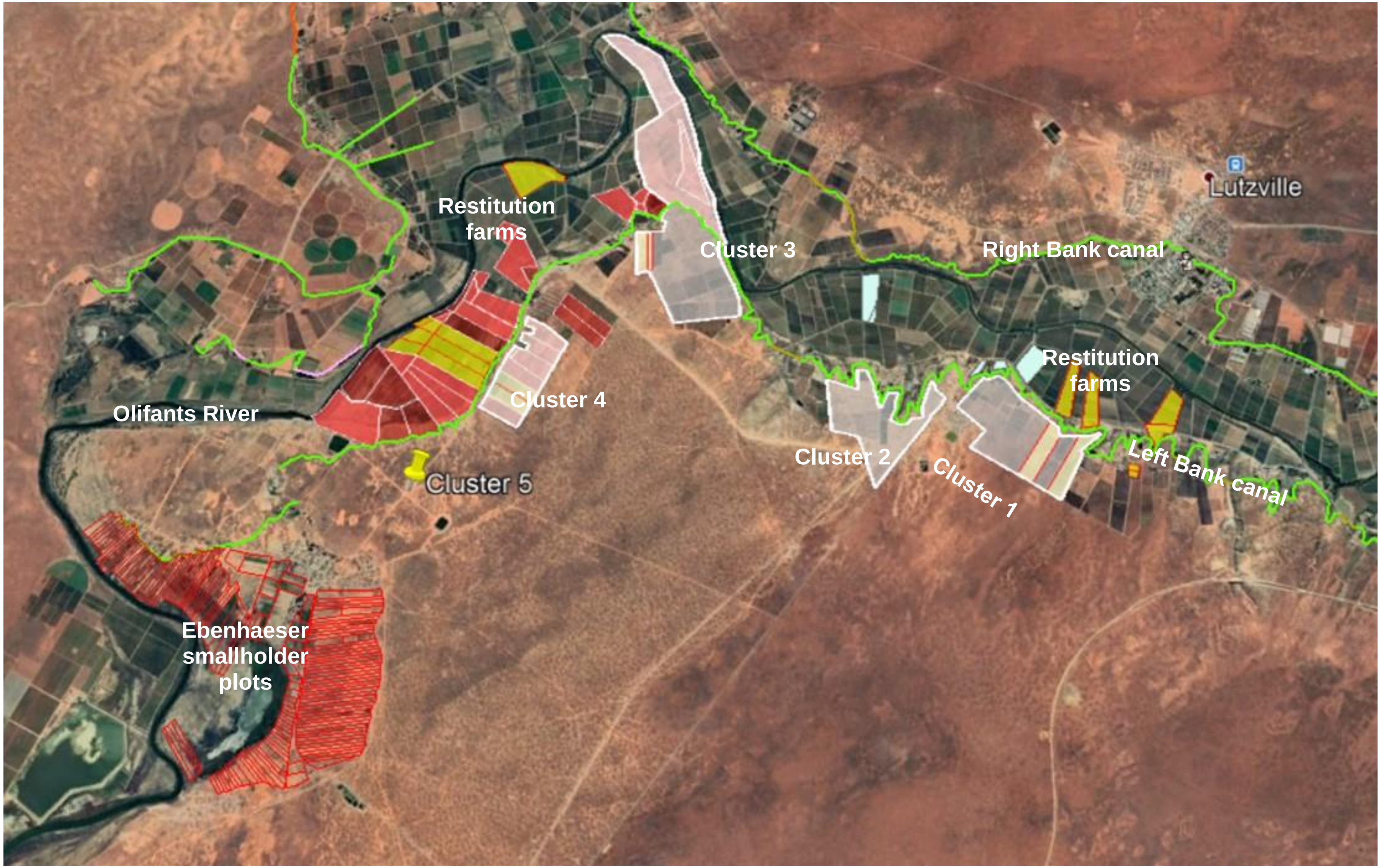


Figure 1-4: Ebenhaeser augmentation irrigation clusters

Domestic water supply to towns in the Cederberg and Matzikama Municipalities will be augmented, and water will be provided to meet future industrial and mining water requirements.

1.5 The Record of Implementation Decisions

The Record of Implementation Decisions (RID) is the official document to transfer a project from the feasibility stage to the implementation stage (detailed design construction and commissioning). The RID is signed off by the Chief Director: National Water Resource Planning (CD: NWRP) and is accepted by the Chief Director: Infrastructure Development (CD: ID)).

The RID records the scheme configuration and other related requirements for implementation, after approval by the Minister. The RID describes the scope of the Project and the specific configuration of the scheme, summarises all decisions as approved, stipulates the required implementation timelines and the financing or funding arrangements, and the finalisation of required institutional arrangements.

This RID provides outcomes of the following aspects for the proposed Jan Dissels Scheme, Right Bank Canal Scheme and Ebenhaeser Scheme:

- Detailed planning;
- Conceptual designs;
- Cost estimates; and
- Recommendations for implementation.

This RID should be read with the Feasibility Design Report (Report No P WMA 09/E10/00/0417/13) for the *Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam (WP0485),* hereafter referred to as the *Clanwilliam Bridging Study.*

The RID also includes the Environmental Authorisation, which is issued after the environmental impact assessment (EIA) process is complete.

2 Water Resources

2.1 Yield Analysis

2.1.1 Historic and Stochastic System Yields

Detailed analysis and modelling of the existing and potential water resource availability in the Olifants River Catchment, following from the proposed raising of the Clanwilliam Dam, was undertaken as part of the *Feasibility Study for the Raising of the Clanwilliam Dam*. The analysis was based on extended, uncalibrated hydrology up to 2005.

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

Yields were determined for various scenarios, for a range of dam raising options, relative to the yield of the existing LORGWS, which comprises Clanwilliam Dam, Bulshoek Weir and the associated distribution infrastructure. The decrease in yield, due to the implementation of the ecological Reserve, was determined for the existing dam (the dam safety work scenario), as well as for three dam raising scenarios (5 m, 10 m and 15 m respectively) that were evaluated as part of the study.

The yield for a 13 m dam raising was determined by interpolating between the results for the 10 m and 15 m raising. For a 13 m dam raising, it was found in the Dam Raising Feasibility Study that the scheme would have an incremental historic firm yield (HFY) of 69.5 million m^3/a.

Yield analysis results derived from historical streamflow sequences are shown in **Figure** 2-1.

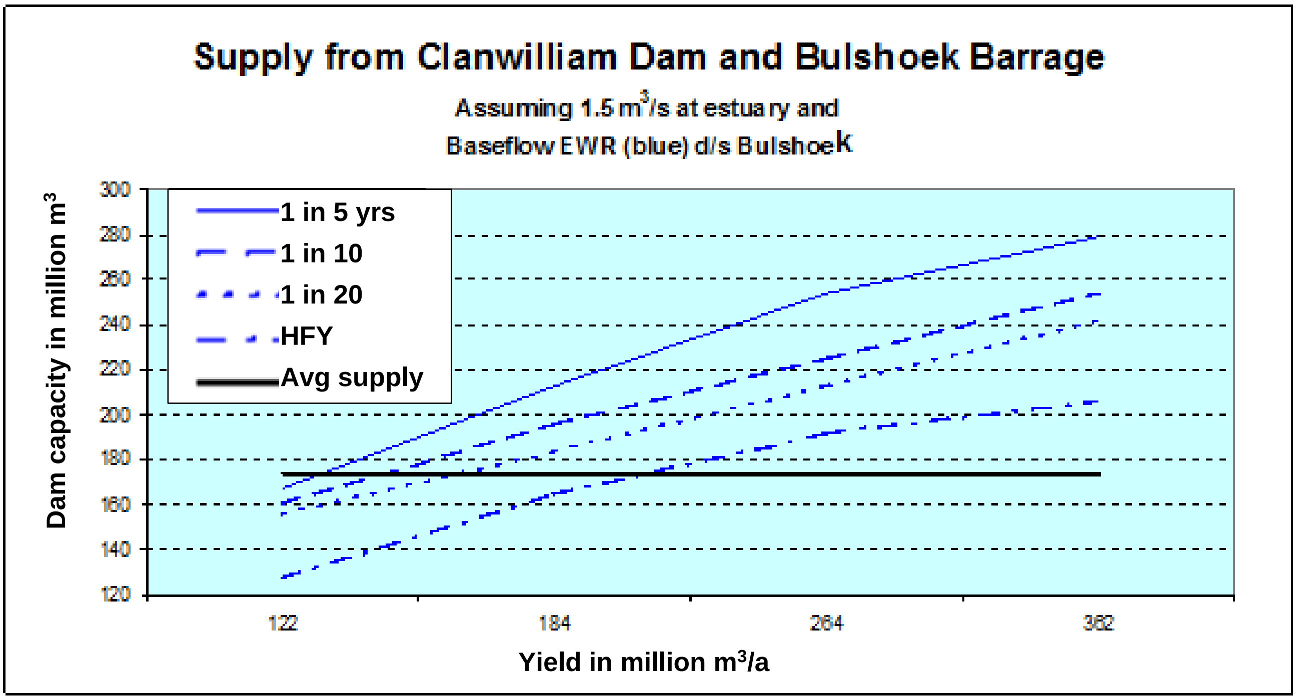


Figure 2-1: Reliability of supply from the current and a raised Clanwilliam Dam

2.1.2 Updated Interpretation of Historical Modelling

The previous modelling undertaken was re-interpreted in the Clanwilliam Bridging Study, with refinement of certain information such as distribution water losses and existing water use values where considered necessary.

The incremental available yield after raising of the Clanwilliam Dam, at a 91% assurance of supply (1:10 year) is 82.0 million m^3/a.

The capacity of the dam would increase from the existing 122 million m^3 to 321 million m^3 following the raising.

2.1.3 Assurance of supply

Existing farmers in the LORGWS currently receive, and in the past received, water at an unacceptably low assurance of supply, with very regular curtailments due to droughts. The need to improve the overall assurance of supply for the LORGWS was identified. Improving the assurance of supply to existing users would not involve actual changes in water allocations, but only an improvement of the reliability at which the water is supplied. This would benefit current irrigators during periods of drought and provide for more assured agricultural planning, so that users can be more certain of obtaining preferably their full quota, but at least an increased percentage of their quota in very dry years.

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

For municipalities and industries, the assurance of supply is deemed to be 98%.

2.2 Recommendations for Detailed Design

Based on an assurance of supply of 91% (1:10 year) the incremental available yield, after raising of Clanwilliam Dam, is 82.0 million m^3/a. The capacity of the dam would increase from the existing 122 million m^3 to 321 million m^3 following the raising.

No further work is recommended for detailed design.

3 Overview of Clanwilliam Bridging Study Findings

A brief overview of the Clanwilliam Bridging Study is given below to highlight the other investigations undertaken, the options analysis process followed and the suite of irrigation development schemes recommended, in addition to the three schemes described in this RID for implementation.

3.1 HDI Farmers Assessment

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

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

Some of the findings were as follows:

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

3.2 Soil Survey

The extension of the soil survey entailed identification of the soil types, soil suitability and amelioration measures of the additional area covering about 10 300 ha of land lying between 60 m to 100 m above river level, between Clanwilliam Dam and Klawer. This was used to extend the existing survey, completed during 2004 as part of the Clanwilliam Dam Raising Feasibility Study, which covered the area up to 60 m above river level.

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

3.3 Water Requirements

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

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

Aggregate crop water requirements per study zone were determined for planning purposes. Water requirements of the identified potential irrigation areas were then calculated, considering aggregate crop water requirements, crop rotation factors where applicable and leaching requirements.

The future requirement for industrial, domestic and mining use was determined as 0.6 million m^3/a.

3.4 Options Analysis

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

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

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

3.5 Preferred Suite of Irrigation Schemes

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

Table 3-1.

Table 3-1: Comparison of Recommended Schemes

Scheme	Irrigable Area (ha)	Incr. Req + Losses (Mm^3/a)*	Scheme Loss %	Capital Cost (R million)	Total NPV Cost (R million)	URV (R/m^3)	Environ-mental impact	Risks	Opportunity for smallholders/ restitution
Jan Dissels	462	4.26	0%	83.2	100.2	2.03	High	Environmental opposition	Yes
Clanwilliam	298	2.46	0%	34.5	58.6	1.84	Medium	Limited area of existing irrigation & land ownership	Yes
Transfer of lower Jan Dissels River allocations	0	1.00	0%	0.0	0.0	0.00	Low	Low but irrigators may potentially oppose it	-
Zandrug	1 209	9.15	5%	117.8	196.8	1.52	High	Interest of land owners to switch existing irrigation to higher-value crops & land ownership	Partial
Bulshoek	266	2.25	5%	25.9	44.4	1.56	Medium	Interest of land owners to switch existing irrigation to higher-value crops & land ownership	No
Right Bank canal (incl. 4 Trawal irrigation areas)	2 339	25.65	15%	573.2	782.3	3.05	Medium	Funding of betterments & land ownership	No
Klawer Phase 1 (flow- restricted)	412	5.09	22%	77.1	108.5	2.25	Low	Canal structural integrity, land ownership, operational complexity	Yes
Klawer Phase 2 (partial development)	438	5.32	20%	158.0	192.2	1.71	Low	Funding of betterments & land ownership	Yes
Coastal 1 (flow-restricted)	89	1.21	34%	41.6	51.5	4.92	Low	Canal structural integrity, high cost, operational complexity	Yes
Ebenhaeser	361	4.66	28%	512.9	536.7	12.77	Low	Canal structural integrity, high cost, operational complexity	Yes
TOTALS	**5 874**	**61.05**		**1624.3**	**2071.2**				

** In addition to existing allocations*

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

Table 3-2.

Table 3-2: Proposed Phasing of Recommended Schemes

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

The following schemes were identified for feasibility-level design:

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

These schemes are shown in Figure 3-1, except for the Ebenhaeser Scheme, which is located in the far North-West of the Olifants River catchment, between Lutzville and Ebenhaeser towns. Only partial development of the Klawer and Coastal 1 potential areas (as shown on the map) has been recommended, due to limitations such as high relative scheme costs and limited additional water availability or better opportunities being available.

Figure 3-1: Location of recommended irrigation areas

3.6 Way Forward for Other Irrigation Developments

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

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

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

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

The recommended type of development per recommended irrigation development scheme (including all government water schemes (GWSs) for completeness) is indicated in Table 3-3.

Table 3-3: Recommended type of development for irrigation schemes

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

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

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

4 Water Supply From The Project

4.1 Water Requirements

Water requirements have been determined inclusive of leaching requirements, which is described in Sub-section 4.2.

4.1.1 Jan Dissels Scheme

An area east of Clanwilliam Dam and close to Clanwilliam town was identified as suitable irrigable land for this scheme (**Figure** 1-2). The area is *inter-alia* suitable for the development of smallholder plots, given its proximity close to Clanwilliam town and existing markets. The land is owned by the State. Following a botanical survey to account for environmental sensitivity concerns by environmental authorities, and meetings held with the land users, being Cederberg Local Municipality and Augsburg Agricultural Gymnasium, the scheme was conceptualised.

The irrigation water requirement for the estimated 462 ha of irrigable land is 4.26 million m^3/a, based on aggregate crop water requirements of the study zone and allowance for leaching.

The design capacity for the scheme infrastructure is 23.2 Mℓ/d (0.269 m^3/s), based on a crop monthly peak factor of 1.99.

4.1.2 Right Bank Canal Scheme

The new canal will have an increased capacity (compared to the existing left bank main canal) to supply new irrigation development and other future uses, in addition to existing users (current canal flow capacity plus allowance for an increased assurance of supply). The scheme will supply the four proposed new irrigation areas in the Trawal region to be privately developed, namely the Zypherfontein 1, Trawal, Zypherfontein 2 and Melkboom irrigation areas.

The capacity of the Right Bank Canal should be designed for the various flow components as shown in **Table 4-1**, along with adequate freeboard. The total peak design flow rate for the proposed Right Bank Canal at the outlet of the Bulshoek Weir is calculated as **11.40 m^3/s**.

Table 4-1: Right Bank Canal peak design flow rates

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

4.1.3 Ebenhaeser Scheme

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

The incremental volume of water that can annually be diverted from the Vredendal left bank canal section and the Retshof right bank canal section was determined from an evaluation of historical canal flows and consideration of likely future flows, after Clanwilliam Dam has been raised. Taking into account pragmatic operational rules for the diversion of canal flows, and expected conveyance and storage water losses, total water availability from the scheme was determined as 4.66 million m^3/a, including losses of 1.01 million m^3/a, to irrigate 361 ha of irrigable area. The water availability (excluding water losses) for irrigation is thus 3.65 million m^3/a and the minimum balancing dam capacity needed to bridge the summer peak period is 2.152 million m^3.

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

Water requirements and design flow rates per cluster are shown in **Table 4-2**.

Table 4-2: Ebenhaeser Scheme cluster water requirements and design flow rates

Water Requirement Cluster	Irrigable Area (Hectares)	Water Requirement (Mm^3/a)	Design Flow (m^3/s)*
Restitution farms (80% of volume)			
Cluster 1	49	0.71	0.047
Cluster 2	28	0.40	0.027
Cluster 3	65	0.94	0.062
Cluster 4	60	0.87	0.057
Ebenhaeser CPA smallholders (20% of volume)			
Cluster 5	72	0.73	0.048

** based on a crop monthly peak factor of 2.09*

4.2 Water Quality Considerations

Raw water will be supplied from the schemes for mainly irrigation and also for other water uses. While water treatment will be required for some uses, such as municipal use and for some industries, such treatment will be done by others and does not form part of these schemes.

The irrigation water requirements are affected by the quality of the irrigation water. The water quality in Clanwilliam Dam and in Bulshoek Weir is ideally suited for irrigation use.

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

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

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

4.3 Recommendations for Detailed Design

Jan Dissels Scheme: Revisit the extent of the irrigation area, in terms of any changes emanating from the EIA to be undertaken, and the associated water requirements and design flow.

Right Bank Canal Scheme: Revisit the design flow rate, taking into consideration alternate design flow (and funding) scenarios, in light of the outlet flow capacity of the Bulshoek Weir, which needs to be more accurately determined.

Ebenhaeser Scheme: Refine the extent of the identified irrigation clusters and if necessary, consider other HDI farmers that should be included in the scheme.

Confirm or revisit the split of the available volume for Ebenhaeser irrigation of 80% to restitution farms and 20% to smallholder plots, and the associated crop water requirements, and adjust cluster water requirements and design flows as necessary for any required changes.

5 Geological, Geotechnical and Materials Investigation

5.1 Introduction

The geological and geotechnical evaluation comprised:

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

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

5.2 Regional geology

The 1:250 000 Geological Series mapping and other publications were consulted to describe the regional geology.

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

Mechanical disintegration is the dominant mode of rock weathering in areas of lower rainfall, whereas chemical decomposition dominates areas of higher rainfall.

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

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

5.3 Jan Dissels Scheme

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

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

5.3.1 Geology

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

5.3.2 Geotechnical considerations

5.3.2.1 Excavation considerations

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

5.3.2.2 Slope stability and lateral support

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

5.3.2.3 Soil corrosiveness

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

5.3.2.4 Foundations

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

According to the classifications, the colluvium is mainly suitable as bedding cradle and selected fill blanket, i.e. SC1 and SC2 bedding material types, and the residual quartzitic sandstone is generally suitable for foundations. It should be noted that occasional sandy clay material (with a plasticity index of 18%), within the residual quartzitic sandstone horizon, was found in localised areas. This material is not suitable as bedding and backfill material.

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

5.3.2.5 Access Road

There is an existing gravel road from the 'Ou Kaapse' Road to the site for the Sub-option 1 rising main route. It is uncertain whether this road would require upgrading; if so, quartzitic sandstone from the Cape Supergroup and possibly shale can be used as crushed stone for construction / base material.

Should access be required along the entire length of the Sub-option 2 rising main route, a road would need to be constructed from the dam wall for approximately the first kilometre or so along the route. Most of this distance is against a steep hill, which is not practical for an access road. The rising main would be readily accessible for the remainder of the route.

5.3.2.6 Further Investigations

Test pits could not be excavated at either of the pump station sites due to access constraints. The geotechnical conditions for the pump station have therefore not been investigated in sufficient detail. It is recommended that follow-up geotechnical investigations be conducted, specifically where insufficient data was obtained for the pump station.

Follow-up investigations would also address aspects such as confirmation of the geological continuity (laterally and with depth) across the site.

Any additional design optimisations would also require that appropriate geological and geotechnical investigations are carried out.

In addition, the low soil pH value as found in all samples suggests corrosive conditions, yet the laboratory results yielded conductivity values which are generally lower than 10 mS/m and therefore classified as non-corrosive. It is therefore recommended that additional chemical testing be conducted to confirm the corrosiveness of the soils.

5.4 Right Bank Canal Scheme

5.4.1 Geology

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

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

5.4.2 Geotechnical Considerations

The engineering geological / geotechnical implications and considerations for each of the respective components of the Right Bank Canal scheme have been summarised in Chapter 3 of the unnumbered *Right Bank Canal Design Sub-Report* and described in more detail in the *Geotechnical Investigations Report. Vol II: Right Bank Canal Scheme (P WMA 09/E10/00/0417/8).*

The geotechnical considerations for the scheme are summarised below.

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

The **geological profile** for the initial 1 900 m essentially comprises bedded, very hard rock quartzitic sandstone. For the remainder of this section similar bedrock is expected, but beneath a cover of colluvial talus material.

None of the test pits intersected the **water table**.

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

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

5.4.2.2 New Right Bank Canal

The **geological profile** over the approximate 30 km route of the new Right Bank Canal is naturally highly variable and comprises combinations of soil overburden comprising sands, silts and clays, with coarse fractis comprising gravels and cobbles; all over bedrock that either comprises quartzitic sandstone, of shale. Bedrock was not intersected, and then commonly occurs at depths beneath refusal on cemented sand or terrace gravels. The canal routing was sub-divided on the basis of expected similar geological conditions, i.e. similar geotechnical influences.

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

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

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

5.4.2.3 Road crossings

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

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

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

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

5.4.2.4 Olifants River Crossing (Syphon 1)

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

Shallow **water tables** must be expected in the river as well as on the right abutment.

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

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

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

5.4.2.5 Doring River Crossing (Syphon 2A)

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

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

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

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

5.4.2.6 Extended Doring River Syphon (Syphon 2B)

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

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

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

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

5.4.3 Conclusions and Recommendations

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

5.5 Ebenhaeser Scheme

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

5.5.1 Geology

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

5.5.2 Excavation stability

The test pit sidewalls largely collapsed in the very loose to medium dense aeolian sands during the field investigations. The stability of excavations during construction may be compromised and shoring or battering of excavations will be required. Attention must be paid to the presence of seepage and terrace gravels.

As part of safe practice during construction, stability assessment would be required for deeper excavations that are left open for longer periods. These assessments should be conducted by a suitably qualified and experienced geotechnical practitioner.

5.5.3 Soil corrosiveness

The soils along the Ebenhaeser scheme corridor are generally non-corrosive to extremely corrosive. This indicates that special considerations need to be taken for the steel and concrete components, in particular for the concrete reservoir, and inlet and outlet structure for the balancing dam.

The high density polyethylene (HDPE) pipe that is proposed for the scheme generally has an excellent corrosion resistance. Therefore, no corrosion problems are likely to be encountered for the pipelines.

5.5.4 Other factors

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

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

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

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

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

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

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

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

5.5.5 Balancing Dam

5.5.5.1 Foundation indicators

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

5.5.5.2 Material strength and permeability

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

5.5.5.3 Embankment foundation and materials

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

5.5.5.4 Foundation of spillway

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

5.5.5.5 Embankment fill materials

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

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

5.6 Recommendations for Detailed Design

Geological, geotechnical and materials investigations were done for the three schemes. Geotechnical field investigations undertaken, including geophysical surveys, test pitting and in-situ field testing, for the preliminary conveyance infrastructure routes, informed the selection of the preferred pipeline routes and infrastructure positions. Core drilling of three syphons for the Right Bank Canal Scheme and one syphon for the Ebenhaeser Scheme will provide information for the detailed design of the syphons.

Further geotechnical investigations required are the following:

1) Conduct follow-up geotechnical investigations for the Jan Dissels Scheme, specifically where insufficient data was obtained for the recommended pump station site.
2) Conduct additional chemical testing to confirm the corrosiveness of the soils for the Jan Dissels Scheme.
3) For the Right Bank Canal and Ebenhaeser Schemes, take into account findings from the core drilling that was undertaken along the syphon routes.

6 Topographical Survey

6.1 Methodology

The topographical survey was undertaken at an accuracy that is suitable for detailed design. It was decided that the quickest and most practical approach would be to undertake a Light Detection and Ranging (LIDAR) survey.

Southern Mapping was contracted to produce a LIDAR survey of the areas as indicated in **Figure 6-1** to **Figure 6-3**. The survey mapping was done in November 2019 and small extensions to the survey were done in August 2020.

Figure 6-1: Survey area for the Jan Dissels Scheme

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

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

Figure 6-2: Survey area for the Ebenhaeser Scheme

6.2 Survey Data

The following deliverables were submitted in electronic format:

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

The supporting *Topographical Survey Report* on the control survey undertaken includes the coordinated lists of the photo control stations established and employed, existing survey beacons and new survey beacons established. A separate report on the establishment of ground control points is included in an Appendix of the report.

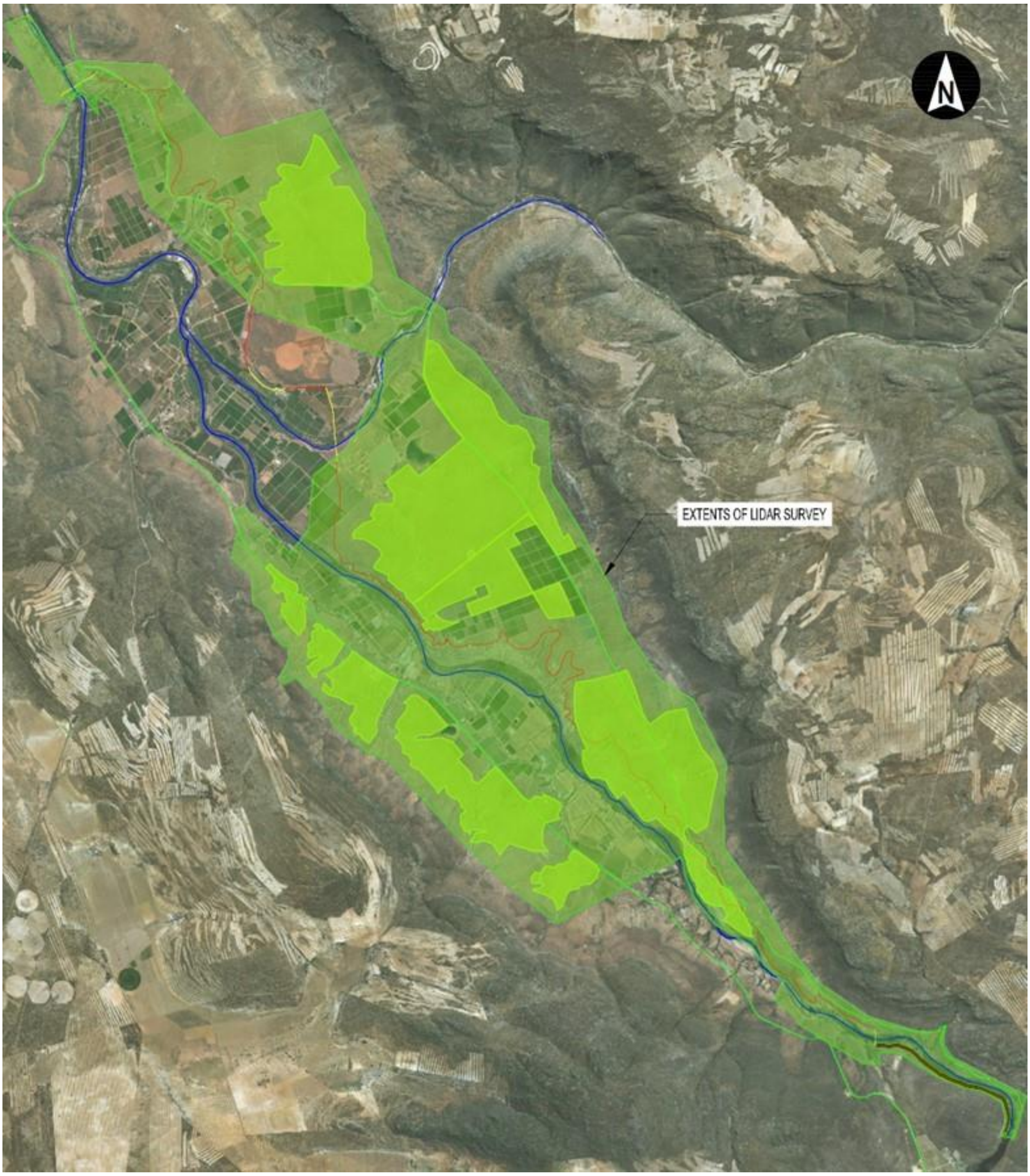


Figure 6-3: Survey area for the Right Bank Canal

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

The details of the topographical surveys undertaken are reported in the *Topographical Survey Report* (Report No. P WMA 09/E10/00/0417/7).

6.3 Recommendations for Detailed Design

A LIDAR topographical survey was completed by Southern Mapping for the three schemes designed at feasibility level. The accuracy of the available survey data is considered sufficient to undertake the detailed designs of the proposed infrastructure for the three schemes. Accurate topographical information in the form of digital terrain modelling data, high quality ortho-photos and line mapping of salient features for the feasibility study were provided.

Further topographical surveying required is as follows:

1) Undertake a ground centreline survey along the final chosen canal and pipeline routes, prior to construction commencing. This will serve as a final check on the canal and pipelines' vertical alignment and verification of the survey data.
2) A more site-specific survey is required for the railway and existing culvert crossings on the Ebenhaeser gravity pipeline.

7 Scope of Work for the Jan Dissels Scheme

7.1 Overview of the Scheme

The Jan Dissels Scheme is located on the right bank of the Clanwilliam Dam and adjacent to Clanwilliam town.

Two routes for a rising main were identified:

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

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

Figure 7-1 shows the layout of the bulk water infrastructure components for the Jan Dissels Scheme, which is described in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*.

Water will be pumped from an outlet point below the raised Clanwilliam Dam wall, on the right bank, to a concrete reservoir on top of the hill, on the divide between the Olifants River and Jan Dissels River valleys.

An access road to the reservoir will have to be constructed, either from the “Ou Kaapse” Road or from the township development close by.

Additional electrical supply is required for the pump station, noting that the power supply for Clanwilliam Town must also be upgraded. A possibility is for the scheme to be (*inter-alia*) supplied from the future proposed hydro power plant, to be located on the left bank at the raised Clanwilliam Dam. It is recommended that Eskom be engaged during the detailed design phase of the project.

Figure 7-1: Layout of the Jan Dissels Scheme

7.2 Intake Pump Station

Water will be pumped from an outlet point (provided by others) below the raised Clanwilliam Dam wall on the right bank, to the balancing reservoir. With the raising of the dam wall the existing pump station, supplying the town of Clanwilliam, will be demolished and a new pump station will be constructed. Two options are available for the new pump station:

- Option 1 is to integrate the Jan Dissels Pump Station with the new proposed pump station for the town; and
- Option 2 is to construct a new pump station in the same position as the existing pump station after it is demolished.

The proposed options are shown in **Figure 7-2**. Drawing, No. 168668/15 in Appendix A1 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*, shows the future layout of the right bank outlet works.

A pump configuration of one (1) duty pump and one (1) standby pump is proposed for the Rising Main Route 2 pump station. The characteristic system curves for Rising Main 2 pump station are shown in **Figure 7-3**. The details of a commercially available pump that could be used are shown below.

The following information about the KSB Omega 250-600A pump is relevant:

- Impeller size = 606 mm;
- Full-size impeller = 610 mm;
- Hydraulic efficiency of pump = 82.2%;
- NPSH required = 2.9 m;
- Head rise to shut-off = 10%;
- Maximum power absorbed for 606 mm impeller = 520 kW (recommended motor size is 500 kW, operating at 1 450 rpm); and
- Maximum power absorbed at duty point = 398 kW.

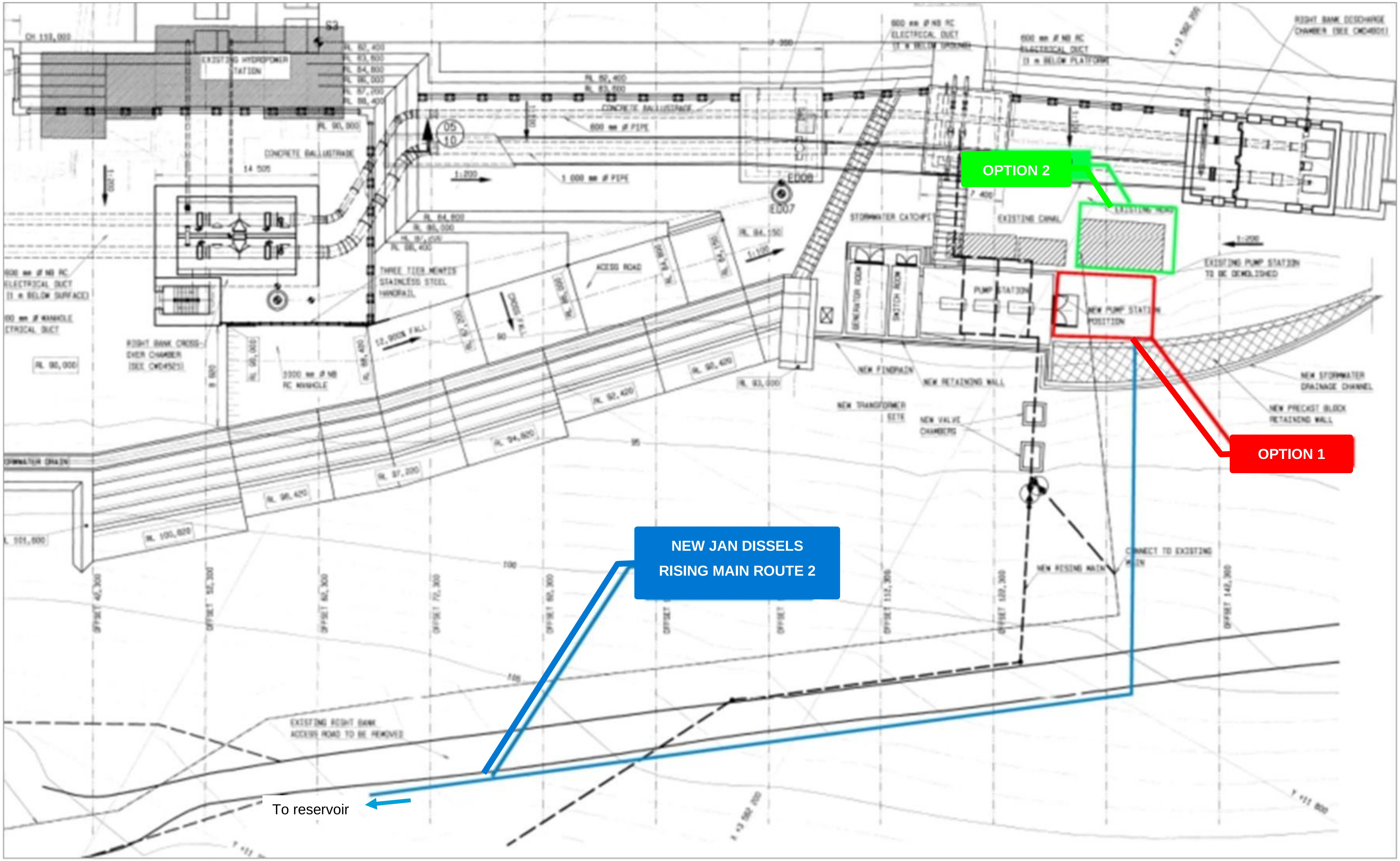


Figure 7-2: Jan Dissels Rising Main Route 2 Pump Station

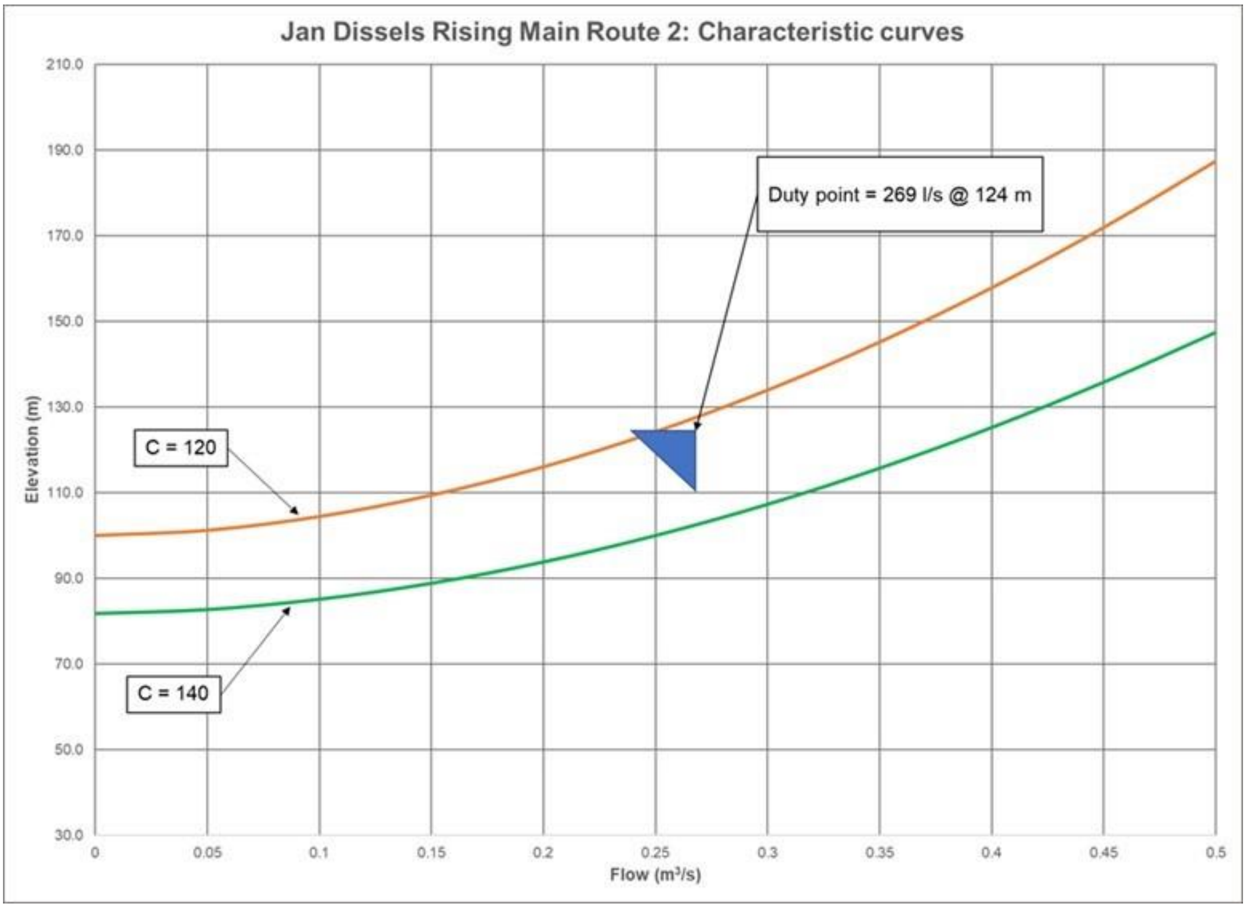


Figure 7-3: Characteristic and pump curve for Rising Main 2 pump station

It is evident from **Figure 7-3** that the high-lift pump station has a duty point of 23.2 Mℓ/d (0.269 m^3/s) at a total pumping head of approximately 124 m.

Figure 7-4 shows the hydraulic gradient lines of the Rising Main Route 2 to the concrete reservoir for a flow of 23.2 Mℓ/d (0.269 m^3/s) through a DN 500 pipeline.

7.3 Farm Dam/Reservoir

The reservoir is designed to store the flow of 269 ℓ/s pumped over 12 hours, which equates to a reservoir with an active capacity of 11 600 m^3 (11.6 Mℓ). It is proposed that a 12 000 m^3 (12 Mℓ) reinforced concrete reservoir be provided. The reservoir's minimum operating level is 202 masl and the full supply level is 208 masl.

A new access road will have to be constructed to the reservoir and a new power supply provided.

The proposed layout plan and detail for the reservoir is shown in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* on drawings 113834-0000-DRG-CC-0203 and 113834-0000-DRG-CC-0204 in Appendix A1.

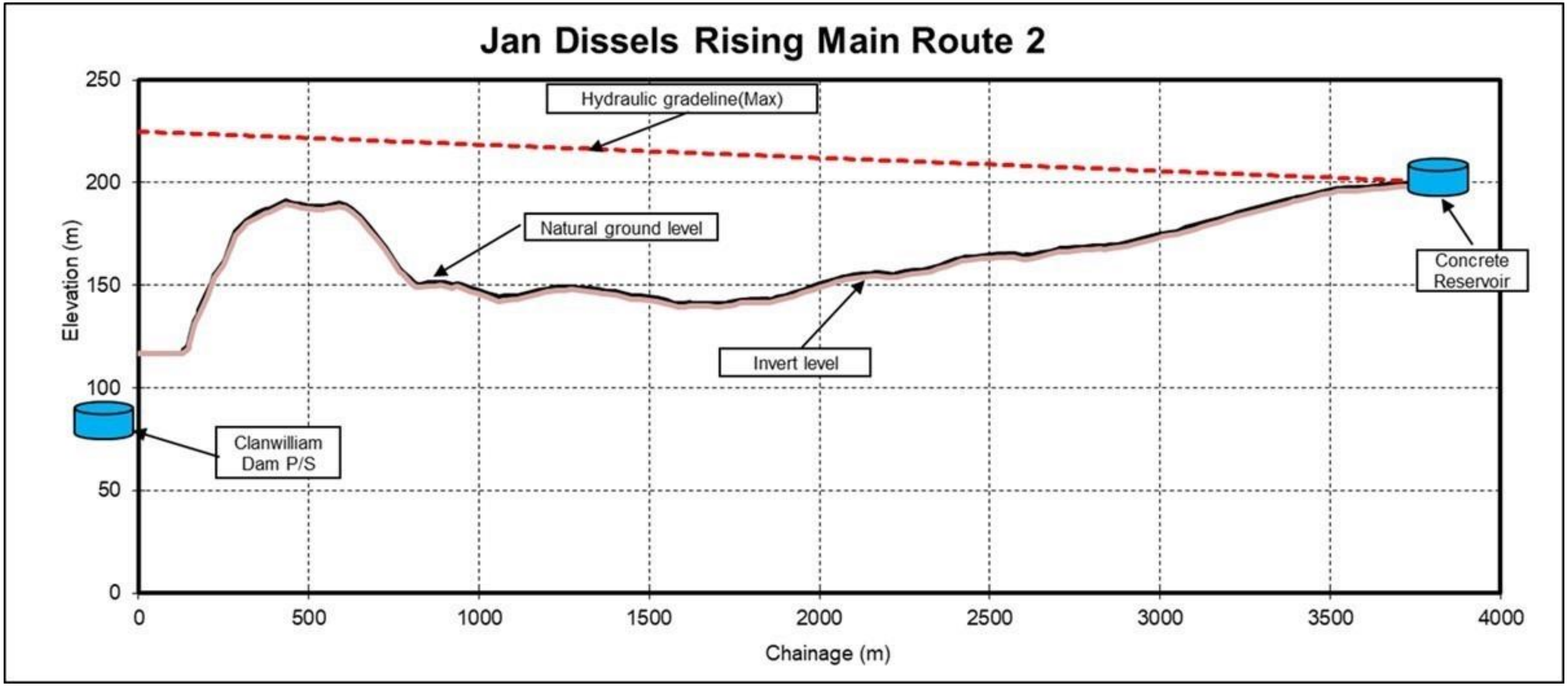


Figure 7-4: Rising Main Route 2 to Reservoir: HGL for 23.2 Mℓ/d in aged DN 500 pipeline

7.4 Recommendations for Detailed Design

The following recommendations are applicable to the detailed design and construction phases of the Jan Dissels Scheme:

a) The extent of the irrigation to be developed will need to be confirmed before the detailed design can commence. This is influenced by the practical use of land within the scheme, and environmental considerations and associated approvals.

b) Follow-up geotechnical investigations should be conducted, specifically where insufficient data was obtained for the recommended pump station site.

c) Additional chemical testing should be conducted to confirm the corrosiveness of the soils.

d) A ground centreline survey should be done along the final chosen pipeline routes, prior to construction commencing. This will serve as a final check on the pipeline's vertical alignment and verification of the survey data.

e) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources of this material.

f) During the detailed design, the pipeline routes and infrastructure locations will need to be confirmed, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

g) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.

h) The choice of pipe material needs to be confirmed during the detailed design phase of the project, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.

i) Eskom should be engaged during the detailed design phase of the project regarding electrical supplies to the pump stations.

j) Refine the selection of pump types.

k) Submit the proposed road crossing details to the relevant road authority for their approval during the detailed design stage.

l) Reconsider the sizing of the concrete balancing reservoir, taking into account the operational procedures of the smallholder farmers' component of the scheme, which will mainly irrigate during the day. Consider if adequate allowance has been made for emergency situations to counter load shedding and breakdowns, and allow for maintenance.

m) Reconsider the energy costs used in the cost calculations, optimising it for Eskom's Time of Use tariffs, to achieve savings in energy cost over the life cycle of the project.

n) The syphon through the Jan Dissels River will form part of the on-farm irrigation conveyance infrastructure and environmental implications need not be addressed in the detailed design.

8 Scope of Work for the Right Bank Canal Scheme

8.1 Introduction

Several major breaks have been experienced along the Bulshoek / Lower Olifants Canal due to ageing infrastructure. The Right Bank Canal Scheme is designed to replace the existing left bank main canal, starting at Bulshoek Weir, with a new canal on the right bank of the Olifants River, which will have an increased capacity to also supply new irrigation development and other future uses.

8.2 Scheme Overview and Components

Several options were compared and evaluated for the different components of the Right Bank Canal Scheme (refer to Chapter 5 of the '*Conceptual Design Sub-Report*' of this study). The proposed scheme is required to serve the identified new irrigation areas of Trawal, Zypherfontein 1, Zypherfontein 2, and Melkboom, as shown in **Figure** 1-3.

A general layout arrangement of the proposed scheme consists of the following:

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

8.3 Canal Design

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

The layout of the Right Bank Canal Scheme is shown in **Figure 8-1**.

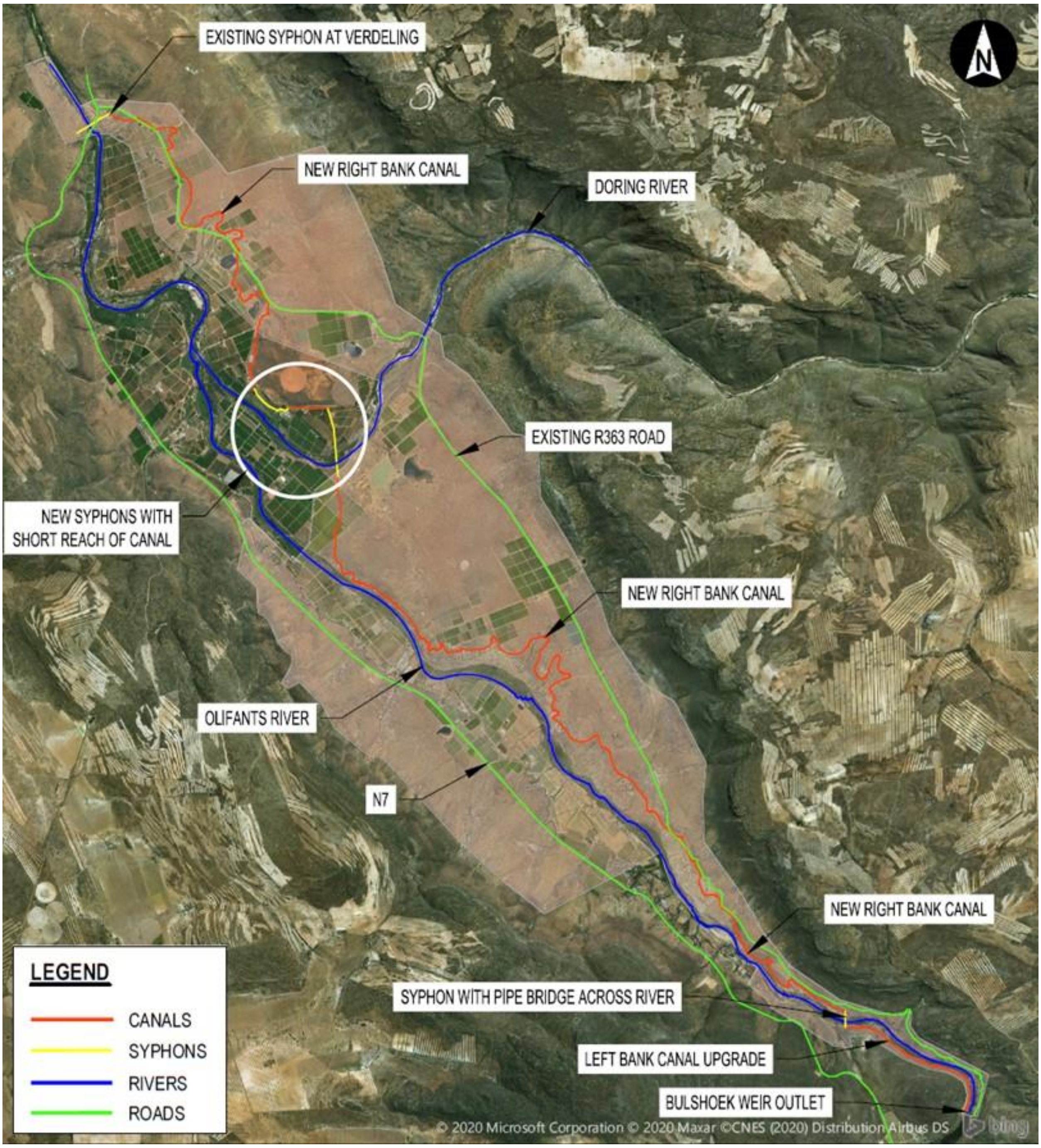


Figure 8-1: Overall layout of the Right Bank Canal Scheme

8.3.1 Bulshoek Weir Outlet Works and Available Hydraulic Energy

Due to the age and condition of the Bulshoek Weir it would be risky to blast in the vicinity of the weir to construct a new outlet to serve the proposed Right Bank Canal.

Based on an analysis of the existing outlet works (refer to Section 5.3.1 of the '*Right Bank Canal Design Sub-report*'), it is estimated that the existing outlet structure has a flow capacity of 11.5 m^3/s and does not need to be modified to release the peak design flow of 11.4 m^3/s into the proposed Right Bank Canal. The water level immediately downstream of the five sluice gates (see **Figure 8-2**) is controlled by the gates themselves and is approximately 61.0 masl. This level was used as the starting level for the feasibility design.

It is important to note that the Bulshoek Weir is a national monument. For the betterment works project previously undertaken on the dam structure, it was a requirement that the aesthetics of the Bulshoek Weir not be affected. It is assumed that a similar restriction will be applied to any construction works affecting the weir as it currently stands and operates.

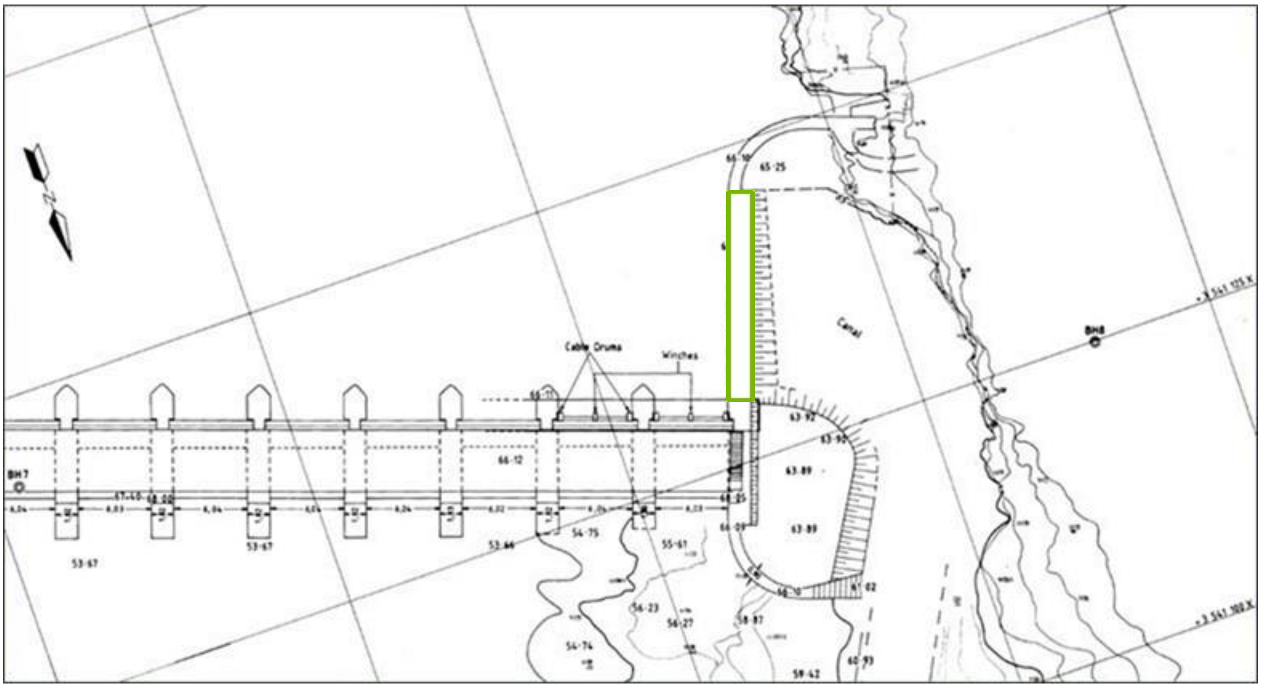


Figure 8-2: Plan view of Bulshoek Weir showing existing outlet structure (green)

8.3.2 Vertical Alignment

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

8.3.3 Horizontal Alignment

The routing of the canal is north, north-west from Bulshoek Weir to the existing syphon at Verdeling. Refer to Drawing No. 113838-0000-DRG-CC-0001 in the Appendices of the *Right Bank Canal Design Sub-Report* for the detailed routing.

For the first 3 km the horizontal alignment of the proposed new main canal follows the current horizontal alignment of the existing Left Bank Canal. The existing canal however needs to be upgraded to ensure that it can accommodate the increased capacity required for the additional irrigation and other users. The canal would maintain its trapezoidal cross-section, but would be widened for the additional flow, and its lining must be rehabilitated to reduce the likelihood of future canal breaks.

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

After about 6.41 km the valley opens up and is flatter, and more favourable terrain for a canal becomes prevalent. The main canal will then follow the natural contours. The alignment crosses the Doring River at approximately 21.91 km with a syphon, followed by a short reach of canal and another short syphon to avoid a steep sandy hill. From approximately 24.70 km to the Verdeling Syphon at 33.55 km, the canal again follows the natural contours of the land. A summary of the canal reaches and their chainage is shown in **Table 8-1**.

Table 8-1: Summary of canal reaches and chainage

Reach	From Chainage (km)	To Chainage (km)
Left Bank Upgrade	0.00	3.05
Right Bank Reach 1	3.35	21.91
Right Bank Reach 2	23.18	23.86
Right Bank Reach 3	24.70	33.55

8.3.4 Canal Hydraulics and Cross-Section

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

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

Refer to **Figure 8-3** and **Table 8-2** for the differences between the two types of trapezoidal canals recommended. A drawing (Drawing No. 113838-1000-DRG-CC-0001) of the canal cross-section is included in the Appendices of the *Right Bank Canal Design Sub-Report*. The differences between the two types of canal are summarised as follows:

- Canal type T1 is a shallower section with flatter side slopes, proposed for the flatter, more open topography found in the lower Olifants River valley. Type T1 is recommended from about chainage 6.41 km in Reach 1 up to the end of Reach 3 at Verdeling.
- Canal type T2 is a deeper section with steeper side slopes, minimising the total section width. This section is proposed for the steeper, more extreme topography found in the relatively upper valley of the Olifants River just downstream of the Bulshoek Weir. Type T2 is recommended for the upgrading of the existing Left Bank Canal up to chainage 3.05 km, and then again on the right bank from chainage 3.35 km to about 6.41 km.

Table 8-2: Canal sections - design parameters

Parameter	Symbol (refer to Figure 8-3)	Type T1	Type T2
Canal Shape		Trapezoidal	Trapezoidal
Canal Slope		1:5 000	1:5 000
Bottom width (m)	b	2.8	5.0
Side slope (1V:xH)	x	1:1.5	1:0.5
Top flow width (m)	B1	8.64	6.82
Top canal width	B2	9.91	7.22
Flow depth (m)	y	1.945	1.824
Flow velocity (m/s)		1.025	1.057
Froude number		0.288	0.269
Freeboard (m)		0.423	0.396
Total depth (m)	D	2.370	2.220
Fill slope (1V:S_{FILL})	S_{FILL}	1:1.5	1:1
Cut slope (1V:S_{CUT})	S_{CUT}	1:1.5	1:1
Roadway width (m)	W_{ROAD}	4.0	1.5 (no road)

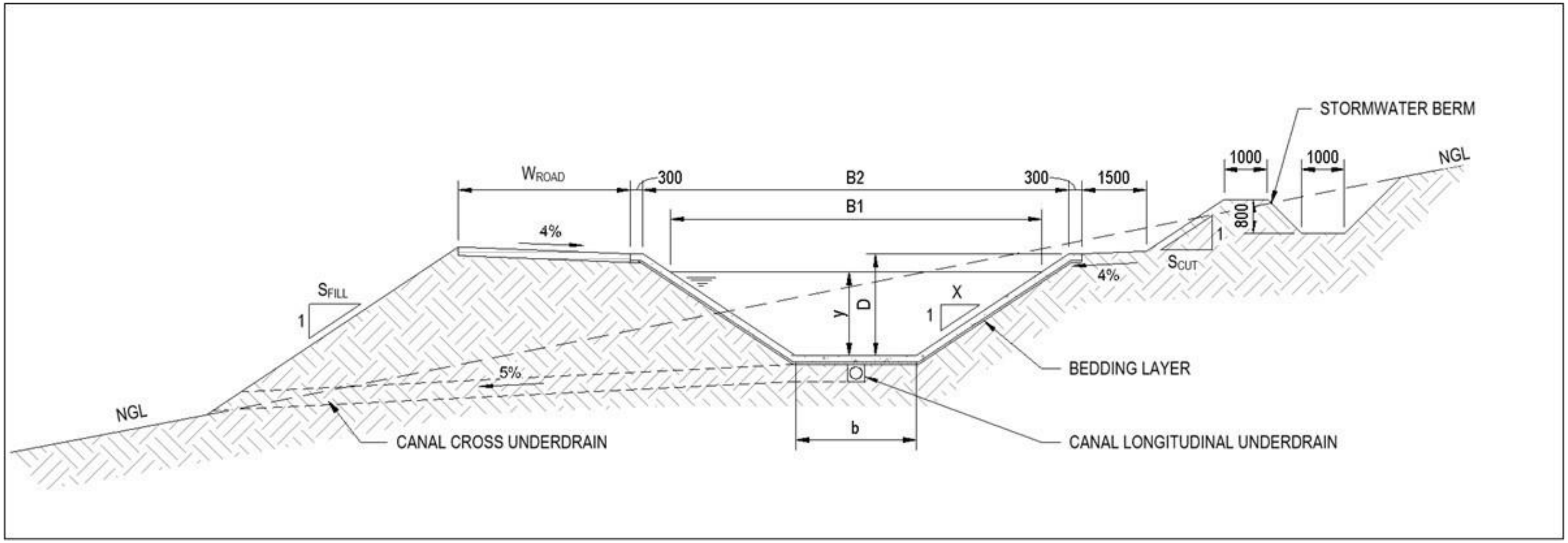


Figure 8-3: Trapezoidal canal cross-section (Types T1 and T2)

8.3.5 Canal Freeboard

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

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

- A 20% overload + velocity wave action (current DWS practice);
- Normal loading velocity wave action + curve wave action (South African National Roads Agency (SANRAL) Drainage Manual).

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

8.3.6 Canal Lining

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

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

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

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

8.3.7 Typical Canal Underdrainage

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

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

Cross-drains must be provided regularly, typically every 200 m. The spacing thereof must be optimised during the detail design phase. These cross-drains typically consist of a DN200 mm pipe with a slope of at least 1% downhill away from the cut side to daylight on the fill side of the canal. These pipes should either be connected to the longitudinal drainage pipes with tee pieces or be placed end to end, wrapped in 3.4 mm thick (Bidim type) geofabric, as shown in and **Figure 8-5**.

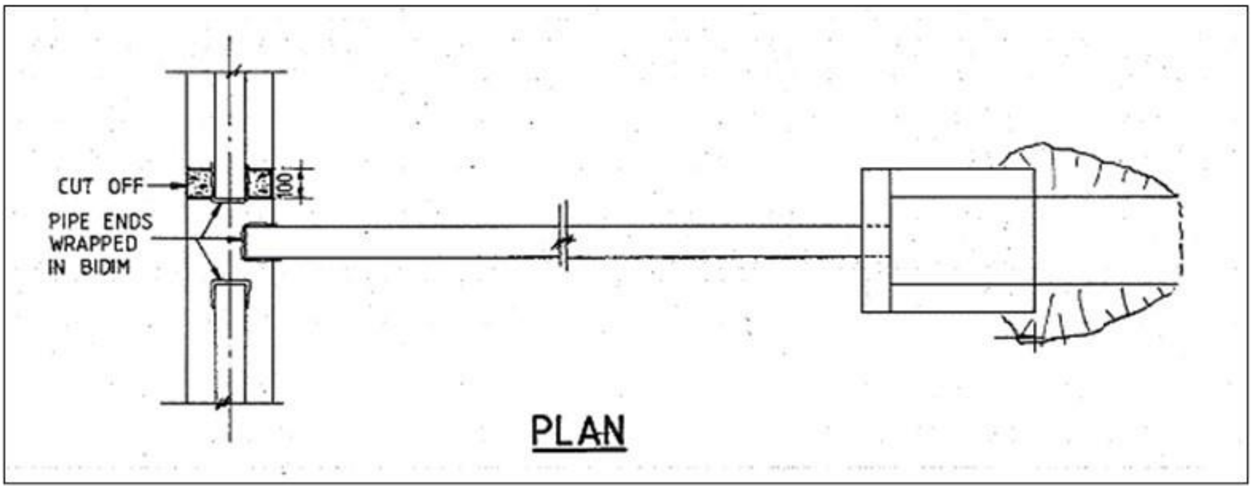


Figure 8-4: Typical longitudinal and cross underdrain connection

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

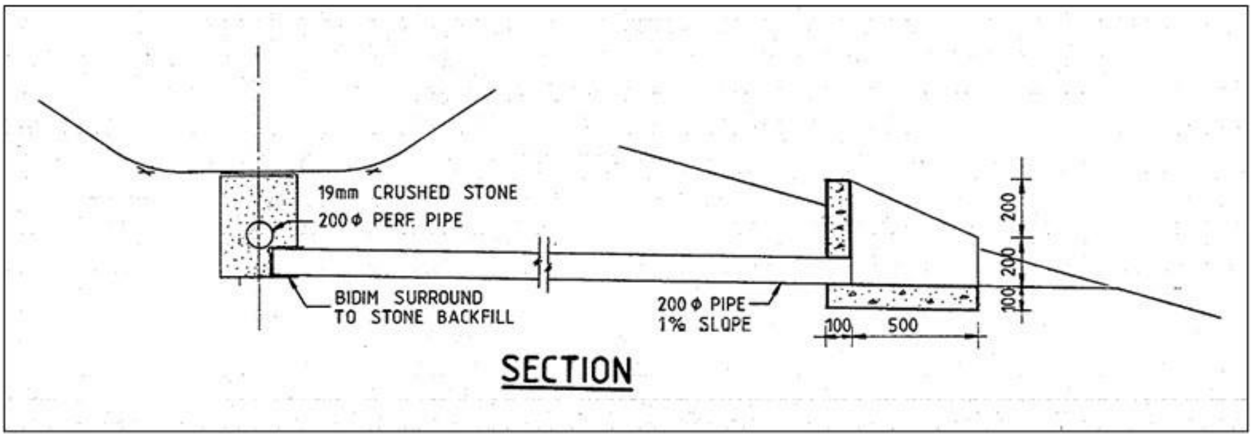


Figure 8-5: Typical section through cross underdrainage

8.3.8 Storm Water and Cross-Drainage Culverts

The new canal will create storm water catchments on natural slopes or when crossing natural drainage lines. To account for this, a storm water drain shall be constructed to intercept the natural flow. In the case where the canal is in cut, this drain shall be located where the cut daylights to the natural ground level on the upstream side of the canal. In the case where the canal is in fill, the drain shall be placed at the bottom of the fill. See **Figure 8-3** in **Section 8.3.4** for the location of this storm water drain. The drain shall be trapezoidal in shape, with a bottom width of 1 000 mm and a depth of 1 000 mm. The side slopes shall be 1:1 and sufficiently protected from erosion by means of either a concrete lining or drop structures, depending on the slope and flow characteristics.

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

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

8.3.9 Overhaul and Limited Haul

A cut-fill balance is important for the economy of the canal. It is not always possible to achieve this balance due to the topography of the natural ground together with other design parameters. When a cut-fill balance cannot be achieved, material needs to be imported from borrow pits where there is more fill or spoiled in spoil areas where there is less fill.

The route of the canal achieves a cut-fill balance over several reaches, indicating that there will be very limited mass haul needed. Where fill is needed under the canal, the material can be obtained by the cut material in adjacent canal reaches.

8.3.10 Flow Measurement

Flow measurement should be incorporated into the canal design to improve the water management of the system, including loss detection and management of flow in the canal. The use of Crump weirs for flow measurement is recommended. A drawing of a crump weir is included in the Appendices of the *Right Bank Canal Design Sub-Report* (Drawing. No. 113834-1000-DRG-CC-0004).

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

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

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

Ideally flow measurement structures should be provided at each of the new canal off-takes (refer to **Section 8.3.14**) to improve the performance monitoring of the canal and improve the water management of the system.

8.3.11 Rejects

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

8.3.12 Canal Road Access

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

8.3.13 Special Considerations of the Left Bank Canal Upgrade

There are some other considerations that are particular to the upgrading of the Left Bank Canal, most notable the fact that the existing canal would be closed during construction. To overcome this, it would be necessary to pump water from the Olifants River into the existing canal downstream of the 3 km section to be upgraded. A flow of approximately 12 000 m^3/h (3.33 m^3/s) would need to be pumped at a head of 20 m, over a distance of 75 m from the Olifants River to the canal.

It is anticipated that upgrading of the canal could be completed during the 20-week low-flow period. However, there is a potential risk of delays during construction resulting in higher costs related to temporary pumping. To mitigate this risk the construction can be undertaken over two consecutive calendar years. Electrical power supply sources will need to be investigated for the temporary pumping.

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

8.3.14 New Canal Off-Takes

New off-takes from the canal will be required to supply the irrigation blocks of the proposed development options, such as the new irrigation schemes in the Trawal area (refer **Table 8-3**). The off-takes will either be supplied under gravity or via a pump system due to the topography of the irrigation areas. Refer to Section 5.4 of the '*Right Bank Canal Design Sub-report*' for details of the gravity and pump station off-takes, and flow measurement.

Table 8-3: Off-take demands for new irrigation developments

Off-take	Average flow (m^3/s)	Peak flow rates (m^3/s)
Zypherfontein 1	0.201	0.437
Zypherfontein 2	0.186	0.355
Trawal	0.154	0.404
Melkboom	0.166	0.360

The existing Doring canal section (on the right bank upstream of Verdeling) will be phased out once the Right Bank Canal Scheme has been completed. This will require that the farmers currently being supplied by the Doring canal be provided with off-take points from the Right Bank Canal.

8.4 Syphons

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

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

8.4.1 Routing of Syphons

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

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

8.4.2 Hydraulic Design

Syphons are designed to minimise frictional losses as far as possible to ensure that the tie-in at Verdeling has a positive head of at least 1.0 m. The syphons were designed in accordance with the design parameters listed in **Table 8-4**.

Refer to **Figure 8-6** for a cross-section of a typical underground steel pipe syphon installation. **Figure 8-7** shows a cross-section of a typical concrete rectangular portal culvert syphon installation.

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

Table 8-4: Syphon design parameters

Parameter	Syphon 1	Syphon 2A	Syphon 2B
From Chainage – approx. (m)	3 050	21 910	23 860
To Chainage – approx. (m)	3 350	23 180	24 700
Elevation at start (masl)	60.40	55.65	53.87
Elevation at end (masl)	59.29	54.00	52.68
Length (m)	300	1 270	840
Type	X42 Steel pipe	Reinforced concrete culvert	Reinforced concrete culvert
Shape	Circular	Rectangular	Rectangular
Size (mm)	DN 2400	2800 x 2400 (W x H)	2800 x 2400 (W x H)
Wall thickness (mm)	16	400	400
Design friction coefficient k_s (aged pipe) (mm)	0.15	2.0	2.0
Design discharge (m^3/s)	11.4	11.4	11.4
Design velocity (m/s)	2.48	1.70	1.70
Design head loss, including friction and local head losses (m)	1.11	1.65	1.19

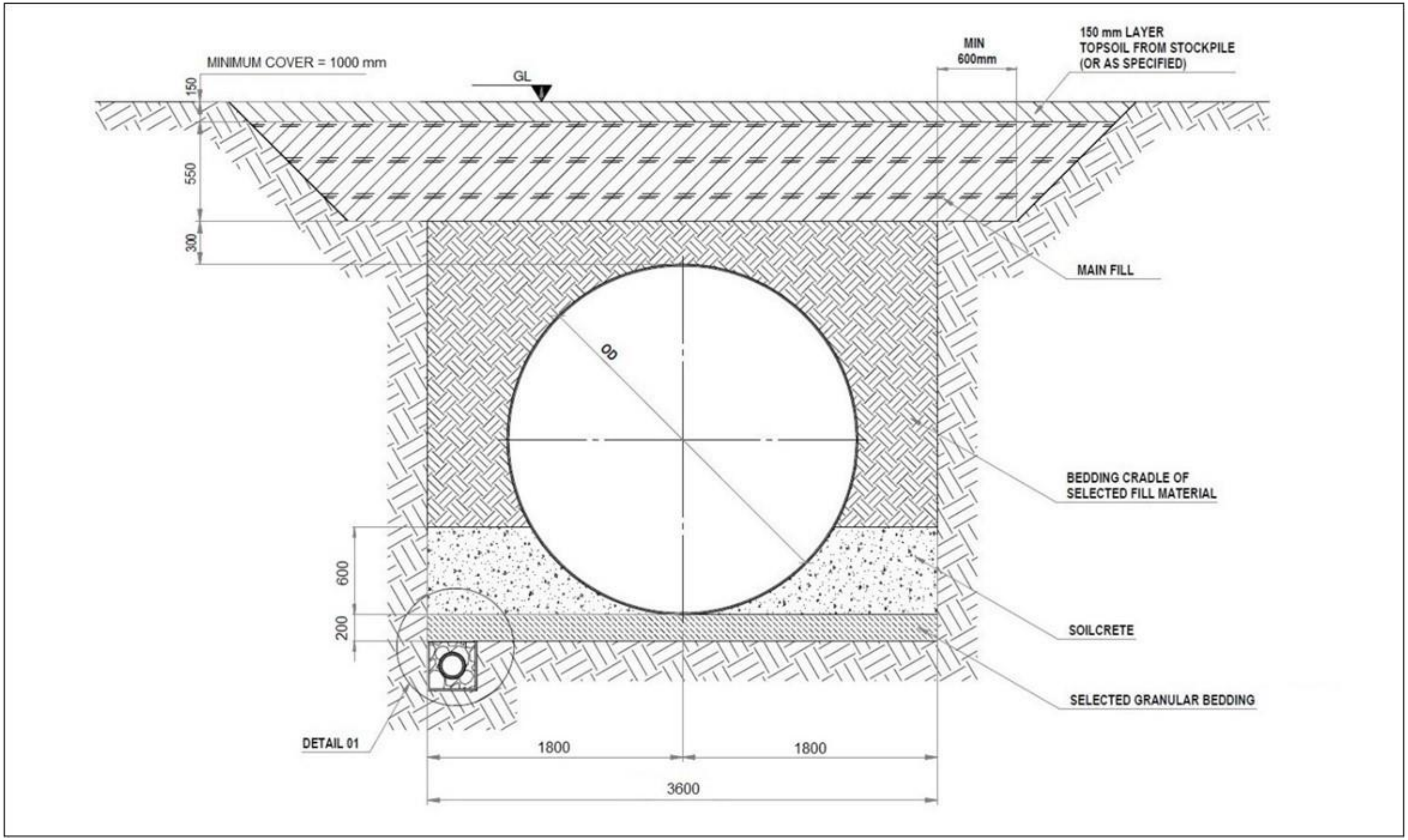


Figure 8-6: Typical cross-section of Syphon 1 – underground portion of pipe installation

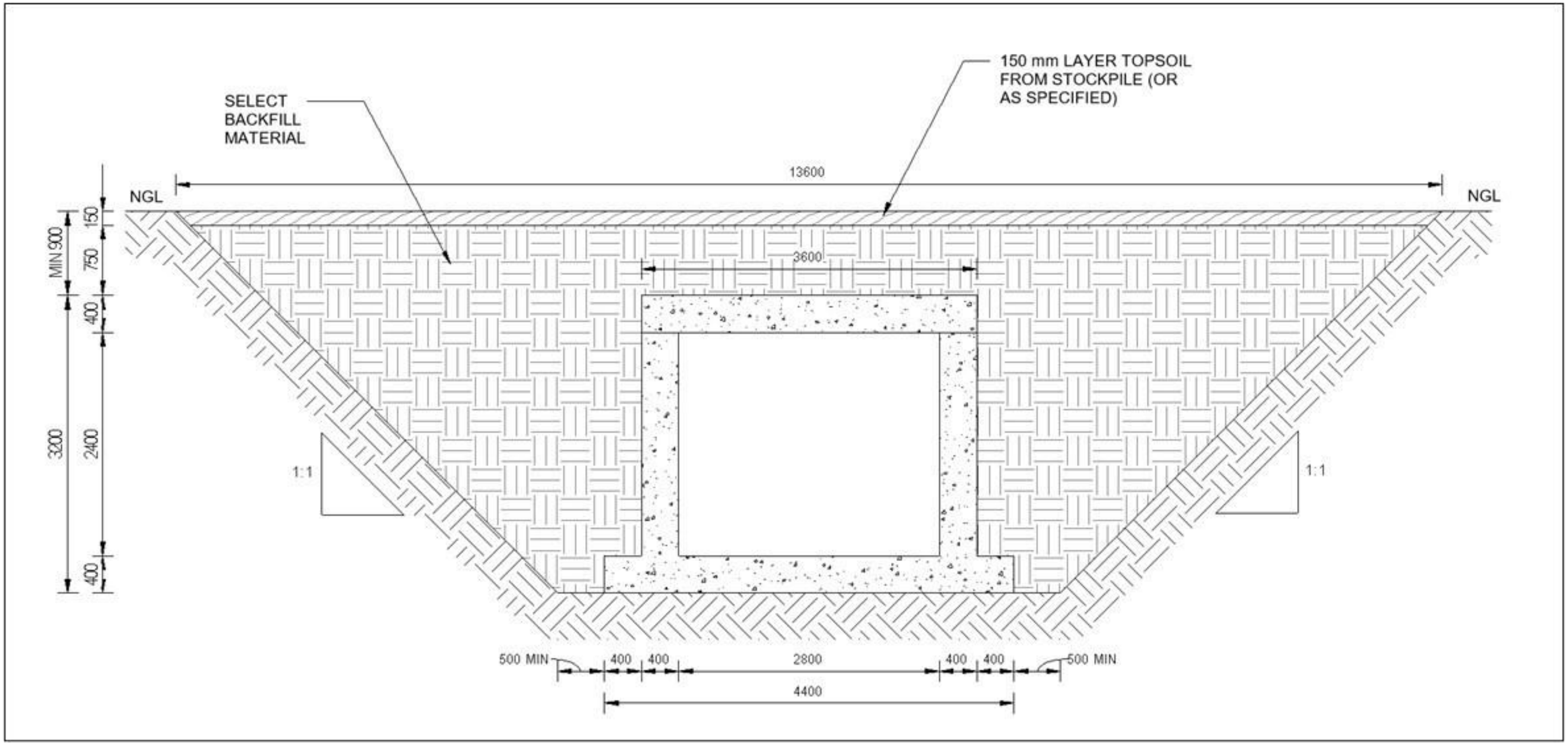


Figure 8-7: Typical cross-section of Syphon 2 - rectangular portal culvert

8.4.3 Installations Above and Below Ground

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

A drawing of a typical pipe bridge is included in the Appendices of the *Right Bank Canal Design Sub-Report* (Drawing. No. 113834-1000-DRG-CC-0010).

Syphon 2 is placed below ground to allow future farming development over the syphon. The Doring River is a perennial river and it would make sense to construct the syphon below ground during the dry season. There would be no need for a pipe bridge or pipe jacking, which are both impractical for these sites.

8.4.4 Syphon Inlet Structure

The Syphon 1 inlet on the left bank, consisting of an open reinforced concrete structure, will supply flow to the Right Bank Canal, across the Olifants River, and also service the now secondary Left Bank Canal. The structure will thus have a side syphon inlet, with gates that can control the flow for either the new Right Bank Canal or the existing Left Bank Canal.

The inlet structure is to be provided with a trash rack at the entrance to screen out large floating debris and reduce possible ingress of any other foreign material into the syphon pipe. A long weir reject with erosion protection is also provided upstream of the Syphon 1 intake. Silt will be flushed out of the syphon using scour valves. A required submergence depth of 1.7 m was determined to ensure a sufficient hydraulic seal, and care should be taken to ensure that this depth is covered during detailed design. All losses through the trash rack were considered.

Figure 8-8 shows the Syphon 1 inlet. A drawing of a typical syphon inlet for the Right Bank Canal is provided in the Appendices of the *Right Bank Canal Design Sub-Report* (Drawing. No. 113834-1000-DRG-CC-0006).

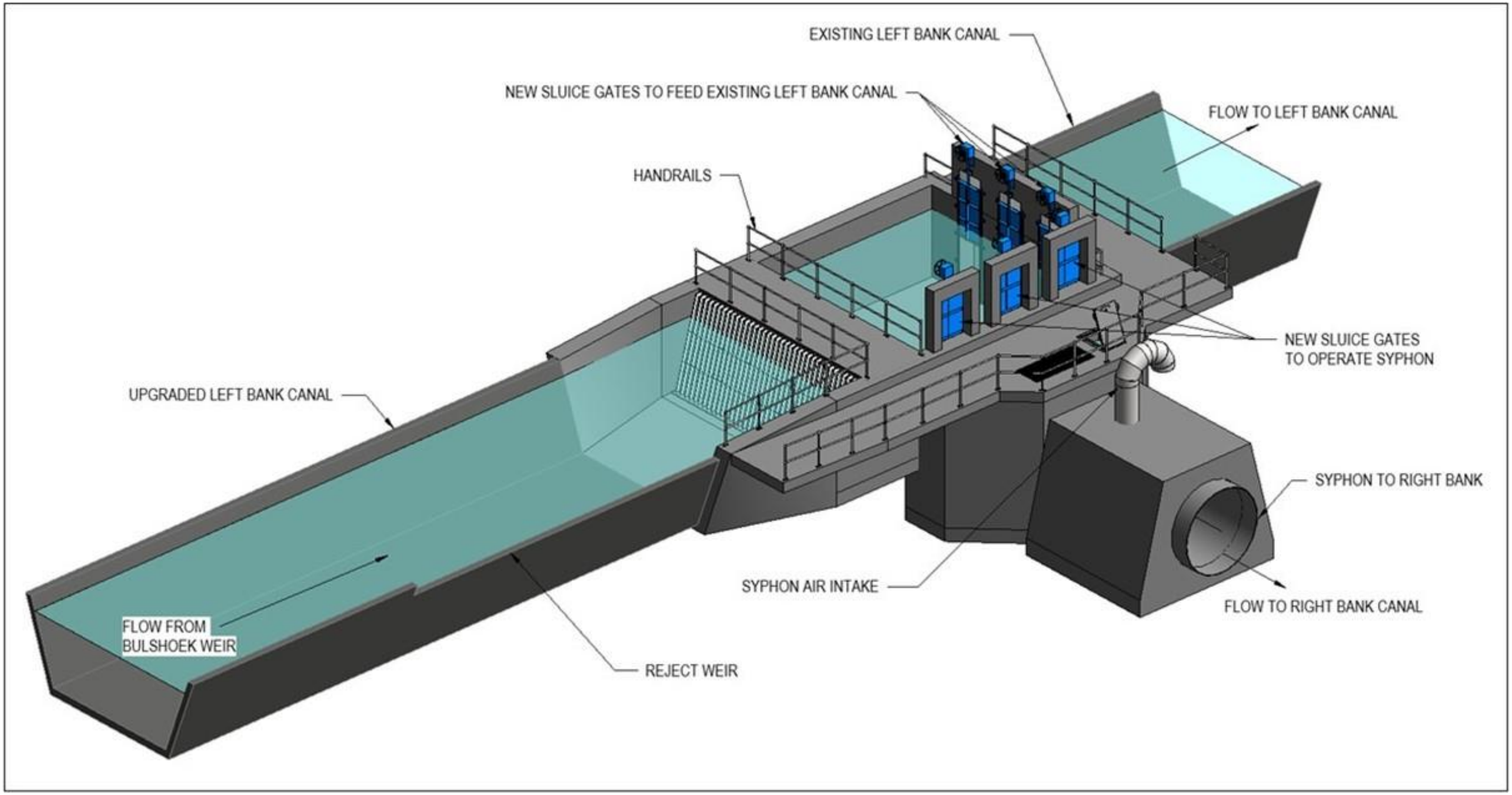


Figure 8-8: Left Bank Canal syphon inlet structure (Syphon 1)

8.4.5 Syphon Outlet Structure

An open reinforced concrete structure is proposed for the typical syphon outlet. All three syphon outlet structures will be similar as there are no unique requirements at any of the outlets. A drawing of a typical syphon outlet is provided in the Appendices of the *Right Bank Canal Design Sub-Report* (Drawing. No. 113834-1000-DRG-CC-0007).

8.4.6 Syphon Dewatering

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

Scour valve chambers will be used to house the scour valves. Details of a typical scour chamber and mechanical arrangement are shown in **Figure 8-9**. The scour valve chamber can be optimised during the detailed design of the system.

Orifice plates should be incorporated to limit flow velocities through the valves and to prevent cavitation of the scour pipes downstream of the orifice plates. Single orifice plates will be used where the pressure is less than 30 m. Two orifice plates will be used where the pressure exceeds 30 m.

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

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

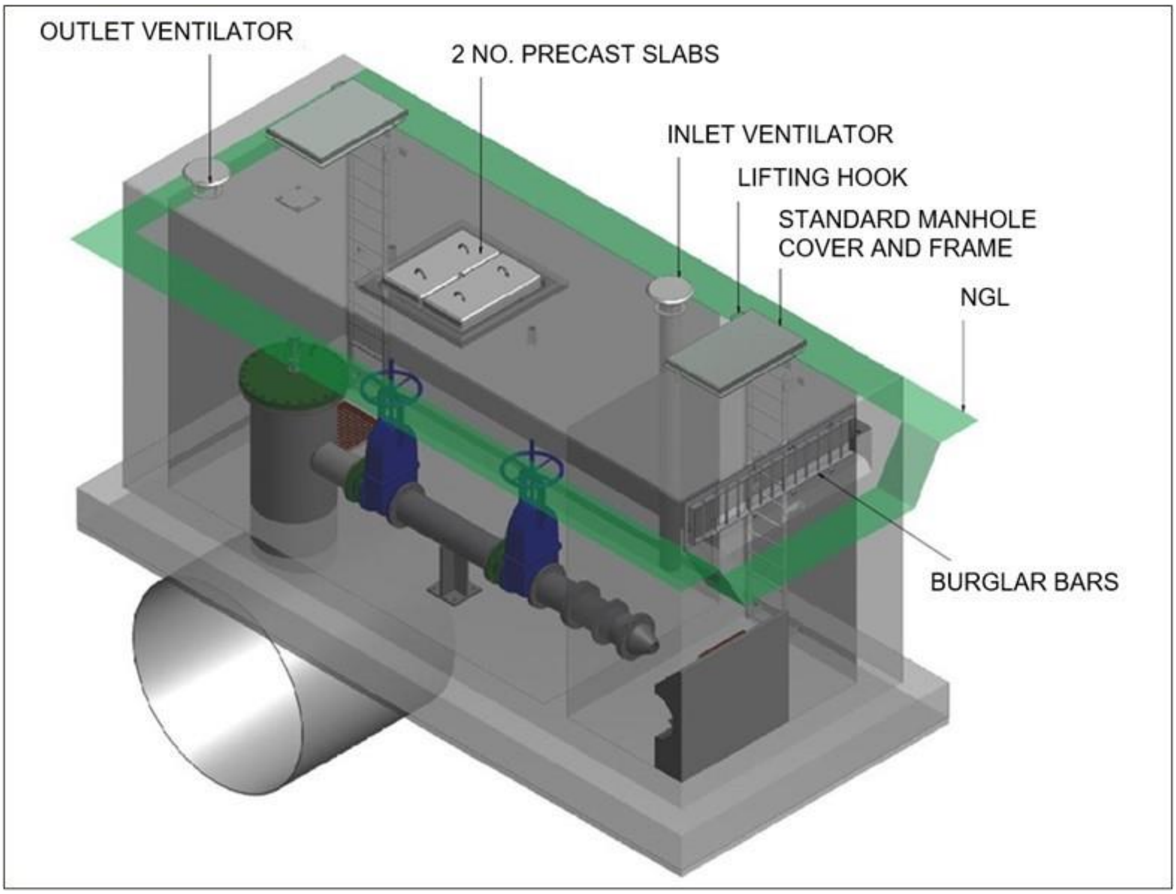


Figure 8-9: Typical scour detail for syphons

8.4.7 Air Valves on Syphon

Sizing and positioning of air valves is based on the rate at which air will be introduced or expelled from the pipeline, taking account of the following:

- Filling conditions;
- Dewatering conditions;
- Pipe rupture;
- Normal operating conditions;
- Scour points; and
- Total head.

Care should be taken to provide at least 5 m of positive head at an air valve to ensure that it closes properly.

A typical air valve chamber and mechanical arrangement is shown in **Figure 8-10**.

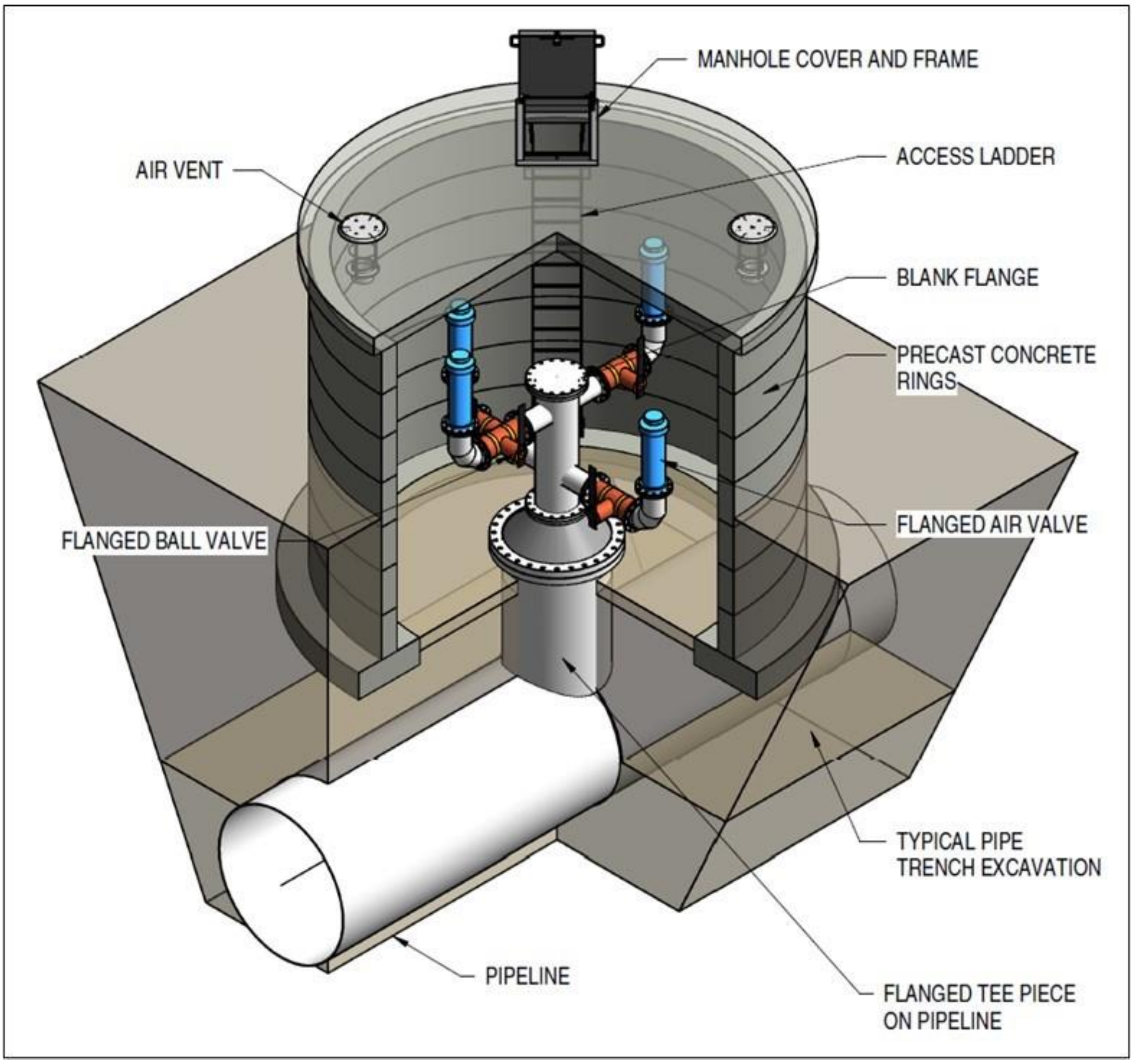


Figure 8-10: Typical air valve chamber

8.5 Existing Verdeling Syphon

8.5.1 Existing Outlet Structure and Syphon

The proposed Right Bank Canal needs to tie in with the existing syphon at Verdeling. This syphon currently operates by conveying flow from the Left Bank Canal, across the Olifants River, to the outlet and distribution canals on the right bank. At the outlet the flow divides west and south-east. The south-eastern small canal (Doring section) will be replaced by the new Right Bank Canal. **Figure 8-11** shows the existing Verdeling syphon and its operation.

According to correspondence with design engineers of the syphon at Verdeling (Element Consulting Engineers), it is a DN 2000 steel pipe and approximately 650 m long. The current left bank inlet's operating level is at 50.443 masl and the right bank outlet's operation level is at 49.488 masl.

In the '*Right Bank Canal Design Sub-report*', it was concluded that the syphon does not currently operate at its peak capacity and that there should be spare head room for increased flows from the left bank to the right bank.

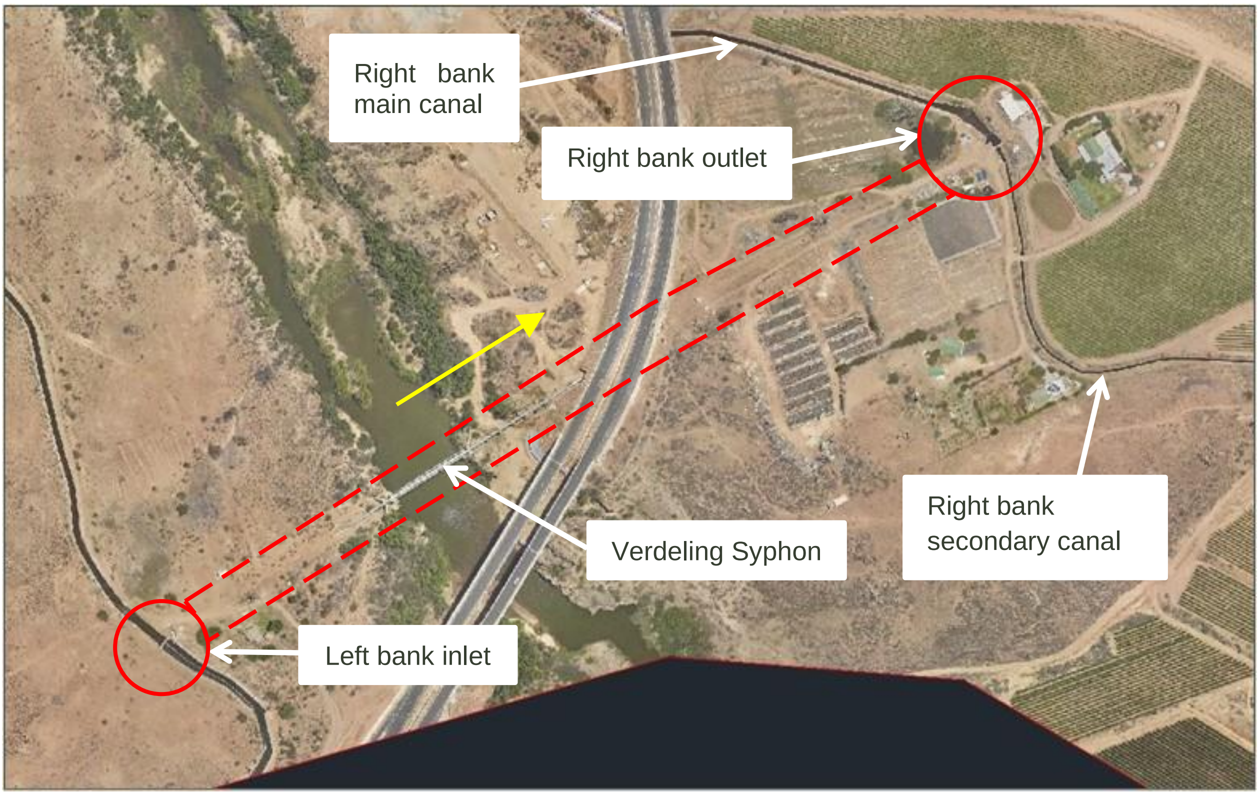


Figure 8-11: Layout and operation of existing Verdeling Syphon

8.5.2 Proposed Inlet Structure

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

Refer to the new inlet structure drawing included in the Appendices of the *Right Bank Canal Design Sub-Report* (Drawing. No. 113834-1000-DRG-CC-0008).

As the current syphon has a physical level difference of approximately 0.96 m to accommodate the design flow from left bank to right bank, the height of the proposed new inlet must be increased by at least the 0.96 m, plus the design head difference, to reverse the flow (as discussed in **Section 8.5.4**). The walls of the new inlet will be placed on top of the existing structure and strengthened. Vertical sluice gates will control the flow through the syphon and to the existing right bank distribution canal. A Crump weir flow measuring station must be placed downstream of the inlet to confirm flow to the right bank distribution canal. A trash rack will be placed upstream of the inlet, as well as a reject with relevant erosion protection and a stream path back to the river.

The design water level in the new inlet structure is **51.000 masl**, and wall height (including freeboard) is 51.500 masl. The current operating water level in the left bank inlet is 50.443 masl, which gives 0.557 m of positive pressure head. As evident in the hydraulic calculations shown in **Section 8.5.4** below, this is more than the minimum required head of 0.504 m by a factor of safety of at least 1.1. It must also be noted that the pipe roughness chosen for the hydraulic calculations is conservative, and as explained in **Section 8.5.3** below, the design flow is still more than the capacity of the Left Bank Canal.

8.5.3 New Syphon Design Flow Capacity

The total peak design flow rate for the reversed Verdeling Syphon is calculated as **4.02 m^3/s**, as shown in **Table 8-5**. Refer to Section 7.3 of the '*Right Bank Canal Design Sub-report*' for details on the design flow capacity.

Table 8-5: Verdeling Syphon peak design flow rates

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

8.5.4 Proposed Reversed Verdeling Syphon Hydraulics

The reversed (right bank to left bank) syphon duty is based on the above total peak design flow rate of 4.021 m^3/s. As the pipe diameter and design flow rate are fixed, the available head and assumed pipe roughness will equate to the flow velocity. The scenario of an old syphon with maximum flow and higher friction factors (aged pipe) was investigated. An aged steel pipe roughness of 0.15 mm was assumed, and the hydraulics are shown in **Table 8-6**.

Table 8-6: Verdeling Syphon design parameters

Parameter	Reversed Verdeling Syphon
Length (m)	650
Elevation at start (masl)	51.000
Elevation at end (masl)	50.443
Type	X42 Steel pipe
Shape	Circular

Parameter	Reversed Verdeling Syphon
Size (mm)	DN 2000
Wall thickness (mm)	14
Design friction coefficient k_s (aged pipe) (mm)	0.15
Design discharge (m^3/s)	4.021
Design velocity (m/s)	1.275
Available head difference between upstream and downstream end of syphon (m)	0.557
Design head loss, including friction and local head losses (m)	0.504

8.6 Recommendations for Detailed Design

The following recommendations are applicable to the detailed design and construction phases of the Right Bank Canal Scheme:

a) If the required design flow capacity is revised, the scheme routing and sizing of infrastructure should be amended.

b) A more detailed analysis and survey of the existing Bulshoek Weir Outlet should be conducted to verify the capacity. This could influence the decision to increase the canal capacity, which could require alterations to the current outlet.

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

d) A ground centreline survey needs to be done along the final chosen canal routes, prior to construction commencing. This will serve as a final check on the canal's vertical alignment and verification of the survey data.

e) The canal routes and infrastructure locations will need to be confirmed, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

f) Consider adjusted offtake points for the four new irrigation developments, should information be available.

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

h) Investigate the influence of the approved Marblesharp farm dam, located on the proposed Zypherfontein 1 irrigation scheme, on the horizontal alignment of the canal route.

9 Scope of Work for the Ebenhaeser Scheme

9.1 Overview of the Scheme

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

The Lower Olifants River Water Users Association (LORWUA) has requested that balancing storage of 150 000 m^3 be added to the storage volume of the balancing dam, to be used for stabilising the operation of the lower sections of the existing right and left bank canals. LORWUA has also requested that the scheme be able to divert 24 Mℓ/d (0.278 m^3/s) back from the balancing dam, which can be discharged into the right (12 Mℓ/d) and left bank (12 Mℓ/d) canals, respectively, at times of low flow in the canal.

Figure 9-1 and **Figure 9-2** show the layout and bulk water infrastructure components for the Ebenhaeser Scheme.

The *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* provides details of the feasibility design of the scheme.

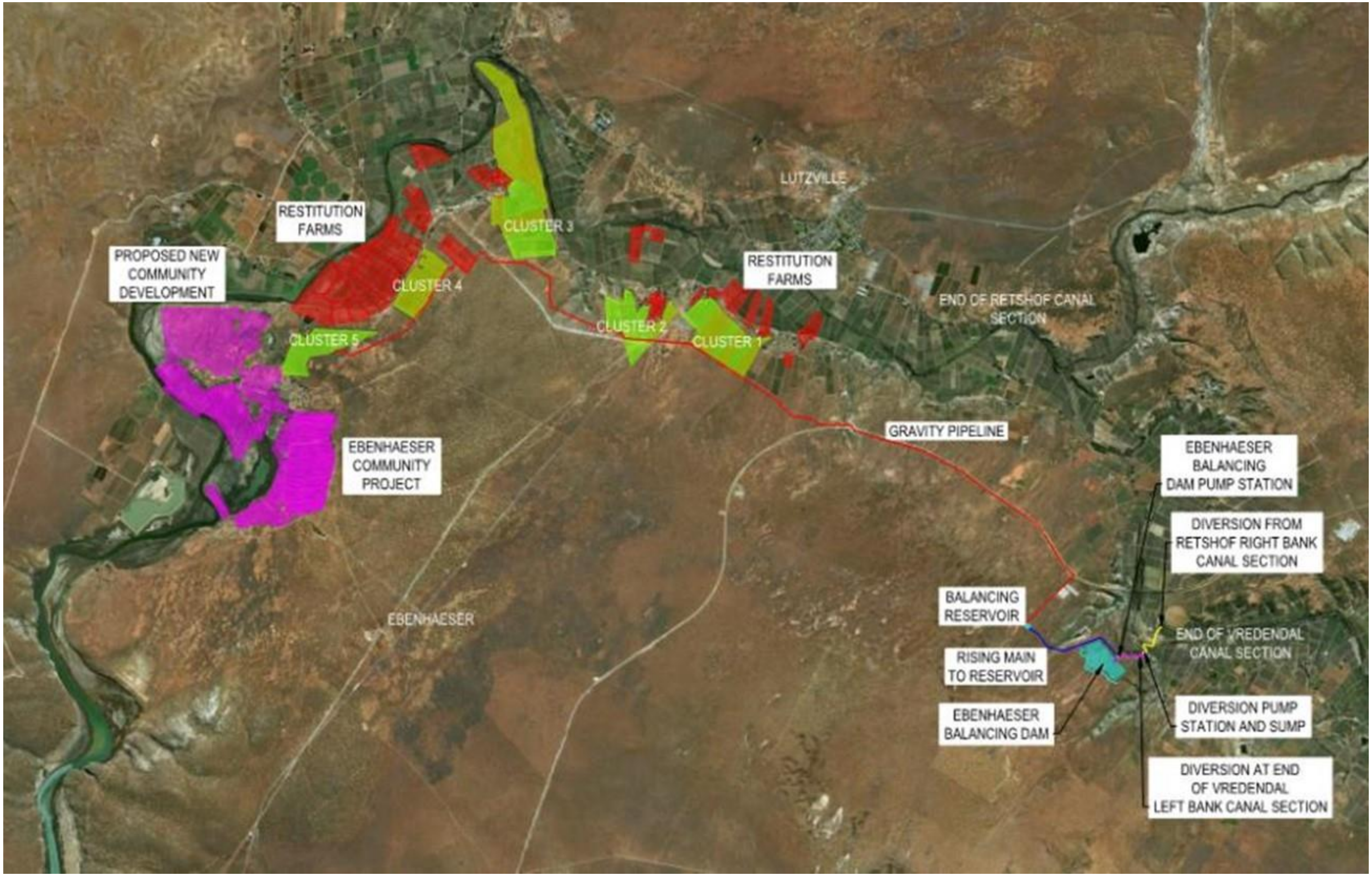


Figure 9-1: Layout of Ebenhaeser Scheme

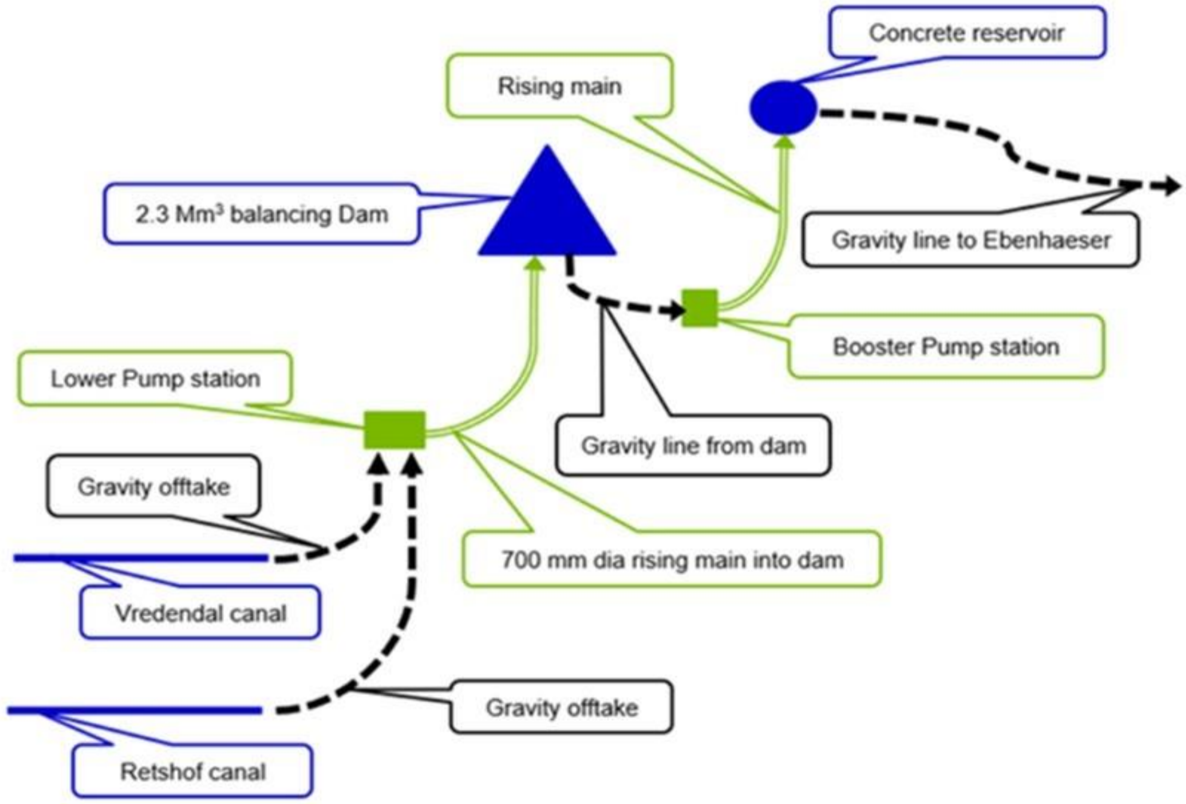


Figure 9-2: Schematic Layout of Ebenhaeser Scheme

9.2 Canal Diversion Structures

Two diversion structures will be required, on the right bank canal at Retshof and on the left bank canal at Vredendal, respectively.

The diversion point in the right bank Retshof canal section is in the middle of a long bend, reasonably close to the Sishen-Saldanha railway line.

The proposed diversion point in the left bank Vredendal canal section is in a cutting upstream of a long weir, just upstream of a tunnel.

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

The proposed diversion structure configurations are shown in **Figure 9-3** (typical section view) and in **Figure 9-4** (typical plan view).

Detail of the Retshof right bank canal offtake is shown on drawing 113834-0000-DRG-CC-0103 and detail of the Vredendal left bank canal offtake is shown on drawing 113834-0000-DRG-CC-0106 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*.

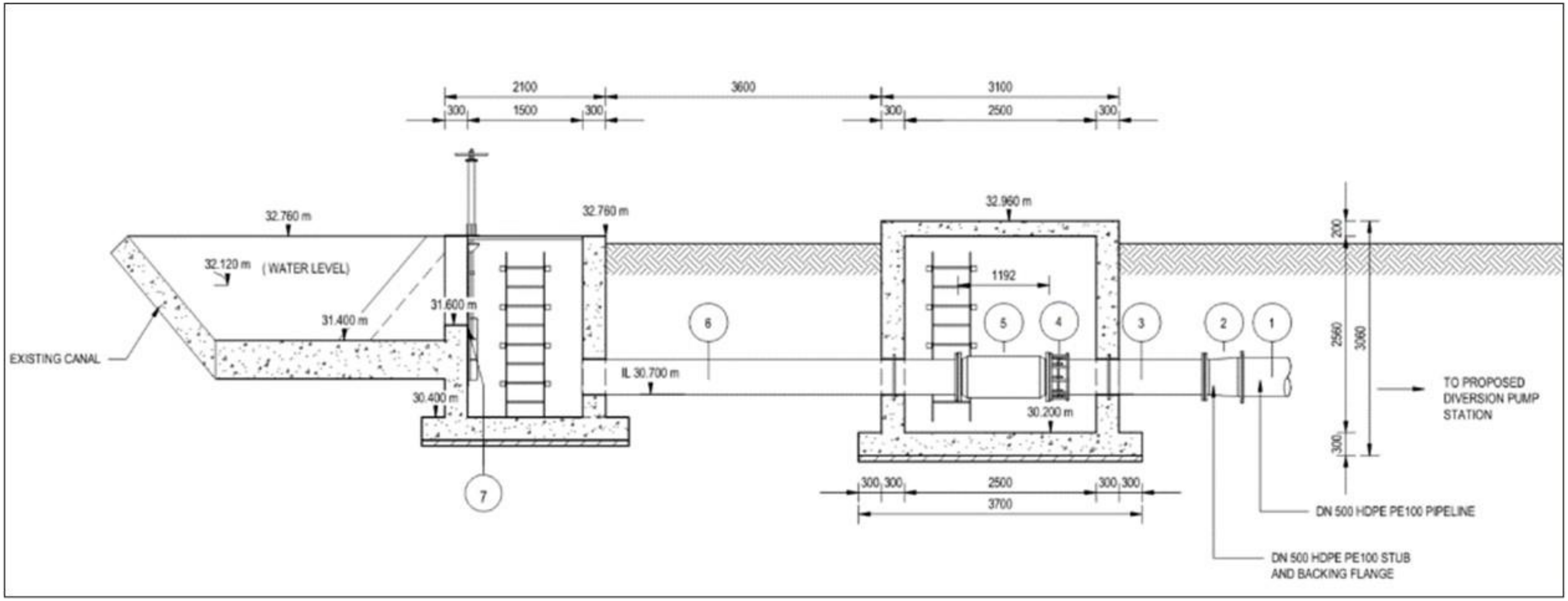


Figure 9-3: Typical section of Canal Diversion Structure

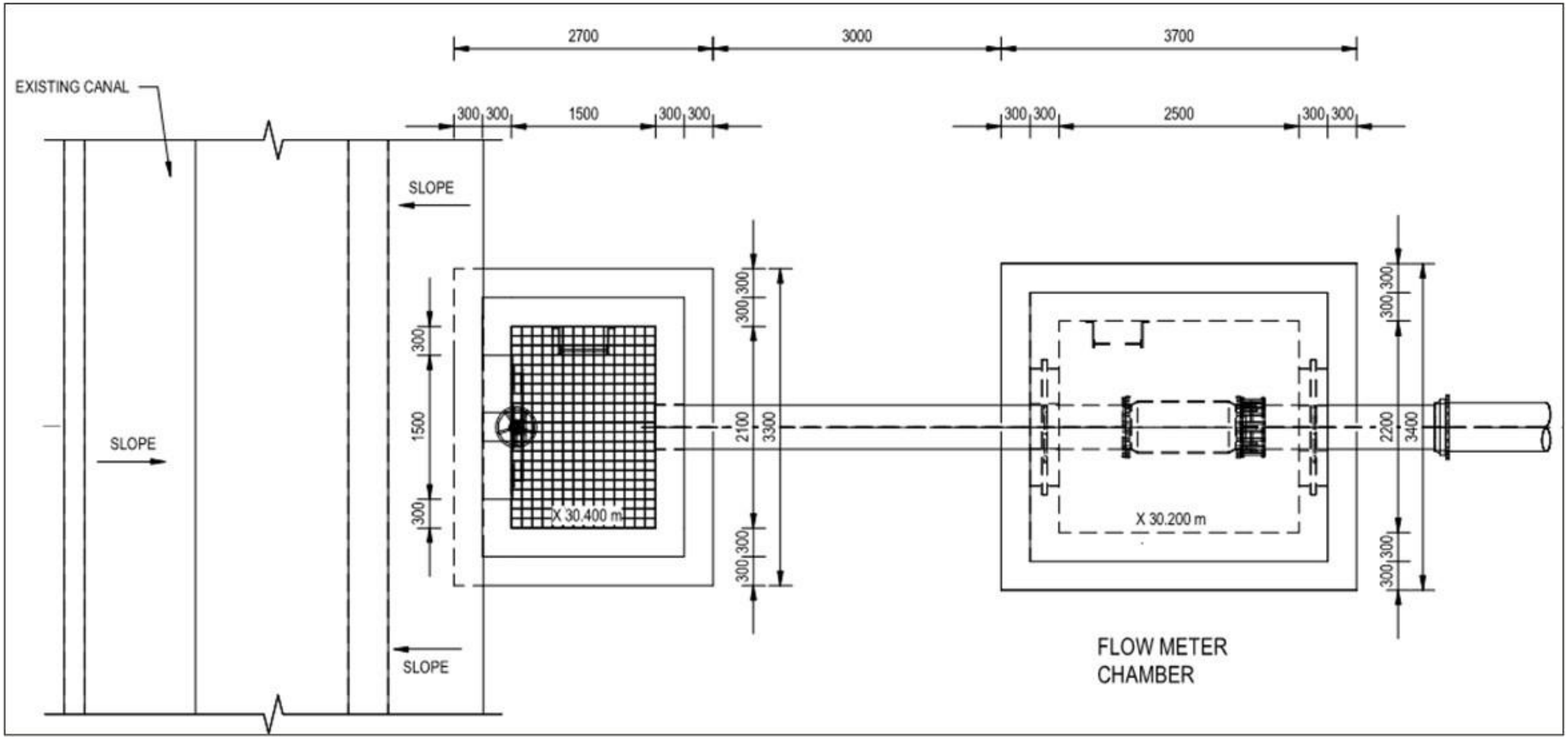


Figure 9-4: Typical plan view of Canal Diversion Structure

9.3 Diversion Gravity Pipelines

9.3.1 Description of the pipelines

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

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

From the sump, the raw water will be pumped to the Ebenhaeser balancing dam. The design flow for the right bank canal diversion gravity main is 0.29 m^3/s, as recommended in the *Conceptual Design Sub-Report*. The design flow for the left bank canal diversion gravity main is 0.36 m^3/s. The proposed horizontal pipeline alignments for the diversion gravity pipelines are shown on the layout drawing 113834-0000-DRG-CC-0101 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*.

Figure 9-5 shows the hydraulic gradient line of the Retshof Canal Diversion Gravity Main for a flow of 25.5 Mℓ/d (0.29 m^3/s) and using a DN 500 HDPE pipe.

It is evident from **Figure 9-5** that a residual pressure of approximately 18 m would be available at the inlet to the sump. The DN 500 HDPE pipe will result in a velocity of 1.94 m/s at a flow of 25.5 Mℓ/d. This high velocity is preferred to ensure that sediment remains in suspension in the syphon underneath the Olifants River.

Figure 9-6 shows the hydraulic gradient line of the Vredendal Canal Diversion Gravity Main for a flow of 30.80 Mℓ/d (0.36 m^3/s) and using a DN 560 HDPE pipe.

It is evident from **Figure 9-6** that the residual head at the inlet to the sump would be approximately 25 m. The DN 560 HDPE pipe will result in a velocity of 1.89 m/s at a flow of 30.8 Mℓ/d.

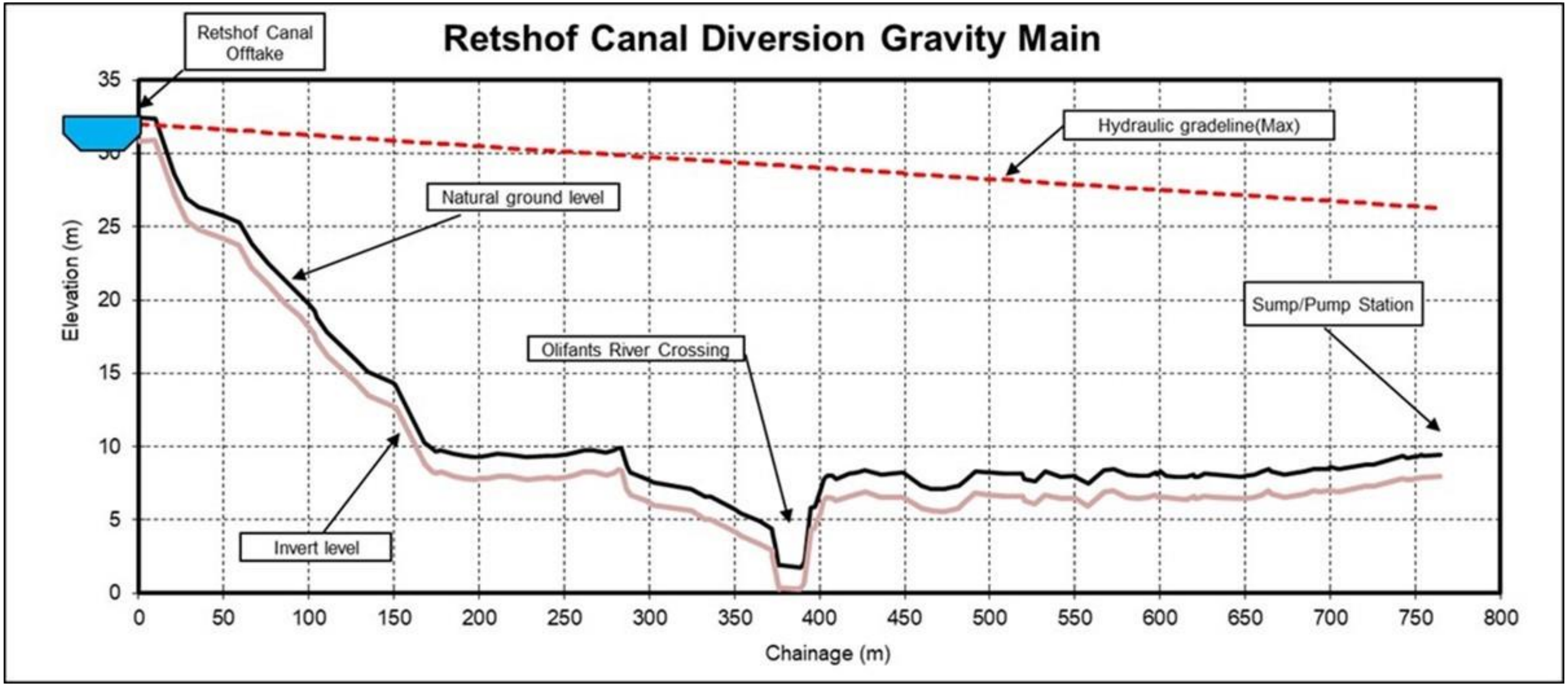


Figure 9-5: Right Bank Canal Diversion Gravity Main: HGL for 25.5 Mℓ/d in aged DN 500 pipeline

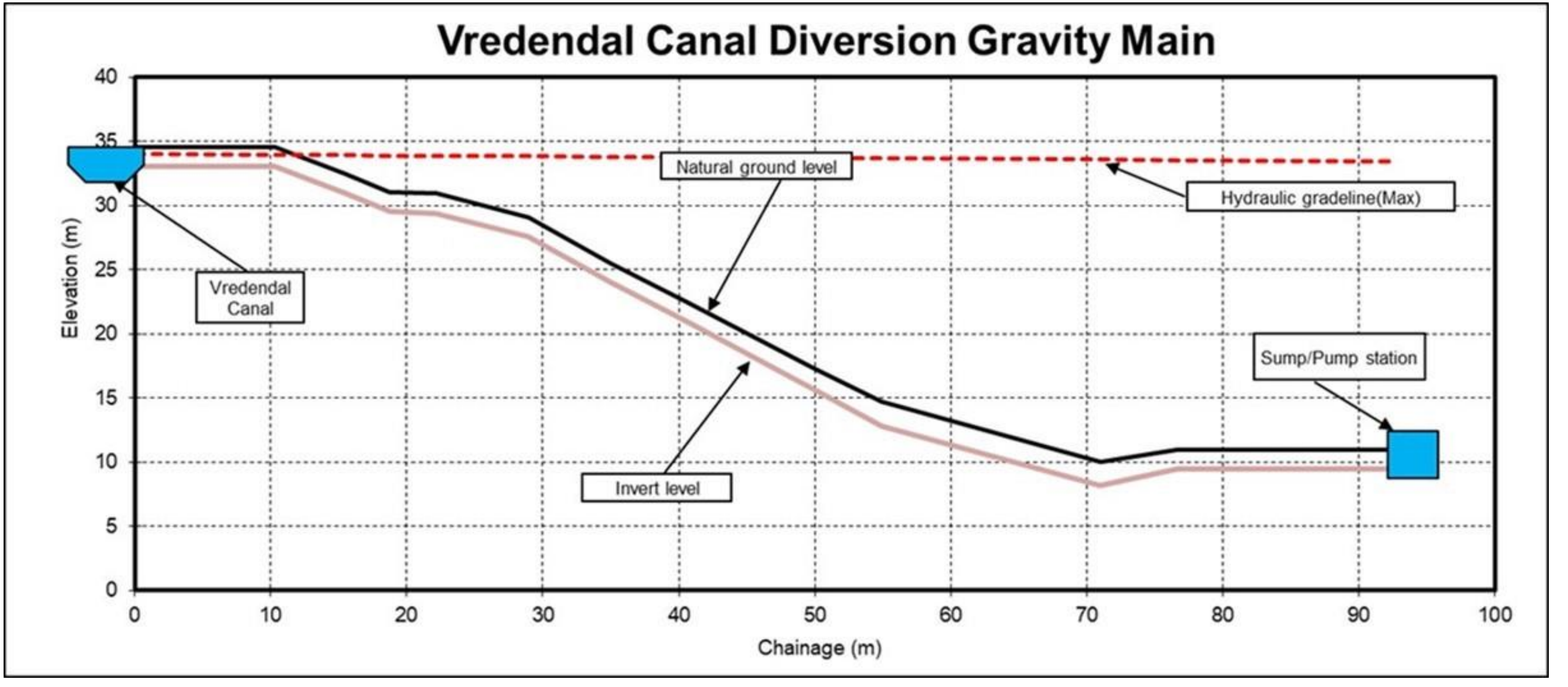


Figure 9-6: Left Bank Canal Diversion Gravity Main: HGL for 30.80 Mℓ/d in aged DN 560 pipelines

9.3.2 Olifants River Crossing

A syphon will be required to cross the Olifants River on the diversion gravity main from the Retshof right bank canal. The crossing is located approximately 380 from the Retshof canal offtake point, and the length across the river is approximately 37 m. Refer to Section 5.3.3 in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* for above and below ground installation considerations.

It is recommended that a below ground syphon crossing be implemented using a DN 500 stainless steel pipe.

Typical details for a below ground concrete encased crossing and a crossing undertaken by means of directional drilling are shown in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* on drawings 113834-0000-DRG-CC-0117 and 113834-0000-DRG-CC-0118 in Appendix A2.

9.4 Diversion Pump Station and Sump

The diversion sump will collect water from the Retshof and Vredendal canal diversion gravity mains. The pump station will pump the water via the diversion rising main to the Ebenhaeser Balancing Dam.

9.4.1 Pump Duties

A pump configuration of two (2) duty pumps and one (1) standby pump is proposed for the Diversion Pump Station. The details of a commercially available pump that could be used are shown below.

The following information about the KSB ETA 300-400 pump is relevant:

- Impeller size = 400 mm;
- Full-size impeller = 430 mm;
- Hydraulic efficiency of pump = 84.6%;
- NPSH required = 7.2 m;
- Head rise to shut-off = 20%;
- Maximum power absorbed for 400 mm impeller = 180 kW (recommended motor size is 200 kW operating at 1 450 rpm); and
- Maximum power absorbed at duty point = 166 kW.

Figure 9-7 shows the characteristic and pump curves for the diversion pump station.

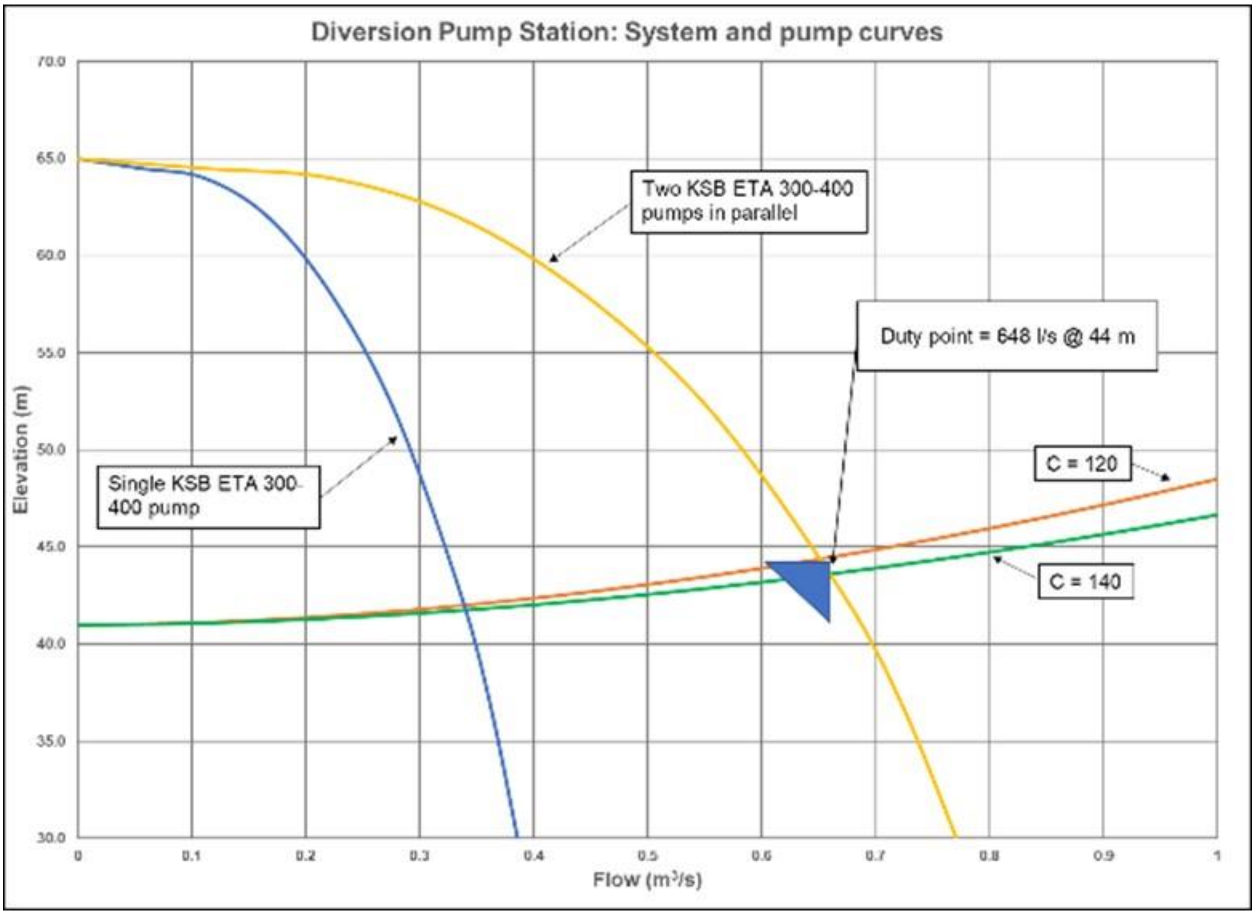


Figure 9-7: Characteristic and pump curve for diversion pump station

It is evident from **Figure 9-7** that the diversion pump station has a duty point of 56 Mℓ/d (0.65 m^3/s) at a total pumping head of approximately 44 m. It is proposed that variable speed drives (VSDs) be installed so that the pump station can match the inflow from the two canal off-takes, which will vary on a daily and weekly basis. The VSDs will require a smaller diversion sump and will reduce the number of stops and starts required.

9.4.2 Diversion sump

The diversion sump is designed to store the flow from the Retshof and Vredendal canals, pumped over a one (1) hour period, i.e. 292 ℓ/s + 356 ℓ/s = 648 ℓ/s pumped over a one hour period, which equates to an active sump capacity of 2 300 m^3 (2.3 Mℓ). It is proposed that a 2 500 m^3 (2.5 Mℓ) sump or reservoir be provided. The sump's minimum operating level is 8.5 masl and the full supply level is 13.5 masl.

The existing power supply is about 130 m from the proposed pump station location. The existing overhead line would need to be extended to the pump station. The layout of the diversion pump station and sump is shown in **Figure 9-8**.

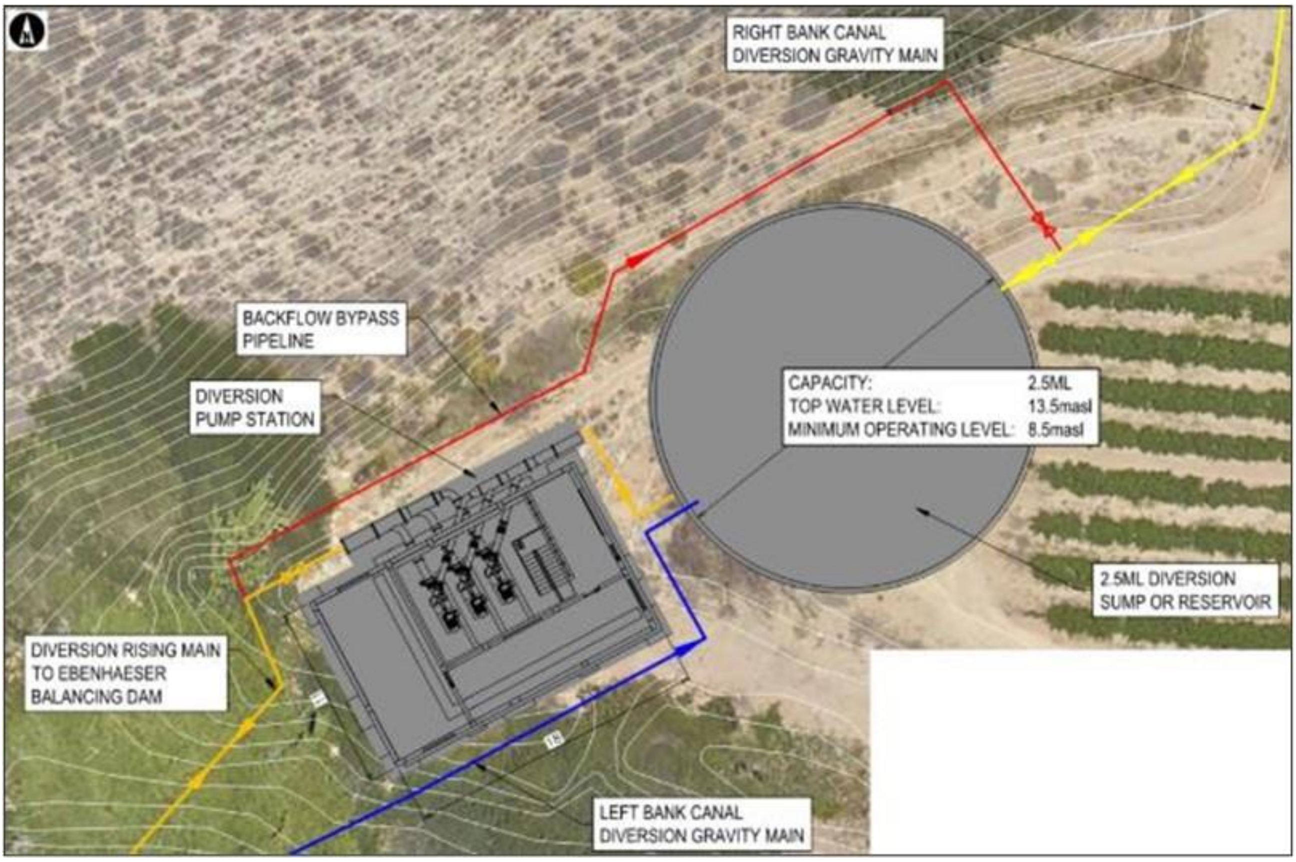


Figure 9-8: Plan view of Diversion Pump Station and Sump

9.5 Diversion Rising Main

9.5.1 Description of pipeline

The proposed diversion rising main (520 m in length) will convey water from the Diversion Pump Station to the Ebenhaeser Balancing Dam. The design flow for the rising main is 0.65 m³/s. It is proposed that a DN 710 HDPE pipe be used, which will result in a velocity of 2.08 m/s. The higher velocity has a minimal impact on the pumping head due to the short length of the rising main. The proposed horizontal pipeline alignment for the diversion rising main is shown in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* on the layout drawing 113834-0000-DRG-CC-0101 in Appendix A2.

Figure 9-9 shows the hydraulic gradient line of the Diversion Rising Main for a flow of 56 Mℓ/d (0.65 m³/s).

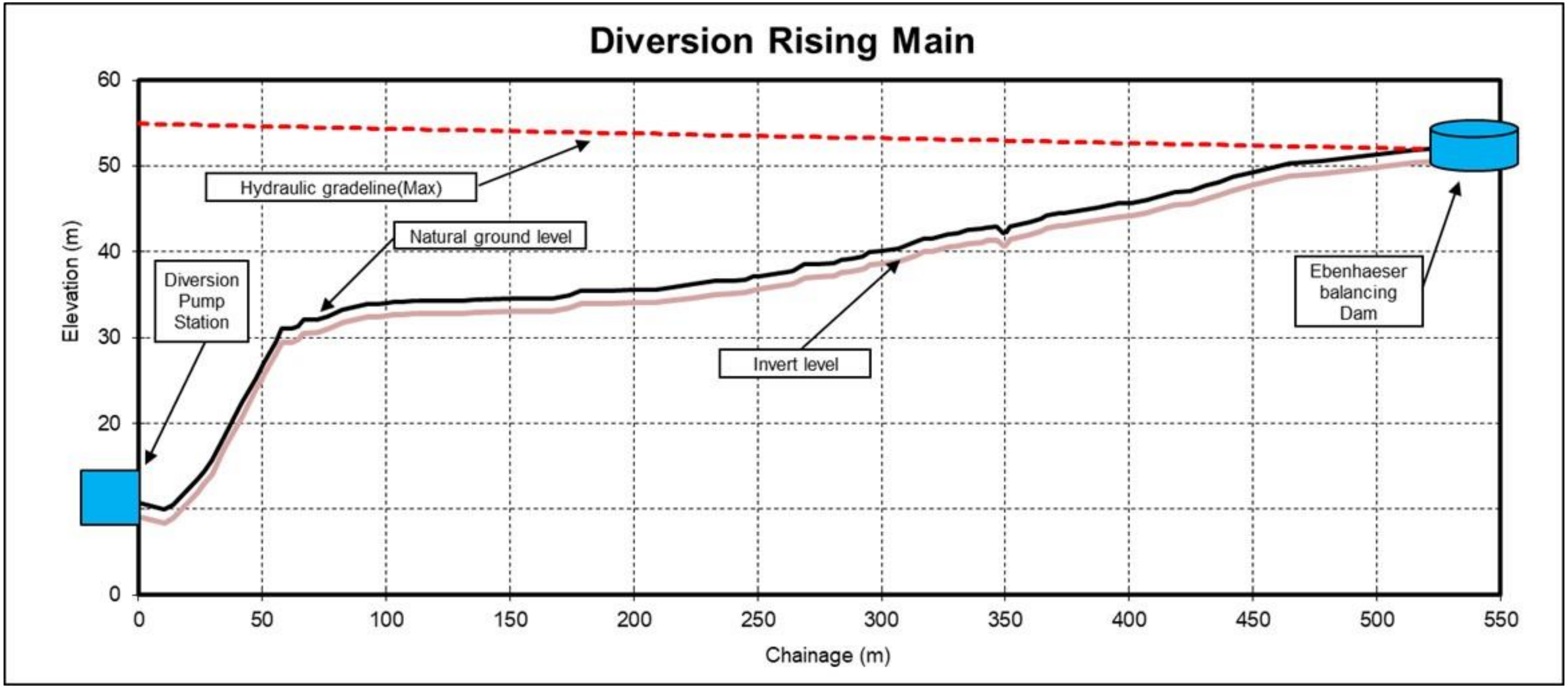


Figure 9-9: Diversion Rising Main: HGL for 56 Mℓ/d in aged DN 710 pipeline

9.6 Ebenhaeser Balancing Dam return flow to canals

The diversion rising mains are designed to allow water from the Ebenhaeser balancing dam to be supplied back under gravity to the Vredendal left bank and Retshof right bank canals when needed. LORWUA has requested a total return flow of 24 Mℓ/d (0.278 m^3/s), i.e. 12 Mℓ/d (0.139 m^3/s) to be supplied to each of the canals. Water will be fed under gravity from the Ebenhaeser Balancing Dam along the diversion rising main with a bypass provided at the diversion pump station to discharge water to the Retshof canal.

Drawing 113834-0000-DRG-CC-0105 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* shows the option to combine the flow meter chambers for the discharge and diversion structure at the Retshof canal. Provision will be made for an additional offtake from the diversion rising main to discharge water into the Vredendal canal.

A typical discharge detail for both canals is shown in **Figure 9-10** and on drawing 113834-0000-DRG-CC-0116 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*. The discharge configuration will have an isolation valve, diaphragm flow control valve and flow meter to monitor the water discharged into the canal.

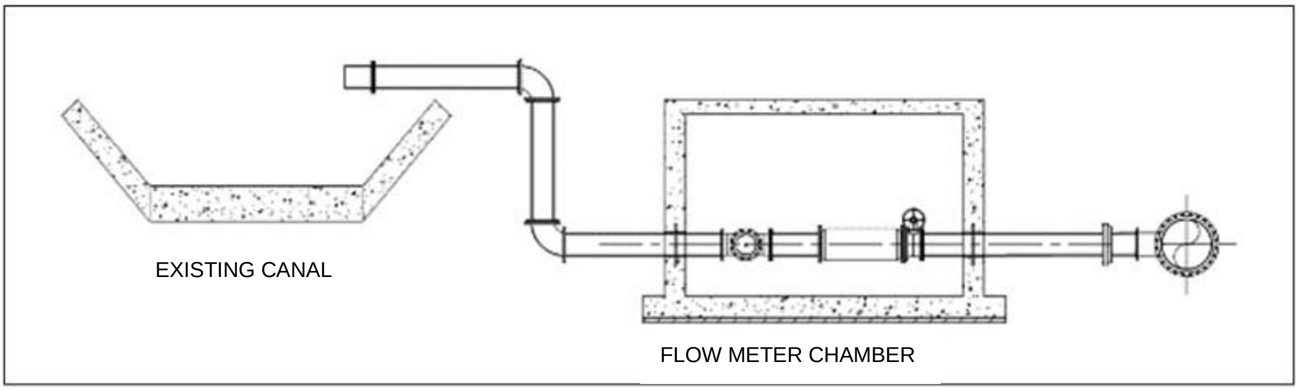


Figure 9-10: Typical detail of canal discharge configuration

Figure 9-11 shows the hydraulic gradient line of the return flow from the Ebenhaeser Balancing Dam Pump Station to the Retshof Canal offtake location for a flow of 24.0 Mℓ/d.

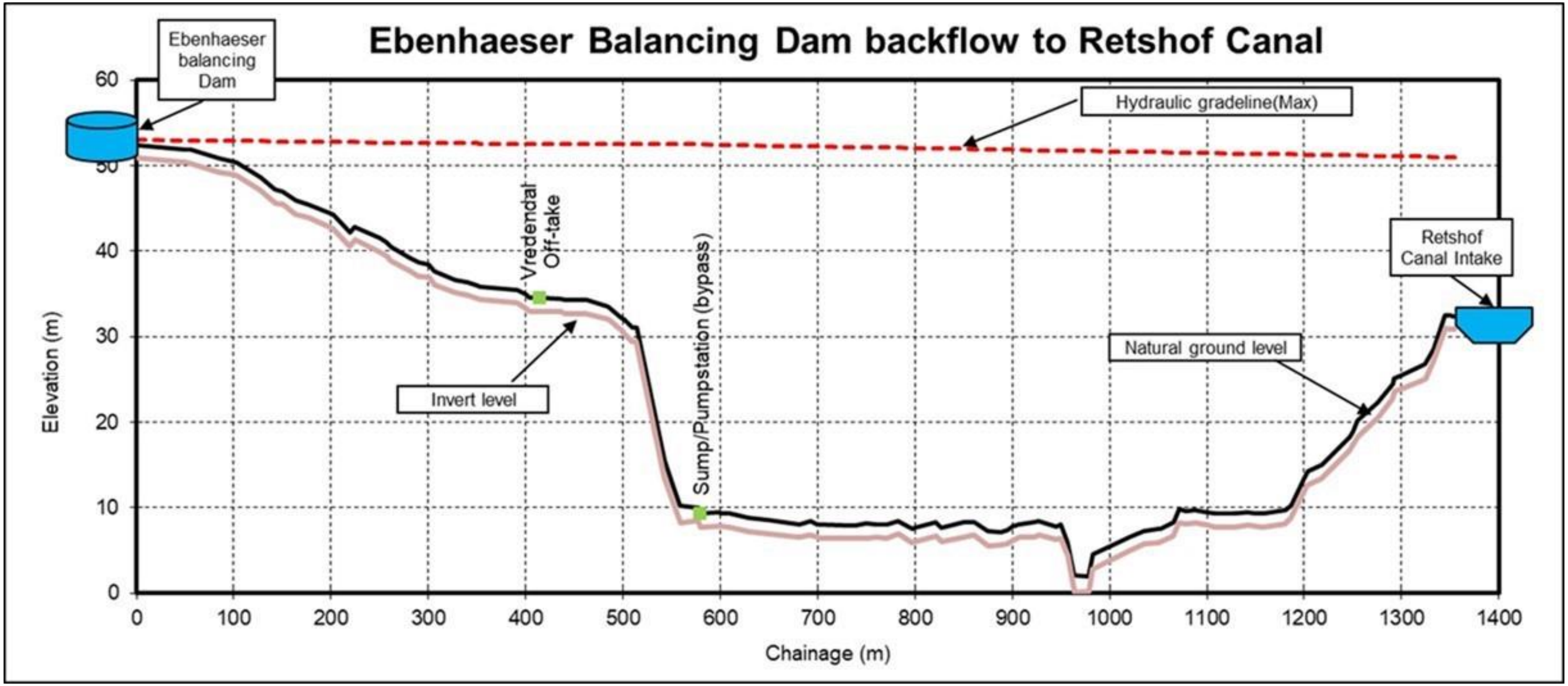


Figure 9-11: Right Bank Canal Diversion Gravity Main (return flow): HGL for 24 Mℓ/d

It is evident from **Figure 9-11** that the residual heads at the Vredendal left bank and Retshof right bank canals would be approximately 18 m and 19 m, respectively. This is sufficient head to install a diaphragm flow control valve to limit the flow to each canal to 12 Mℓ/d.

9.7 Ebenhaeser Balancing Dam

9.7.1 Salient features of the proposed dam design

The salient features of the proposed Ebenhaeser Balancing Dam are presented in **Table 9-1**.

Table 9-1: Main details of the Ebenhaeser Balancing Dam

Parameter	Value
Classification	
Size	Medium
Hazard potential	Significant
Classification	Category 2
Dam Site	
Location (coordinates)	31°37'43.63"S 18°23'57.73"E
River	Off channel
Closest town	Lutzville
Distance	10 km
Property description	Bakleiplaas A182: T58032/2000 (Privately owned)
Catchment and flood parameters	
Catchment area	0.9 km^2
Recommended Design Flood (RDF) magnitude	Incoming 3.6 m^3/s Outgoing 0.3 m^3/s
Water surface elevation at RDF discharge	70.45 masl
Safety Evaluation Flood (SEF) magnitude	Incoming 24.0 m^3/s Outgoing 0.9 m^3/s
Water surface elevation at SEF discharge	70.60 masl
Probable Maximum Flood (PMF)	34.3 m^3/s
Dam statistics	
Dam type	Lined homogeneous earthfill embankment
Total crest length	1371 m
Maximum height above riverbed level	19.2 m
Embankment NOC	72.2 masl
Full supply level (FSL)	70.4 masl

Parameter	Value
Gross storage capacity at FSL	2.32 million m^3
Surface area of water at FSL	26.3 ha
Minimum Operating Level (MOL)	55.0 masl
Base width of dam at maximum cross section	100 m
Embankment Fill	639,000 m^3
Crest width	5 m
Upstream slope	1V:3H
Downstream slope	1V:2H
Riverbed level at downstream toe	53.0 masl
Spillway	
Spillway type	Uncontrolled trapezoidal by-wash with concrete sill on the right flank discharging into partially lined channel.
Crest level	70.4 masl
Crest length	3 m
Freeboard	1.8 m
Energy dissipation	None
Outlet details	
Inlet and outlet pipes	The dam will have two pipes of 700 mm dia each which serve as the inlet and outlet pipes. The pipes will be encased in reinforced concrete through the embankment. At the downstream end, each of the pipes will have an arrangement to control the inlet and outlet flows. At the upstream end the outlet pipe will connect to an upstream sieve inlet.

9.7.2 Site overview

9.7.2.1 Location and layout

The proposed location of the Ebenhaeser Balancing Dam (**Figure 9-12**) is about 100 m west of a bend in the R363 road, some 11 km north west of Vredendal, on the privately owned Bakleiplaas A182 property. The proposed offtake from the Vredendal canal is situated just below and east of the R363 road, some 200 m from the proposed embankment.

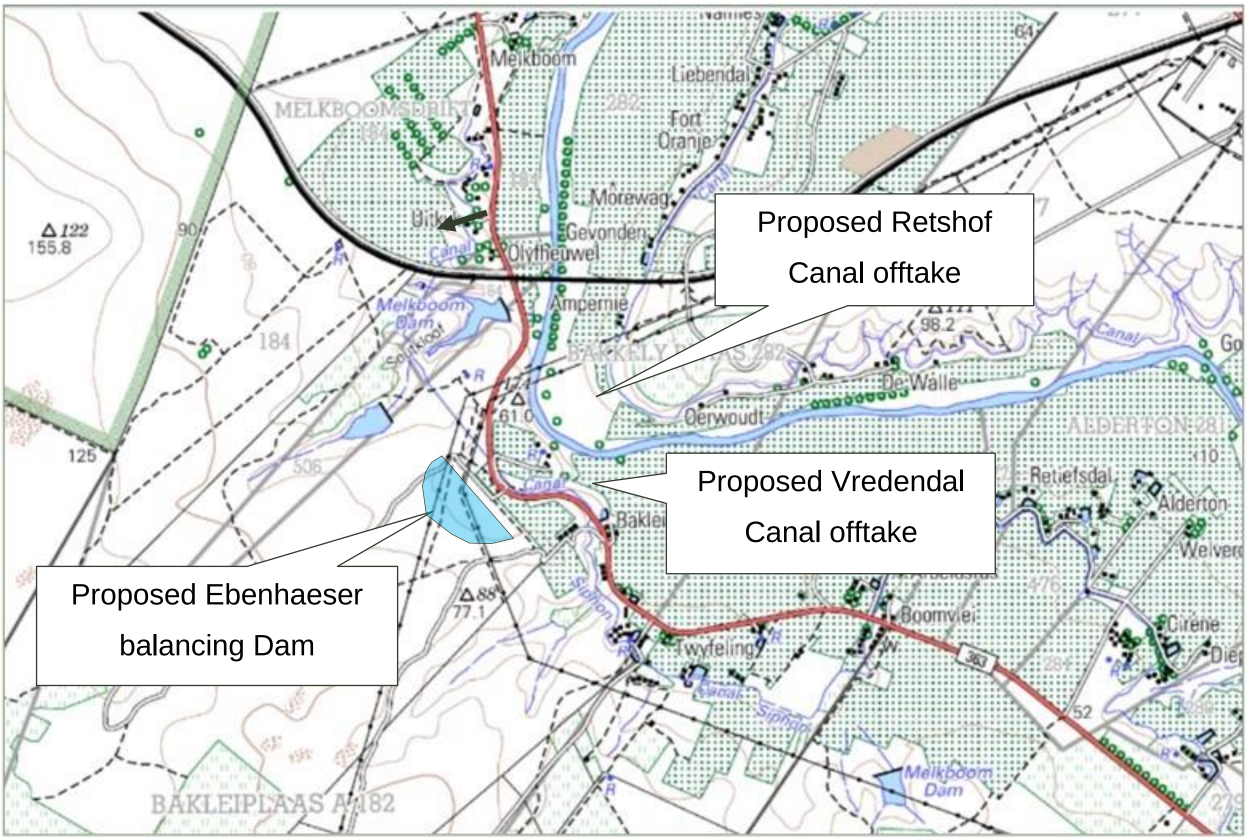


Figure 9-12: Locality plan of the proposed Ebenhaeser Balancing Dam

9.7.2.2 Storage requirement

A gross storage capacity of 2.32 million m^3 is required to divert 3.65 million m^3 water from the Vredendal and Retshof canals, including 0.15 million m^3 for return flow into the canals for operational purposes.

9.7.2.3 Storage capacity

A Storage vs. Depth curve and a Surface Area vs. Depth curve for the dam basin were generated from the topographical surveys at the proposed dam wall position. These curves are presented in **Figure 9-13** below.

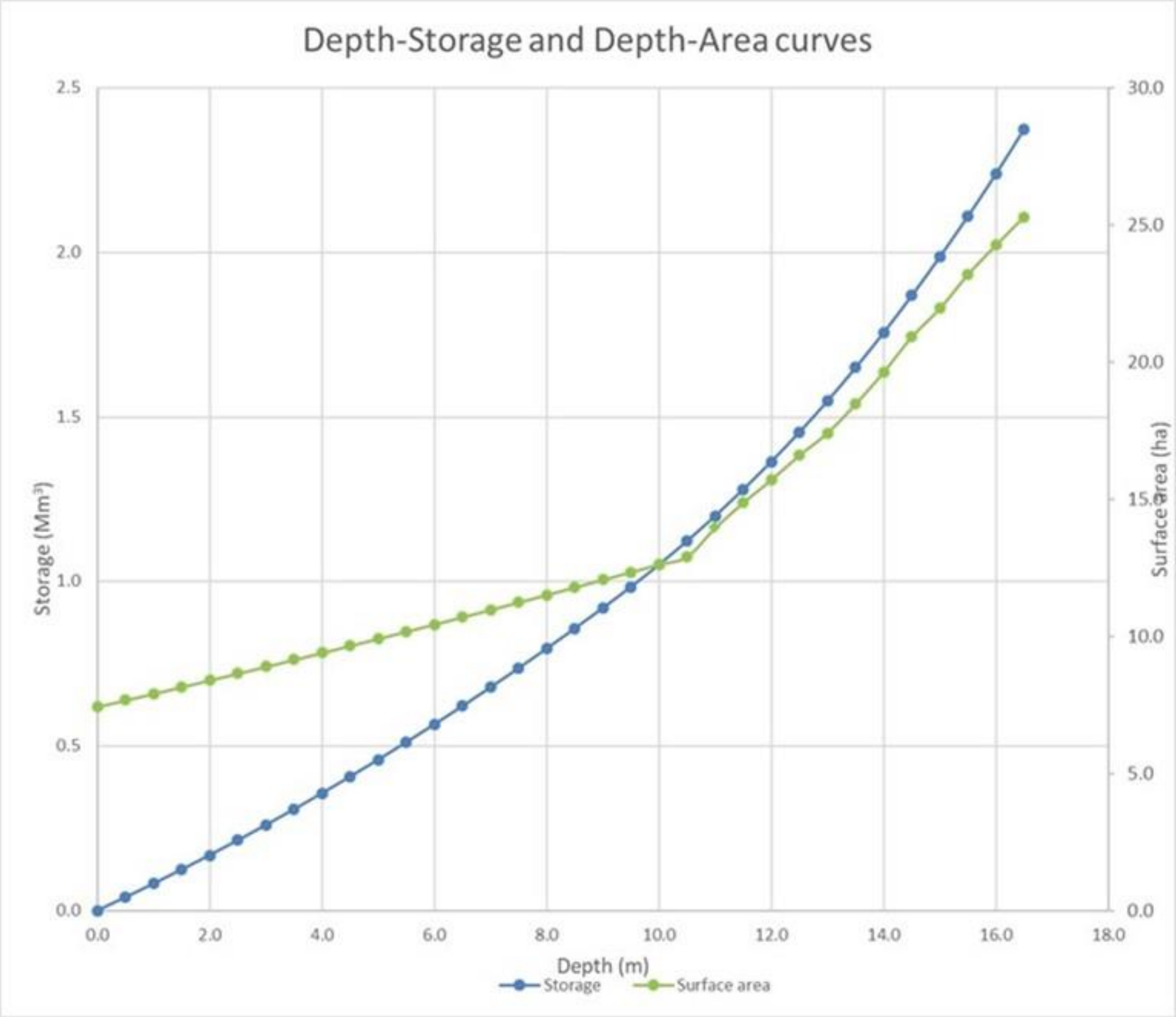


Figure 9-13: Depth-Storage and Depth-Area curves for Ebenhaeser Balancing Dam

The storage volume includes the assumed 85% volume of material excavated from the basin for use as fill material in the embankment.

9.7.3 Dam safety classification

The dam will be classified as a Category II dam due to the wall height and potential risk. Refer to **Section 6.3** of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report.* This classification is further used in the determination of the freeboard requirements, as well as for the recurrence intervals of the design floods.

9.7.4 Flood hydrology

Based on the small size of the catchment area (0.9 km^2) and its drainage path, (**Figure 9-14**) it was decided to follow two deterministic approaches for the estimation of the design floods namely the SCS and Rational Methods. The catchment characteristics used for the flood determination are given in **Table 9-2**.

Table 9-2: Catchment parameters for Ebenhaeser Balancing Dam

Characteristic	Value
Area	0.9 km^2
Length of longest watercourse	1.5 km
Slope of longest watercourse (10/85)	0.0347 m/m
Average catchment slope	5.66 %

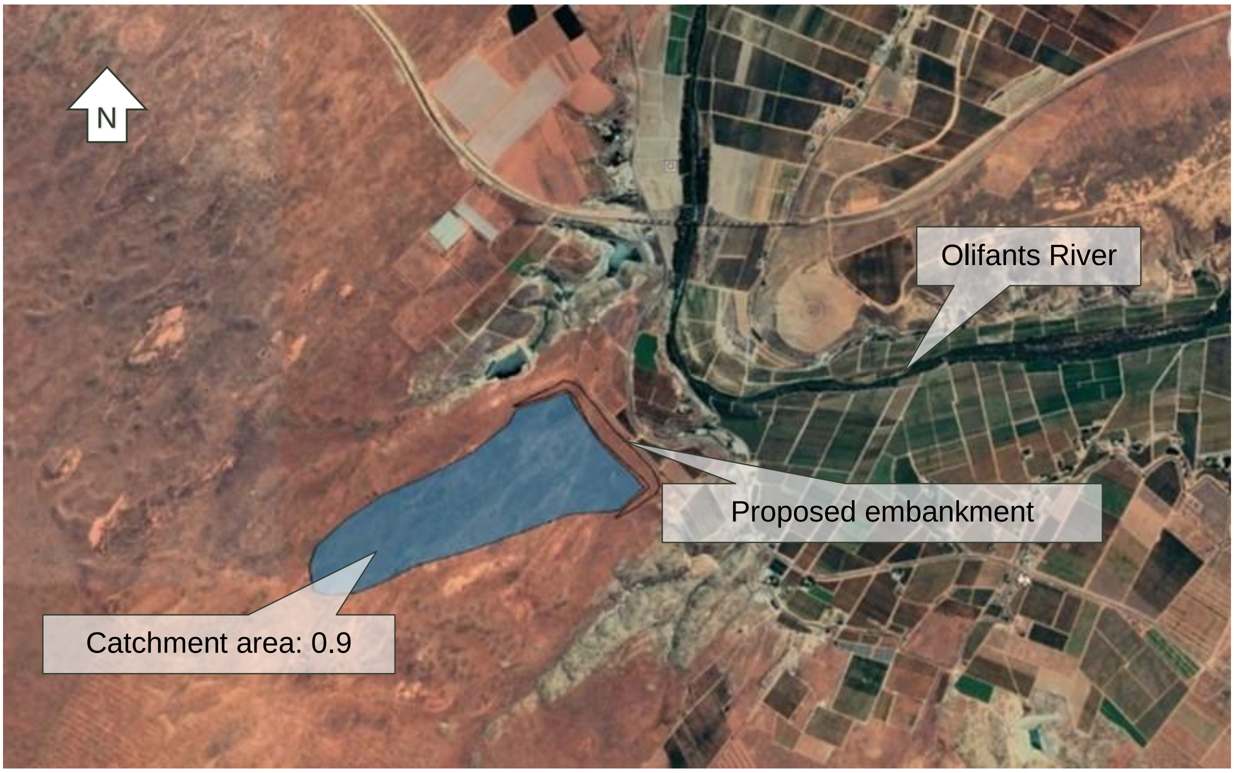


Figure 9-14: Ebenhaeser Balancing Dam catchment

The two methods resulted in a 1:100 year recurrence interval (1.0 % Annual Exceedance Probability (AEP)) flood peak of 3.2 m^3/s and a Probable Maximum Flood (PMF) peak of 34.2 m^3/s.

For a Category 2 dam, the SANCOLD Guidelines in Relation to Floods (SANCOLD, 1991) recommend that:

a) The Recommended Design Flood (RDF) is equal to the 1:100 year recurrence interval (1.0 % AEP) flood peak of 3.2 m^3/s.

b) The Safety Evaluation Flood (SEF) is equal to 70% of the PMF, namely 24.0 m^3/s.

Both these floods will be highly attenuated by the large area of the dam in relation to the small flood inflows.

9.7.5 Embankment and Lining Design

9.7.5.1 Dam type selection

Geotechnical investigations show that the materials in the basin are sandy, have very little clay, and are very permeable, and thus the dam needs to be lined.

It is proposed that the embankment dam, comprising a homogenous fill zone, should be lined with a HDPE membrane. A 150 mm thick layer of geocell (such as Hyson cell) filled with a sand and cement mixture (soilcrete) will be used to protect the HDPE liner on the upstream slopes from long term UV damage, mechanical damage and possible vandalism.

On the flatter floor portion of the dam the HDPE lining will be covered with a 300 mm thick compacted layer of general fill.

9.7.5.2 Embankment layout and detail

The embankment layout is typically U-shaped to account for the topography, which is more of a gentle incline than a broad valley. It is proposed that the embankment will be constructed with material excavated from the dam basin. Refer to Drawings in Appendix A3 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* for the layout and cross-section of the balancing dam.

The embankment cross-section (**Figure 9-15**) has typical slopes of 1V:3H on its upstream side and 1V:2H on its downstream side. The crest is approximately 1 371 m long and 5 m wide with a 2% cross-fall toward the upstream side for surface drainage.

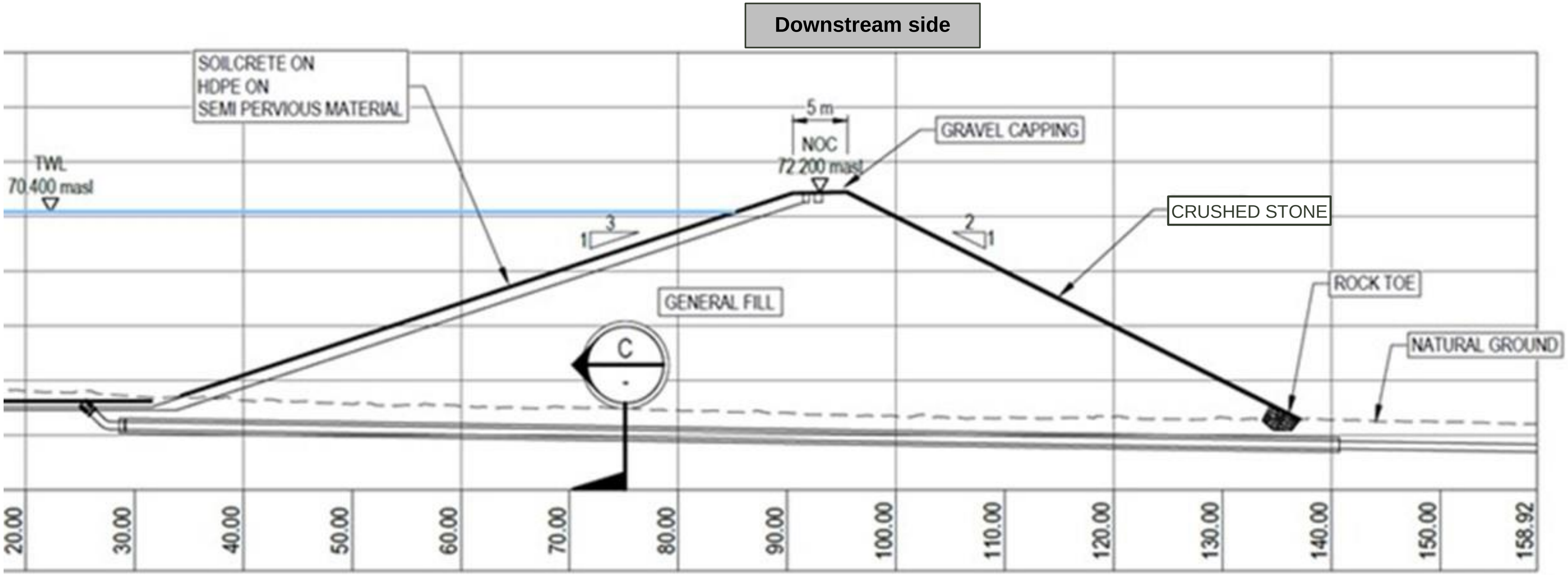


Figure 9-15: Illustrative cross-section through the proposed balancing dam embankment

The lowest level at the valley bottom is 53.0 masl and the embankment has a required NOC level of 72.2 masl, which results in a maximum wall height of 19.2 m.

The upstream face is protected by an HDPE lining covered by a sand-cement (soilcrete) layer 150 mm thick (perpendicular thickness). The downstream face is protected by a 250 mm thick layer of crushed stone.

The internal zoning of the homogenous embankment consists of general fill excavated from the dam basin. The upstream slope and dam basin are lined with HDPE to prevent seepage. The lining on the upstream embankment slope and slopes around the dam is protected with a sand-cement (soilcrete) layer. The underdrainage system can consist of an underdrain running all along the upstream toe of the embankment leading to an underdrainage pipe, which daylights below the downstream toe.

9.7.5.3 Lining detail

The 1.5 mm HDPE liner will cover the entire basin up to the NOC contour and be anchored in the crest. On all the embankment and basin slopes that are steeper than 1V:4H or above approximately 60 masl, the lining will be double textured (rough on both sides to increase friction at contact with material layers) and covered with a layer of sand-cement (soilcrete). The rest of the basin, below approximately 60 masl, will be lined with a smooth 1.5 mm HDPE liner and covered with 300 mm thick compacted general fill layer.

9.7.6 Spillway

9.7.6.1 Spillway design

The spillway will be located on the right abutment so that it can drain into the nearby natural drainage channel. The spillway and embankment layout are shown in **Figure 9-16** below. Further details can be found on Drawing 113834-0000-DRG-CC-003 in Appendix A3 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report.*

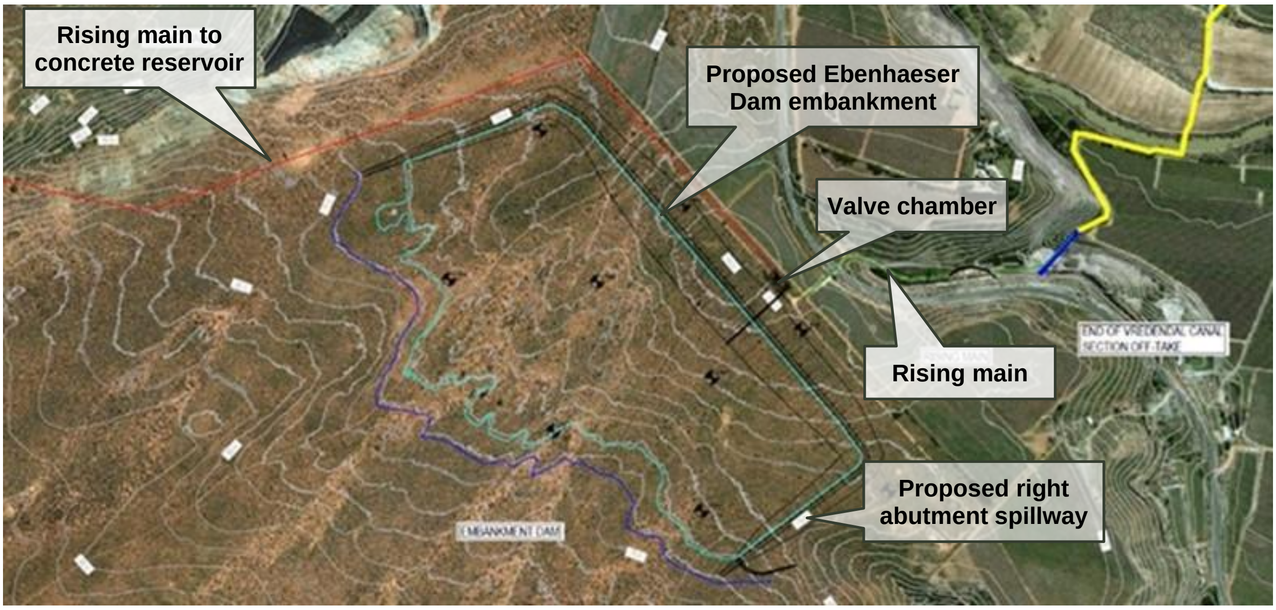


Figure 9-16: Plan view of the embankment showing proposed spillway location

9.7.6.2 Discharge channel

The 1.8 m freeboard is primarily to accommodate wave action and not to accommodate flood events. The discharge channel will only be used for continuous flow should the pumps be left on when the dam is full or during an SEF event, which means that achieving a rock foundation is not critical. The first 35 m of the discharge channel should be lined with armorflex or gabions. The rest of the channel can remain unlined.

The channel is trapezoidal, has side slopes of 1V:1H and extends for 100 m. The base width narrows from 3.0 m to a nominal 1.0 m and has a longitudinal slope of 0.063 m/m (1:15). Further details can be found on Drawing 113834-0000-DRG-CC-003 in Appendix A3 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report.*

9.7.6.3 Flood routing

The outcomes of the flood determination, embankment design and spillway design were used in a level pool flood routing exercise. The hydrographs from the SCS flood determination method were used for the flood routing. The incoming flood peaks were attenuated by 97%.

9.7.7 Freeboard

The required Freeboard for the embankment (height between FSL and NOC) was calculated to be 1.8 m, mainly due to allowance for wave action. Refer to Section 6.8 in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report.*

9.7.8 Outlet works

9.7.8.1 Inlet/Outlet works configuration

The outlet works consist of a chamber at the downstream toe of the main embankment. There are two 700 mm diameter outlet pipes, encased in concrete, under the embankment, which daylight in the chamber. One of the pipes is a dedicated gravity outlet pipe. The other pipe connects to the rising main from the canal offtake. The encased pipework through the embankment should be made of stainless steel.

The layout of the balancing dam and outlet works is shown in **Figure 9-17**. Further details can be found on Drawing 113834-0000-DRG-CC-001 in Appendix A3 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report.*

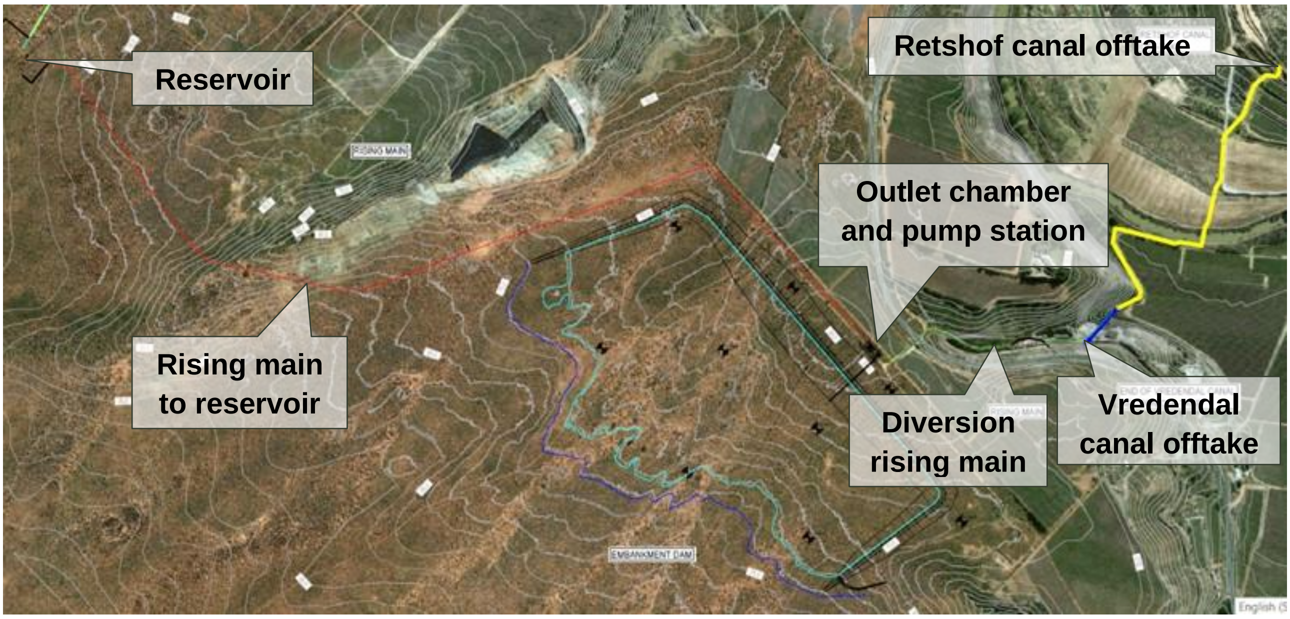


Figure 9-17: Ebenhaeser Balancing Dam and supply/connection pipe layout

The two 700 mm diameter inlet/outlet pipes will be encased in reinforced concrete through the embankment. The concrete pipe encasement will have battered slopes to improve the compaction and contact between backfill and the encasement.

It is proposed that a scour outlet be connected to the main outlet pipe to the booster pump station, such that it will discharge into a small trench, with an option to eventually return to the nearby Vredendal canal.

9.7.9 Associated infrastructure

9.7.9.1 Instrumentation

A row of settlement beacons should be installed on the downstream edge of the crest of the embankment at 50 m intervals, along with reference beacons.

Monitoring of water depth can be done either with a set of water depth markers located on the upstream slope near to the outlet works or by installing an electronic water depth gauge (e.g. vibrating wire piezometer), which would enable remote water level monitoring of the proposed Ebenhaeser Balancing Dam.

The proposed dam design may include an underdrain system. The main perforated drains collect at points along the toe and daylight through concrete drainage outlets. This will enable the visual and volumetric monitoring of the seepage through the embankment at various points along the downstream toe.

9.7.9.2 Storm water diversion

Due to the very small catchment and the fact that the dam is off-channel, only minor river diversion works would be required during construction .

A perimeter drain should be installed just beyond the NOC contour of the basin to divert any storm water away from the dam so as not to contaminate the quality of the pumped water. This could also serve as storm water diversion during construction.

9.8 Ebenhaeser Balancing Dam Inlet/Outlet Chamber

The proposed dam will be supplied from the DN 710 diversion rising main, which will also be used to transfer water back to the canals when needed. Water from the balancing dam will also be pumped via a DN 560 rising main to a concrete balancing reservoir located to the west of the proposed balancing dam (refer to **Figure 9-1**).

The outlet works consist of a chamber below the right flank of the downstream toe of the embankment. Two DN 700 inlet and outlet pipes encased in concrete will daylight in the chamber.

The proposed pipework configuration is shown in **Figure 9-18**. The inlet pipe will be fitted with a non-return valve to prevent uncontrolled return flow from the balancing dam to the rising main. Isolation valves will be installed upstream and downstream of the non-return valve for maintenance purposes.

The outlet pipe from the dam will split to the rising main/pump station pipeline to the concrete reservoir, and also connect to the inlet pipeline to allow return flow to the canals. The connection to the inlet pipeline will be fitted with isolating valves and a non-return valve to prevent water from being pumped directly to the booster pump station that will supply the concrete reservoir. The outlet pipeline isolating valve will generally be in the closed position and will only be opened when return flow to the canals is required.

The layout of the inlet/outlet chamber is also shown on drawing 113834-0000-DRG-CC-0112 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report.*

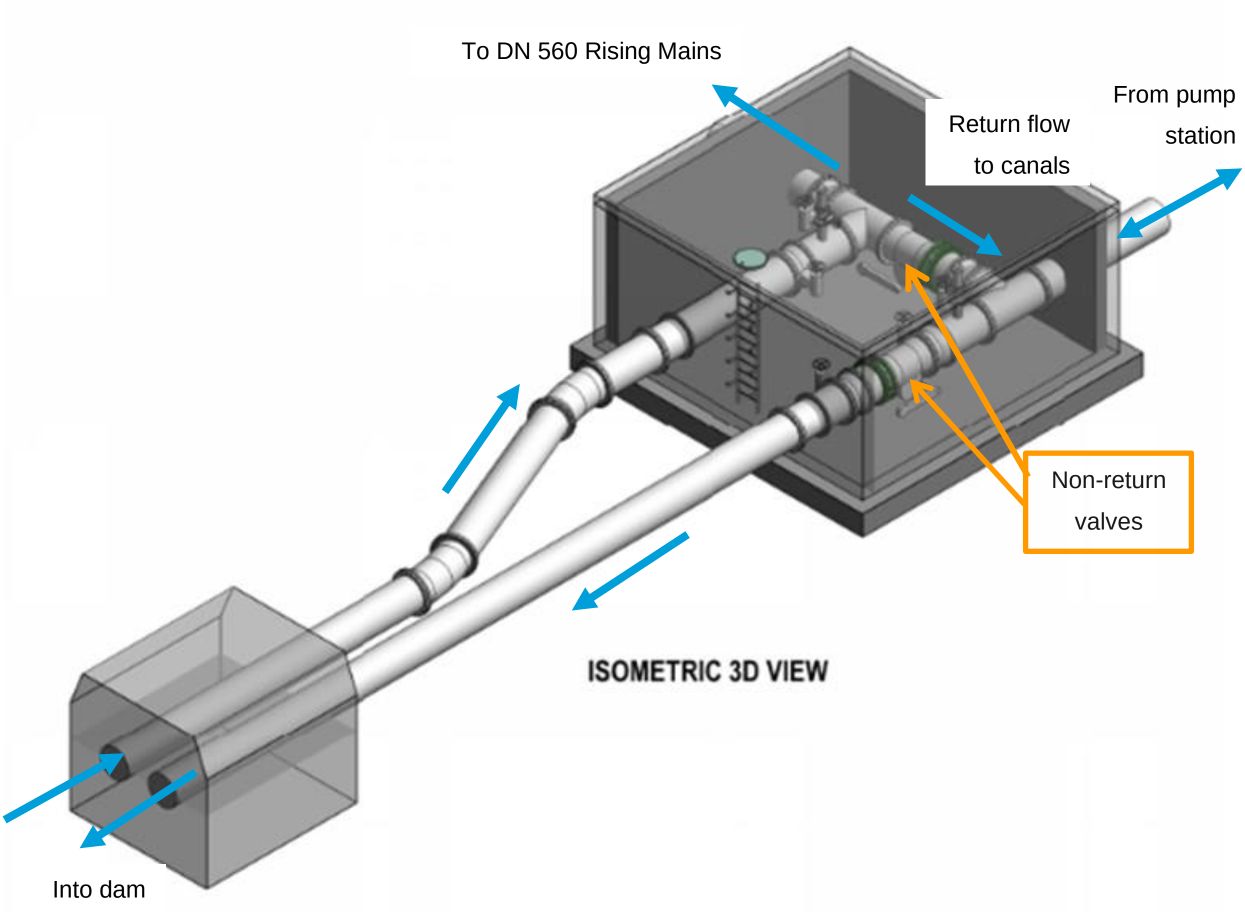


Figure 9-18: Isometric view of Ebenhaeser Balancing Dam Inlet/Outlet Chamber

9.9 Ebenhaeser Balancing Dam Pump Station

The Ebenhaeser Balancing Dam Pump Station will pump water from the Ebenhaeser balancing dam via a DN 560 rising main to a concrete balancing reservoir. A pump configuration of one (1) duty pump and one (1) standby pump is proposed for the pump station. The details of a commercially available pump that could be used are shown below.

The following information about the KSB ETA 250-50 pump is relevant:

- Impeller size = 434 mm;
- Full-size impeller = 500 mm;

- Hydraulic efficiency of pump = 82.5%;
- NPSH required = 4.1 m;
- Head rise to shut-off = 13%;
- Maximum power absorbed for 434 mm impeller = 190 kW (recommended motor size is 200 kW, operating at 1 460 rpm); and
- Maximum power absorbed at duty point = 162 kW.

Figure 9-19 shows the characteristic and pump curves for the pump station.

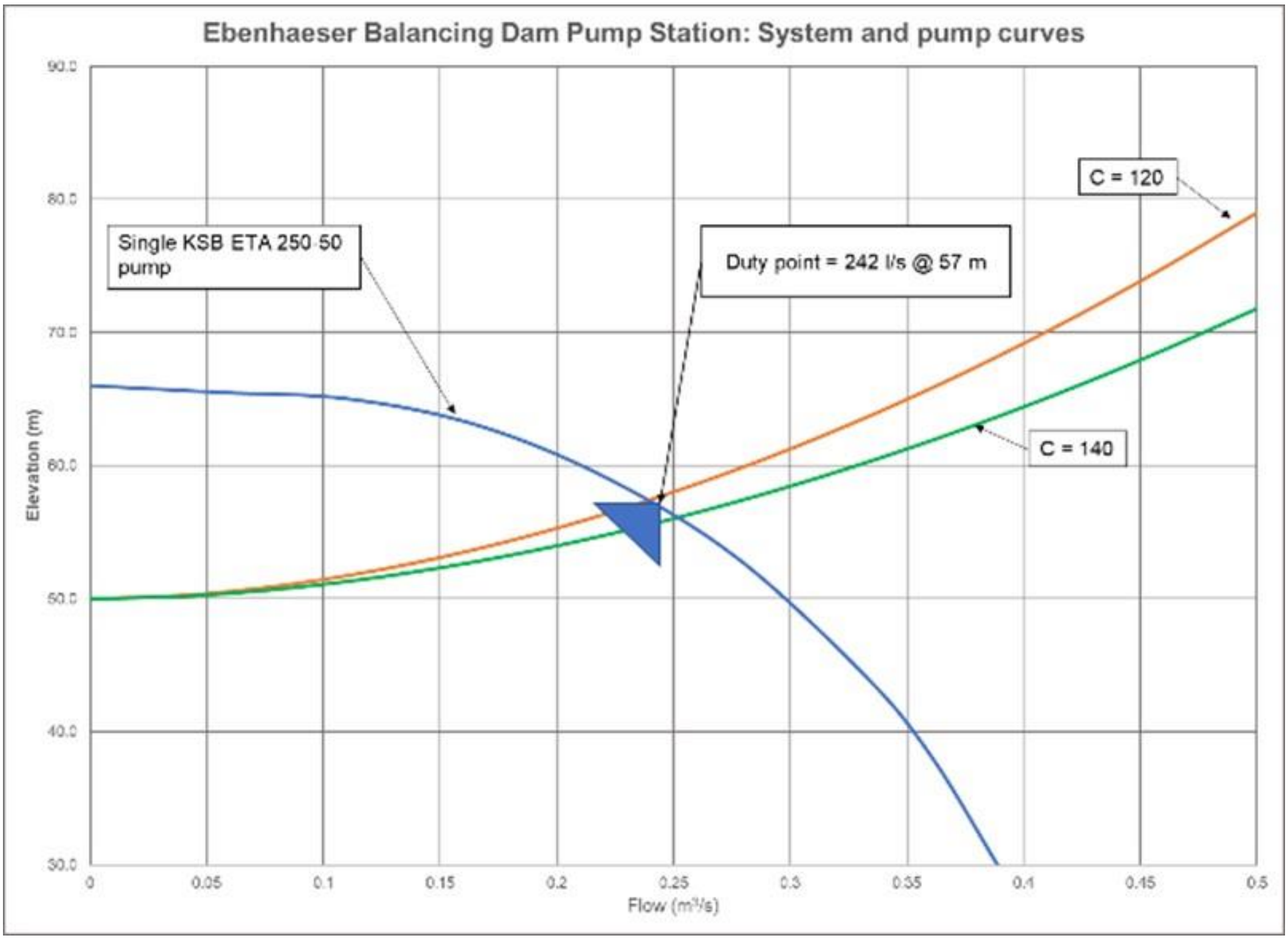


Figure 9-19: Characteristic and pump curve for Ebenhaeser Balancing Dam Pump Station

It is evident from **Figure 9-19** that the pump station has a duty point of 20.9 Mℓ/d (0.242 m^3/s) at a total pumping head of approximately 57 m. The layout of the Ebenhaeser balancing dam pump station is shown in **Figure 9-20** and in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* on drawing 11383-0000-DRG-CC-0111 in Appendix A2.

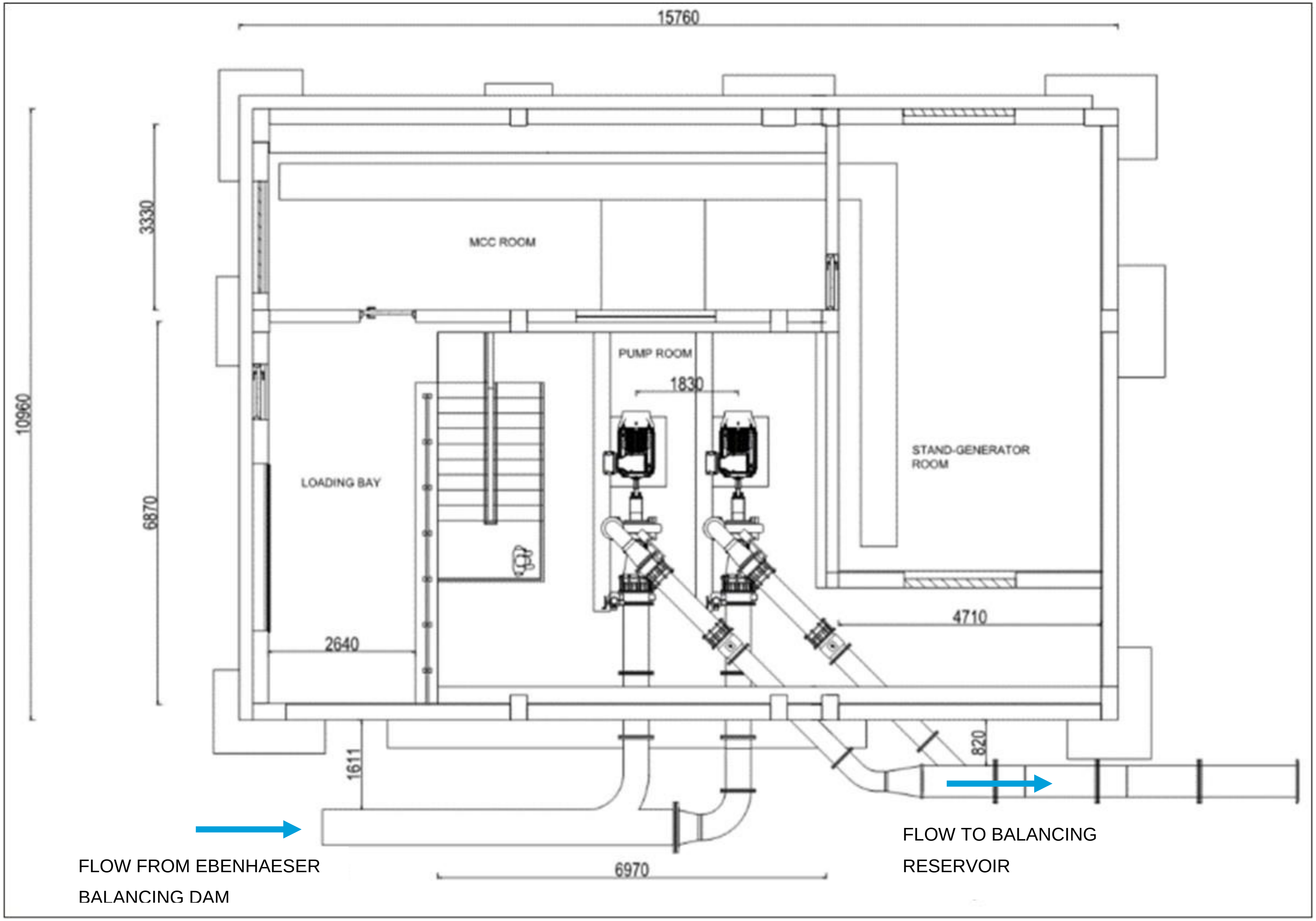


Figure 9-20: Plan view of Ebenhaeser Balancing Dam Pump Station

9.10 Rising Main to Concrete Balancing Reservoir

9.10.1 Description of pipeline

The proposed rising main (1 975 m in length) will convey water from the Ebenhaeser Balancing Dam to the Concrete Balancing Reservoir. The design flow of the rising main is 0.242 m^3/s. It is proposed that a DN 560 HDPE pipe be used, which will result in a velocity of 1.28 m/s.

The proposed horizontal pipeline alignment for the rising main is shown in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* on the layout drawing 113834-0000-DRG-CC-0107 in Appendix A2.

Figure 9-21 shows the hydraulic gradient line of the rising main to the concrete balancing reservoir for a flow of 20.9 Mℓ/d (0.242 m^3/s).

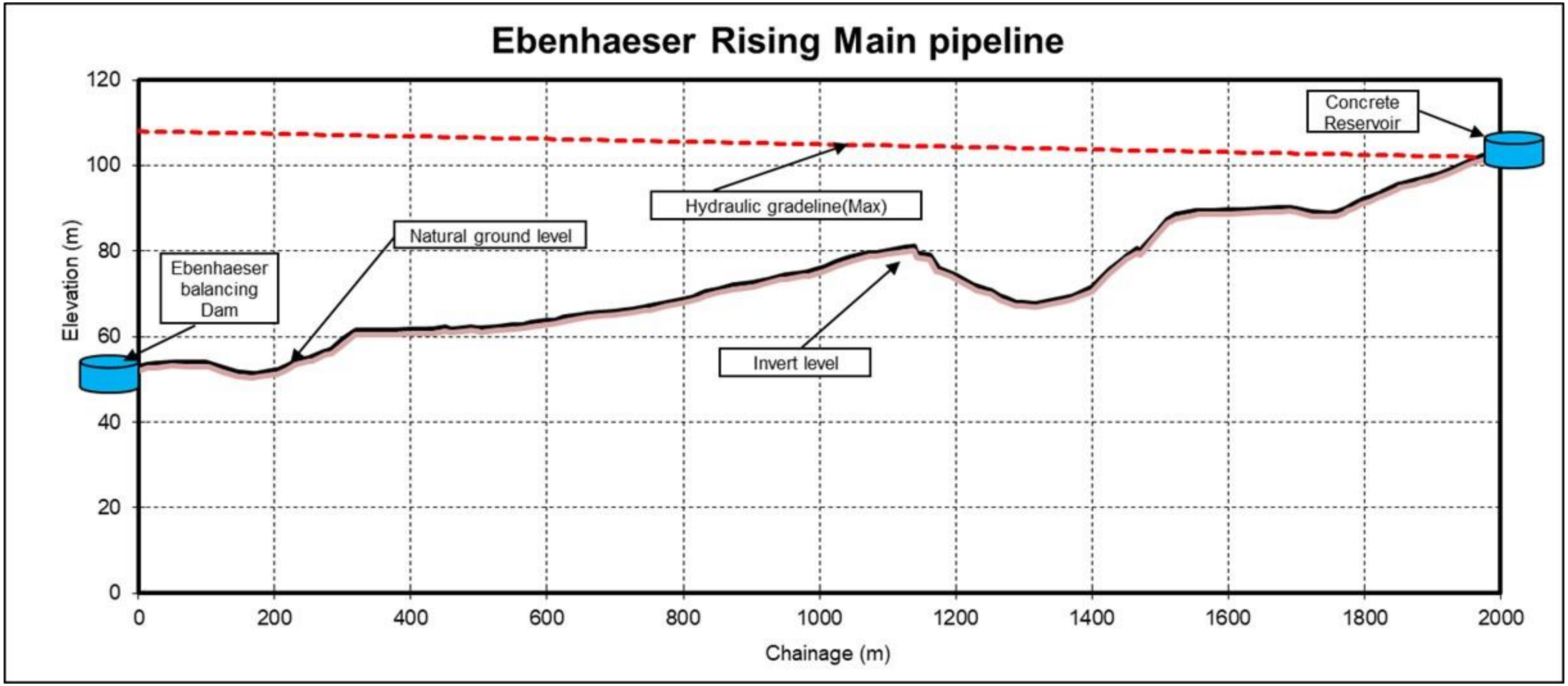


Figure 9-21: Rising Main to Concrete Reservoir: HGL for 20.9 Mℓ/d in aged DN 560 pipeline

9.11 Concrete Balancing Reservoir

The concrete balancing reservoir is designed to store the flow of 242 ℓ/s pumped over 12 hours, which equates to a reservoir with an active capacity of 10 450 m^3 (10.45 Mℓ). It is proposed that an 11 000 m^3 (11 Mℓ) reinforced concrete reservoir be provided. The reservoir's minimum operating level is 99.5 masl and full supply level is 105.5 masl. These levels are based on an assumption that the reservoir will be sunken half depth.

A new access road will have to be constructed to the reservoir.

The proposed layout plan for the concrete balancing reservoir is shown on drawing 113834-0000-DRG-CC-0108 and the reservoir detail is shown on drawing 113834-0000-DRG-CC-0114, in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*.

9.12 Gravity Pipeline and Distribution Mains

9.12.1 Gravity Pipeline to Five Clusters

9.12.1.1 Description of the pipelines

The proposed gravity pipeline will convey water from the concrete balancing reservoir to the five water requirement clusters along the route (a total length of 17 700 m). The proposed horizontal pipeline alignment for the gravity pipeline is shown on the layout drawings 113834-0000-DRG-CC-0109 and 113834-0000-DRG-CC-0110 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*. Pipeline diameters were optimised to ensure sufficient residual head at each cluster off-take. The design flow rats and proposed pipeline diameters are shown in **Table 9-3**.

Table 9-3: Gravity Pipeline to Five Clusters: Design flow rates and diameters

Gravity pipeline	Design flow (m^3/s)	Diameter (mm)
Section 1: Reservoir to Cluster 1	0.242	630
Section 2: Cluster 1 to Cluster 2	0.195	560
Section 3: Cluster 2 to Cluster 3	0.168	500
Section 4: Cluster 3 to Cluster 4	0.106	400
Section 5: Cluster 4 to Cluster 5	0.048	355

Figure 9-22 shows the hydraulic gradient line of the gravity pipeline to the five clusters for the flow rates and pipe diameters shown in **Table 9-3**.

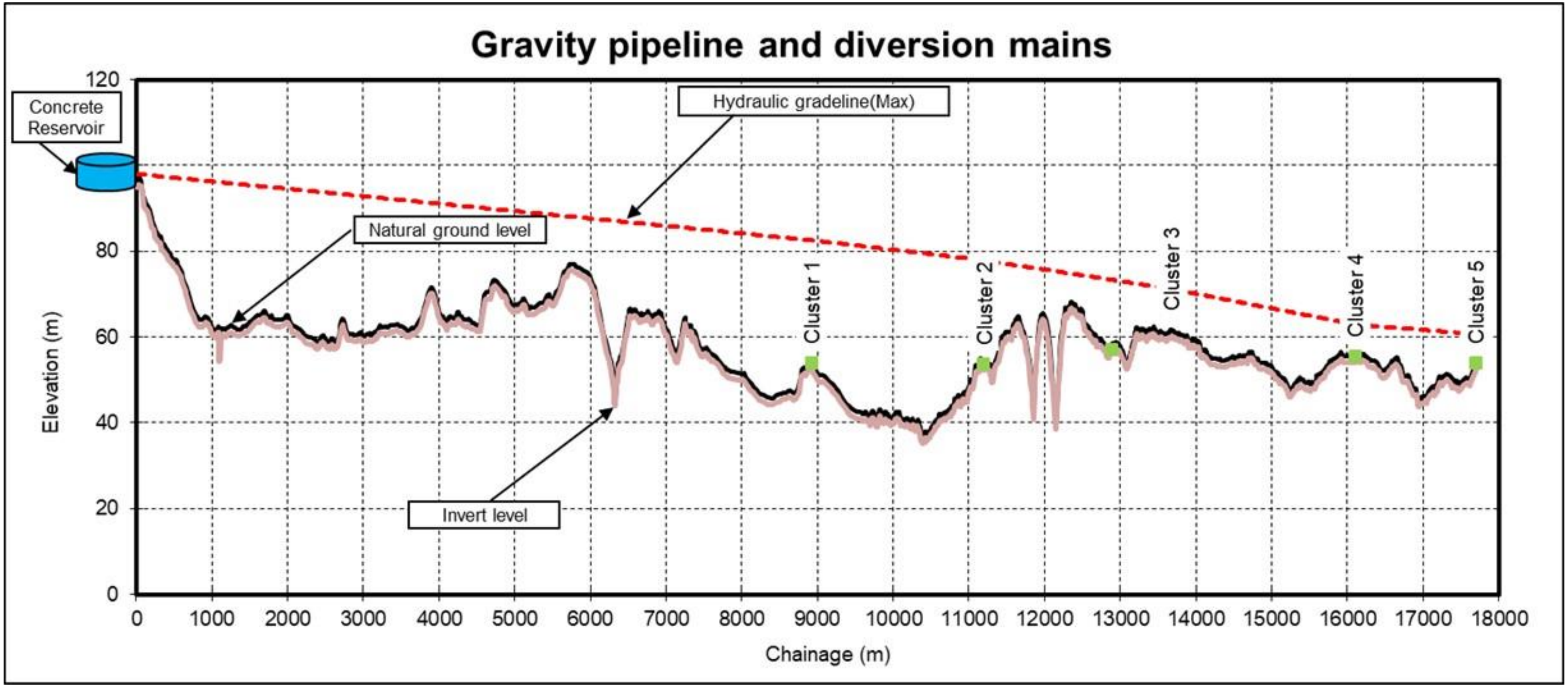


Figure 9-22: Gravity pipeline and diversion main offtakes at clusters: Hydraulic gradient line

9.12.1.2 Railway Crossing

The gravity pipeline will have to cross a railway line approximately 1 250 m downstream of the concrete balancing reservoir. It is proposed to cross the railway line with a concrete sleeve pipe installed by means of pipe jacking.

9.12.1.3 Culvert Crossing near Railway line

Approximately 6 500 m downstream of the concrete balancing reservoir there is an existing culvert underneath the road adjacent to the railway line.

It is proposed that the gravity pipeline be laid adjacent to the road on top of the existing culvert. Note that the culvert might need to be extended. The length of the span and the details of the crossing will be determined during the detailed design phase of the project, upon receiving more site-specific survey information of the existing culvert.

9.12.1.4 Road Crossing

It is proposed that concrete pipe sleeves be installed where major roads are crossed, and that minor road crossings be performed by open trench excavation. The major road crossings are to be done by pipe jacking or micro-tunnelling.

9.12.2 Distribution Mains for Clusters

Water will be conveyed to the edge (high point) of the water requirement clusters from where the water will be distributed to the irrigators via distribution mains in future (designed by others).

Table 9-4 summarises the design flow rates at each off-take, the expected head range at the off-takes, as well as the proposed off-take diameter.

Table 9-4: Cluster Offtake chamber details

Distribution Mains	Offtake flow (m^3/s)	Min head @ Offtake (m)	Max head @ Offtake (m)	Offtake Diameter (mm)
Cluster 1 Offtake	0.047	32	38	200
Cluster 2 Offtake	0.027	27	33	160
Cluster 3 Offtake	0.062	13	19	200
Cluster 4 Offtake	0.058	10	16	200
Cluster 5 Offtake	0.048	10	16	200

A typical detail of the offtake chamber is shown in **Figure 9-23**.

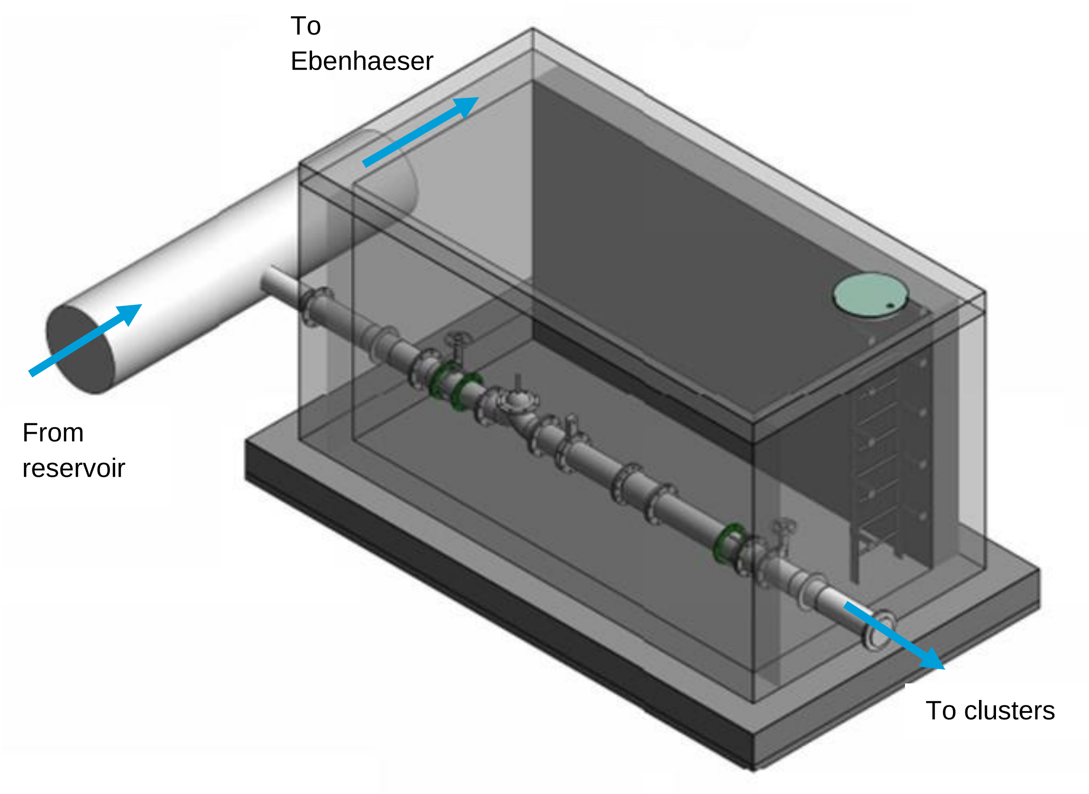


Figure 9-23: Isometric view of typical cluster offtake chamber

A tee will be provided on the gravity pipeline at each cluster offtake position leading into a chamber. Each chamber will have a flow control valve and a flow meter, with isolation valves upstream and downstream, in order to service the flow control valve. A blank flange will be fitted on the downstream side, outside the chamber, ready for the distribution mains to be connected in the future.

9.13 Recommendations for Detailed Design

The following recommendations are applicable to the detailed design and construction phases of the Ebenhaeser Scheme:

a) A ground centreline survey should be done along the final chosen pipeline routes, prior to construction commencing. This will serve as a final check on the pipeline's vertical alignment and verification of the survey data.

b) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources of this material.

c) During the detailed design, the pipeline routes and infrastructure locations will need to be confirmed, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

d) The detailed design of the scheme will need to account for findings from the further geotechnical investigations that were undertaken, i.e. the geophysical evaluation and core drilling of the syphon route through the Olifants River for the right bank gravity pipeline syphon.

e) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.

f) The choice of pipe material needs to be confirmed during the detailed design phase of the project, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.

g) Eskom should be engaged during the detailed design phase of the project regarding electrical supplies to the pump stations.

h) The selection of pump types needs to be refined as part of the detailed design phase.

i) Reconsider the sizing of the concrete balancing reservoir, taking into account the operational procedures of the smallholder farmers component of the scheme, which will mainly irrigate during the day. Consider if adequate allowance has been made for emergency situations to counter load shedding and breakdowns, and allow for maintenance.

j) The proposed railway crossing details on the Ebenhaeser gravity main need to be submitted to the relevant railway authority for their approval.

k) The proposed road crossing details need to be submitted to the relevant road authority for their approval.

l) A more site-specific survey is required for the railway and existing culvert crossings on the Ebenhaeser gravity pipeline.

m) The assumptions made in the determination of the desired balancing dam storage volume (e.g. siltation from the canal and infiltration losses) should be checked and refined.

n) The embankment zoning and dimensions of the balancing dam are based on typical values for embankment dams of this size using similar materials. The zoning dimensions must thus be designed based on the actual material properties and design constraints for the particular zones, which are used as input into a slope stability analysis.

o) Further investigation into the required thickness and other properties of the balancing dam lining will be needed. Specifications for the stone size and protrusions of the materials layers above and below the liner must also be investigated to prevent damage during construction.

p) The relocation of three power lines affected by the position of the balancing dam need to be addressed.

q) Reconsider the energy costs used in the cost calculations, optimising it for Eskom's Time of Use, to achieve savings in energy cost over the life cycle.

10 Implementation Arrangements

10.1 Land Requirements, Land Acquisition and Wayleaves

10.1.1 Jan Dissels Scheme

Landowners will need to be consulted regarding the pipeline routes and associated infrastructure over their properties. It is recommended that a 9 m wide servitude be registered along the proposed pipeline routes and that the proposed pipeline be positioned in the centre of the servitude. During the construction phase, it is proposed that provision be made for a 25 m wide working width (temporary servitude) along the proposed pipeline routes.

10.1.1.1 Rising Main from the Raised Dam Wall

The surface area required for the 3 740 m long pipeline, including a 9 m wide servitude, is 3.37 ha. The surface area required for the reservoir is 0.17 ha.

The land required for the Rising Main pump station at the dam wall will not have to be acquired, as this falls within the Clanwilliam Dam area, which is owned by DWS.

The Rising Main route will cross two surfaced roads, namely the Deon Burger Road and the entrance/exit roads to the Clanwilliam Dam Resort. Approval will be required from the provincial roads department for the road crossings and possible construction works in the road reserve.

The route will transect the Ramskop Nature Reserve, which is managed by the Cederberg Municipality. There are indications that existing pipelines are present in this area and that the construction of the pipeline could potentially be approved by the Management Authority, which would be the Municipality in this case. This route does however include the removal of indigenous vegetation and would probably require temporary and permanent access tracks to be constructed.

10.1.1.2 Clanwilliam Dam

As DWS is the owner of Clanwilliam Dam and is also expected to be the owner of the scheme, no issues are foreseen with abstraction from the raised dam.

10.1.1.3 Access Road from the 'Ou Kaapse' Road or township

An access road to the proposed concrete reservoir must be constructed from the "Ou Kaapse" Road or the township development located close by. There is an existing gravel road to the proposed site. It is uncertain whether this road would require upgrading.

10.1.1.4 Jan Dissels River Syphon

Environmental implications of the syphon through the Jan Dissels River will be considered as part of the on-farm irrigation conveyance infrastructure, and is not part of the implementation of the bulk water scheme.

10.1.1.5 Cederberg Municipality

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

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

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

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

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

10.1.1.6 Augsburg Agricultural Gymnasium

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

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

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

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

10.1.2 Right Bank Canal Scheme

Figure 10-1 shows the existing infrastructure that will be affected by the canal alignment, which includes the major components described below.

10.1.2.1 Canal Access Road

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

10.1.2.2 Existing Left Bank Canal Road

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

10.1.2.3 R363 Provincial Road and Farm Roads

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

The proposed canal crosses the R363 a total of four (4) times and it crosses major farm roads a total of 11 times. A bridge needs to be provided at each of these crossings.

The locations of the crossings are shown in **Figure 10-1**.

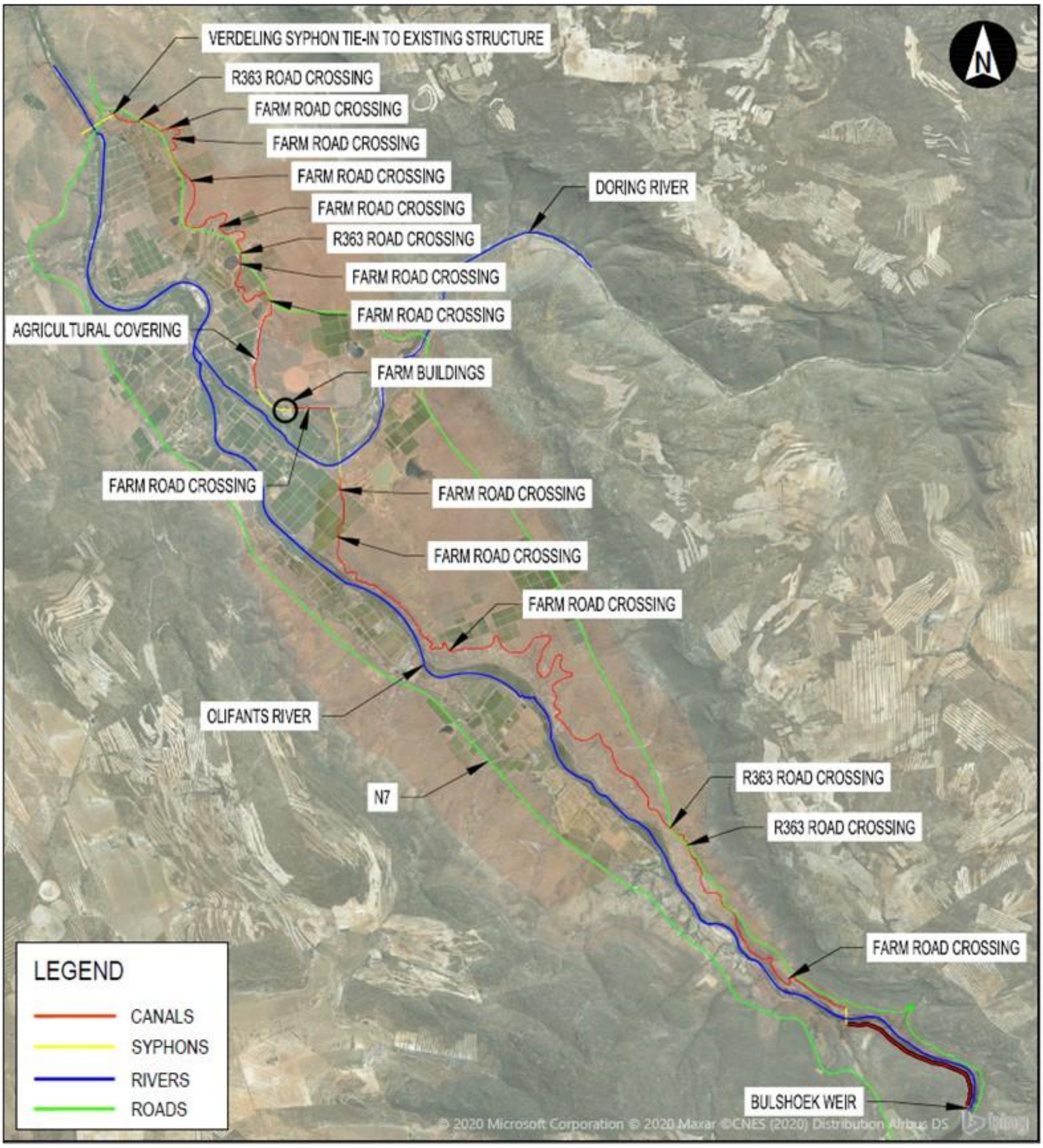


Figure 10-1: Existing infrastructure affected by the Right Bank Canal route

10.1.2.4 Farm Owners

The horizontal alignment for the proposed Right Bank Canal runs through privately owned farms. These landowners will need to be consulted regarding the canal route and associated infrastructure over their properties. Land and servitudes for the canal will need to be acquired from these landowners. Compensation for the land acquired will include infrastructure affected by the project.

10.1.2.5 Existing Syphon at Verdeling

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

10.1.2.6 Syphons

Both the Olifants and Doring River syphons, as well as the syphon along the steep section near the Doring River syphon, are located on privately owned farms. These landowners will need to be consulted regarding the canal route and associated infrastructure over their properties. Land and servitudes for the canal will need to be acquired from these landowners. Compensation for the land acquired will include infrastructure affected by the project.

10.1.3 Ebenhaeser Scheme

10.1.3.1 Landowners

The scheme will traverse several farms, owned by various landowners. These landowners will need to be consulted regarding the pipeline routes and associated infrastructure over their properties. The portion of land upon which the Ebenhaeser Balancing dam is to be located is known as Bakleiplaas 182 and is privately owned.

It is recommended that a 9 m wide servitude be registered along the proposed pipeline routes and that the proposed pipeline be positioned in the centre of the servitude.

During the construction phase, it is proposed that provision be made for a 25 m wide working width (temporary servitude) along the proposed pipeline routes.

The surface area required for the 3 720 m long pipelines (portion of the gravity main and rising main) on undeveloped private land, including a 9 m wide servitude, is 3.35 ha. The surface area required for the reservoir is 0.21 ha.

The surface area required for the 1 360 m long diversion pipelines on developed private land, including a 9 m wide servitude, is 1.22 ha. The surface area required for the pump stations and balancing tank is 0.14 ha.

Figure 10-2 shows the remaining Financial Assistance Land Administration (‘FALA’) (blue and orange areas) of the Department of Agriculture, Land Reform and Rural Development (DALRRD) located near the existing Ebenhaeser Community Scheme. The diversion infrastructure, rising main pipelines, balancing dam and reservoir will be located on private land, which either needs to be acquired or servitudes need to be registered. Most of the gravity pipeline will be located on State land. **Figure 10-3** shows the main bulk infrastructure components that will be located on private land.

10.1.3.2 R362 & R363 Provincial Roads

The proposed diversion rising main (from the diversion pump station to the Ebenhaeser Balancing Dam) will cross the R363 road. The gravity pipeline (from the concrete balancing reservoir to the irrigation clusters) will cross the R362 road. Both roads are owned by the Western Cape Department of Transport and Public Works. Approval will be required from the provincial roads department for the road crossings and possible construction works in the road reserve.

10.1.3.3 Railway line

The proposed gravity pipeline from the concrete balancing reservoir to the irrigation clusters will cross the railway line once at an existing bridge. The railway belongs to Transnet and forms part of the Transnet Freight Rail. Approval will be required from Transnet for the railway crossing and possible construction works in the railway reserve.

10.1.3.4 Existing Left Bank and Right Bank Canal

No issues are expected with obtaining permission from DWS and LORWUA for construction of offtakes on the existing left and right bank canals to provide water to the Ebenhaeser Scheme.

10.1.3.5 Olifants River Syphon

The syphon through the Olifants River will be located on a privately owned farm. The landowner will need to be consulted regarding the canal route and associated infrastructure over the property. Land and servitudes for the canal will need to be acquired from the landowner. Compensation for the land acquired will include infrastructure affected by the project.

10.1.4 Wayleaves

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

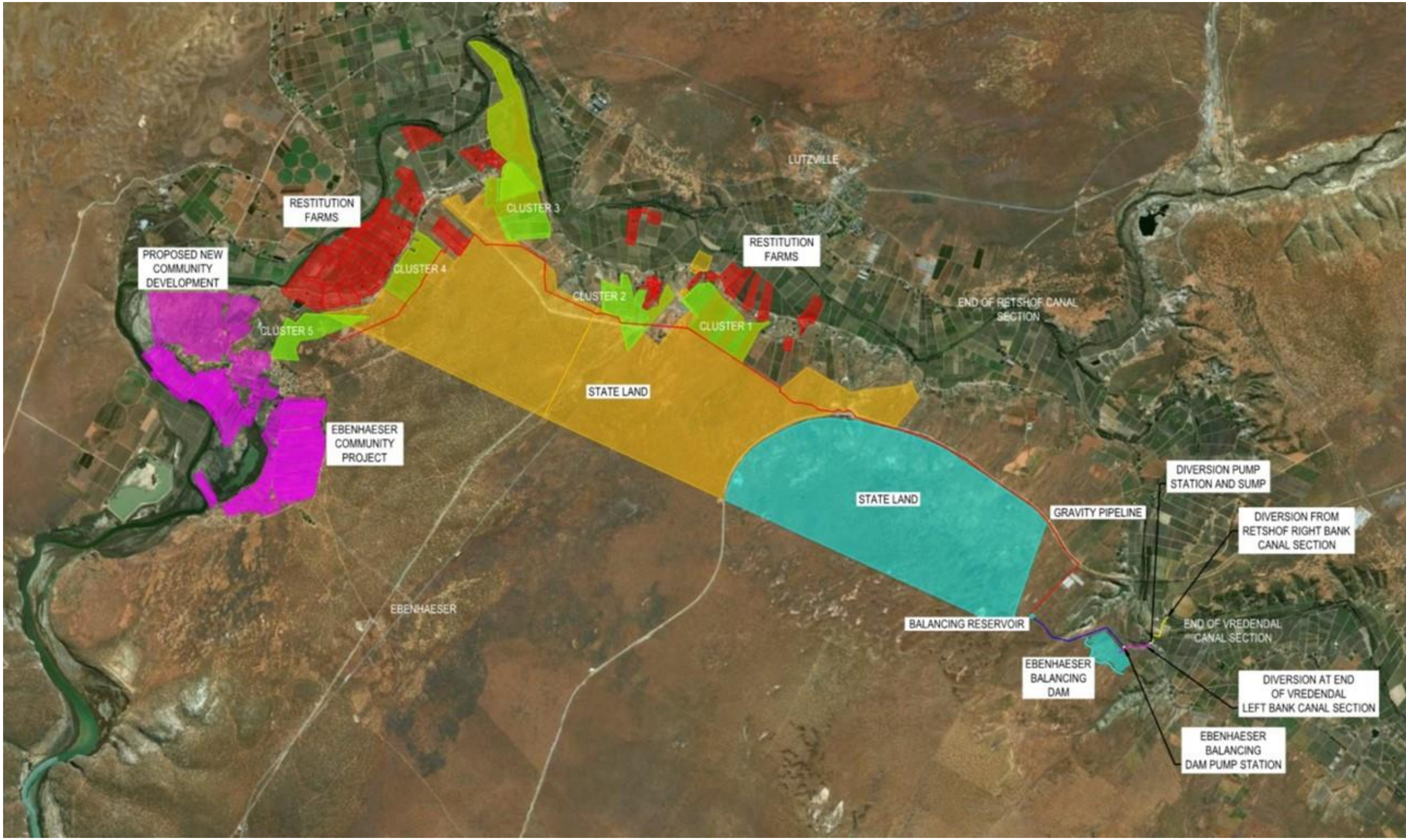

RESTITUTION FARMS
PROPOSED NEW COMMUNITY DEVELOPMENT
CLUSTER 3
CLUSTER 4
CLUSTER 5
CLUSTER 2
CLUSTER 1
LUTZVILLE
RESTITUTION FARMS
END OF RETSHOF CANAL SECTION
STATE LAND
EBENHAESER COMMUNITY PROJECT
STATE LAND
DIVERSION PUMP STATION AND SUMP
GRAVITY PIPELINE
DIVERSION FROM RETSHOF RIGHT BANK CANAL SECTION
EBENHAESER
BALANCING RESERVOIR
END OF VREDENDAL CANAL SECTION
EBENHAESER BALANCING DAM
DIVERSION AT END OF VREDENDAL LEFT BANK CANAL SECTION
EBENHAESER BALANCING DAM PUMP STATION

Figure 10-2: Remaining state land at the Ebenhaeser Scheme

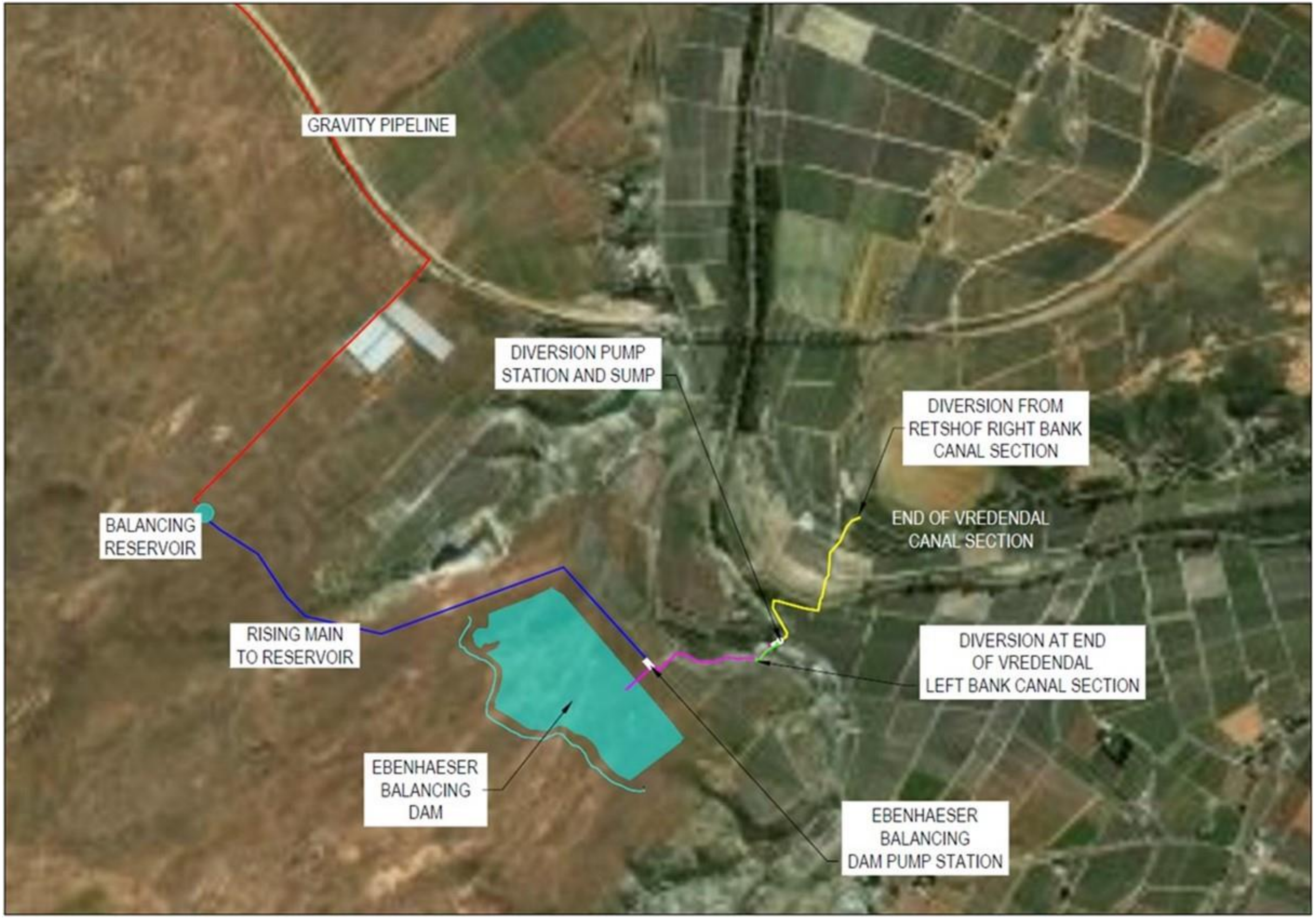

GRAVITY PIPELINE
DIVERSION PUMP STATION AND SUMP
DIVERSION FROM RETSHOF RIGHT BANK CANAL SECTION
END OF VREDENDAL CANAL SECTION
BALANCING RESERVOIR
RISING MAIN TO RESERVOIR
DIVERSION AT END OF VREDENDAL LEFT BANK CANAL SECTION
EBENHAESER BALANCING DAM
EBENHAESER BALANCING DAM PUMP STATION

Figure 10-3: Ebenhaeser Scheme Bulk infrastructure components

10.2 Operation and Maintenance Requirements

10.2.1 Jan Dissels Scheme

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

The West Coast District Municipality is the water service authority and Cederberg Municipality is the water service provider. Because this scheme will provide bulk raw water, it falls outside the mandate of Cederberg Municipality. An alternate operator to consider would therefore be the West Coast District Municipality.

10.2.2 Right Bank Canal Scheme

Once the proposed Right Bank Canal has been completed, it is proposed that the existing main canal (Trawal canal section), on the left bank of the Olifants River, continues to supply the existing irrigators and proposed additional irrigators on the left bank of the Olifants River, between Bulshoek Weir and Verdeling, as an interim measure. Following the significantly reduced flow in this canal section, the maintenance may be adjusted to focus on the bottom section of the canal profile.

In the short- to medium-term, the Right Bank Canal would then supply all current irrigation supplied via the existing main canal, except for the current irrigators located on the left bank, as mentioned above. All new irrigation (from additional allocations following the raising of Clanwilliam Dam) downstream of Bulshoek Weir will be supplied via the Right Bank Canal, except for additional irrigation to be located on the left bank, as mentioned above.

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

Syphons will need to be regularly drained via the lined channels provided to the natural water courses.

10.2.3 Ebenhaeser Scheme

10.2.3.1 Releases from Bulshoek Weir

During weeks when there is identified spare flow capacity in the Vredendal and Retshof canal sections, and when the balancing dam is not full, additional flows will be released from Bulshoek Weir, equal to the spare weekly capacity in the Vredendal and Retshof canal sections respectively (plus estimated canal losses). This rule should be revisited should the Klawer Phase 1 Scheme be implemented, to accommodate the flows required by the Klawer Phase 1 Scheme. This may entail requesting weekly requirements for the Ebenhaeser Scheme according to a pre-planned annual schedule and monitoring whether planned diversion volumes are being met.

For weeks when the requested irrigation demands from irrigators (plus estimated canal losses) exceed the canal capacities, the same rule will apply to current and future irrigators, including the beneficiaries of this scheme.

10.2.3.2 Scheme Operation

Water will be pumped to the balancing dam from the canal diversion points, with diversion ceasing should the dam be full. Diversion rates from the canal off-take points should be equal to the canal flow release rates. There is some concern of the effect of the additional head on the integrity of the existing canals, as flows will increase in canal sections on average once this scheme has been implemented.

The balancing dam should be operated to be full just before the start of the irrigation peak season, likely in early November. At the end of the peak season, the dam will be empty; having been drawn down over a period of 4.5 to 5 months.

From the balancing dam, water will be pumped to the concrete reservoir, and gravitated for irrigation as needed.

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

10.3 Institutional Arrangements

10.3.1 Introduction

The implementation arrangements for the infrastructure of the three proposed bulk water supply schemes are described below. It is a possibility that the funding model of one or more of the schemes may influence the implementation and operation of such scheme/s, but further information on funding is not currently available.

The ‘on-farm’ components of the schemes will be separately implemented.

It is recommended that a professional service provider (PSP) be appointed via an open tender process to undertake the design and construction supervision of the three schemes. The PSP will also be responsible for the preparation of tender documents to appoint a private contractor via an open tender process. The Chief Directorate Engineering Services can assist with this process and provide management and guidance to the PSP and contractor.

10.3.2 Jan Dissels Scheme

It is expected that DWS will be the owner of the scheme. It is not yet evident who will operate the scheme, but it is likely that DWS will operate it, as the scheme will receive water from the adjacent Clanwilliam Dam.

The West Coast District Municipality is the water service authority and Cederberg Municipality is the water service provider. Because this scheme is a bulk raw water supply, it falls outside the mandate of Cederberg Municipality. An alternate operator to consider would therefore be the West Coast District Municipality.

10.3.3 Right Bank Canal Scheme

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

10.3.4 Ebenhaeser Scheme

DWS will be the owner of the scheme. It is recommended that the scheme be operated by LORWUA, as the operational releases from Bulshoek Weir and the management of the balancing dam need to be carefully integrated with releases for existing irrigators or canal augmentation flows.

There are indications that the Ebenhaeser community and restitution farmers may object to the operation of the scheme by LORWUA. They may prefer a private operator, even if only for a portion of the scheme, potentially for the conveyance from the balancing dam to the irrigation clusters.

10.4 Funding arrangements

The proposed Jan Dissels Scheme will be located on State-owned land. The Right Bank Canal Scheme and the Ebenhaeser Scheme will form part of the LORGWS. It is expected that all three schemes will be implemented as Government Waterworks and funded by National Treasury.

Funding from National Treasury will need to be secured. This will enable the project to be implemented as soon as the detailed design and tender documentation are ready, and environmental authorisation has been received.

It should however be remembered that the Jan Dissels and Ebenhaeser schemes are reliant on the additional water that will be available after Clanwilliam Dam has been raised.

Alternative funding and associated implementation arrangements can however not be excluded, especially in a post-Covid-19 situation.

10.5 Implementation programme

The implementation programmes for each of the three schemes, which includes the required tasks and milestones, with estimated timeframes, has been included in **Appendix A**.

The estimated durations for the implementation of the schemes are as follows:

- Jan Dissels Scheme: 6 years;
- Right Bank Canal Scheme: 9.5 years; and
- Ebenhaeser Scheme: 8 years.

11 Cost Estimates

Detailed bills of quantities have been included as Appendices in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* and the *Right Bank Canal Design Sub-Report* respectively. All cost estimates are at October 2020 prices.

11.1 Jan Dissels Scheme

11.1.1 Capital Costs

Table 11-1 provides a summary of the costs for the recommended Route 2 option (pumping from an outlet at the wall of the raised Clanwilliam Dam).

Table 11-1: Cost estimate summary for the Jan Dissels Scheme (excl. VAT)

No	Description	Amount (R million)
1	Main Pipelines	20.242
2	Pump Station	7.740
3	Balancing Reservoir	13.200
	Subtotal (a)	**41.182**
4	Preliminary and General Items (40%)	16.473
	Subtotal (b)	**57.655**
5	Contingencies (25%)	14.414
	Total (October 2020 prices, excl. VAT)	**72.069**

11.1.2 Project Cost Estimate

The project cost estimate for the construction of the recommended Jan Dissels Scheme, including other miscellaneous costs, professional fees and land acquisition costs, is shown in **Table 11-2**.

Table 11-2: Jan Dissels Scheme Project Cost Estimate (incl. VAT)

No	Description	Amount (R million)
1	Rising Main Route 2	72.069
2	Access road (0.5 km long)	0.500
3	Electrical supply	3.000
	Total: Construction costs	**75.569**
4	Professional fees	7.557
	Value Added Tax (15%)	12.469
5	Land acquisition	0.071
	TOTAL (October 2020 prices, incl. VAT)	**95.700**

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

11.2 Right Bank Canal Scheme

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

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

The capital cost of the Right Bank canal and directly associated infrastructure (excluding the capital cost of pump stations, pipelines, farm dams, professional design and support, and land acquisition to supply the four irrigation areas) is estimated to be **R 1 832.8 million (incl. VAT)** (refer to **Table 11-3** for the cost summary).

Table 11-3: Cost estimate for the proposed Right Bank Canal Scheme (incl. VAT)

Description	Bill Reference / Rate	Cost (R million)
Outlet		**0**
Use existing Bulshoek Weir outlet	BOQ-01	0
Canals		**645.128**
Left Bank Upgrade (0.00 km - 3.05 km)	BOQ-02	144.599
Right Bank Reach 1 (3.35 km - 21.91 km)	BOQ-03	351.432
Right Bank Reach 2 (21.18 km - 23.86 km)	BOQ-04	12.912
Right Bank Reach 3 (24.70 km - 33.55 km)	BOQ-05	136.185
Syphon 1		**30.428**
Syphon 1 Inlet	BOQ-09	3.450
Syphon 1 Pipework and Pipe Bridge	BOQ-06	26.260
Syphon 1 Typical Outlet	BOQ-11	0.718
Syphon 2A		**65.763**
Syphon 2A Typical Inlet	BOQ-10	2.656
Syphon 2A Concrete Culvert	BOQ-07	62.389
Syphon 2A Typical Outlet	BOQ-11	0.718
Syphon 2B		**44.218**
Syphon 2B Typical Inlet	BOQ-10	2.656
Syphon 2B Concrete Culvert	BOQ-08	40.843
Syphon 2B Typical Outlet	BOQ-11	0.719
Verdeling Inlet		**4.458**
Verdeling Syphon Tie-in Structure	BOQ-12	4.458
Typical Road Crossings		**29.614**
R363 Road Crossing (4 No. crossings)	BOQ-13	7.897
Major Farm Road Crossing (11 No. crossings)	BOQ-13	21.717
SUBTOTAL A		**R 819.611**
Preliminary & General (% of subtotal A)	40%	327.844
SUBTOTAL B		**R 1 147.455**
Contingencies (% of subtotal B)	25%	286.864
SUBTOTAL C		**R 1 434.319**

Description	Bill Reference / Rate	Cost (R million)
Professional Fees (% of subtotal C)	10%	143.432
Land Acquisition	BOQ-14	15.979
TOTAL COST (excl. VAT)		**R 1 593.730**
VAT	15%	239.059
TOTAL COST (incl. VAT) (2020 prices)		**R 1 832.789**

A summary of the assumptions made to cost each component of the project is given below. All bills of quantities are included in Appendix B of the *Right Bank Canal Design Sub-Report.* The BOQ-00 SUMMARY in Appendix B of the Sub-Report includes a summary of all structures.

The following over-arching assumptions were made regarding the costing of the system:

- Excavation of soft material at R 100 /m³ and hard rock at R 530 /m³;
- Selected backfill from stockpile at R 140 /m³;
- Formwork: Gang formed at R 750 /m² and horizontal at R 1 250 /m²;
- Structural Concrete (35 MPa) at R 2 050 /m³;
- Structural Reinforcing at R 15 000 /ton;
- Structural Steel (incl. delivery and erection) at R 61 840 /ton; and
- New access roads at R 350 000 /km.

Preliminary and general, contingencies and professional fees were assumed as follows:

- Preliminary and General at 40% of construction cost;
- Contingencies at 25% of construction cost plus preliminary and general; and
- Professional fees at 10% of construction cost plus preliminary and general plus contingencies.

Refer to **Section 8** of the '*Right Bank Canal Design Sub-Report*' for additional details of the cost estimate.

11.3 Ebenhaeser Scheme

11.3.1 Capital Cost

11.3.1.1 Pipelines, Pump Stations and Canals

Table 11-4 provides a summary of the cost estimate for the various scheme components and types of work (excluding the balancing dam).

Table 11-4: Capital Cost estimate for Pipelines, Pump Stations and Canals (excl. VAT)

No	Description	Ebenhaeser Scheme (R million)	LOWRUA Betterment cost (R million)	Combined Cost (R million)
1	Pipelines	139.654		139.654
2	Canal Diversion Structures	2.531		2.531
3	Diversion Pump Station and Sump	8.490		8.490
4	Ebenhaeser Balancing Dam Return flow to canals		1.736	1.736
5	Ebenhaeser Balancing Dam Inlet/Outlet Chamber	2.274		2.274
6	Ebenhaeser Balancing Dam Pump Station	6.900		6.900
7	Balancing Reservoir	13.200		13.200
8	Distribution Mains Offtake Chambers	1.188		1.188
	Subtotal (a)	**R 174.238**	**R 1.736**	**R 175.974**
	Preliminary and General Items (40%)	69.695	0.694	70.390
	Subtotal (b)	**R 243.933**	**R 2.430**	**R 246.364**
	Contingencies (25%)	60.983	0.608	61.591
	Total (October 2020 prices, excl. VAT)	**R 304.917**	**R 3.038**	**R 307.955**

11.3.1.2 Ebenhaeser Balancing Dam

A capital cost estimate for the balancing dam was conducted based on the geotechnical information and detailed topographical survey data. **Table 11-5** below shows a summary of this cost estimate. The 'LORWUA Betterment Cost' is the cost of an additional 150 000 m^3 balancing dam storage, and required conveyance and other infrastructure.

Table 11-5: Capital Cost Estimate for the Balancing Dam (excl. VAT)

No	Description	Ebenhaeser Dam (2.17 Mm^3) (R million)	LORWUA Betterment Cost (0.15 Mm^3) (R million)	Combined Cost (2.32 Mm^3) (R million)
1	Earthworks	62.863	4.963	67.826
2	HDPE lining	23.791	1.878	25.669

3	Concrete works	1.815	0.143	1.958
4	Mechanical and other	1.373	0.108	1.481
	Subtotal (a)	**R 89.841**	**R 7.093**	**R 96.934**
	Preliminary and General Items (40%)	35.936	2.837	38.774
	Subtotal (b)	**R 125.777**	**R 9.930**	**R 135.708**
	Contingencies (25%)	31.444	2.483	33.927
Sub-total (October 2020 prices, excl. VAT)		**R 157.222**	**R 12.413**	**R 169.635**

11.3.2 Construction Cost of the Ebenhaeser Scheme

Table 11-6 shows the construction cost of the Ebenhaeser Scheme.

Table 11-6: Ebenhaeser Scheme Construction Cost Estimate (excl. VAT)

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Capital Cost (R million)
Pipelines, pumps and canals	304.917	3.038	307.955
Balancing dam	157.222	12.413	169.635
Total Capital Cost (October 2020 prices, excl. VAT)	**R 462.138**	**R 15.451**	**R 477.589**

11.3.3 Total Project Cost Estimate

Table 11- shows a summary of the total project cost estimate, inclusive of other miscellaneous scheme costs.

Table 11-7: Ebenhaeser Scheme Project Cost Estimate (incl. VAT)

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Cost (R million)
Ebenhaeser Scheme	462.138	15.451	477.589
Access roads	2.220	0.020	2.240
Electrical supply	1.040	0	1.040
Sub-Total: Construction costs	**R 465.398**	**R 15.471**	**R 480.869**
Professional fees (10%)	46.540	1.547	48.087
Value Added Tax (15%)	69.810	2.321	72.130
Land acquisition	0.930	0.041	0.971
TOTAL (October 2020 prices, incl. VAT)	**R 582.678**	**R 19.380**	**R 601.086**

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

12 Legislative Compliance

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

12.1 Water Use Licence

The proposed schemes will require separate water use licence applications (WULAs) in terms of Section 21 of the National Water Act (NWA).

Water uses that need to be included in the WULA (as relevant for each scheme) are:

i. Taking water from a water resource (development of irrigation areas) - Section 21(a);
ii. Storing water (dam) - Section 21(b);
iii. Impeding or diverting the flow of water in a watercourse (dam and associated conveyance infrastructure) - Section 21(c); and
iv. Altering the bed, banks, course or characteristics of a watercourse (conveyance infrastructure and balancing dam) - Section 21(i).

12.1.1 Jan Dissels Scheme

The need for water use licensing for the Jan Dissels Scheme is not envisioned as part of the implementation of the scheme. If the pipeline does however cross any rivulets, a WULA would be required in terms of Section 21(i) of the NWA.

The prospective water users would be responsible for undertaking WULA processes for Section 21(a) and 21(b) water uses (for irrigation development), which would be separate from the process for the implementation of the scheme.

12.1.2 Right Bank Canal Scheme

Water use licensing for the Right Bank Canal Scheme will be required as part of the implementation of the scheme. WULAs in terms of Section 21(c) and 21(i) of the NWA will be required for crossing the Olifants and Doring rivers, and other streams and drainage lines.

The prospective water users would be responsible for undertaking WULA processes for Section 21(a) and 21(b) water uses (for irrigation development), which would be separate from the process for the implementation of the scheme. The WULA process and deliverables will comply with GN R267/2017.

12.1.3 Ebenhaeser Scheme

The volume of water to be stored in the balancing dam exceeds the maximum volume generally authorised under GN 538 (2016 with effect from March 2017) Appendix A. The dam will thus require a WULA in terms of Section 21(b) of the NWA.

The three syphons that will be constructed through significant rivers will require Section 21(c) and 21(i) WULAs to be undertaken for each of these. The WULA process and deliverables will comply with GN R267/2017.

As the balancing dam and some of the proposed scheme routes and sites are located within minor drainage lines, Section 21(c) and 21(i) applications for these may also be required.

The prospective water users would be responsible for undertaking WULA processes for Section 21(a) and 21(b) water uses (for irrigation development), which would be separate from the process for the implementation of the scheme.

12.2 Dam Safety Requirements

The following legal requirements apply to new dams, alterations to existing dams or repair of dams that failed, as issued by the Dam Safety Office:

1) Apply for classification of the dam with the Dam Safety Office (DSO) (part of the Department of Water and Sanitation). The Ebenhaeser balancing dam is expected to be classified as a Category II dam. This requires the services of an Approved Professional Person (APP).
2) The APP will be responsible for the design work as well as submitting an application to the DSO for a Licence to Construct, which comprises an application form, design report, engineering drawings and construction specifications.
3) A Water Use Licence or written authorisation must be obtained from the Regional Director of the relevant region before a Licence to Construct can be issued.

4) During construction, the APP must submit quarterly reports to the DSO on progress of the construction of the dam.
5) Before the construction completion and impoundment is set to commence, the APP must apply to the DSO for a Licence to Impound. This involves the compilation and submission of an operation and maintenance manual and emergency preparedness plan.
6) After completion of all construction work, the APP must register the dam, submit a completion report, completion drawings and a completion certificate stating that the work has been completed according to his/her specifications.

12.3 Licence for Borrow Area

At this stage it is anticipated that a borrow area(s) may be required to source construction material, which could trigger listed activities under GN R983 and R985. Provision should therefore be made for a separate application to be submitted to the Department of Mineral Resources and Energy (DMRE) for the authorisation of these listed activities.

12.4 Ecological Water Requirements

In accordance with the NWA, any new or raised dam is required to make ecological water requirement (EWR) releases in order to sustain the downstream riparian environment. It is unlikely that there will be any required releases from the Ebenhaeser balancing dam as it is off-channel and will have a perimeter trench diverting any runoff around the dam. No allowance for the EWR has thus been made in the design.

12.5 Environmental Impact Assessment

12.5.1 Introduction

Following the completion of the Clanwilliam Bridging Study, separate EIA processes for the Jan Dissels, Right Bank Canal and Ebenhaeser Schemes is undertaken, in terms of all applicable environmental legislation, in a combined EIA study with separate components. The EIA includes the preparation and submission of a WULA for the schemes in terms of Section 21 and Section 22(3) of the NWA.

In terms of the National Environmental Management Act (NEMA), and Environmental Impact Assessment Regulations, as amended on 4 December 2014, and any later amendments, an Environmental Authorisation for the three proposed schemes is required from DEFF, who is the Competent Authority. The procedural requirements for the EIA process are set out in GN R983 of 2014 (as amended). Of greatest importance is the multi-staged approach to public participation and stakeholder engagement stipulated by these regulations.

Impact mitigation measures and environmental management are set out in an Environmental Management Programme (EMPr) and address the life-cycle of the project. The EMPr is compiled as part of the EIA process and submitted as part of the final EIA report to the competent authority.

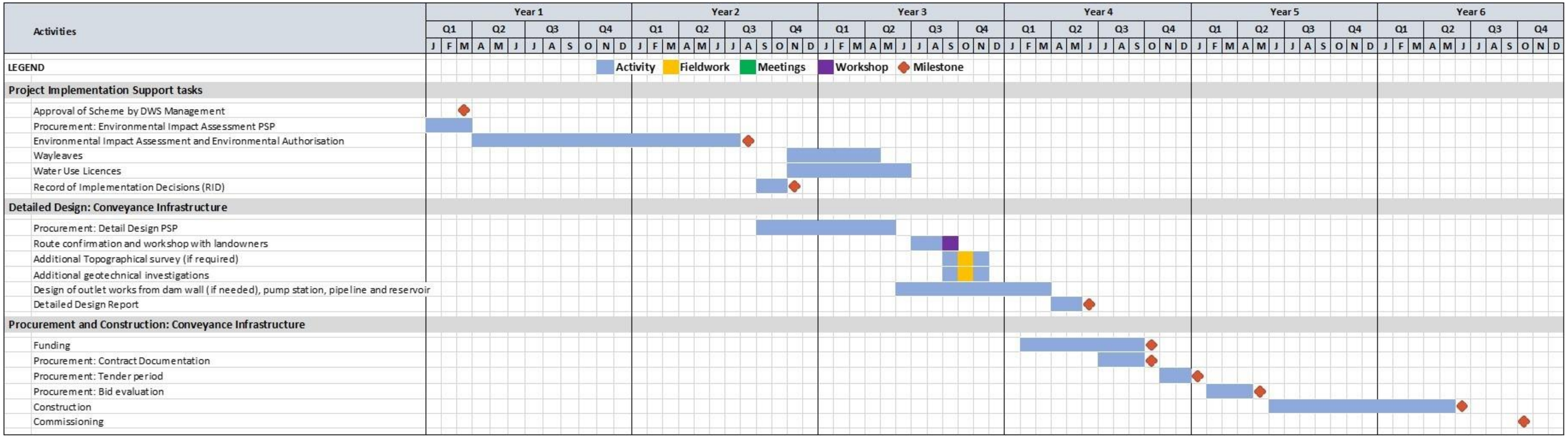
12.5.2 Environmental Authorisation

Note that in terms of Section 24C (2)(d)(i) of NEMA and Section 43 (1)(c)(i), DEFF is the Competent Authority for all listed activities under GN R983 to R985. They could potentially select to delegate responsibility to the Provincial Authority, which is DEA&DP.

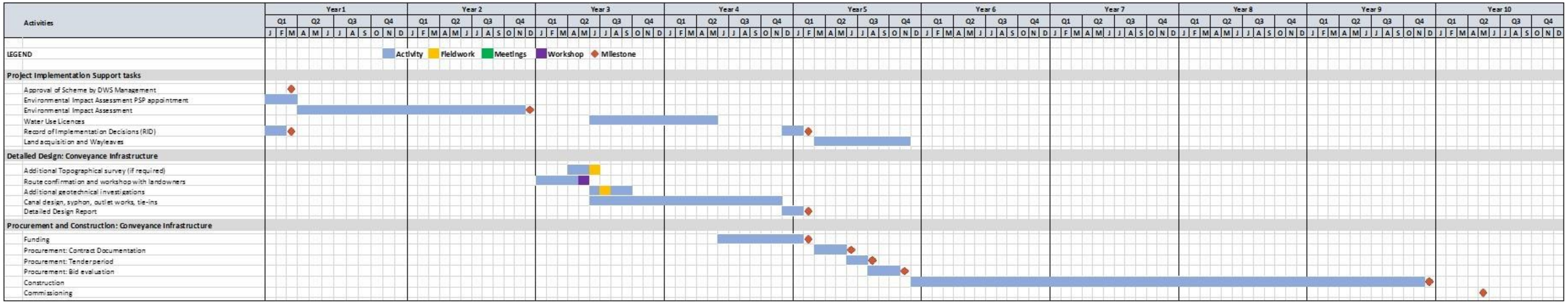
Appendices

Appendix A: Scheme Implementation Programmes

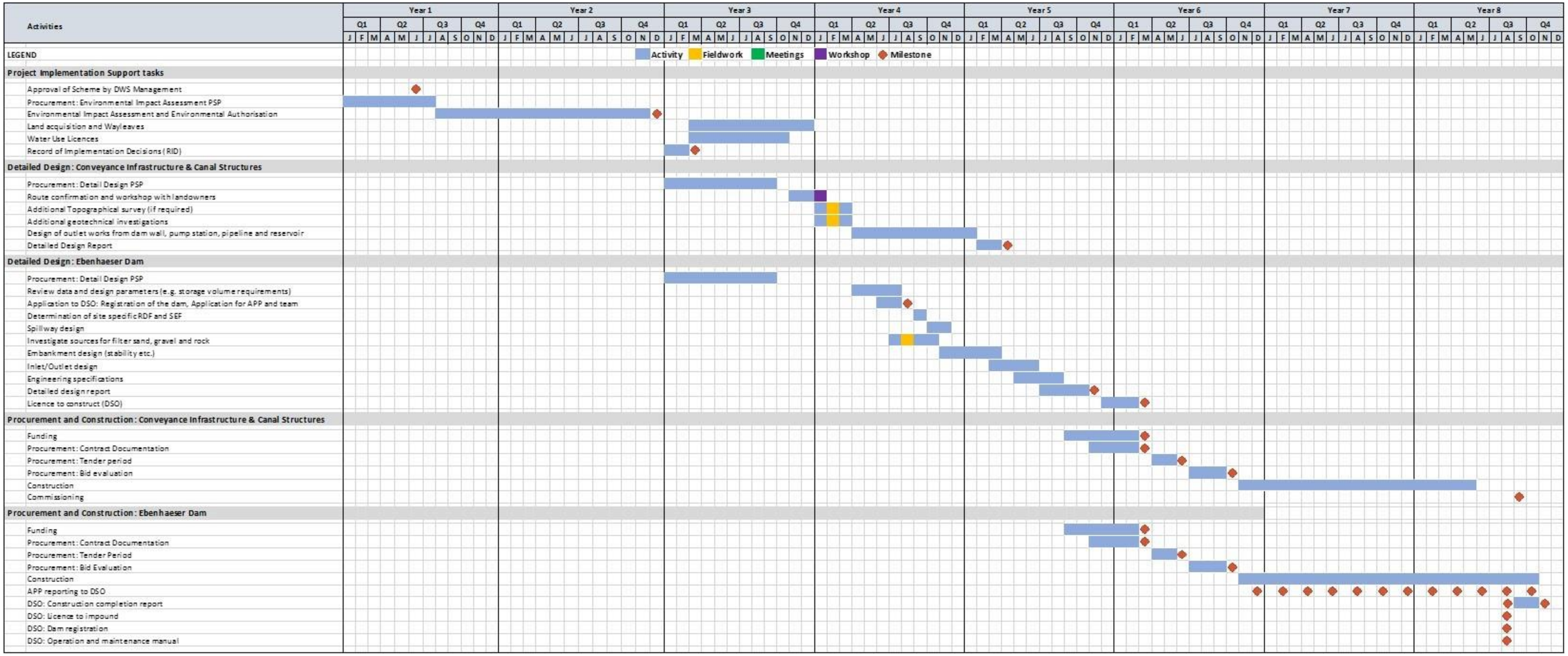
A1: IMPLEMENTATION PROGRAMME - Implementation Support, Detail Design and Construction of the Jan Dissels Scheme



A2: IMPLEMENTATION PROGRAMME - Implementation Support, Detail Design and Construction of the Right Bank Canal Scheme



A3: IMPLEMENTATION PROGRAMME - Implementation Support, Detail Design and Construction of the Ebenhaeser Scheme



Abbreviations:

APP Approved Professional Person

DSO Dam Safety Office

RDF Recommended Design Flood

SEF Safety Evaluation Flood

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