DWS Report No. P WMA 09/E10/00/0417/13

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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

Feasibility Design Report

June 2021

Department of Water and Sanitation
Directorate: Water Resource Development Planning

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

APPROVAL

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

FEASIBILITY DESIGN REPORT

June 2021

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

Reports produced as part of this project are indicated below.

Bold type indicates this report.

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

Concise Description of the Content of Study Reports

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

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

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

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

Executive Summary

Introduction

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

This report provides an integrated summary of the feasibility design undertaken for the identified development schemes, as documented in the four design sub-reports:

- Conceptual Design Sub-Report;
- Environmental Screening Sub-Report;
- Jan Dissels and Ebenhaeser Schemes Design Sub-Report; and
- Right Bank Canal Design Sub-Report.

This design sub-reports are supported by the Topographical Survey Report and the three Geotechnical and Soils Investigations Reports, one report per scheme.

Suite of Preferred Irrigation Schemes

The preferred suite of proposed irrigation schemes, to be developed using water made available following the raising of Clanwilliam Dam, comprise of five schemes located upstream of Bulshoek Weir and five schemes located downstream of Bulshoek Weir. Of these schemes, the following schemes were identified for feasibility-level design:

- **Jan Dissels Scheme** located near Clanwilliam Town, to receive a pumped supply from the Clanwilliam Dam;
- **Right Bank Canal Scheme**, replacing the existing main canal with a canal of increased capacity on the right bank of the Olifants River, including capacity to supply new downstream irrigation development and other future uses. This scheme is essential to ensure a secure future water supply to the lower Olifants River irrigators and other users, and to the prosperity of the region;
- **Ebenhaeser Scheme**, using spare capacity in existing canal section/s to provide water to restitution farms and to augment the supply to the existing community at Ebenhaeser.

Topographical Survey

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

Geological, Geotechnical and Materials Investigation

The geological and geotechnical evaluation comprised:

- A **desk study** of available information for recommended schemes to be designed, and a reconnaissance visit to the various scheme elements, conducted during March 2020;
- Geotechnical **field investigations** for the preliminary conveyance infrastructure routes 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, in-situ field testing including dynamic cone penetration tests, sampling and laboratory testing;
- Compilation of detailed geotechnical interpretive **reports** for the three schemes; and
- **Core drilling of a total of four syphon routes** for the Right Bank Canal Scheme and Ebenhaeser Scheme respectively, undertaken in early 2021 and subsequent updating of the reports.

Environmental Screening and Scheme Assessments

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

More detailed **environmental assessments** were then undertaken, to support the feasibility design of the three schemes.

Two meetings were held, in August 2019 and November 2020 respectively, with environmental authorities to get greater clarity on the **environmental approvals process** of the proposed suite of irrigation schemes, and specifically the three schemes designed. It was confirmed that the Department of Environment, Forestry and Fisheries (DEFF) will be the Competent Authority for EIA decision-making, since Department of Water and Sanitation (DWS) will apply as the Proponent for the three schemes. They may delegate this responsibility to the Provincial Department of Environmental Affairs and Development Planning (DEA&DP). If the applicants will be private landowners, such as joint venture developments on private land, then the environmental authorisation entity will be DEA&DP.

Jan Dissels Scheme Feasibility Design

An area east of Clanwilliam Dam and close to Clanwilliam town, was identified as suitable irrigable land (**Figure E1**). The area is *inter-alia* suitable for the development of smaller plots, given its proximity close to Clanwilliam town and existing markets. A botanical survey was undertaken to confirm the extent of environmental sensitivity, and to define the scheme's irrigable area. The water requirement for the potential 462 ha of irrigable land is 4.26 million m^3/a.

Two routes for a rising main pipeline were identified:

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

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

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

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

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

The scheme is very feasible from a cost perspective and is considered a favorable scheme for implementation.

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

Figure E1: Layout of Jan Dissels Scheme

Right Bank Canal Feasibility Design

The Right Bank Canal Scheme is designed to replace the existing left bank main canal, which starts at Bulshoek Weir, with a new canal on the right bank of the Olifants River. The new canal will have an increased capacity to also supply new downstream irrigation development and other future uses. This scheme is essential to ensure a secured future supply, given the high risk of disruption and shortfall in supply that the poor state of the existing canals, and especially the main (Trawal section) canal, poses to the lower Olifants River irrigators, to other users, and to the prosperity of the region.

The scheme will supply the four significant new potential irrigation areas in the Trawal region, namely the Zypherfontein 1 and 2, Trawal and Melkboom irrigation areas. The scheme will be situated on privately-owned land.

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

The proposed Right Bank Canal Scheme uses the existing outlet works from the Bulshoek Weir and requires upgrading of the first three (3) km of the existing Left Bank Canal. It then crosses the Olifants River to connect into a new canal, which continues until it reaches the existing syphon at Verdeling. Bulk distribution and storage infrastructure to the four irrigation areas were designed at reconnaissance level.

A general layout arrangement of the proposed scheme is shown in **Figure E2** and consists of the following components:

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

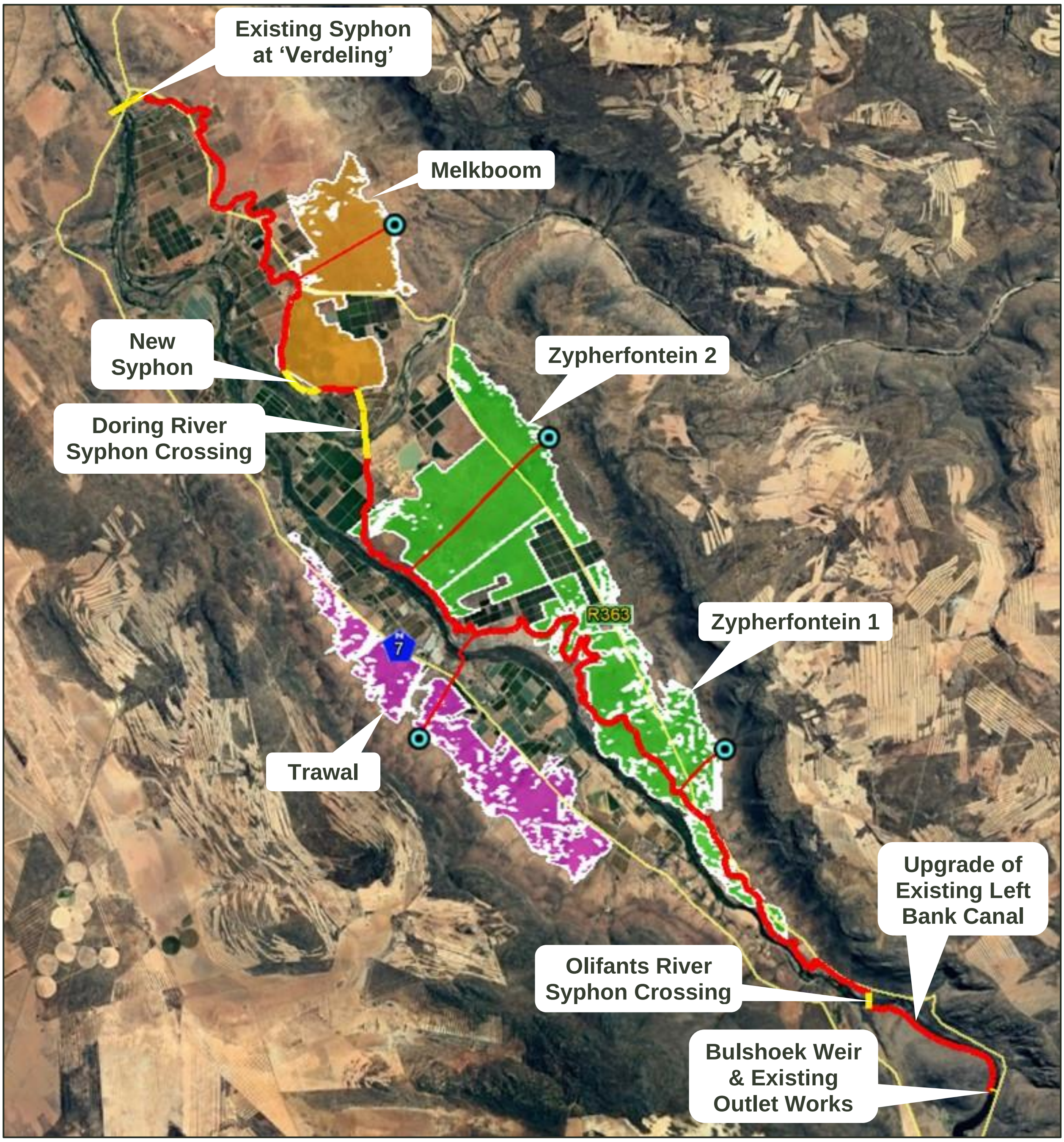

Figure E2: Layout of the Right Bank Canal Scheme

Ebenhaeser Scheme Feasibility Design

The Ebenhaeser Scheme will make use of spare flow capacity in the existing right bank and left bank canal sections (downstream of Verdeling). Augmentation of the water supply to prioritised restitution farms in the Ebenhaeser area has a high priority from a social and political perspective, to ensure that such restitution farms can be successfully farmed, by increasing current inadequate water allocations. In addition, this scheme can to a limited extent augment supply to the existing historically disadvantaged community at Ebenhaeser. Five water requirement clusters were identified, in consultation with community representatives. The water availability of the scheme is 4.66 million m^3/a, including losses (conveyance losses and balancing dam evaporation) of 1.01 million m^3/a, to irrigate 361 ha of irrigable area. The volume of water available for irrigation (excluding water losses) is 3.65 million m^3/a.

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

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

From the right bank Retshof diversion, water will be conveyed via a 500 mm diameter, 765 m long gravity pipeline, including a syphon underneath the Olifants River, to a 2.5 Mℓ diversion sump and pump station. Water will also be gravitated from the Vredendal canal to the sump, from the existing long weir via a 560 mm diameter, 93 m long gravity pipeline. From the sump, water will be pumped via a 700 mm diameter, 520 m long rising main pipeline, to a 2.32 million m^3 lined earthfill balancing dam. The dam will be situated South-West of and close to the Vredendal left bank canal diversion point, opposite the R363 road between Vredendal and Lutzville. The diversion rising mains are designed to allow water from the Ebenhaeser balancing dam to be supplied back under gravity to the left bank and right bank canals when needed.

From the balancing dam, water will be pumped to a 11 000 m^3 (11 Mℓ) concrete balancing reservoir, via a 560 mm diameter, 1 975 m long rising main pipeline. From the concrete balancing reservoir, water will be gravitated to high points adjacent to the water requirement clusters, with adequate minimum pressure provided, via a 17 700 m long gravity pipeline, varying from 630 mm to 355 mm diameter.

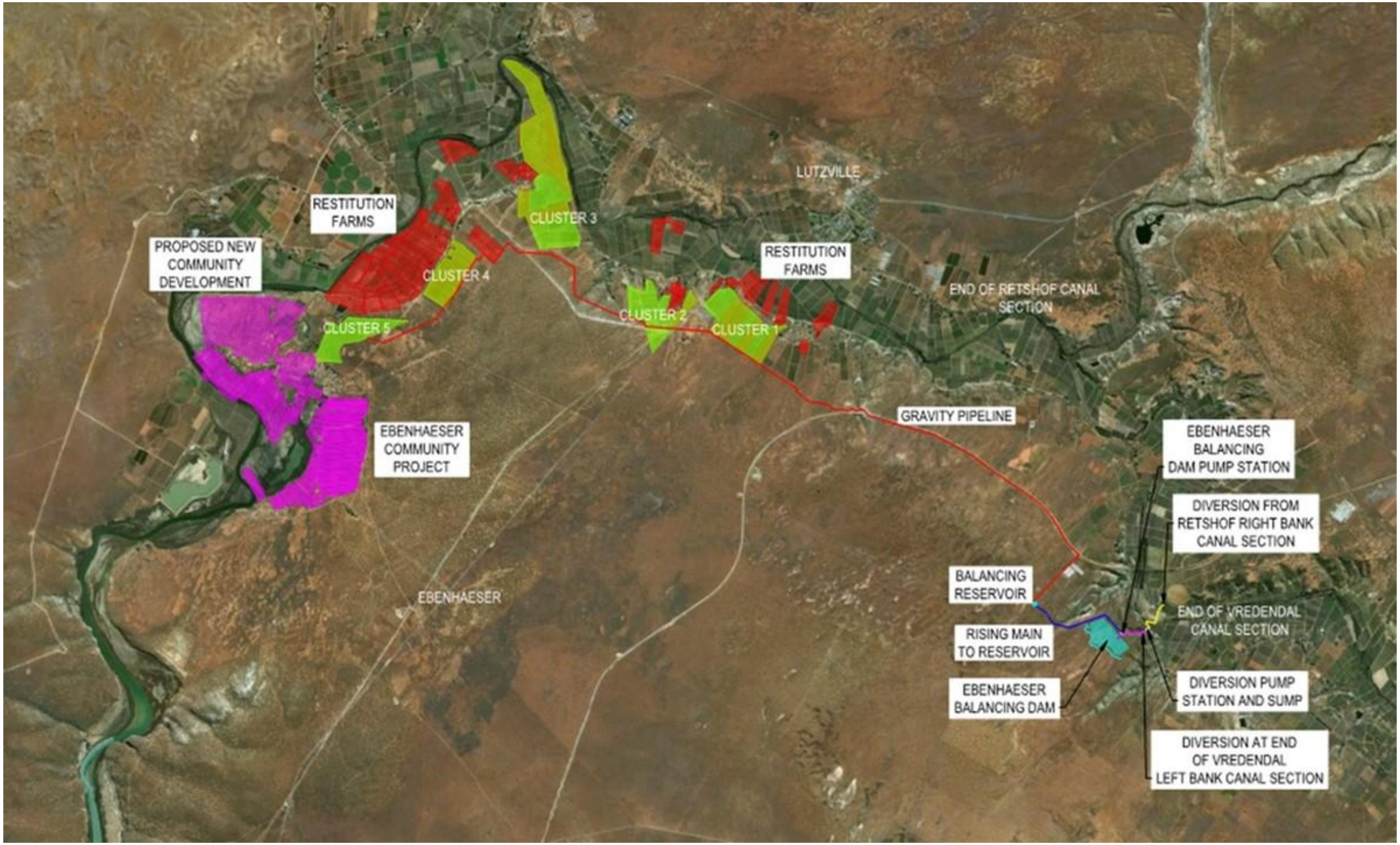

Figure E3: Layout of the Ebenhaeser Scheme

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

Feasibility-level Cost and Implementation Analysis

Jan Dissels Scheme

The summary of the cost estimates for the construction of the two Jan Dissels Scheme options, other miscellaneous costs, professional fees and land acquisition costs are shown in **Table E1** and **Table E2** respectively.

Table E1: Jan Dissels Scheme Route 1 Project Cost Estimate, incl. VAT

No	Description	Amount (R million)
1	Rising Main Route 1	52.626
2	Access road (1 km long)	1.000
3	Electrical supply	3.000
	Total: Construction costs	**R 56.626**
4	Professional fees (10%)	5.663
	Value Added Tax (15%)	9.343
5	Land acquisition	0.013
	TOTAL (October 2020 prices, incl. VAT)	**R 71.700**

Table E2: Jan Dissels Scheme Route 2 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	**R 75.569**
4	Professional fees	7.557
	Value Added Tax (15%)	12.469
5	Land acquisition	0.071
	TOTAL (October 2020 prices, incl. VAT)	**R 95.700**

A financial comparison (2020 prices, excluding VAT) to compare the capital cost, net present value (NPV) and unit reference value (URV) of the bulk water infrastructure of the two sub-options was undertaken, and the results are indicated in **Table E3**. This evaluation excludes the cost of access roads, distribution pipes and on-farm reservoirs.

Table E3: Comparative costing of sub-options (2020 costs, excl. VAT)

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

Right Bank Canal Scheme

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)**. This cost breakdown is shown in **Table E4**.

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 (desktop) level of design.

Should a new Right Bank main canal not be constructed, then two small bulk water schemes would supply the same four irrigation areas. The capital cost of the two small schemes to supply the four irrigation areas is the attributable ‘Development’ capital cost component of the Right Bank Canal Scheme. The combined estimated October 2020 capital cost of the development component of the two small schemes is R 573.16 million, excluding VAT.

The difference between the development cost of the two small schemes and the full cost of the Right Bank Canal Scheme (including bulk distribution and storage infrastructure to supply the four irrigation areas) is deemed the ‘Betterment’ capital cost. The betterment capital cost component of the scheme is therefore R 1 421.5 million, excluding VAT.

Table E4: Right Bank Canal Scheme Project Cost Estimate, incl. VAT

Description	Cost (R million)
Outlet	0
Canals	645.128
Syphons	140.409
Verdeling Inlet	4.458
Typical Road Crossings	29.614
Sub-Total A	**819.611**
Preliminary & General Items (40%)	327.844
Sub-Total B	**1 147.455**
Contingencies (25%)	286.864
Total Capital Cost (excl. VAT)	**1 434.319**
Professional design and support (10%)	143.432
Land Acquisition	15.979
Total Cost (excl. VAT)	**1 593.730**
VAT (15%)	239.059
TOTAL (October 2020 prices, incl. VAT)	**1 832.789**

The comparative costing (NPV and URV) of the Right Bank Canal Scheme is shown in **Table E5**. The attributable NPV betterment costs are the difference between the NPVs of the development costs (for the two small schemes) and the full cost of the Right Bank Canal Scheme.

Table E5: Comparative Costing of Scheme - (2020 costs, excl. VAT)

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

Ebenhaeser Scheme

Table E6 provides a summary of the total capital cost estimate for the scheme.

Table E6: Ebenhaeser Scheme Capital Cost Estimate (excl. VAT)

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Capital Cost (R million)
Pipelines, pumps and canals	174.238	1.736	175.974
Balancing dam	89.841	7.093	96.934
Total Capital Cost (October 2020 prices, excl. VAT)	**R 264.079**	**R 8.829**	**R 272.908**

The construction cost of the Ebenhaeser Scheme consists of the capital cost plus allowance for Preliminary and General Items and Contingencies, plus other miscellaneous scheme costs (access roads and power supply). **Table E7** shows the project cost of the scheme.

Table E7: Ebenhaeser Scheme Project Cost Estimate, incl. VAT

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Cost (R million)
Total Capital Cost	264.079	8.829	272.908
Preliminary & General Items (40%)	105.632	3.532	109.163
Subtotal	**R 369.711**	**R 12.361**	**R 382.071**
Contingencies (25%)	92.428	3.090	95.518
Construction Cost Estimate	**R 462.138**	**R 15.451**	**R 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**

The comparative cost values for the Ebenhaeser Scheme (2020 prices, excluding VAT) are provided in **Table E8**. The URV for this scheme is R 12.77/m^3, which indicates that it is an expensive scheme.

Table E8: Ebenhaeser Scheme: Development NPV (2020 costs, excl. VAT)

Cost Item	Cost
Total NPV Cost (R million)	R 536.71
Unit Reference Value (R/m^3) at 8% discount rate	R 12.77

Legislative Compliance

Water Use Licencing and Dam Safety

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

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

Licence for Borrow Area

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

Ecological Water Requirement

No releases from the Ebenhaeser balancing dam for ecological water requirements are foreseen.

Environmental Compliance

In terms of the National Environmental Management Act (No. 107 of 1998, as amended) (NEMA), separate Environmental Authorisations for the three proposed schemes will be required. The Environmental Impact Assessment process for the proposed schemes is expected to start in 2021/22. It will follow a multi-staged approach to environmental impacts, public participation and stakeholder engagement, as stipulated by these regulations, as well as involve various specialist studies.

Implementation Arrangements

Jan Dissels Scheme

Affected Land, Land Acquisition and Wayleaves

The land required for the rising main pump station at the (raised) dam wall falls within the Clanwilliam Dam area, which is owned by DWS. The surface area required for the rising main pipeline, to be located on land of Cederberg Municipality, including a servitude, is 3.37 ha. The surface area required for the reservoir is 0.17 ha, also located on Cederberg Municipality land.

The rising main route will cross two surfaced roads, namely the Deon Burger Road and the entrance/exit roads to the Clanwilliam Dam Resort. The route will also transect the Ramskop Nature Reserve, which is managed by Cederberg Municipality. An access road to the proposed concrete reservoir must be constructed. During the detailed design of the scheme the various landowners who could be affected should be consulted.

Operation and maintenance

It is anticipated that DWS will be responsible for the operation of the scheme, but this still needs to be confirmed. An alternate operator to consider could be the West Coast District Municipality.

Institutional Arrangements

DWS will be the owner of the scheme.

Right Bank Canal Scheme

Affected Land, Land Acquisition and Wayleaves

The horizontal alignment for the proposed Right Bank Canal runs through privately owned farms. 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.

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

Operation and maintenance

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 new irrigators between Bulshoek Weir and Verdeling, in the short- to medium-term. Following the significantly reduced flow in this canal section, the maintenance may be adjusted to focus on the bottom section of the canal profile. All other water requirements will be supplied by the Right Bank Canal.

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

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

Institutional Arrangements

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

Ebenhaeser Scheme

Affected Land, Land Acquisition and Wayleaves

The scheme will traverse several farms, owned by various landowners, as well as State land owned by Financial Assistance Land Administration (FALA) land of the Department of Agriculture, Land Reform and Rural Development (DALRRD). The portion of land upon which the Ebenhaeser Balancing dam is to be located is known as Bakleiplaas 182 and is privately owned. The private landowners will need to be consulted regarding the pipeline routes and associated infrastructure over their properties. Land and servitudes for the proposed infrastructure will need to be acquired from the landowners. Compensation for the land acquired will include infrastructure affected by the project.

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. 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 proposed diversion rising main (from the diversion pump station to Ebenhaeser Balancing Dam) will cross the R363 road. The gravity pipeline (from the concrete balancing reservoir to irrigation clusters) will cross the R362 road. Both roads are owned by the Western Cape Department of Transport and Public Works. The proposed gravity pipeline from the concrete balancing reservoir to 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.

Operation and maintenance

During weeks when there is identified spare flow capacity in the Vredendal and Retshof canal sections, and when the balancing dam is not full, additional flows will be released from Bulshoek Weir for the scheme, equal to the spare weekly capacity in the Vredendal and Retshof canal sections respectively.

Water will be pumped to the balancing dam from the canal diversion points, with diversion ceasing should the dam be full. Diversion rates from the canal off-take points should be equal to the canal flow rates. The balancing dam should be operated to be full just before the start of the irrigation peak season, likely in early November. From the balancing dam, water will be pumped to the concrete reservoir, and gravitated to irrigators as needed.

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

Institutional Arrangements

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

Wayleaves

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

Further Investigations for Detailed Design

While the accuracy of the contour surveys undertaken for the schemes is considered suitable for detailed design, some further **surveys** of canal and pipeline centrelines and the railway and existing culvert crossings on the Ebenhaeser gravity pipeline will be required. A more detailed analysis and survey of the existing Bulshoek Weir Outlet should be conducted to verify the capacity.

Further **geotechnical investigations** that are required relate to the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources of this material. Follow-up geotechnical investigations should be conducted for the Jan Dissels Scheme for the recommended pump station site and chemical testing to confirm the corrosiveness of the soils. Findings and recommendations from the core drilling of the syphon routes undertaken should be taken into account.

Confirmation of **canal and pipeline routes** and infrastructure locations are needed, after discussions with affected landowners and authorities. The choice of pipe material and quality control inspections of pipes should be addressed, as well as the refinement of pump types.

Developments subsequent to the feasibility design should be taken into account, notably the influence of the approved Marblesharp farm dam, located on the proposed Zypherfontein 1 irrigation scheme on the horizontal alignment of the canal route.

Proposed **road and rail crossing details** need to be submitted to the relevant authorities for their approval.

Reconsider the sizing of the **concrete balancing reservoirs**, taking into account the operational procedures of the smallholder farmers' component of the scheme, and emergency situations to counter load shedding and breakdowns, and allow for maintenance.

Eskom should be engaged regarding **electrical supply** to the pump stations.

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 project life cycle.

If the required Right Bank canal **design flow capacity** is revised, the scheme routing and sizing of infrastructure should be amended.

Consider adjusted **offtake points** for the four new irrigation developments from the Right Bank Canal, should information be available, as well as off-take points to existing irrigation farmers to replace existing off-takes from the Doring Canal section, which will be phased out.

The assumptions made in the determination of the **Ebenhaeser balancing dam** storage volume should be checked and refined. The zoning dimensions must 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. Further investigation into the required thickness and other properties of the balancing dam lining will be needed. The relocation of three power lines, affected by the position of the balancing dam, need to be addressed.

Project Implementation

Professional service providers, appointed via open tender processes, are recommended to undertake the **detailed design and construction supervision** of the schemes, with contractors also appointed via open tender processes. Chief Directorate Engineering Services would then provide the required management and guidance of the PSPs and contractors. The option to undertake detailed design in-house by Chief Directorate: Engineering Services may also be considered with a PSP appointed to assist with construction supervision.

Detailed design for each scheme will commence once the EIA for that scheme has been concluded, and an Environmental Authorisation has been issued. Implementation of the Jan Dissels and Ebenhaeser schemes is dependent on the availability of additional water when the raising of Clanwilliam Dam is completed.

It is expected that all three schemes will be implemented as **Government Waterworks**. The proposed Jan Dissels Scheme will be located on State-owned land. The Right Bank Canal Scheme and the Ebenhaeser Scheme will form part of the Lower Olifants River Government Water Scheme.

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

The potential need for **alternative funding** and associated implementation arrangements can however not be excluded, especially in a post-Covid-19 situation.

Conclusions

Jan Dissels Scheme

After a feasibility level investigation, it is concluded that it is feasible to construct the Jan Dissels Scheme to supply new HDI irrigators, abstracting water from below the raised Clanwilliam Dam wall on the right bank. The proposed scheme comprises a high-lift pump station, pumping via a 3 736 m long DN 500 mm HDPE rising main to a 12 Mℓ reinforced concrete reservoir on top of the hill. Horizontal split-casing pumps are preferred. A new access road will have to be constructed to the reservoir and a new power supply provided.

The available survey data is considered adequate to undertake the detailed designs of the proposed infrastructure, but further geological investigations are required.

The scheme will be owned and operated by DWS.

Right Bank Canal Scheme

The Right Bank Canal Scheme will replace the existing left bank main canal with a new 11.40 m/s capacity canal on the right bank of the Olifants River, transporting water from the existing Bulshoek Weir to the existing 2.0 m diameter syphon at Verdeling. It is concluded that it is feasible to construct the Scheme to supply new HDI irrigators, to be located on privately-owned farms.

Water will be released from the existing outlet works at Bulshoek Weir to the 3.05 km upgraded left bank canal section, and cross the Olifants River on a 2.4 m diameter 300 m long pipe bridge syphon. Water will then flow in a 18.56 km long new reach of trapezoidal canal on the right bank, via two rectangular in-situ concrete syphons and a short reach of canal (1 270 m, 840 m and 680 m long respectively), and via another 8.85 km long new trapezoidal canal to the upgraded existing syphon outlet at Verdeling to act as an inlet (chainage 33.55 km).

The available survey data is considered adequate to undertake the detailed design of the proposed infrastructure.

The scheme will be owned by DWS and operated by LORWUA.

Ebenhaeser Scheme

After a feasibility level investigation, it is concluded that it is feasible to construct the Ebenhaeser Scheme to augment the supply to restitutions farms and the Ebenhaeser Community Project, by making use of spare flow capacity in existing right bank and left bank canal sections, to irrigate an additional 361 ha.

Canal diversion structures will be required at the Retshof right bank and Vredendal left bank canals to create off-take points. Surplus canal flows will be diverted from the diversion structures and will gravitate to a combined balancing sump. From the sump, water will be pumped via the “diversion” rising main to the Ebenhaeser balancing dam. From the 2.32 million m^3 lined earthfill balancing dam (including 150 000 m^3 for operational purposes), 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 available survey data is considered adequate to undertake the preliminary and detailed designs of the proposed infrastructure.

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

The scheme will be owned by DWS and operated by LORWUA.

Recommendations

The following recommendations are applicable to the detailed design and construction phases of the schemes.

Topographical Survey

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

Geotechnical and Materials Investigations

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

Jan Dissels Scheme Feasibility Design

6) It is recommended that the Rising Main Route 2 option be implemented for the Jan Dissels Scheme.
7) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.
8) Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.
9) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.
10) Confirm the choice of pipe material during the detailed design phase of the project, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.
11) Eskom should be engaged during the detailed design phase of the project regarding electrical supplies to the pump stations.
12) Refine the pump type selection.

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

Right Bank Canal Scheme Feasibility Design

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

Ebenhaeser Scheme Feasibility Design

17) An estimate is required of the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources.
18) Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.
19) Independent quality control inspections of the pipes, at the factory and on site, must be included in the construction tender documents.
20) Confirm the choice of pipe material, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.
21) Eskom should be engaged regarding electrical supplies to the pump stations.
22) Refine the pump type selection.
23) Submit the proposed railway crossing details on the Ebenhaeser gravity main to the relevant railway authority for their approval during detailed design stage.
24) Submit the proposed road crossing details to the relevant road authority for their approval during detailed design stage.
25) The assumptions made in the determination of the desired dam storage volume (e.g. siltation from the canal and infiltration losses) should be checked and refined.
26) The dam embankment zoning and dimensions are based on typical values for embankment dams of this size using similar materials. The zoning dimensions must thus be designed based on the actual material properties and design constraints for the particular zones, which are used as input into a slope stability analysis.

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

Legislative Compliance

28) The water use licence applications for storing water, and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), NWA as relevant for the three schemes, is included in the scope of work for the EIA study.
29) The application to DMRE for a Licence for a Borrow Area is included in the scope of work for the EIA study.
30) The Ebenhaeser Balancing Dam safety regulation requirements are as follows:
    - Applications for licences for complying with the dam safety regulations will need to be completed before certain tasks may continue;
    - A licence to construct must be issued by the Dam Safety Office (DSO) before any construction may commence. This application includes the relevant application forms, the Detailed Design Report for the dam with engineering drawings, the water use licence, and engineering specifications;
    - Before the bottom outlets of the dam are closed, thereby commencing the impounding of water, the licence to impound must be obtained from the DSO. This application includes the relevant application forms, the operation and maintenance manual and the emergency preparedness plan.
31) DWS is required to undertake a comprehensive EIA process for each of the schemes, in accordance with NEMA and the 2014 EIA Regulations (GN R982 – 985, as amended). The EIA process is a legal requirement to obtain Environmental Authorisation from DEFF for implementation of the projects.

Implementation Arrangements

32) The planned new irrigation developments and the implementation of the schemes need careful planning and coordination.
33) Further investigations for detailed design should be undertaken, inclusive of topographical surveys, geotechnical investigations, construction materials, electrical power supply, and road and railway crossings.
34) Obtain environmental authorisations for the schemes.
35) Finalise scheme layouts and sizing of components, and undertake detailed design.
36) Obtain the necessary licences for implementation of the schemes.

37) Undertake land acquisition and obtain servitudes, including compensation for affected land and infrastructure
38) Arrange wayleaves from the relevant authorities for road and rail crossings.
39) Finalise institutional agreements.
40) The revision of contractual arrangements with LORWUA should be considered, for the operation of the Right Bank Canal and Ebenhaeser schemes and the joint use of water from the Ebenhaeser balancing dam.
41) The RID should be finalised, after the Environmental Authorisation has been received, and issued to DWS Infrastructure Development to formalise the implementation of the schemes.
42) Funding needs to be secured from National Treasury to enable construction of the project to commence as soon as the detail design is complete and Environmental Authorisation has been received.

Further issues to address

Further issues to address are the following:

43) The principles of the splitting of capital costs and NPVs between new irrigation development and betterment costs (costs attributable to current irrigators) should be re-visited, to ensure equity.
44) Clarify the uncertainty regarding the cost of water from the LORGWS, following the raising of Clanwilliam Dam, so that the potential for a Trawal Government Water Scheme can be assessed with more confidence.
45) Clarify the legal obligations on DWS to ensure that the LORGWS infrastructure remains functional.
46) The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the critical biodiversity areas, following acceptance of the recommendations.
47) Receive authorisation for the proposed new irrigation development areas. The majority of these areas are privately owned, and it is expected that the majority of such development may be via joint venture agreements.
48) To obtain greater clarity on funding options, it is suggested that DWS explain implementation approaches to National Treasury, and request confirmation of National Treasury’s view on such approaches, and any concerns and required procedures.

Contents

Appendices

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Acronyms

APP	Approved Professional Person
CA	Competent authority
CBA	Critical biodiversity area
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
DWAF	(Previous) Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EIA	Environmental impact assessment
EMF	Environmental management framework
EMPr	Environmental Management Programme
ESRI	Environmental Systems Research Institute
EWR	Ecological water requirement
FALA	Financial Assistance Land Administration
FSL	Full supply level
GIS	Geographical information system
GN	Government notice
Ha	Hectare
HDI	Historically disadvantaged individual
HDPE	High density poly ethylene
HWC	Heritage Western Cape
ℓ/s	Litre per day
LIDAR	Light detection and ranging
LORGWS	Lower Olifants River Government Water Scheme

LORWUA	Lower Olifants River Water User Association
Masl	Meters above sea level
Mℓ	Megalitre
Mℓ/d	Megaliter per day
Mm^3/a	Million cubic meter per annum
MOL	Minimum operating level
MPRDA	Mineral and Petroleum Resources Development Act
mS/m	Milli Siemens per meter
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NFA	National Forests Act
NHRA	National Heritage Resource Act
NOC	Non overspill crest
NPV	Net present value
NWRI	National Water Resources Infrastructure branch of DWS
NWA	National Water Act
O&M	Operation and maintenance
P&G	Preliminary and general items
RID	Record of Implementation Decisions
RM	Rising main pipeline
SANRAL	South African National Roads Agency
SANS	South African National Standards
SDF	Spatial development framework
SEA	Strategic environmental assessment
SEF	Safety evaluation flood
TLB	Tractor-loader-backhoe
uPVC	Unplasticised polyvinyl chloride
URV	Unit reference value
VAT	Value added tax
WCDoA	Western Cape Provincial Department of Agriculture
WULA	Water use licence assessment

1 Introduction

1.1 Study objectives

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

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

1.2 Report Objectives

This report provides an integrated summary of the feasibility design undertaken for the identified development options, as documented in the four design sub-reports:

- Conceptual Design Sub-Report;
- Environmental Screening Sub-Report;
- Jan Dissels and Ebenhaeser Schemes Design Sub-Report; and
- Right Bank Canal Design Sub-Report.

This design sub-reports are supported by the Topographical Survey Report and the three Geotechnical and Soils Investigations Reports, one report per scheme.

The report describes the following:

- The main features and costs of the bulk irrigation water conveyance and storage infrastructure of the three recommended development schemes designed at feasibility level;
- The various supporting investigations; and
- The further activities to be undertaken.

While this is the integrated report describing the feasibility design, much of the information has been presented in a summary fashion. It is important to note that the four supporting sub-reports should be consulted for the detailed design descriptions and other relevant information regarding the development schemes.

1.3 Background to the Project

The Clanwilliam Dam is situated in the Olifants River near the town of Clanwilliam in the Olifants/Doorn River Catchment Management Area in the Western Cape. The dam requires remedial work for dam safety reasons, which offers the opportunity to increase the yield at the same time by raising the dam and enlarging the storage capacity. Water use in the region is predominantly for irrigated agriculture. The Clanwilliam Dam is shown in **Figure 1-1**. The study area and overview of the existing conveyance infrastructure, which is discussed in this report, is shown in **Figure 1-2**.

Figure 1-1: Clanwilliam Dam
Photo courtesy of DWS

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

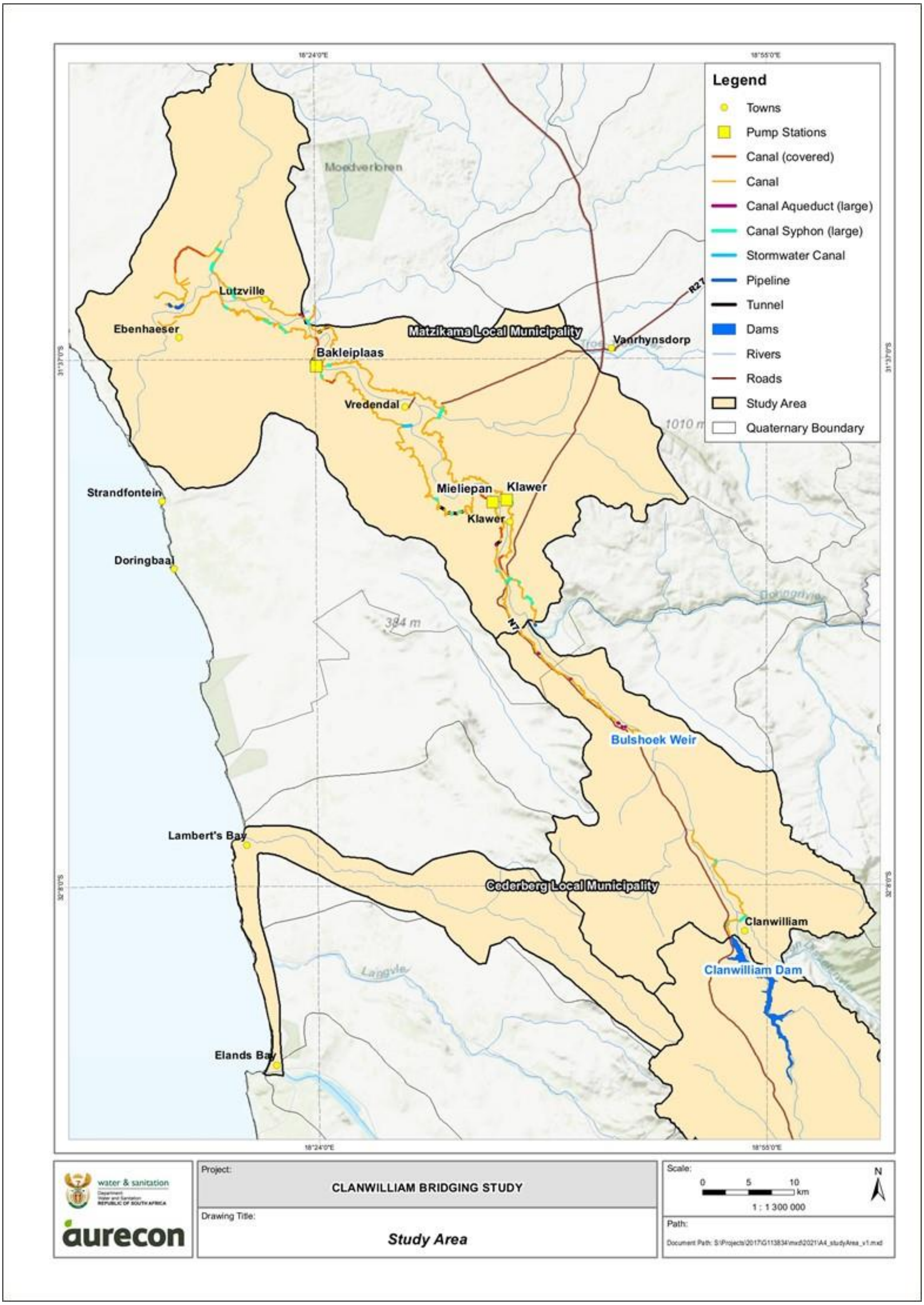

Figure 1-2: Study Area and Existing Bulk Water Infrastructure

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

1.4 Content of this Report

The various report chapters are as follows:

Chapter 1: Introduction and Background (this Chapter)

Introduces and provides background to the feasibility design

Chapter 2: Suite of Preferred Irrigation Schemes

Provides an overview of previous findings and the recommended schemes and implementation phasing.

Chapter 3: Topographical Survey

An overview of the topographical survey undertaken for the three schemes.

Chapter 4: Geological, Geotechnical and Materials Investigation

An overview of the geology and the outcomes and conclusions of the geotechnical and materials investigations undertaken at the three schemes.

Chapter 5: Environmental Screening and Impact Assessment

Describes the environmental screening undertaken for the study area and the environmental evaluations for specific projects.

Chapter 6: Jan Dissels Scheme Design

Documents the further evaluation and refinement of the Jan Dissels Scheme and sub-options considered, provides the scheme layout and features at a conceptual level, as well as the infrastructure components to be designed and cost estimates.

Chapter 7: Right Bank Canal Scheme Design

Documents the further evaluation and refinement of the new Right Bank canal and sub-options considered, provides the scheme layout and features at a conceptual level, as well as the infrastructure components to be designed and cost estimates.

Chapter 8: Ebenhaeser Scheme Design

Describes the further evaluation and refinement of the Ebenhaeser Scheme and sub-options considered, provides the scheme layout and features at a conceptual level, as well as the infrastructure components to be designed and cost estimates.

Chapter 9: Cost Estimates

Discusses the dimensions, assumptions and other factors affecting the costing of the various components of the three schemes and presents capital, operational and other estimated costs.

Chapter 10: Legislative Compliance

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.

Chapter 11: Implementation Arrangements

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

Chapter 12: Further Investigations for Detailed Design

Describes the further investigations that are required to successfully undertake the detailed design.

Chapter 13: Project Implementation

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

Chapter 14: Conclusions

Summarises the conclusions from the feasibility design.

Chapter 15: Recommendations

Lists the recommendations emanating from the feasibility design.

2 Suite of Preferred Schemes

This chapter summarises the preferred suite of irrigation schemes to be developed using water made available following the raising of Clanwilliam Dam. Motivation is provided why the three schemes are recommended and designed at feasibility level.

2.1 Preferred Suite of Irrigation Schemes

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

Schemes located upstream of Bulshoek Weir:

- **Jan Dissels Scheme** located near Clanwilliam Town, to receive a pumped water supply directly from the Clanwilliam Dam.
- **Transfer of scheduled** allocations, which entails transferring identified existing allocations of irrigators in the lower Jan Dissels River to the Olifants River. This will relieve over-allocation and improve the ecological condition of the lower section of the Jan Dissels River.
- **Clanwilliam Scheme** entails pumping from the lake of the raised Clanwilliam Dam to identified irrigation development areas.
- **Zandrug Scheme** entails pumping from the Olifants River to identified irrigation development areas below the raised Clanwilliam Dam and upstream of Bulshoek Weir.
- **Bulshoek Scheme** entails pumping from the Olifants River and the lake of Bulshoek Weir to identified irrigation development areas.
- Schemes located downstream of Bulshoek Weir:
- Right Bank Canal Scheme, consisting of the construction of a new main canal section on the right bank of the Olifants River to replace the existing main canal section on the left bank. This scheme will supply four proposed irrigation development areas near Trawal, namely the Zypherfontein1, Trawal, Zypherfontein 2 and Melkboom irrigation areas. This scheme will overcome the current flow restriction up to the bifurcation of the canal (‘Verdeling’ syphon) and significantly reduce the risk of supply failure.

- Klawer Phase 1 Scheme, using spare capacity in canal section/s to supply the first phase of the Klawer irrigation area close to Vredendal, on the right bank of the Olifants River, after passing through the right bank canal flows intended for the Ebenhaeser Scheme.
- Klawer Phase 2 Partial Development Scheme entails developing a portion of the remaining Klawer irrigation area, following the completion of the new Right Bank main canal and the upgrading of the Klawer canal section.
- Coastal 1 Scheme, using spare capacity in existing canal section/s, located on the left bank of the Olifants River near Vredendal, after passing through the left bank canal flows intended for the Ebenhaeser Scheme, to irrigate a small portion of the Coastal 1 irrigation area.
- Ebenhaeser Scheme, using spare capacity in existing canal section/s to provide water to restitution farms and to augment the supply to the existing community at Ebenhaeser.

The development of the recommended schemes will:

- Broaden the ownership base of the economy to historically disadvantaged (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.

These schemes are shown in **Figure 2-1**, except for the Ebenhaeser Scheme, which is located towards the bottom end of the study area, in the far North-West of the Olifants River catchment, between Lutzville and Ebenhaeser towns. Only partial development of the Klawer and Coastal 1 potential areas (as shown on the map) has been recommended.

Figure 2-1: Location of preferred irrigation areas

2.2 Schemes Designed at Feasibility Level

The following schemes are recommended for implementation and were designed at feasibility level:

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

3 Topographical Survey

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

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

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

Figure 3-1: Survey area for the Jan Dissels Scheme

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

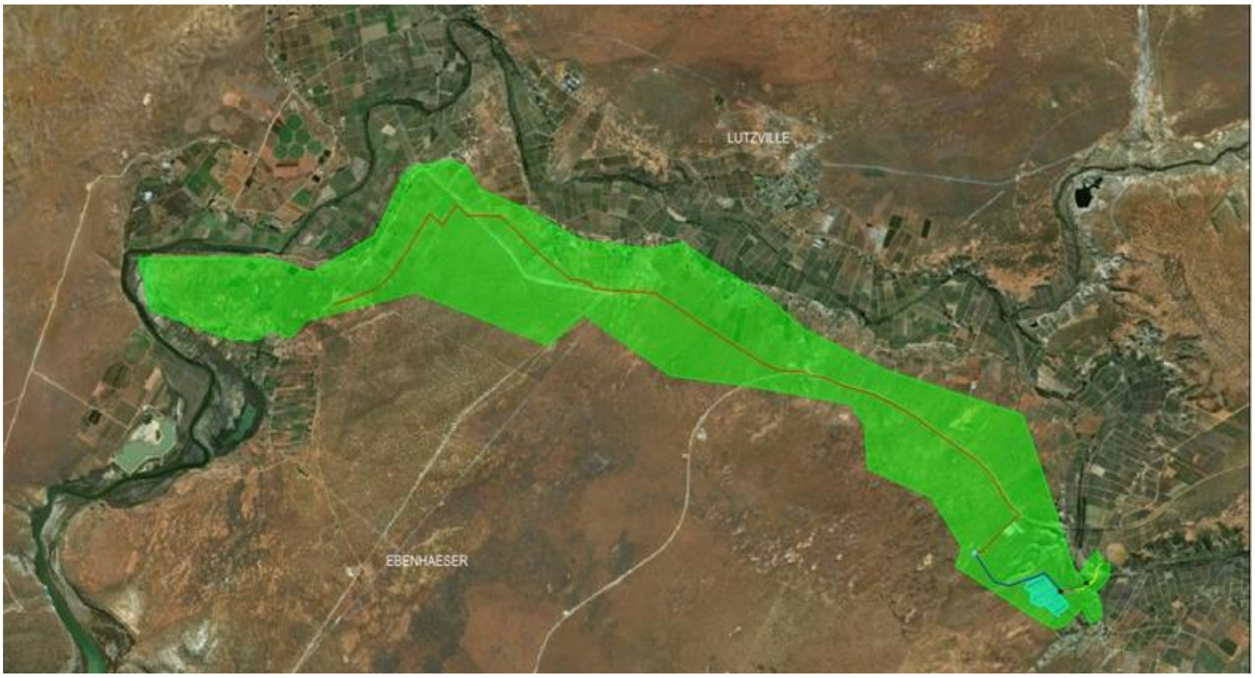

Figure 3-2: Survey area for the Ebenhaeser Scheme

The following deliverables were submitted in electronic format:

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

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

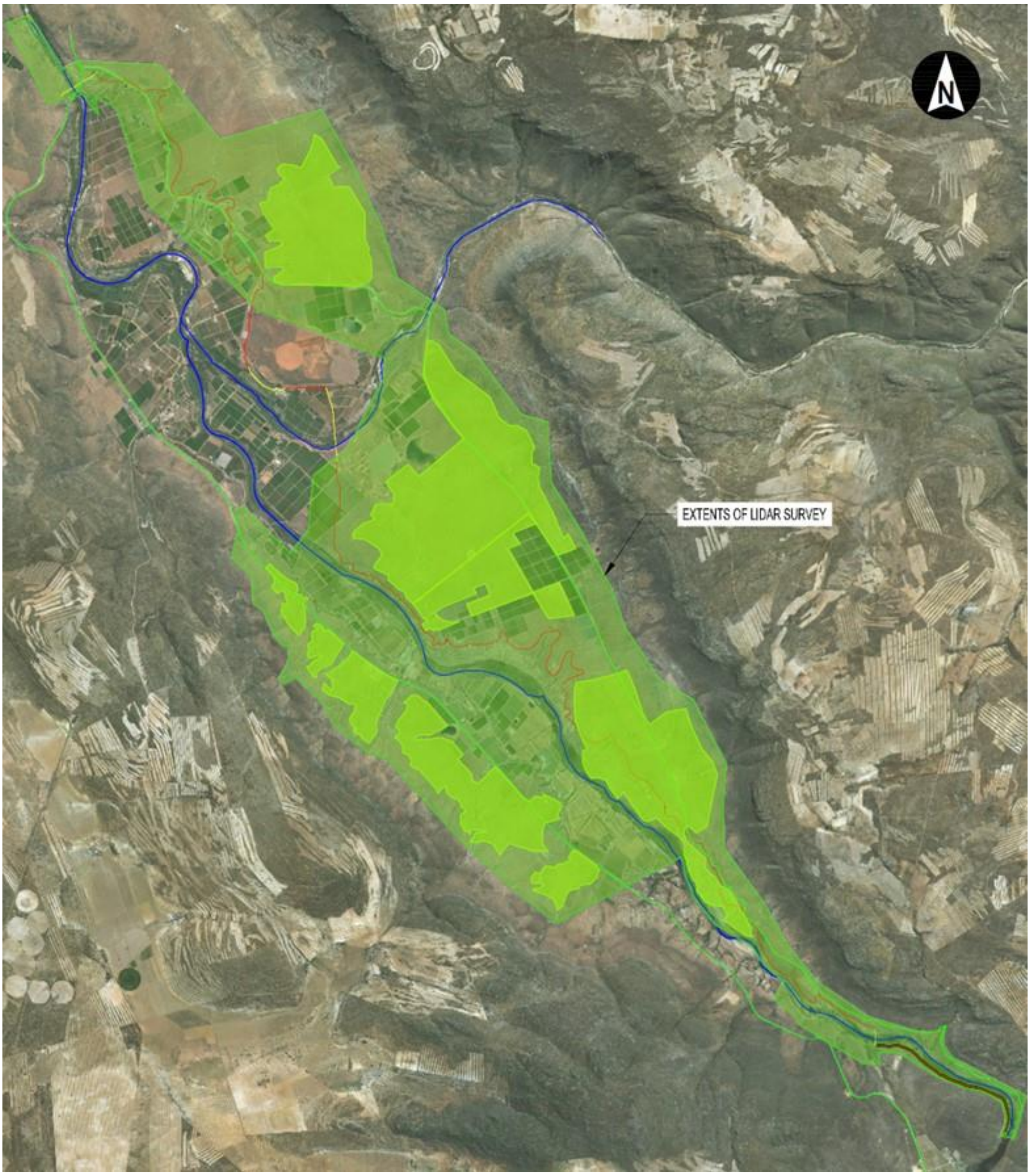

Figure 3-3: Survey area for the Right Bank Canal

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).

4 Geological, Geotechnical and Materials Investigation

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

4.1 Introduction

The geological and geotechnical evaluation comprised:

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

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

4.2 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.

4.3 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).

4.3.1 Geology

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

4.3.2 Geotechnical considerations

4.3.2.1 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.

4.3.2.2 Slope stability and lateral support

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

4.3.2.3 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.

4.3.2.4 Foundations

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

According to the classifications, the colluvium is mainly suitable as bedding cradle and selected fill blanket, i.e. SC1 and SC2 bedding material types, and the residual quartzitic sandstone is generally suitable for foundations. 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.

4.3.2.5 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.

4.3.2.6 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.

4.4 Right Bank Canal Scheme

4.4.1 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.

4.4.2 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 Feasibility 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.

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

The **geological profile** for the initial 1900 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 **excavatibility**, the hard rock / very hard rock quartzitic sandstone bedrock can be considered to represent ‘hard excavations’ in terms of 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.

4.4.2.2 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 commonly 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 the shallow **water table.**

In terms of evaluating **excavatibility**, 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.

4.4.2.3 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 the 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.

4.4.2.4 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. The cliff edge in particular could be subjected to additional loading surcharge, which could also impact on the global stability of the cliff. This aspect needs to be considered during detailed design stage.

4.4.2.5 Doring River Crossing (Syphon 2A)

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

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

Excavatibility 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.

4.4.2.6 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 **excavatibility** 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.

4.4.3 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 into 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.

4.5 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).*

4.5.1 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.

4.5.2 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.

4.5.3 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 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.

4.5.4 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 South African National Standards (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.

4.5.5 Balancing Dam

4.5.5.1 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.

4.5.5.2 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.

4.5.5.3 Embankment foundation and materials

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

4.5.5.4 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.

4.5.5.5 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 Environmental Screening and Scheme Assessments

This Chapter describes the environmental screening undertaken for the study area to support the screening of options as well as the environmental impact evaluations undertaken for the three recommended schemes.

5.1 Environmental Screening

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

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

5.2 Environmental Assessment of Schemes

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

5.2.1 Jan Dissels Scheme

Refer to Chapter 6 for a description of the Jan Dissels Scheme options. The environmental considerations for this scheme are as follows:

- Rising Main Route 1 (RM 1) is located within an area mapped as a Critical Biodiversity Area (CBA). This option would include the removal of indigenous vegetation, but with the pipeline route being much shorter than the alternative, Rising Main Route 2.
- Rising Main Route 2 (RM 2) is not located in any mapped CBA, but does transect the Ramskop Nature Reserve (**Figure 5-1**). This reserve is managed by the Cederberg Municipality.

Figure 5-1: Location of the Ramskop Nature Reserve along the RM Option 2

- There are indications that existing pipelines are present in the area of RM2 and that the construction of the pipeline could potentially be approved by the Management Authority, which would be the Municipality in this case.
- The RM2 route does however include the removal of indigenous vegetation and would probably require temporary and permanent access tracks to be constructed.
- The proposed scheme will be subject to further on-site specialist assessments by a botanical specialist.
- The proposed infrastructure would require a Basic Assessment to obtain authorisation from Department of Environment, Forestry and Fisheries (DEFF).
- If borrow pits are proposed, an application for authorisation should also be submitted to the Department of Mineral Resources and Energy (DMRE) for mining activities.
- The proposed infrastructure would also require heritage authorisation in terms of Section 38 (a) and (c) of the NHRA.
- Water use authorisation in terms of the NWA is discussed in Chapter 10.1 of this report.

5.2.2 Right Bank Canal Scheme

Refer to Chapter 7 for a description of the Right Bank Canal Scheme. The environmental considerations for this scheme are as follows:

- The upgrading of 3 km of the existing Left Bank Canal should consider limiting vegetation clearance, since the site is located partly within a CBA, the Rondeberg Oord Private Nature Reserve and an endangered vegetation type.
- The proposed works should be subject to further on-site specialist assessments by a freshwater and botanical specialist to determine the best environmental options within the sensitive areas and especially the watercourses.
- The work to be undertaken as part of the Left Bank Canal upgrade, syphons through the Olifants and Doring rivers, construction of the Right Bank Canal and any other associated infrastructure would require a Basic Assessment to obtain authorisation from the DEFF.
- If borrow pits are proposed, an application for authorisation should also be submitted to DMRE for mining activities.
- The proposed infrastructure would also require heritage authorisation in terms of Section 38 (a) and (c) of the NHRA.
- The two syphons that will be constructed through rivers would require Section 21 (c) and (i) water use licence applications (WULAs) to be undertaken for each of these.
- Water use authorisation in terms of the NWA is discussed in Chapter 10.1 of this report.

5.2.3 Ebenhaeser Scheme

Refer to Chapter 8 for a description of the Ebenhaeser Scheme. The environmental considerations for this scheme are as follows:

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

- The Ebenhaeser balancing dam will require a WULA in terms of Section 21 (b), (c) and (i) of the NWA. The syphon to be constructed through the Olifants River would require a Section 21 (c) and (i) WULA to be undertaken.
- Water use authorisation in terms of the NWA is discussed in Chapter 10.1 of this report.

5.3 Environmental Approval Process Engagement

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

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

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

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

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

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

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

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

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

5.4 Environmental Recommendations for Feasibility Design

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

1) Undertake site specific specialist assessments and field clarifications to guide engineering design, prior to undertaking the EIA process.
2) Consider an alternative to constructing a rising main (RM) pipeline through the Ramskop Nature Reserve (RM Route 2 of the Jan Dissels Scheme).
3) Determine the preferred RM sub-option for the Jan Dissels Scheme.
4) Determine the exact road and power supply related infrastructure and assess the proposed impacts as part of the EIA process.
5) The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the CBAs, following acceptance of the recommendations. Evaluation of schemes has confirmed that the ecological impact and environmental issues relating to new development significantly influence and limit the scope of development options. Dialogue around these issues has started and further discussion should take place between departments as soon as possible, to agree on the way forward.
6) The DWS should consult internally to determine whether integrated WULAs should be submitted for each scheme, including abstraction, storage and working in watercourses.
7) Alternative options for, or prior to, environmental authorisation in terms of the NEMA, should be considered, such as the undertaking of a Strategic Environmental Assessment (SEA) or Environmental Management Framework (EMF) for all the schemes and associated infrastructure.

6 Jan Dissels Scheme Feasibility Design

This chapter describes the feasibility design of the Jan Dissels Scheme. A design was done for two potential route options, referred to in this report as Rising Main Route 1 and Rising Main Route 2.

6.1 Introduction

An area east of Clanwilliam Dam and close to Clanwilliam town was identified as suitable irrigable land (**Figure 6-1**). The area is *inter-alia* suitable for the development of smaller plots, given its proximity close to Clanwilliam town and existing markets. The land is owned by the State. Following a botanical survey to account for environmental sensitivity concerns by environmental authorities, and meetings held with the land users, being Cederberg Local Municipality and Augsburg Agricultural Gymnasium, the scheme was conceptualised.

Figure 6-1: Jan Dissels irrigation area

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

Chapter 4 of the *Conceptual Design Sub-Report* provides information on the conceptualising and sizing of the scheme, and existing and planned activities on the affected properties.

6.2 Overview of the Scheme

The Jan Dissels Scheme is located on the right bank of the Clanwilliam Dam, which is situated east of the N7 highway, 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 dam wall, on the right bank.

Rising Main Route 1 will pump water directly from a floating intake low-lift pump station in the raised Clanwilliam Dam to a balancing tank approximately 70 m from shore. The tank will be above the full supply level of the raise dam, i.e. 118.25 masl, but with the floating pump station located such that water can be abstracted under minimum operating levels, i.e. 100 masl. From the balancing tank water will be pumped with a high-lift pump station to a concrete reservoir at a suitable high point. From the reservoir water can be gravitated to the identified irrigation areas. **Figure 6-2** 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*.

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

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

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

Figure 6-2: Layout of the Jan Dissels Scheme

6.3 Intake Pump Stations

6.3.1 Rising Main Route 1 Option

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

6.3.1.1 Low-Lift Pump Station

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

The following information about the KSB Amarex KRT K 150-401 pump is relevant:

- Impeller size = 367 mm;
- Full-size impeller = 404 mm;
- Hydraulic efficiency of pump = 81.5%;
- NPSH required = 6.3 m;
- Head rise to shut-off = 68%;
- Maximum power absorbed for 367 mm impeller = 53 kW (recommended motor size is 62 kW); and
- Maximum power absorbed at duty point = 49 kW.

Figure 6-3 shows the characteristic and pump curves for the Rising Main Route 1 low-lift pump, equipped with KSB Amarex KRT K 150-401 pumps.

It is evident from **Figure 6-3** that the low-lift pump station has a duty point of 23.2 Mℓ/d (0.269 m^3/s) at a total pumping head of approximately 30 m. The low-lift pumps would need to be fitted with variable speed drives (VSDs) due to the large variation in the levels of the Clanwilliam Dam (i.e. at a fixed speed, the pump curves do not intersect the lower system curve).

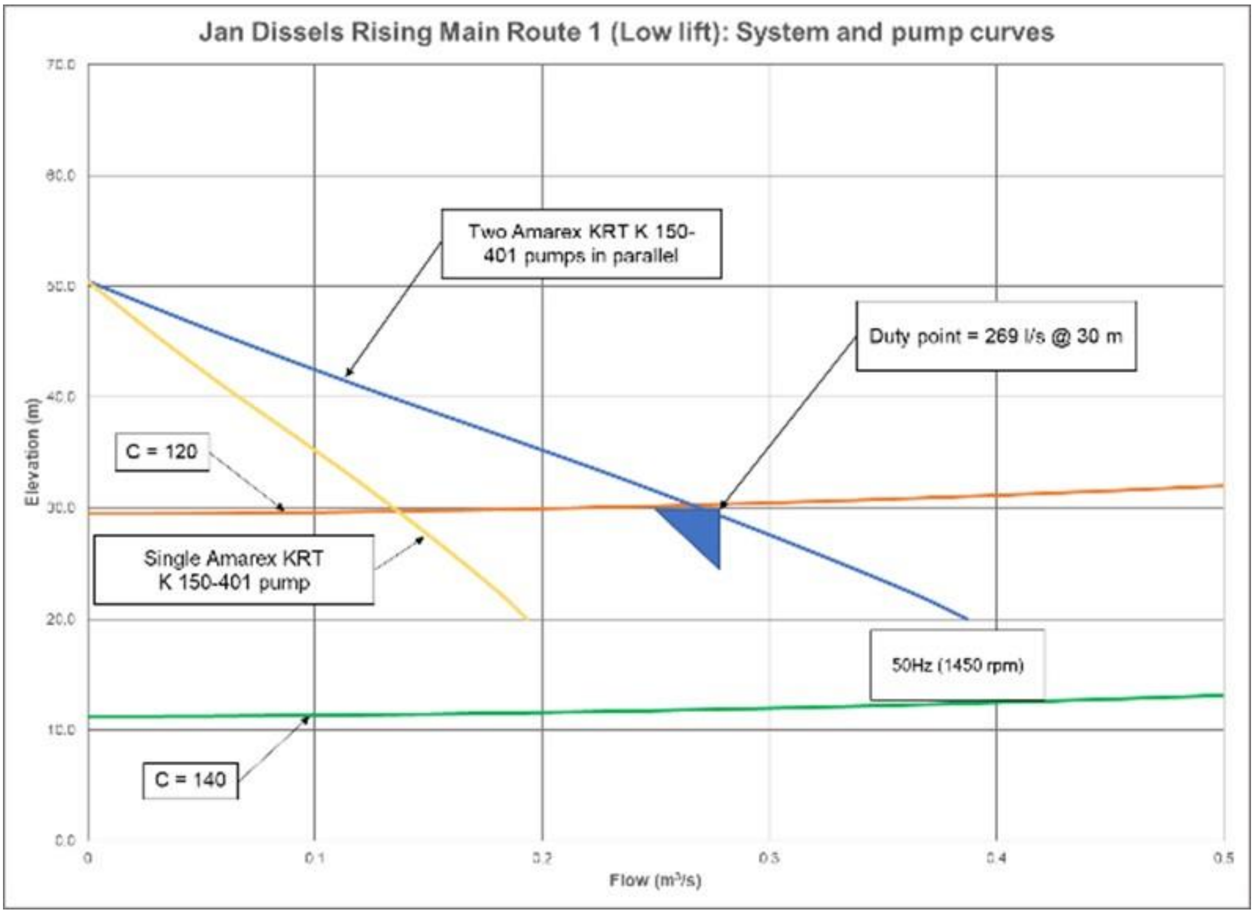

Figure 6-3: Characteristic and pump curve for Rising Main Route 1 Low-Lift pump station

6.3.1.2 High-Lift Pump Station

A pump configuration of one (1) duty pump and one (1) standby pump is proposed for the Rising Main Route 1 High-Lift Pump Station. The details of a commercially available pump that could be used are shown in **Figure 6-4**.

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

- Impeller size = 487 mm;
- Full-size impeller = 500 mm;
- Hydraulic efficiency of pump = 84.9%;
- NPSH required = 4.1 m;
- Head rise to shut-off = 16%;
- Maximum power absorbed for 500 mm impeller = 280 kW (recommended motor size is 300 kW operating at 1 460 rpm);
- Maximum power absorbed at duty point = 227 kW.

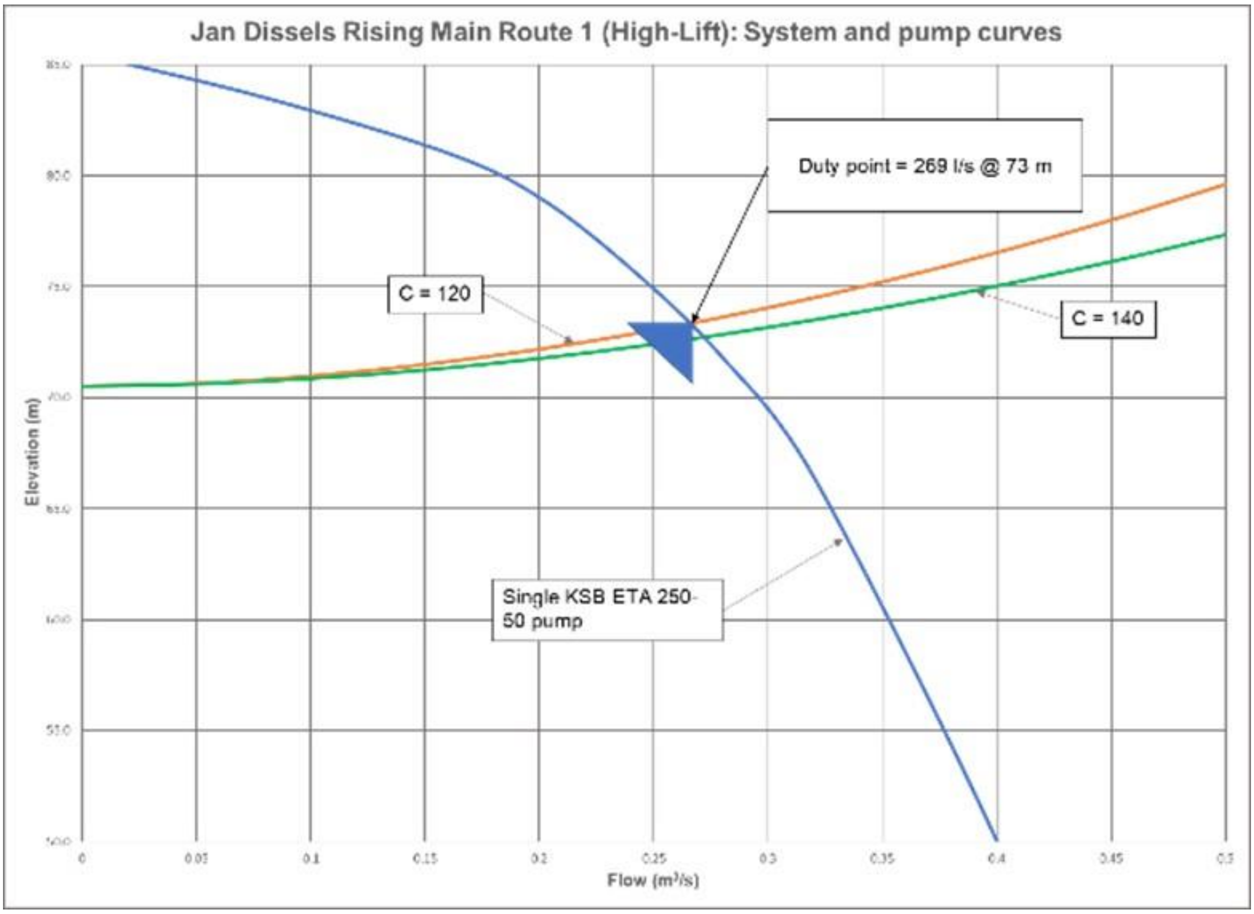

Figure 6-4: Characteristic and pump curve for Rising Main Route 1 High-Lift pump station

It is evident from Error! Reference source not found. that the high-lift pump station has a duty p oint of 23.2 Mℓ/d (0.269 m^3/s) at a total pumping head of approximately 73 m.

6.3.1.3 Balancing Tank

The balancing tank is designed to store the flow of 269 ℓ/s pumped over 1 hour, which equates to a balancing tank with an active capacity of 970 m^3 (0.97 Mℓ). It is proposed that a reinforced concrete tank/reservoir with a 1 000 m^3 (1 Mℓ) capacity be provided. The balancing tank's minimum operating level is 130 masl and the full supply level is 134 masl.

A new access road will have to be constructed to the balancing tank, as well as the low-lift and high-lift pump stations. The proposed layout plan for the low-lift and high-lift pump stations is shown in **Figure 6-5**.

The proposed layout plan for the low-lift and high-lift pump stations, as well as the balancing reservoir/sump, is shown on drawing 113834-0000-DRG-CC-0201 in **Appendix A1** of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*.

Figure 6-6 shows the hydraulic gradient line of the Rising Main Route 1 to the concrete reservoir for a flow of 23.2 Mℓ/d (0.269 m^3/s).

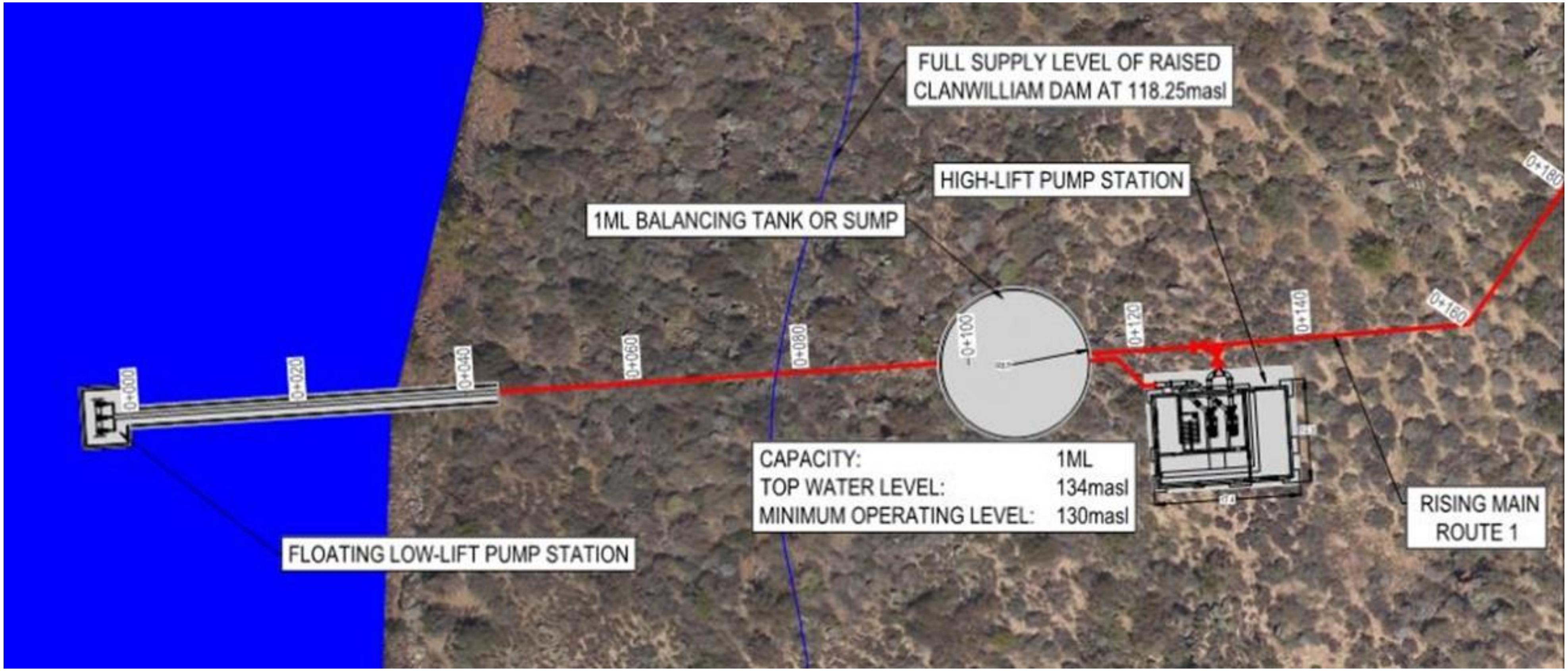

Figure 6-5: Rising Main 1 Low-lift and High-lift pump station layout

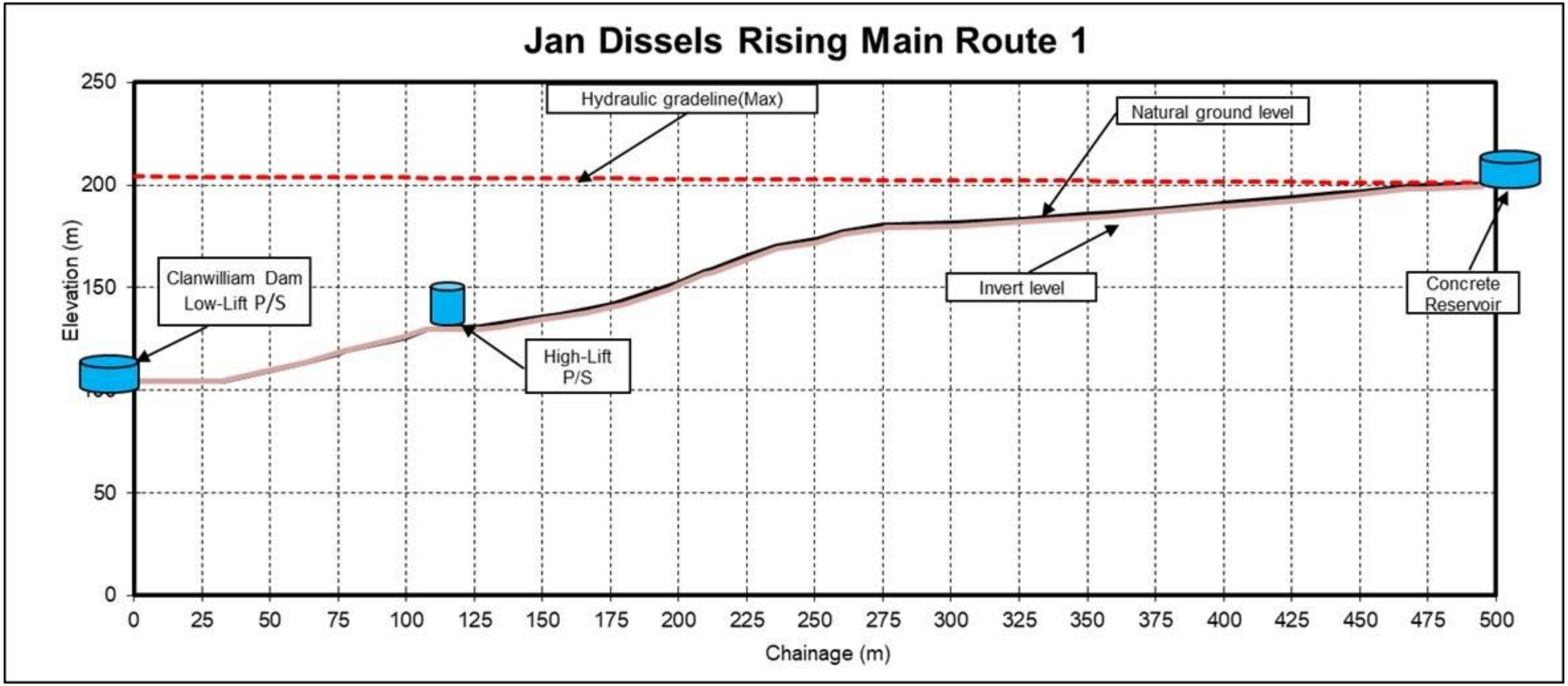

Figure 6-6: Rising Main to Reservoir: HGL for 23.2 Mℓ/d in aged DN 500 pipeline

6.3.2 Rising Main Route 2 Option

The Rising Main Route 2 option entails pumping water 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 6-7** and the full 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.

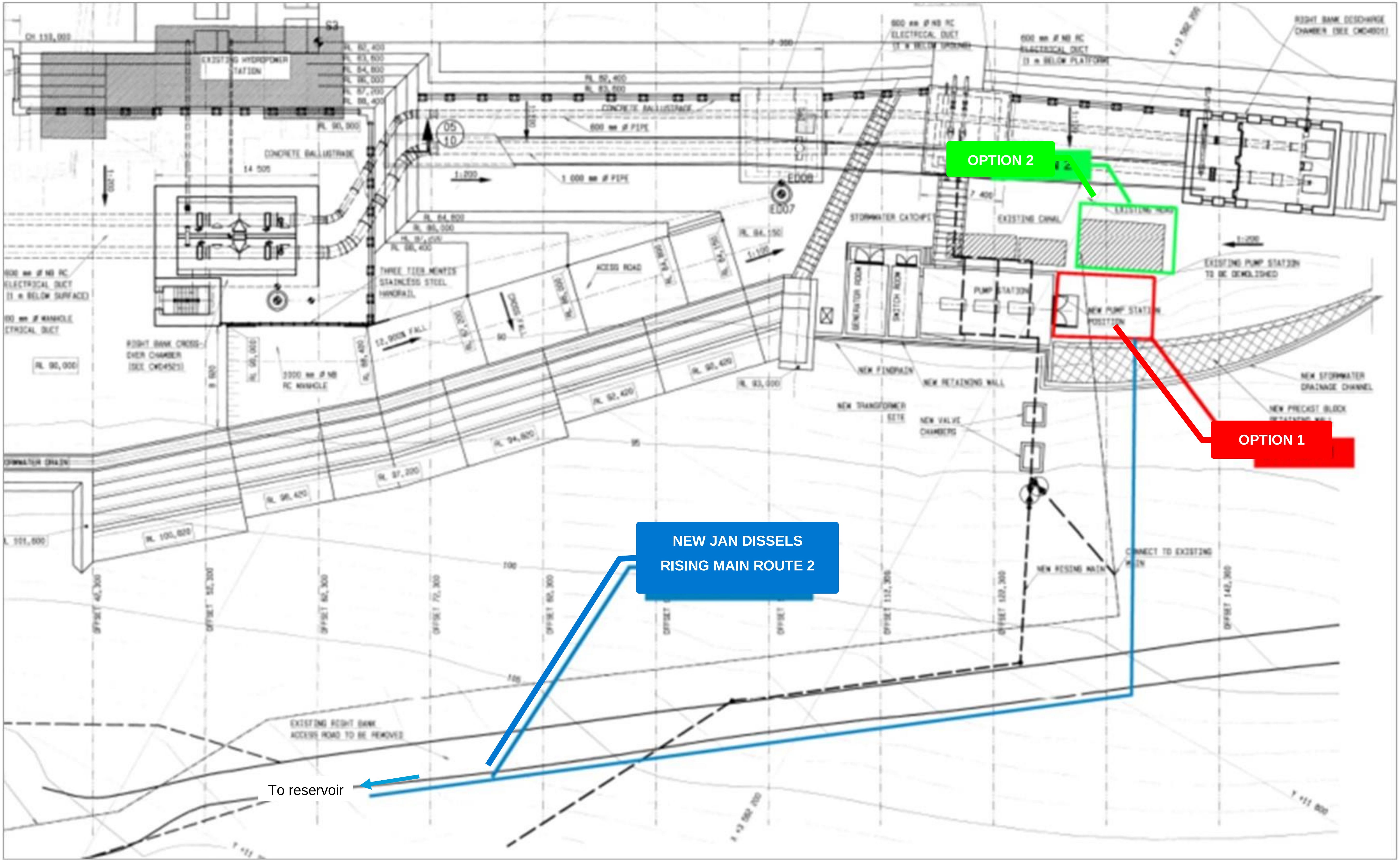

Figure 6-7: Jan Dissels Rising Main Route 2 Pump Station

6.3.2.1 Pump Duties

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 6-8**. 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.

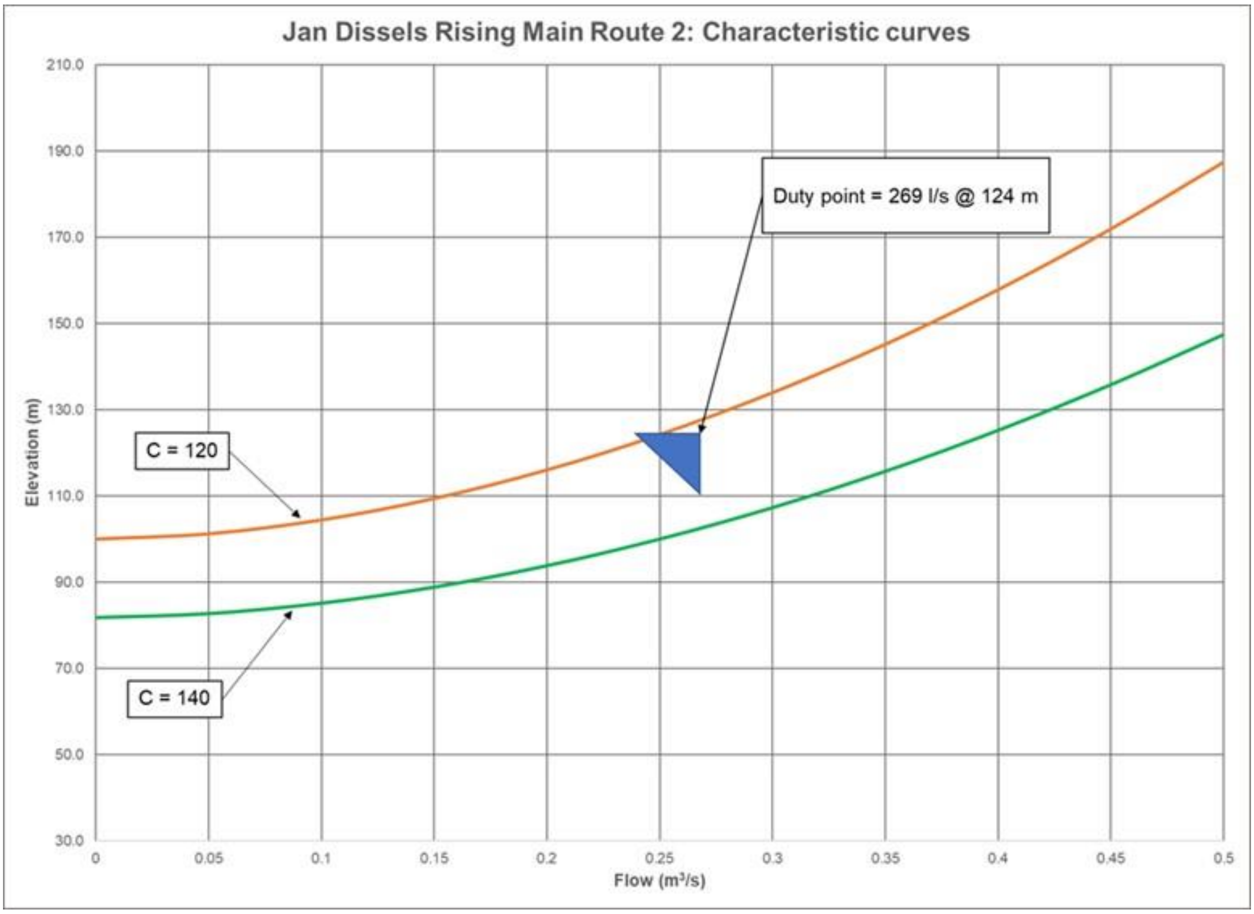

Figure 6-8: Characteristic and pump curve for Rising Main 2 pump station

It is evident from **Figure 6-8** 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 6-9 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).

6.4 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. A new access road will have to be constructed to the reservoir and a new power supply provided. The reservoir's minimum operating level is 202 masl and full supply level is 208 masl.

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**.

6.5 Option Recommended for Implementation

A comparison of the two sub-options was made by calculating the net present value (NPV) and unit reference value (URV) of each. As can be seen in **Table 6-1**, the NPVs and URVs are the same. Other factors were therefore considered in order to choose the best option.

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

Table 6-1: Comparative costing of sub-options RM1 and RM2

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

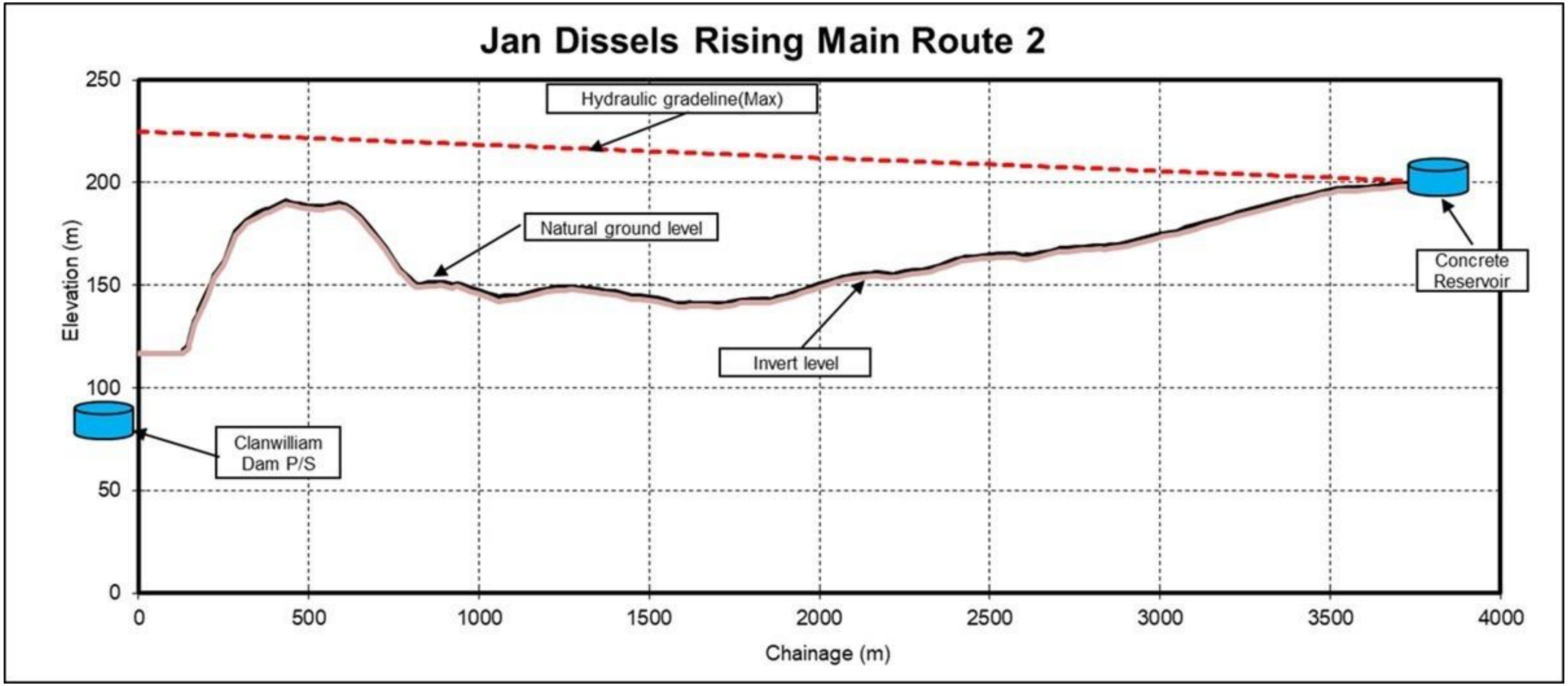

Figure 6-9: Rising Main Route 2 to Reservoir: HGL for 23.2 Mℓ/d in aged DN 500 pipeline

7 Right Bank Canal Feasibility Design

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

7.1 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 downstream irrigation development and other future uses.

7.2 Water Requirements and Design Capacity

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

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

The total peak design flow for the proposed Right Bank Canal at the outlet of the Bulshoek Weir is calculated as **11.40 m^3/s**. The various flow components are shown in **Table 7-1**.

Table 7-1: Right Bank Canal peak design flows

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

7.3 Alternate Peak Design Flow

7.3.1 Introduction

The feasibility level design was carried out using the peak design flow of 11.40 m^3/s. The focus of the project is on the provision for use of additional water made available as a result of the raising of Clanwilliam Dam, i.e. new irrigation for HDIs and the increased assurance of supply to existing irrigators. The study evaluation therefore focussed on the identification of irrigation areas and the associated bulk water conveyance infrastructure to convey the additional flow to such irrigation areas. Provision for improved conveyance infrastructure or storage for existing irrigators was not addressed, besides the need to address implications of their improved assurance of supply to a 91% assurance.

7.3.2 Request for Review and Technical Note

At Project Steering Committee Meeting 12, held on 29 July 2020, the concern was raised that the design flow capacity of the Right Bank Canal should be higher to include requirements of existing irrigators to not remain a constraint to the supply, as well as to consider potential crop changes in future. Mr Keuck of the Department of Agriculture Western Cape noted that with a 91% assurance of supply the crop mix will need to be perennial and that the farmers should be able to plant in the order of 70-80% of the crops, for which ~15% of the total water allocation will be needed in January. Based on these assumptions, Mr Keuck recommended that the canal be sized to supply this peak demand of ~15% and that the 11.4 m^3/s capacity may be too small to improve the situation for existing irrigators. While this may be the worst-case scenario, it would take into account any future development to maximise the economic benefit. A sub-committee was formed to address this concern. The alternate design flow determination has been included in **Appendix A**.

Two approaches were followed namely:

a) Determining the flow similarly to the way it was calculated in this study, considering the existing flows in more detail by splitting irrigation from other water uses and taking into consideration the further variables of potential crop changes and losses. This does not take into account the unallocated volume of 5.1 million m^3/a, which is the remaining volume of the increased assurance of supply to existing irrigators from the raised Clanwilliam Dam, of which a small portion will be used for future use by towns and industries.
b) Assuming that the full unallocated volume of 5.1 million m^3/a is allocated for new development below Bulshoek Weir, although this is an unlikely scenario.

7.3.3 Constraints to Increasing the Right Bank Canal Design Flow Capacity

There may be some challenges to increasing the planned design flow capacity of the Right Bank Canal above 11.4 m^3/s, these being:

- The potential restrictive capacity of the Bulshoek Weir existing outlet structure, which is estimated as 11.5 m^3/s, but needs to be more accurately determined. The level of the intake works relative to the canal is dictated by the existing outlets of this historical structure and it is very unlikely that these levels can be changed. Due to its age and the condition of the weir, it would be risky to blast in the vicinity of the weir to construct a new outlet to serve the proposed Right Bank Canal.
- 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;
- The restrictive capacity of the existing Verdeling syphon, with a peak design flow of 4.02 m^3/s, where the flow would be reversed for the new Right Bank canal;
- Potential change in canal alignment: Should the design flow capacity change, it may reach a point where a different canal route needs to be followed. It will also be necessary to ensure that adequate flow, for an upgraded left bank canal below Verdeling, can be conveyed via the Verdeling syphon, should additional flow allowance be made for existing irrigators from the left bank canal below Verdeling.

7.4 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 7-1**.

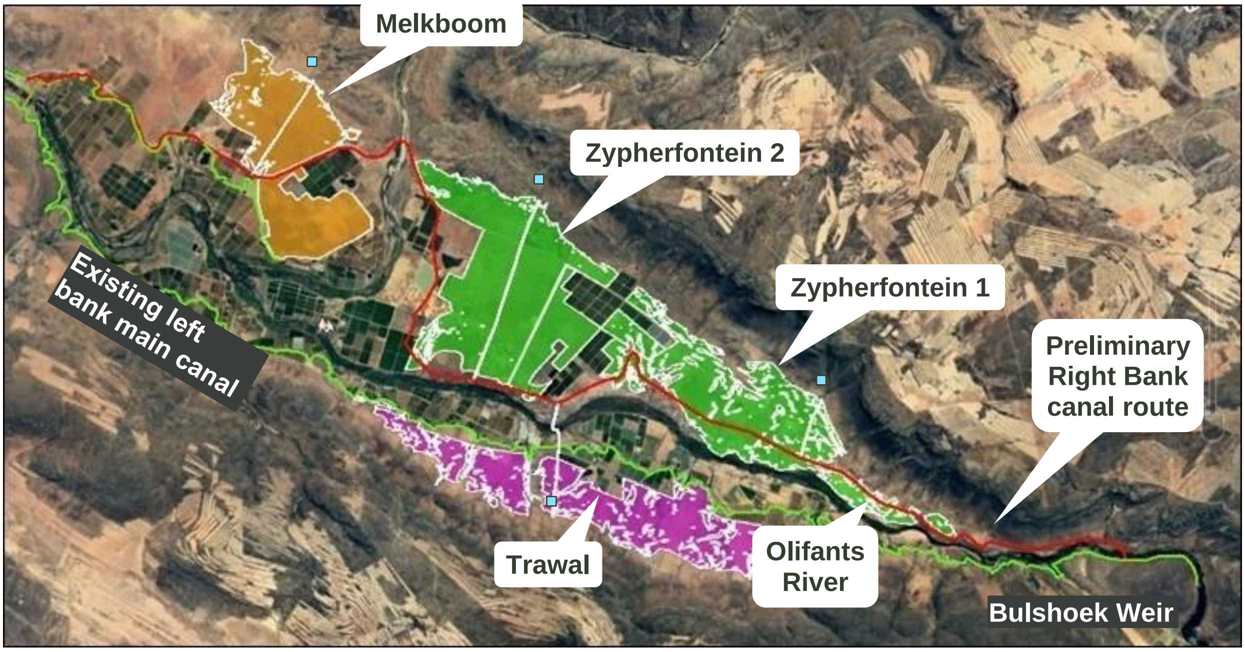

Figure 7-1: New irrigation schemes between Bulshoek Weir and Verdeling Syphon

A general layout arrangement of the proposed scheme is shown in Drawing No. 113834-0000-DRG-CC-0001 of **Appendix B** and **Figure 7-2** on the following page and consists of the following:

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

7.5 Canal Design

The proposed new Main 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 DWS' (1980) '*Guidelines for the Design of Canals and Related Structures*'.

The layout of the Right Bank Canal Scheme is shown in **Figure 7-2**.

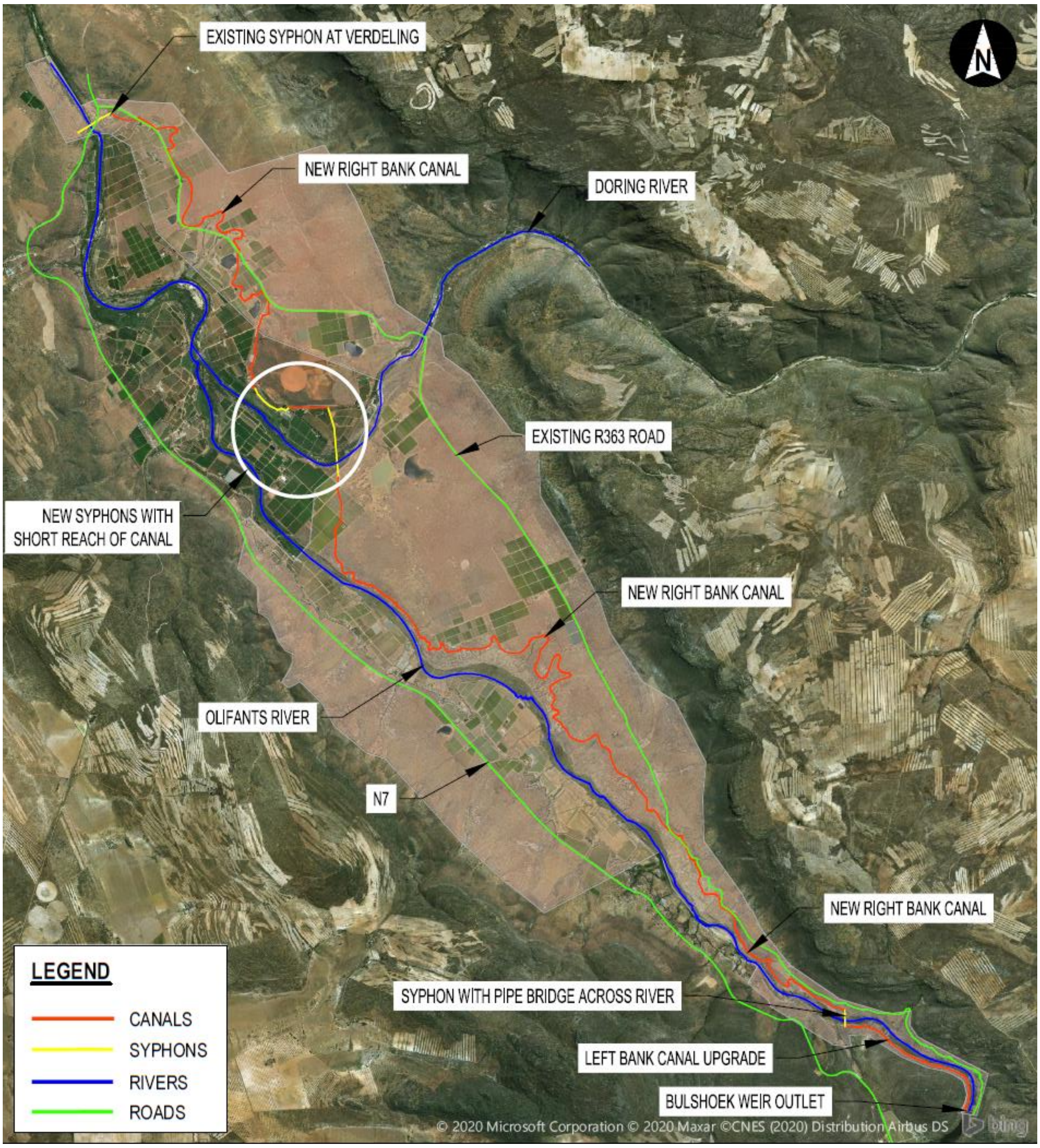

Figure 7-2: Overall layout of the Right Bank Canal Scheme

7.5.1 Bulshoek Weir Outlet Works and Available Hydraulic Energy

Due to the age and condition of the Bulshoek Weir (**Figure 7-3**), it would be risky to blast in the vicinity of the weir to construct a new outlet to serve the proposed Right Bank Canal.

Figure 7-3: Concrete masonry Bulshoek Weir

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 (**Figure 7-4**) has a flow capacity of 11.5 m^3/s and does not need to be modified to release the peak design flow of 11.4 m^3/s into the proposed Right Bank Canal. The water level immediately downstream of the five sluice gates (**Figure 7-5**) 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.

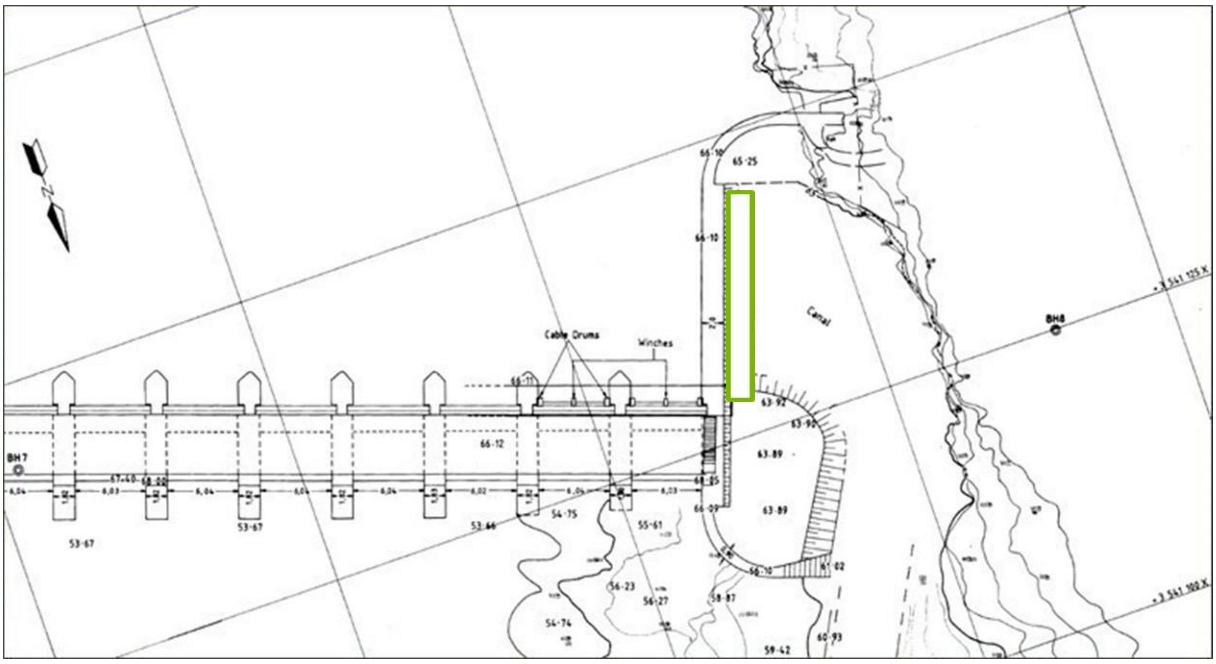

Figure 7-4: Plan view of Bulshoek Weir showing existing outlet structure (green)

Figure 7-5: Bulshoek Weir outlet structure sluice gates

7.5.2 Vertical Alignment

The hydraulic gradient of the open channel is dictated by the canal slope. The slope between the upstream water surface elevation (61.0 masl) at the start of the existing canal, at the 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.

7.5.3 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.

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

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

After about 6.41 km the valley opens up and is flatter, and more favourable terrain for a canal becomes prevalent. The main canal will then follow the natural contours. The alignment crosses the Doring River at approximately 21.91 km with a syphon, followed by a short reach of canal and another short syphon to avoid a steep sandy hill. From approximately 24.70 km to the Verdeling Syphon at 33.55 km, the canal again follows the natural contours of the land. **Table** 7-2 shows a summary of the canal reaches and their chainage.

Table 7-2: 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

7.5.4 Canal Hydraulics and Cross-Section

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

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

Refer to **Figure 7-6** and **Table 7-3** 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 7-3: Canal sections - design parameters

Parameter	Symbol (refer to Error! Reference source not found.)	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

Parameter	Symbol (refer to Error! Reference source not found.)	Type T1	Type T2
Roadway width (m)	W_{ROAD}	4.0	1.5 (no road)

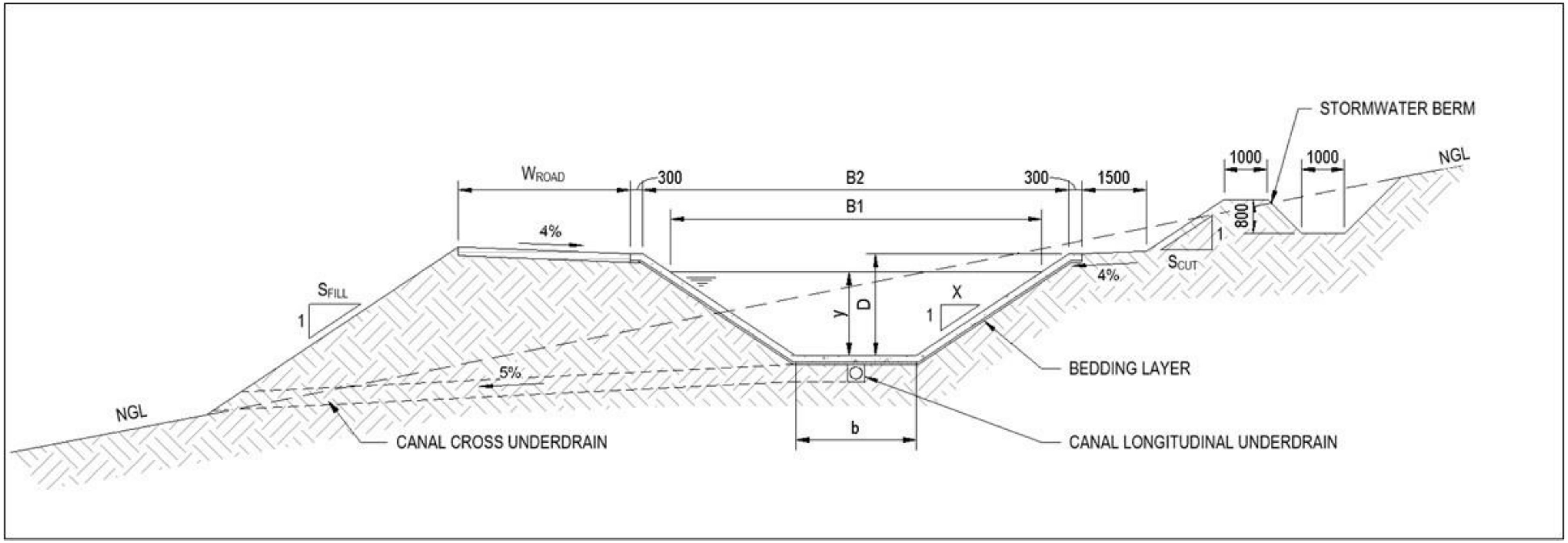

Figure 7-6: Trapezoidal canal cross-section (Types T1 and T2)

7.5.5 Canal Freeboard

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

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

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

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

7.5.6 Canal Lining

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

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

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

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

7.5.7 Typical Canal Underdrainage

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

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

Cross drains must be provided regularly, typically every 200 m. The spacing thereof must be optimised during the detail design phase. These cross drains typically consist of a DN200 mm pipe with a slope of at least 1% downhill away from the cut side to daylight on the fill side of the canal. These pipes should either be connected to the longitudinal drainage pipes with tee pieces or be placed end to end, wrapped in 3.4 mm thick (Bidim type) geofabric, as shown in **Figure 7-7** and **Figure 7-8**.

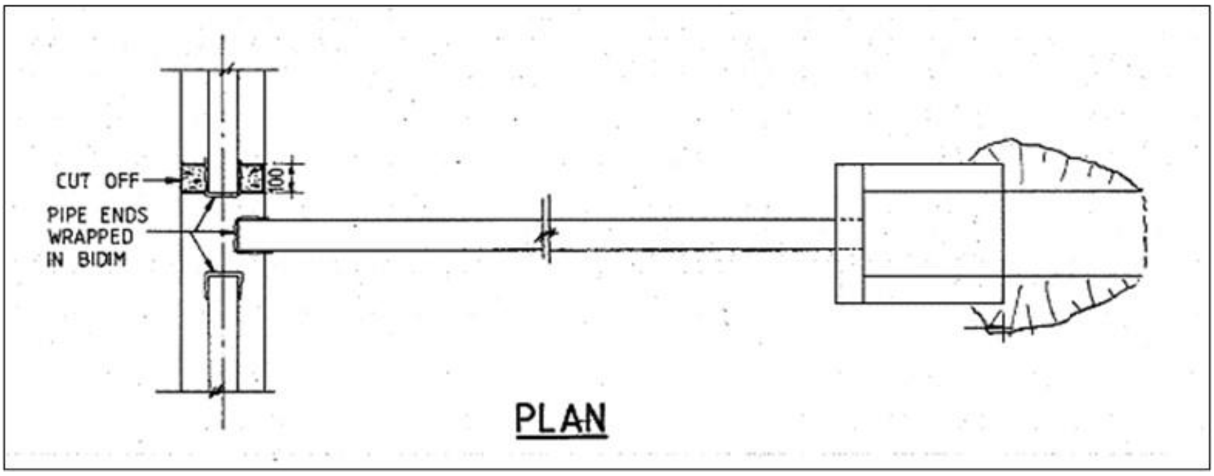

Figure 7-7: Typical longitudinal and cross underdrain connection

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.

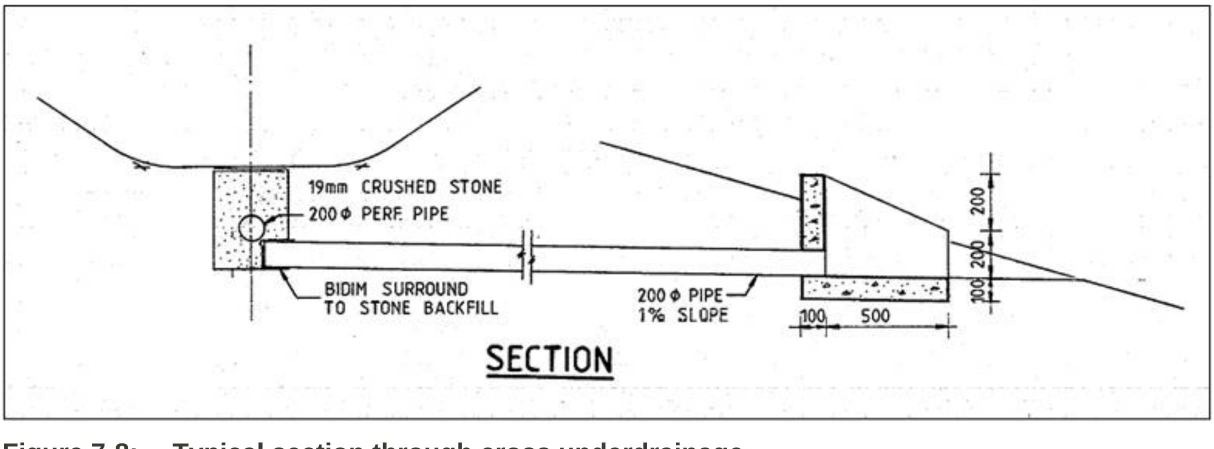

Figure 7-8: Typical section through cross underdrainage

7.5.8 Storm Water and Cross-Drainage Culverts

The new canal will create storm water catchments on natural slopes or when crossing natural drainage lines. To account for this, a storm water drain shall be constructed to intercept the natural flow. In the case where the canal is in cut, this drain shall be located where the cut daylights to the natural ground level on the upstream side of the canal. In the case where the canal is in fill, the drain shall be placed at the bottom of the fill. See **Figure 7-6** in **Section 7.5.4** (of this report) 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.

7.5.9 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.

7.5.10 Flow Measurement

Flow measurement should be incorporated into the canal design to improve the water management of the system, including loss detection and management. The use of Crump weirs for flow measurement is recommended. A 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 optional to place more measuring stations along the route to verify usage.

Ideally flow measurement structures should be provided at each of the new canal off-takes (refer to **Section 7.5.14**) to improve the performance monitoring of the canal and improve the water management of the system.

7.5.11 Rejects

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

7.5.12 Canal Road Access

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

7.5.13 Special Considerations of the Left Bank Canal Upgrade

There are some other considerations that are particular to the upgrading of the Left Bank Canal (as shown in **Figure 7-9**), 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.

Figure 7-9: Existing Left Bank Canal looking downstream (approx. ch. 1.2 km)

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.

7.5.14 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 to **Table** 7-4). 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 7-4: Off-take demands for new irrigation developments

Off-take	Average flow (m^3/s)	Peak flow (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 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.

7.6 Syphons

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

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

7.6.1 Routing of Syphons

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

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

7.6.2 Hydraulic Design

Syphons are designed to minimise frictional losses as far as possible to ensure that the tie-in at Verdeling has a positive head of at least 1.0 m. The syphons were designed in accordance with the design parameters listed in **Table 7-5**.

Refer to **Figure 7-10** for a typical cross-section of a steel pipe and to **Figure 7-11** for a typical concrete culvert 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. At the detailed design phase of the project, structural analysis should be done to confirm the detail (reinforcement and wall thickness) of the culvert for the expected loading conditions.

Table 7-5: 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

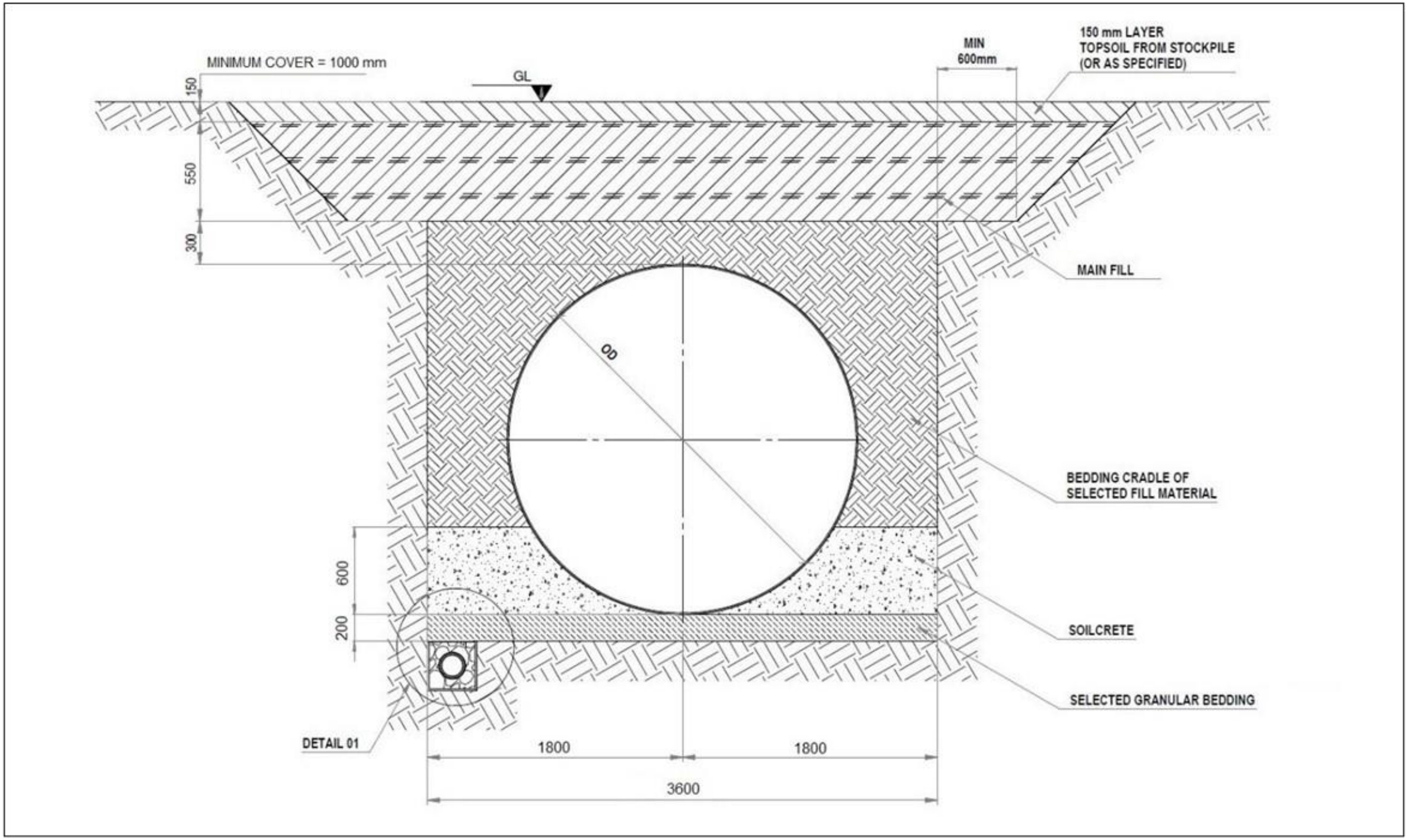

Figure 7-10:Typical cross section of Syphon 1 – underground portion of pipe installation

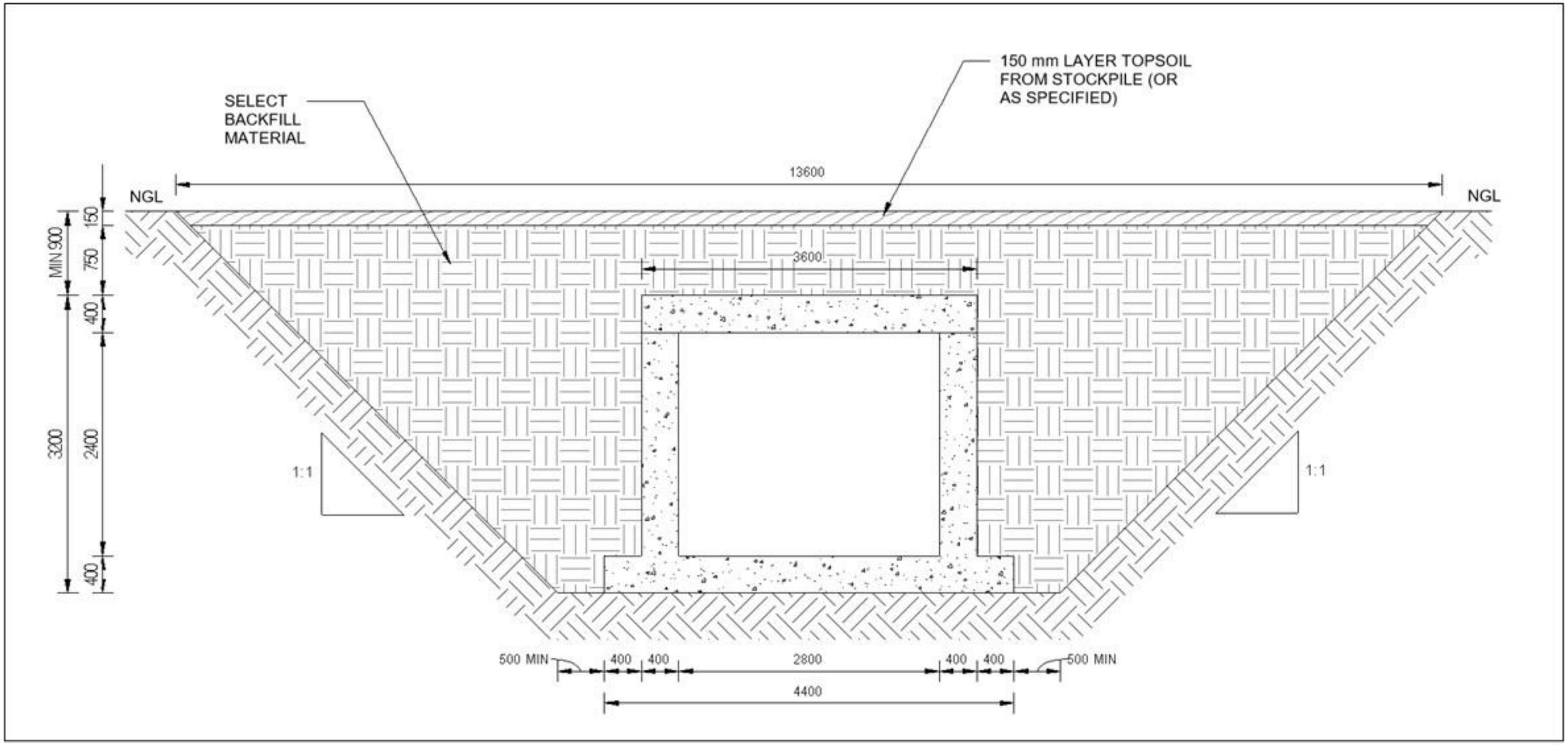

Figure 7-11:Typical cross section of Syphon 2 - rectangular portal culvert

7.6.3 Installations Above and Below Ground

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

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.

7.6.4 Syphon Inlet Structure

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

The inlet structure is to be provided with a trash rack at the entrance to screen out large floating debris and reduce possible ingress of any other foreign material into the syphon pipe. A long weir reject with erosion protection is also provided upstream of the Syphon 1 intake. Silt will be flushed out of the syphon using scour valves. 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 7-12 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).

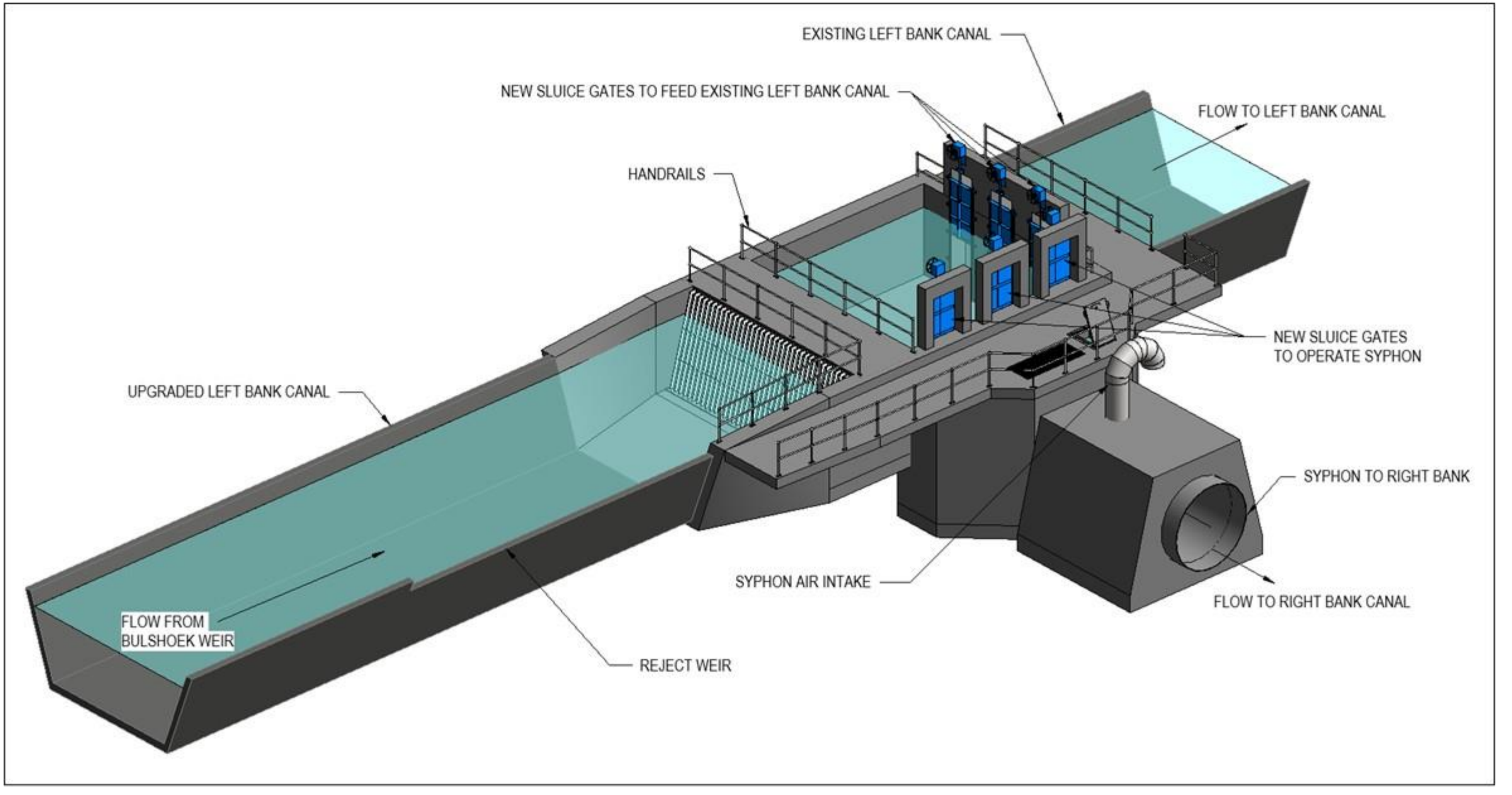

Figure 7-12:Left Bank Canal syphon inlet structure (Syphon 1)

7.6.5 Syphon Outlet Structure

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

7.6.6 Syphon Dewatering

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

Scour valve chambers will be used to house the scour valves. Details of a typical scour chamber and mechanical arrangement are shown in **Figure 7-13**. 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.

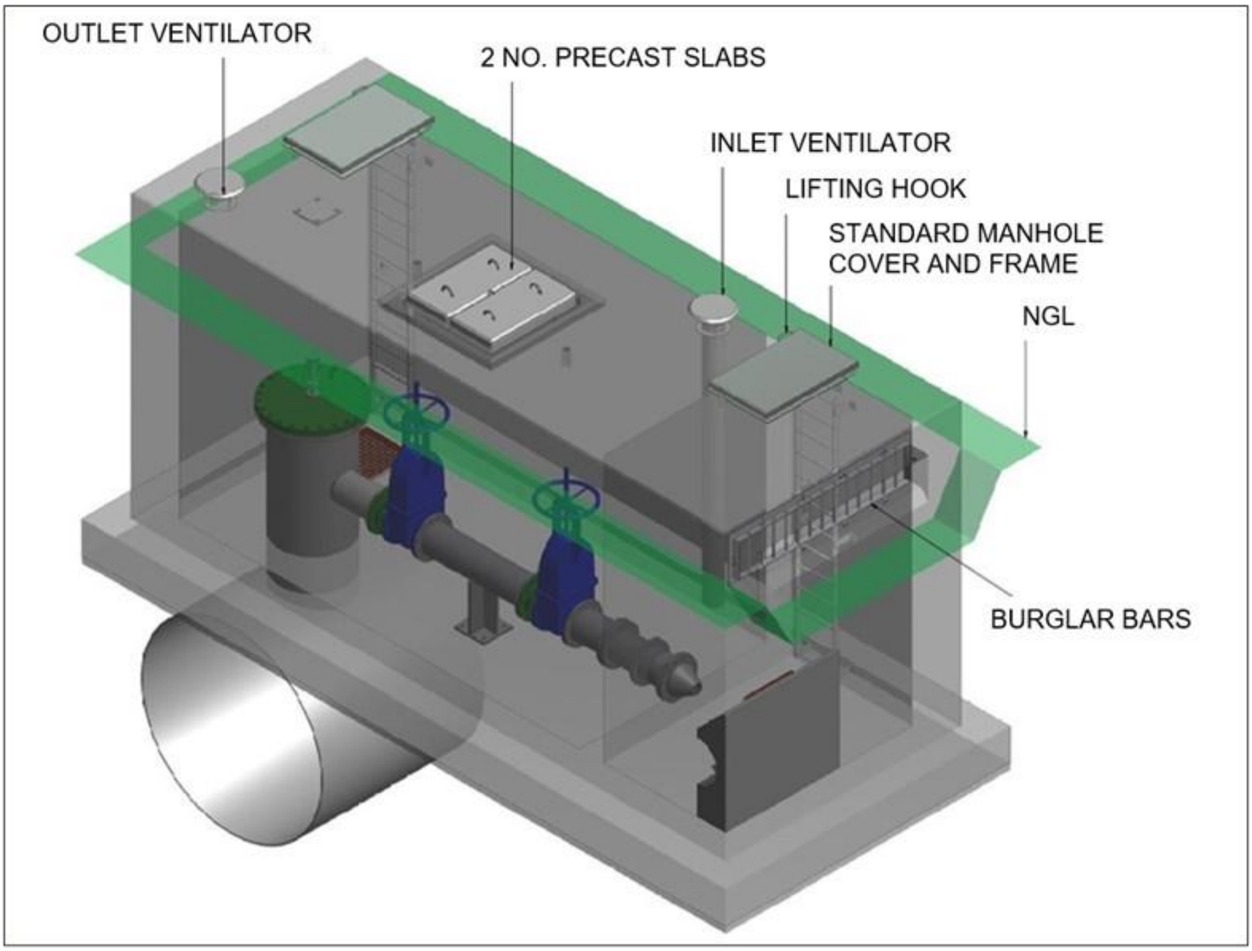

Figure 7-13:Typical scour detail for syphons

7.6.7 Air Valves on Syphon

Sizing and positioning of air valves is based on the rate at which air will be introduced or expelled from the pipeline, 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 7-14**.

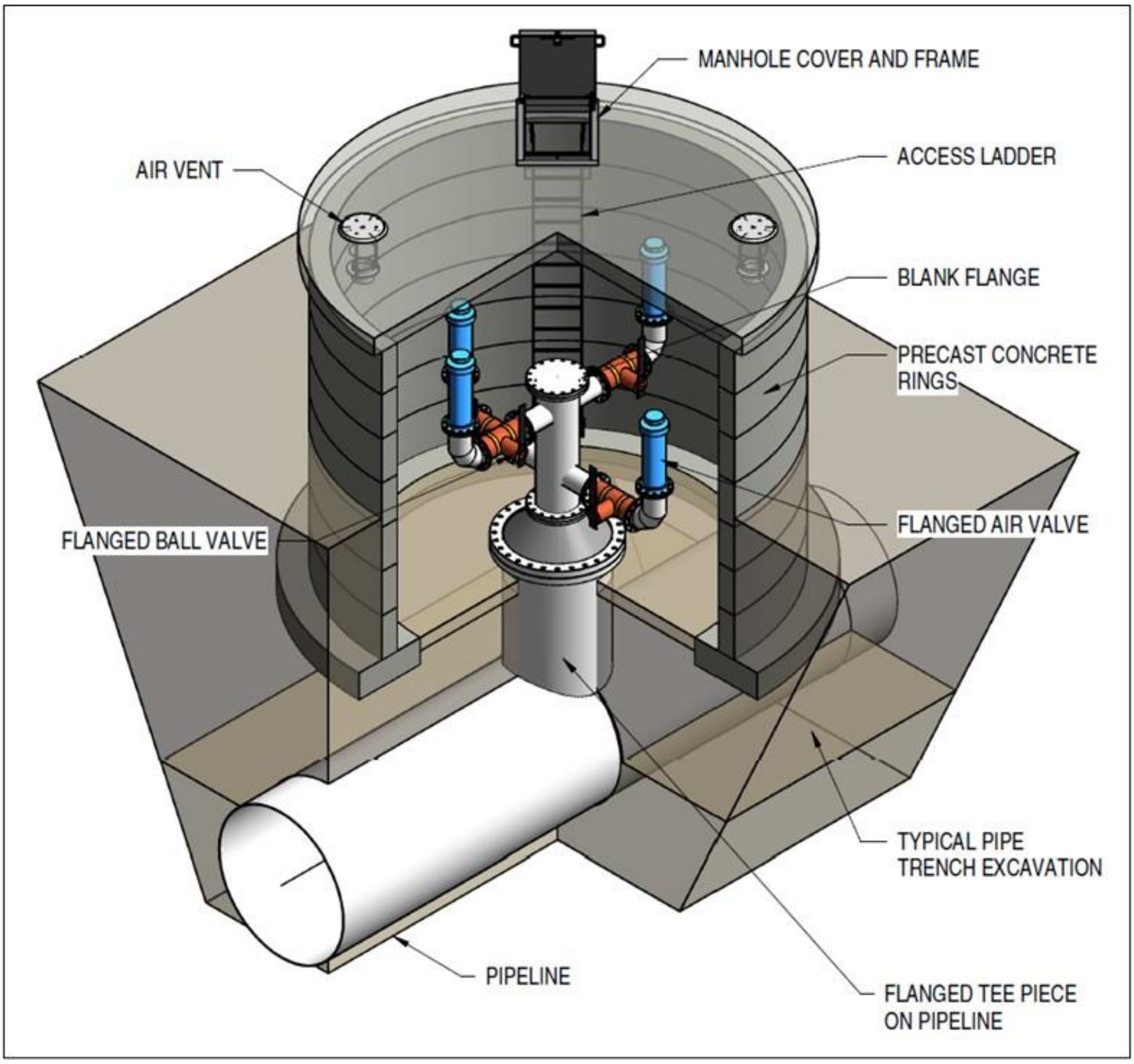

Figure 7-14:Typical air valve chamber

7.7 Existing Verdeling Syphon

7.7.1 Existing Outlet Structure and Syphon

The proposed Right Bank Canal needs to tie in with the existing syphon at Verdeling. This syphon currently operates by conveying flow from the Left Bank Canal, across the Olifants River, to the outlet and distribution canals on the right bank. At the outlet the flow divides west and south-east. The south-eastern small canal (Doring section) will be replaced by the new Right Bank Canal. **Figure 7-15** 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.

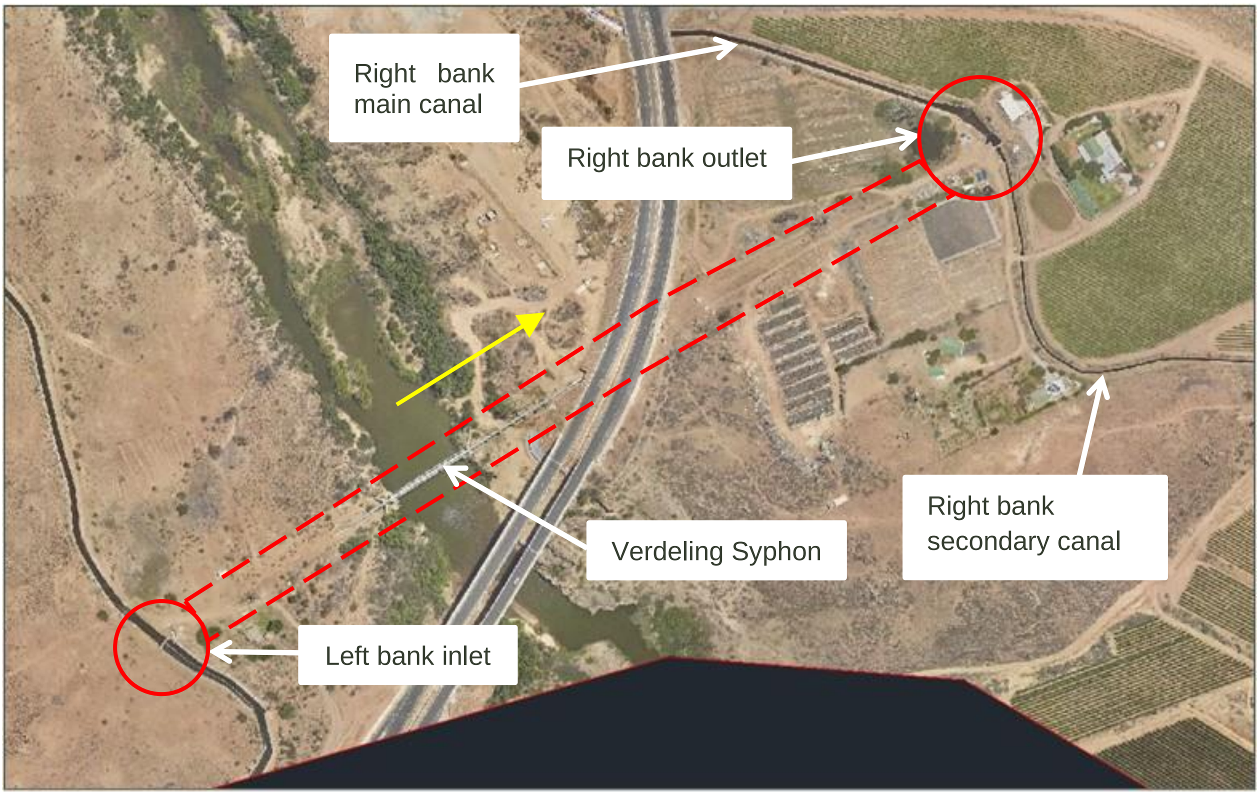

Figure 7-15:Layout and operation of existing Verdeling Syphon

7.7.2 Proposed Inlet Structure

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

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 7.7.4**). The walls of the new inlet will be placed on top of the existing structure and strengthened. Vertical sluice gates will control the flow through the syphon and to the existing right bank distribution canal. A Crump weir flow measuring station must be placed downstream of the inlet to confirm flow to the right bank distribution canal. A trash rack will be placed upstream of the inlet, as well as a reject with relevant erosion protection and a stream path back to the river.

The design water level in the new inlet structure is **51.000 masl**, and wall height (including freeboard) is 51.500 masl. Given that 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 7.7.4** 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 7.7.3** below, the design flow is still more than the capacity of the Left Bank Canal.

7.7.3 New Syphon Design Flow Capacity

The total peak design flow for the reversed Verdeling Syphon is calculated as **4.02 m^3/s**, as shown in **Table 7-6**. Refer to **Section 7.3** of the '*Right Bank Canal Design sub-report*' for details on the design flow capacity.

Table 7-6: Verdeling Syphon peak design flows

Flow component	Flow (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**

7.7.4 Proposed Reversed Verdeling Syphon Hydraulics

The reversed (right bank to left bank) syphon duty is based on the above total peak design flow of 4.021 m^3/s. As the pipe diameter and design flow are fixed, the available head and assumed pipe roughness will equate the flow velocity. The scenario with an old syphon with maximum flow and higher friction factors (aged pipe) was investigated. An aged steel pipe roughness of 0.15 mm was assumed, and the hydraulics are shown in **Table 7-7**.

Table 7-7: 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
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 Ebenhaeser Scheme Feasibility Design

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

8.1 Spare Flow Capacity in Canals and Scheme Sizing

The background to, and sizing of the scheme is explained in Chapter 6 of the *Conceptual Design Sub-Report*.

An assessment of historical flows in the various existing canal sections vs. their maximum flow capacity, identified the spare flow capacity in each canal section for each year. It was established that additional flows can be released from Bulshoek Weir during weeks when there is spare flow capacity in the canal sections, to be diverted at identified diversion points, for storage and use. The abstraction point/s influence the sizing of the scheme.

To allow for the likely increase in flows to existing irrigators before most of the canal infrastructure has been upgraded, and to limit the risk of shortfall in supply of the Ebenhaeser Scheme, it has been assumed that a maximum of 50% of current annual spare canal capacity may be abstracted for the Ebenhaeser Scheme. The calculations of spare capacity in canal sections were further based on selected non-drought years where flows are high, to further limit the risk of a shortfall in supply to the Ebenhaeser Scheme and to be more representative of the situation after the Clanwilliam Dam has been raised. Canal losses are a significant factor and this has been taken into account, for the various canal sections.

An evaluation tool was developed in Excel to determine the abstraction volumes and abstraction patterns for the six identified scheme sub-options. Leaching requirements was also allowed for in the assessment. The scheme water availability was determined as 4.66 million m^3/a, including losses of 1.01 million m^3/a (conveyance losses and balancing dam evaporation), to irrigate 36 ha of irrigable area. The water availability (excluding water losses) for the selected sub-option is thus 3. 65 million m^3/a and the minimum balancing dam capacity needed is 2.152 million m^3.

8.2 Water Requirements

The water requirements of the scheme are explained in Chapter 6.6 of the *Conceptual Design Sub-Report.* The existing Ebenhaeser Community, that is located approximately 12 km from Lutzville has expressed a strong need for expansion of the mostly subsistence farming activities. The successful land claim lodged by the Ebenhaeser Community, which has resulted in farms being handed over to Ebenhaeser Community Project Association, with existing water allocations to some of these farms being inadequate.

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

8.3 Overview of the Scheme

Canal diversion structures will be required at the Retshof right bank and Vredendal left bank canals to create off-take points. Canal flows will be diverted from 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 8-1 and **Figure** 8-2 show the layout and bulk water infrastructure components for the Ebenhaeser Scheme. A drawing showing the key plan of the Ebenhaeser Scheme layout, 113834-0000-DRG-CC-0100, is included in **Appendix C**.

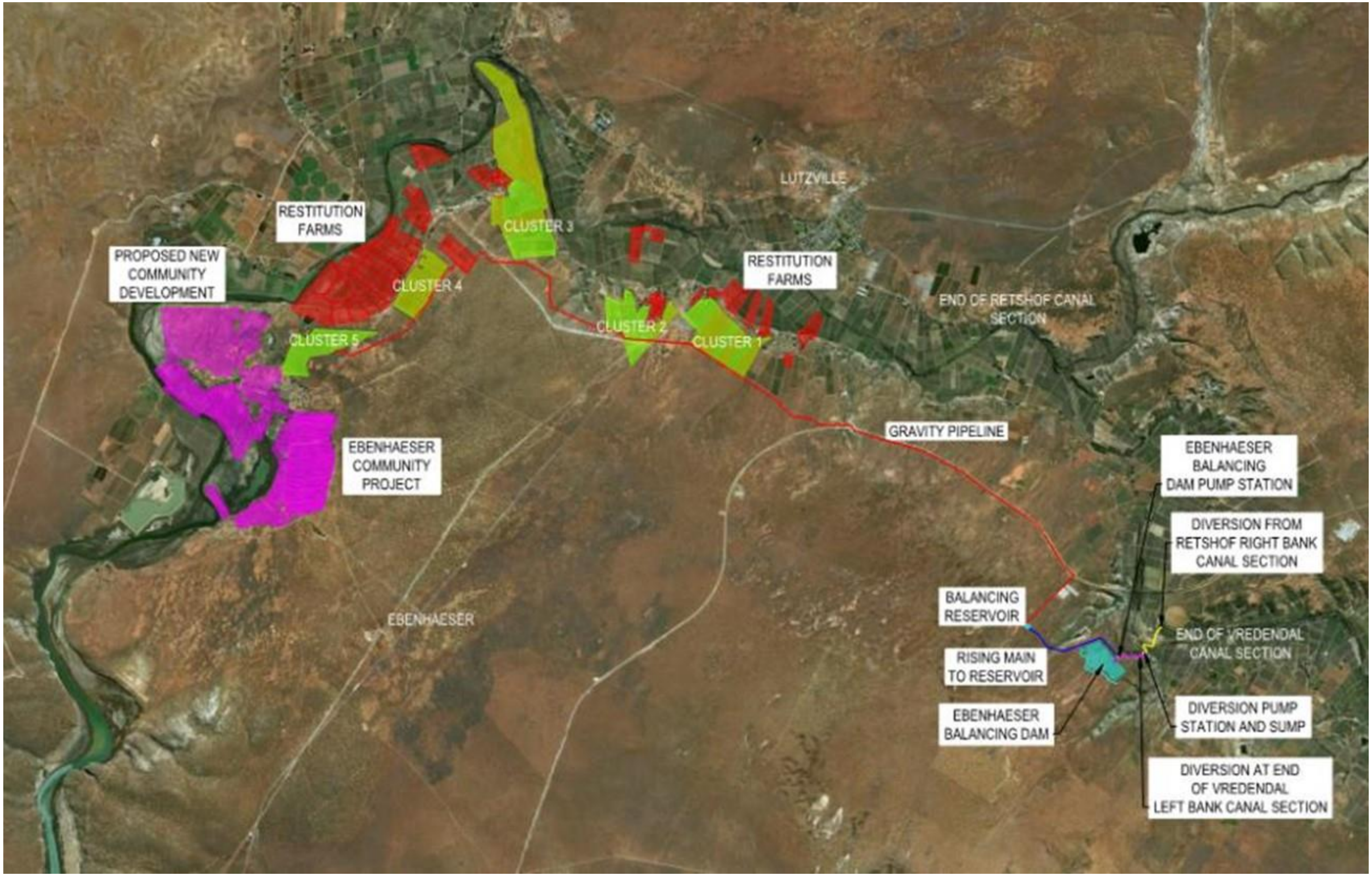

Figure 8-1: Layout of Ebenhaeser Scheme

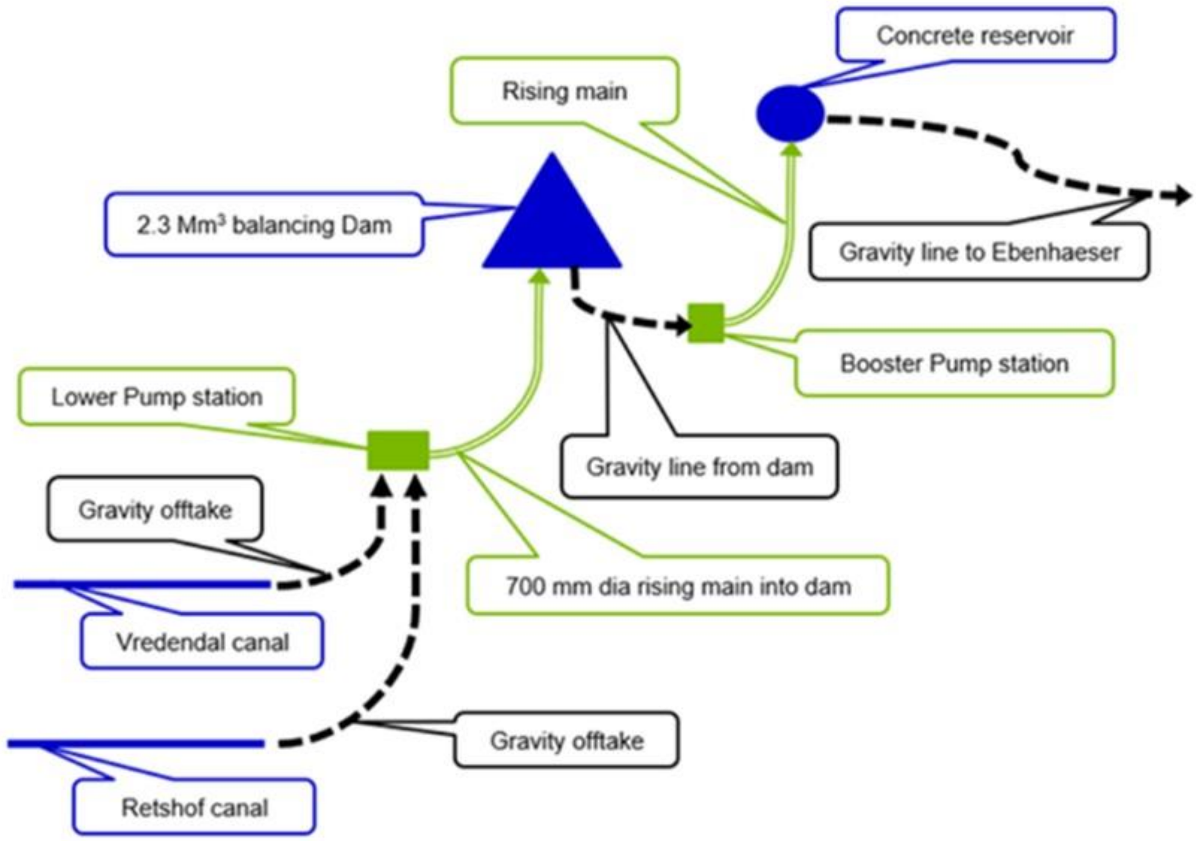

Figure 8-2: Schematic Layout of Ebenhaeser Scheme

8.4 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 layout of these two diversion structures is shown in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report,* Appendix A2.

The diversion point in the right bank Retshof canal section is in the middle of a long bend, as shown in **Figure** 8-3, with the Sishen-Saldanha railway line visible in the background.

Figure 8-3: Proposed position of the Retshof Right bank canal diversion structure

The proposed diversion point in the left bank Vredendal canal section is in a cutting upstream of a long weir, just before a tunnel, as shown in **Figure 8-4**.

Figure 8-4: Proposed position of the Vredendal Left bank canal diversion structure

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** 8-5 (typical section view) and in **Figure** 8-6 (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*.

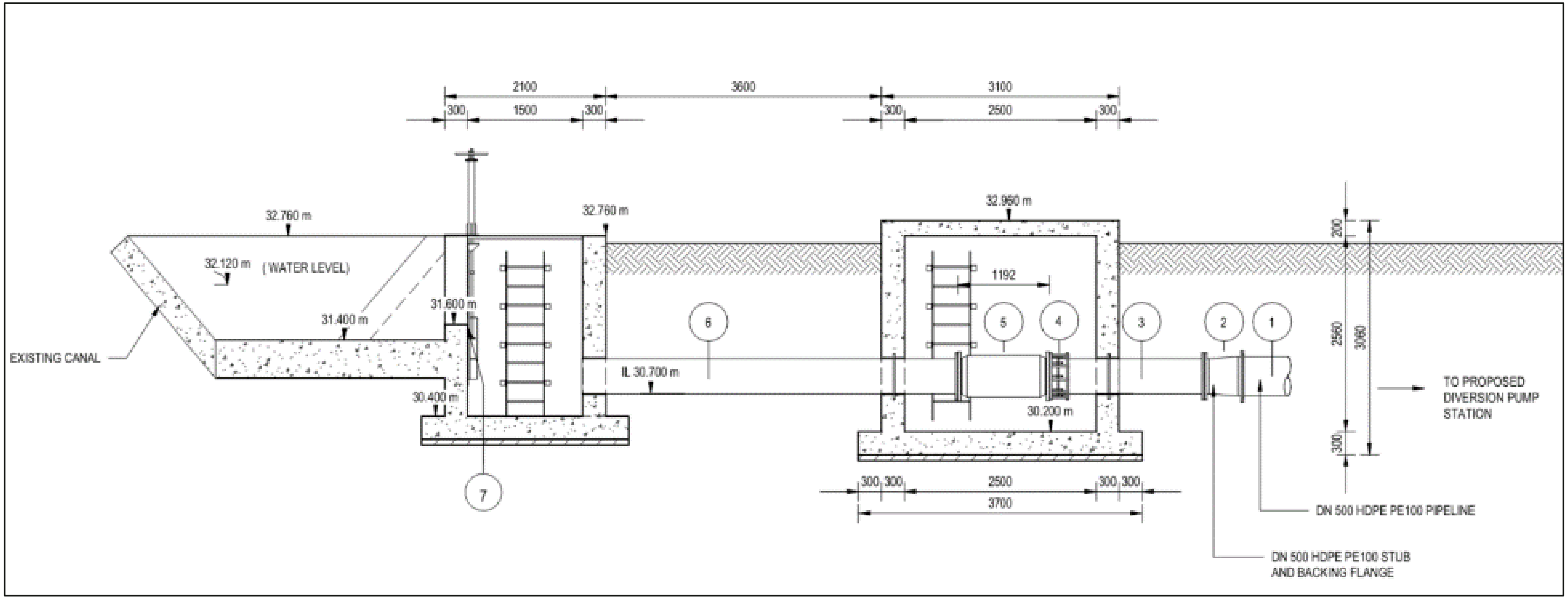

Figure 8-5: Typical section of Canal Diversion Structure

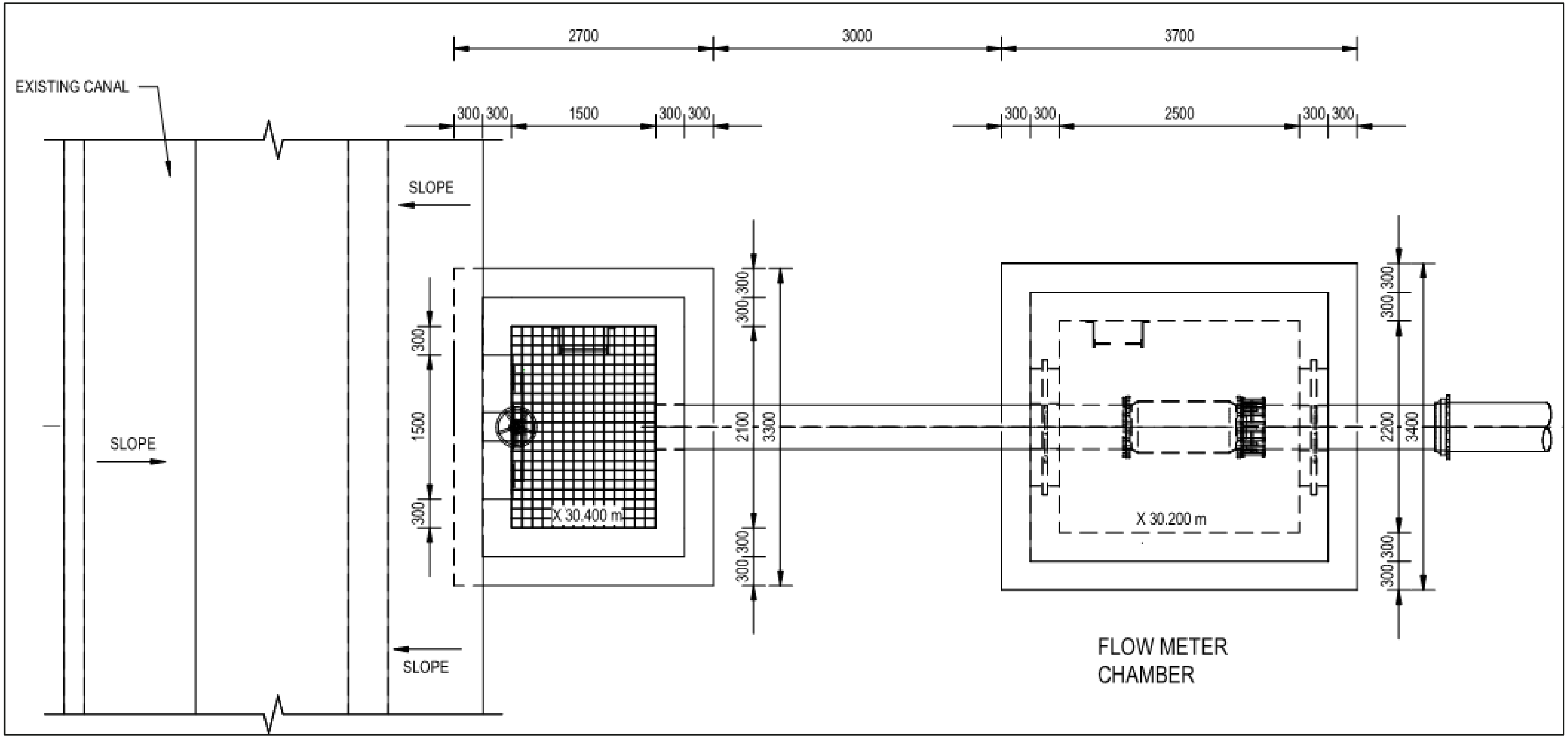

Figure 8-6: Typical plan view of Canal Diversion Structure

8.5 Diversion Gravity Pipelines

8.5.1 Description of the pipelines

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

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

From the sump, the raw water will be pumped to the Ebenhaeser balancing dam. The design flow for the 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 8-7 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 8-7** 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 8-8 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 8-8** 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.

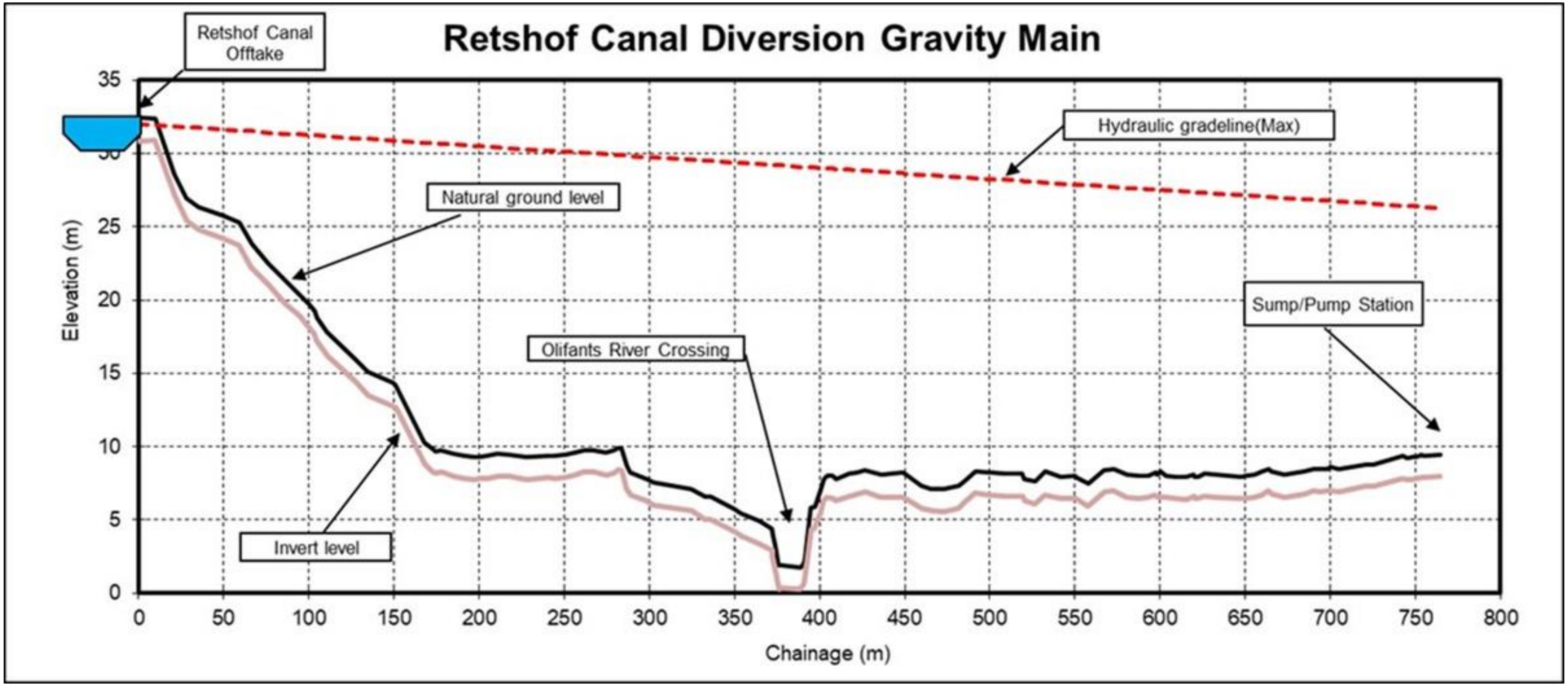

Figure 8-7: Right Bank Canal Diversion Gravity Main: HGL for 25.5 Mℓ/d in aged DN 500 pipeline

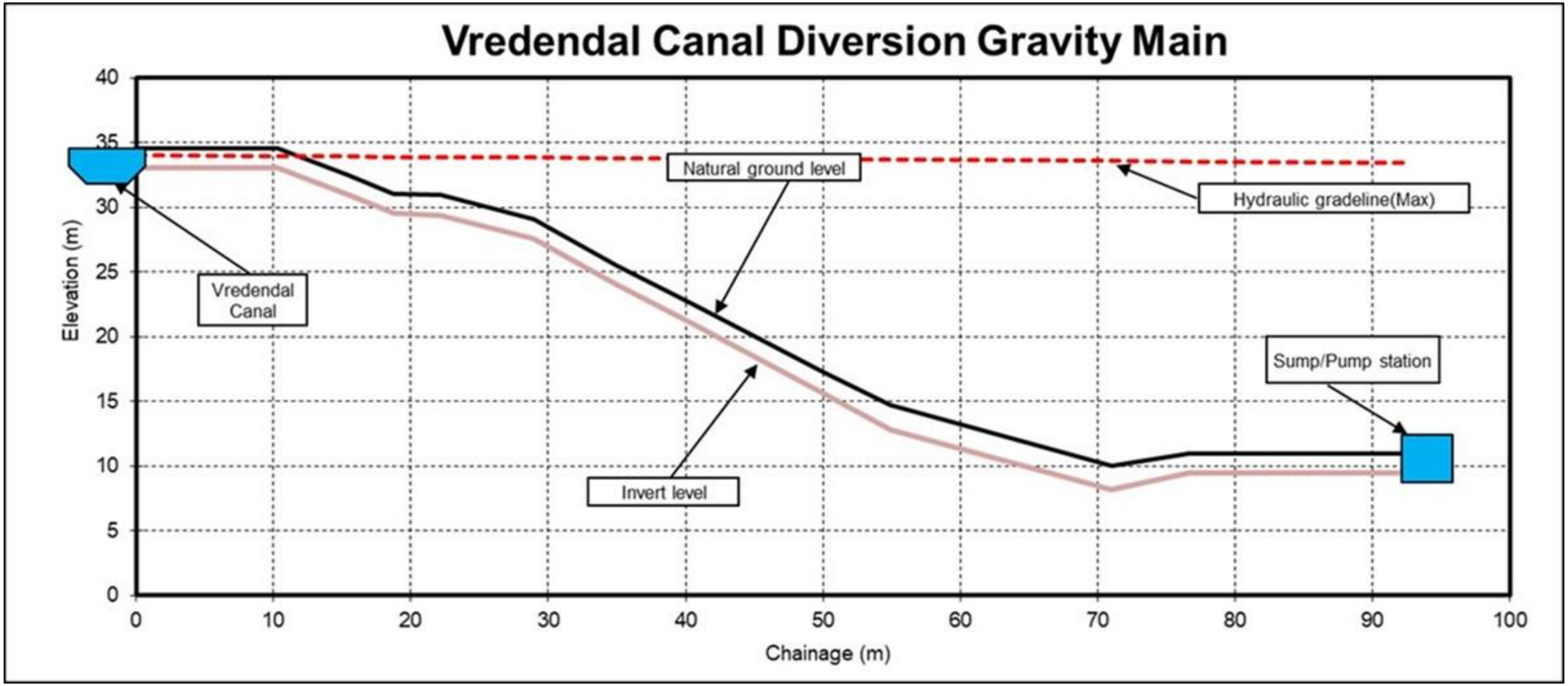

Figure 8-8: Left Bank Canal Diversion Gravity Main: HGL for 30.80 Mℓ/d in aged DN 560 pipelines

8.5.2 Olifants River Crossing

A syphon would be required to cross the Olifants River on the diversion gravity main from the Retshof right bank canal. The crossing is located approximately 380 m 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.

8.6 Diversion Pump Station and Sump

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

8.6.1 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 8-9 shows the characteristic and pump curves for the diversion pump station.

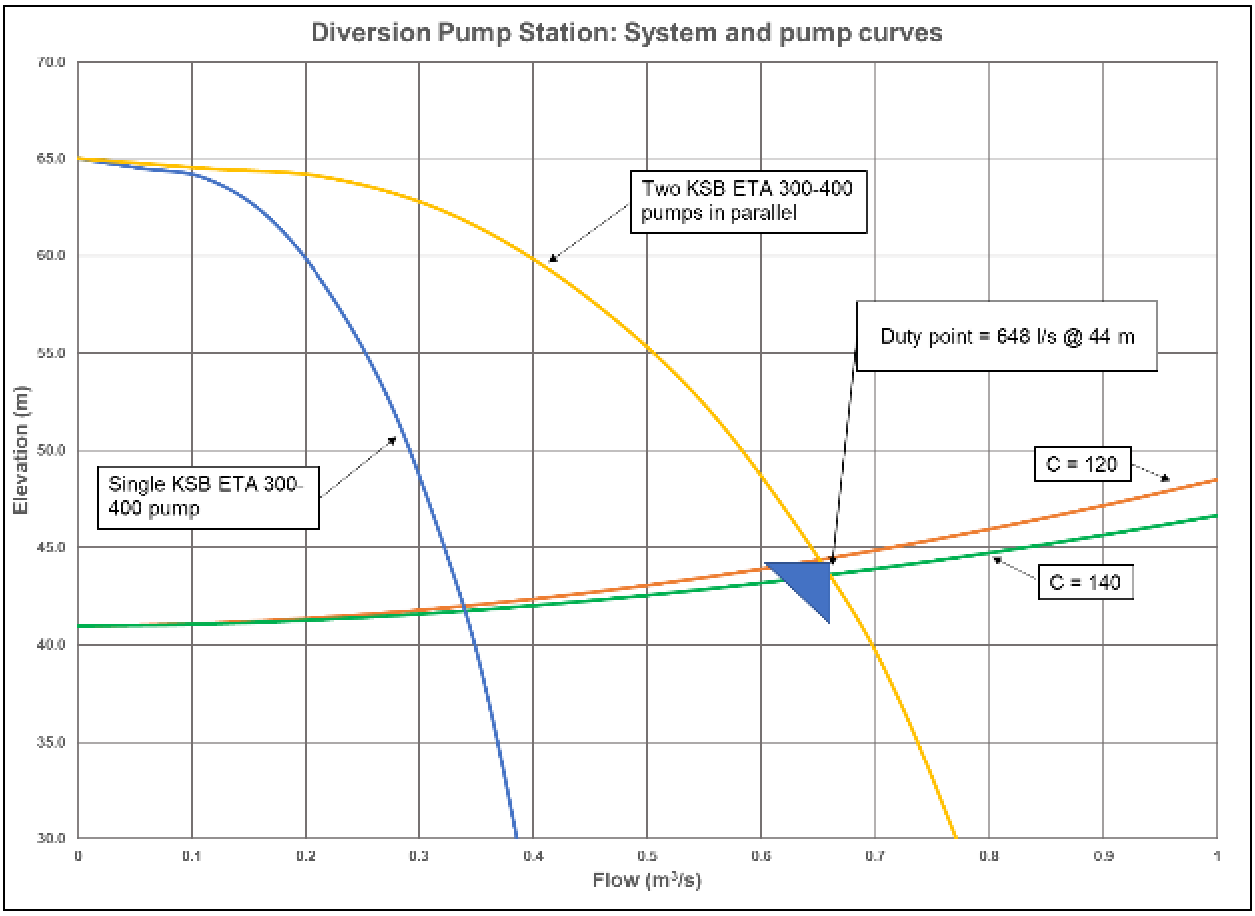

Figure 8-9: Characteristic and pump curve for diversion pump station

It is evident from **Figure 8-9** 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.

8.6.2 Diversion sump

The diversion sump is designed to store the flow from the Retshof and Vredendal canals, pumped over a 1 hour period, i.e. 292 ℓ/s + 356 ℓ/s = 648 ℓ/s pumped over a1 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 8-10**.

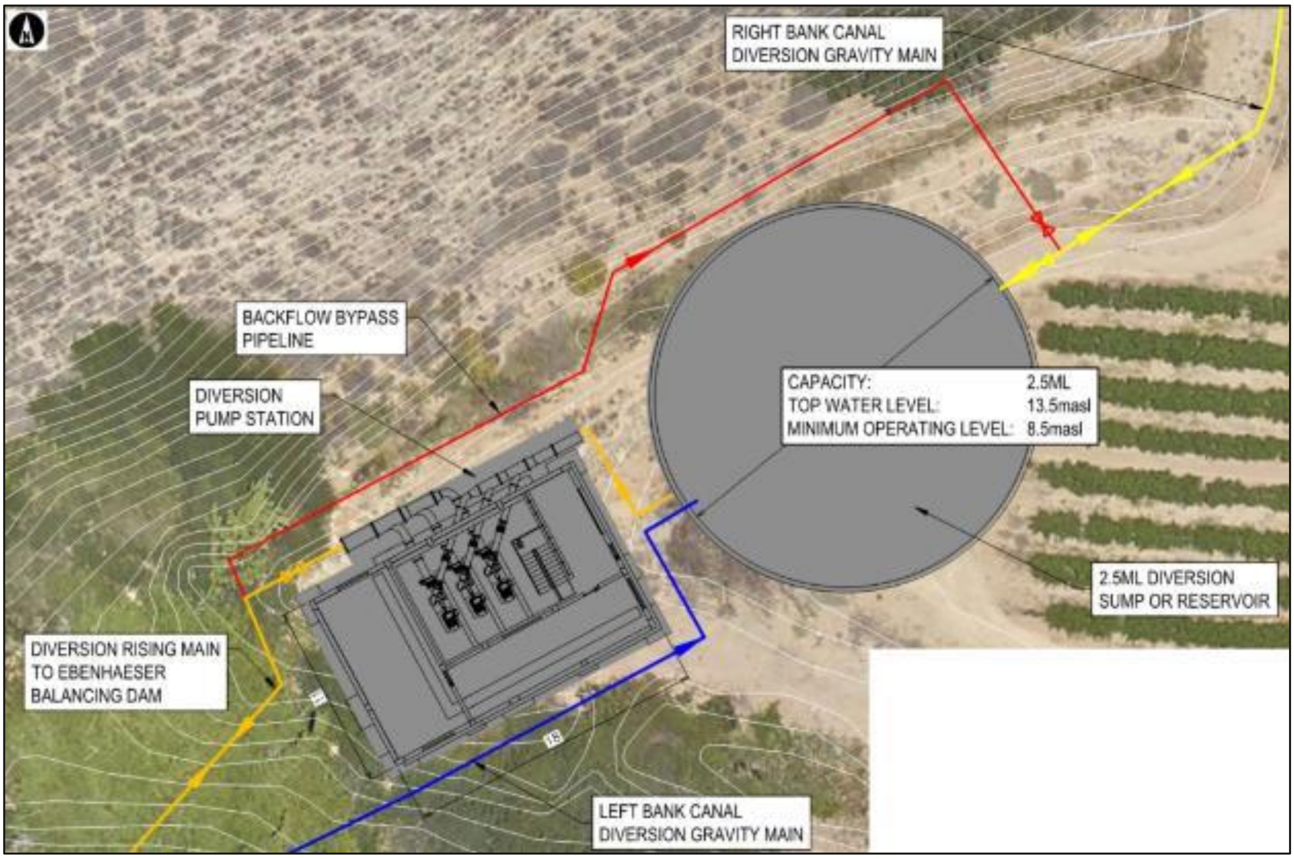

Figure 8-10: Plan view of Diversion Pump Station and Sump

8.7 Diversion Rising Main

8.7.1 Description of pipeline

The proposed diversion rising main will convey water from the Diversion Pump Station to the Ebenhaeser Balancing Dam (520 m in length). 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 8-11 shows the hydraulic gradient line of the Diversion Rising Main for a flow of 56 Mℓ/d (0.65 m³/s).

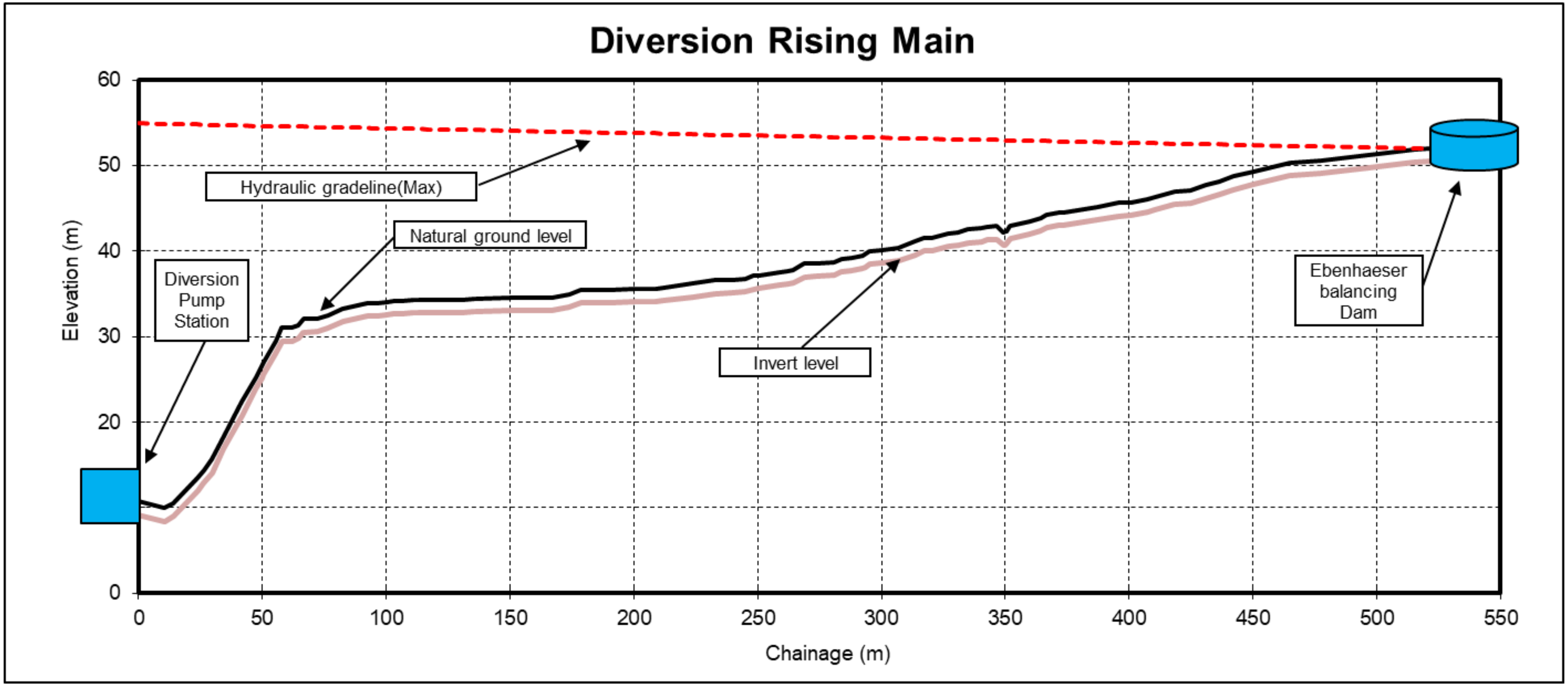

Figure 8-11: Diversion Rising Main: HGL for 56 Mℓ/d in aged DN 710 pipeline

8.8 Ebenhaeser Balancing Dam return flow to canals

The diversion rising mains are designed to allow water from the Ebenhaeser balancing dam to be supplied back under gravity to the Vredendal left bank and Retshof right bank canals when needed. LORWUA has requested a total return backflow 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, to optimise the space. 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 on drawing 113834-0000-DRG-CC-0116 in Appendix A2 of the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* and in **Figure** 8-12. The discharge configuration will have an isolation valve, diaphragm flow control valve and flow meter to monitor the water discharged into the canal.

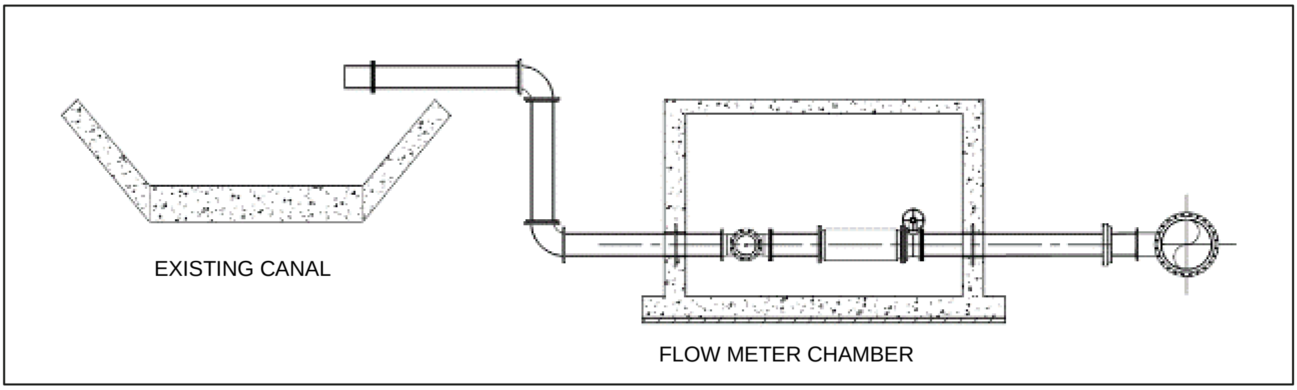

Figure 8-12:Typical detail of canal discharge configuration

Figure 8-13 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.

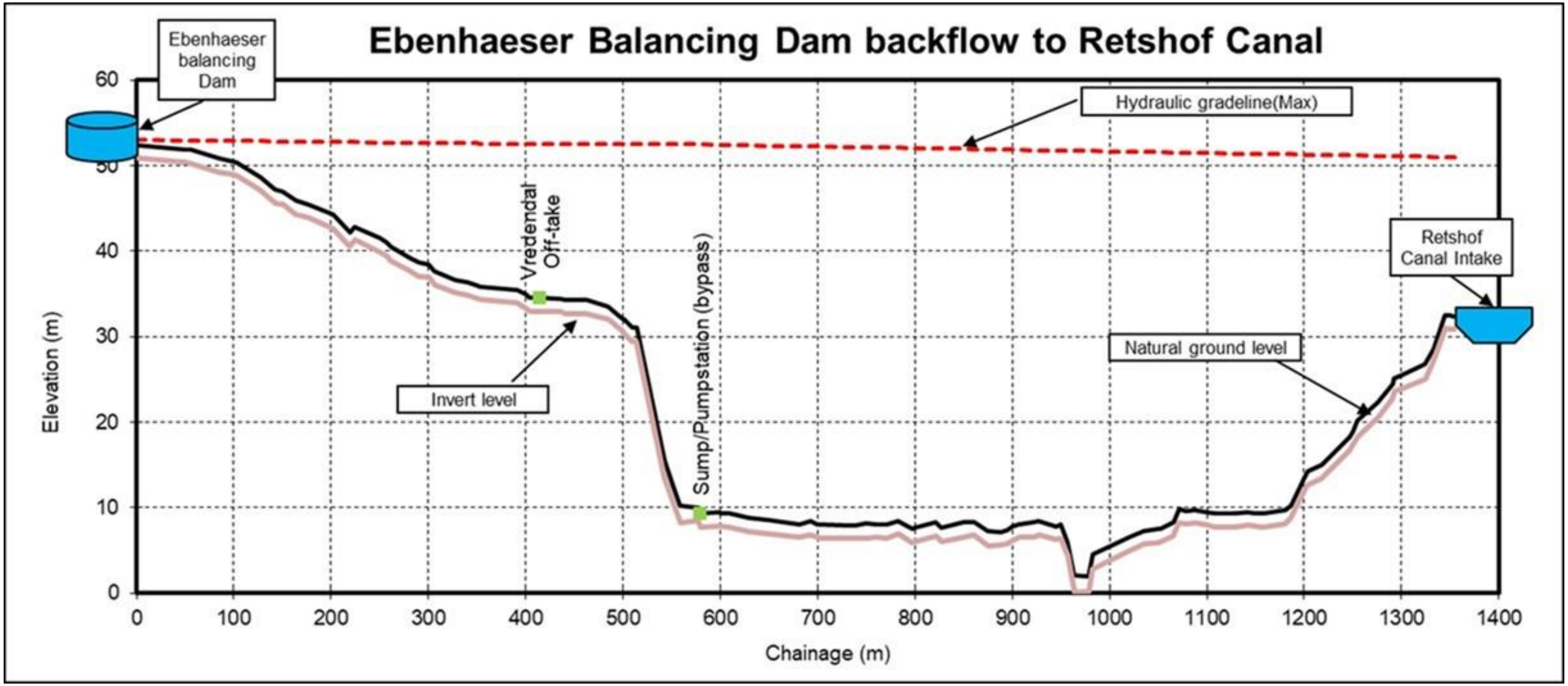

Figure 8-13:Right Bank Canal Diversion Gravity Main (return flow): HGL for 24 Mℓ/d

It is evident from **Figure 8-13** 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.

8.9 Ebenhaeser Balancing Dam

8.9.1 Salient features of the proposed dam design

The salient features of the proposed Ebenhaeser Balancing Dam are presented in **Table 8-1**.

Table 8-1: Main details of the Ebenhaeser Balancing Dam

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

Parameter	Value
Full supply level (FSL)	70.4 masl
Gross storage capacity at FSL	2.32 million m^3
Surface area of water at FSL	26.3 ha
Minimum Operating Level (MOL)	55.0 masl
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.

8.9.2 Site overview

8.9.2.1 Location and layout

The proposed location of the Ebenhaeser Balancing Dam (**Figure 8-14**) is about 100 m west of a bend in the R363 road, some 11 km north west of Vredendal in the Western Cape 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.

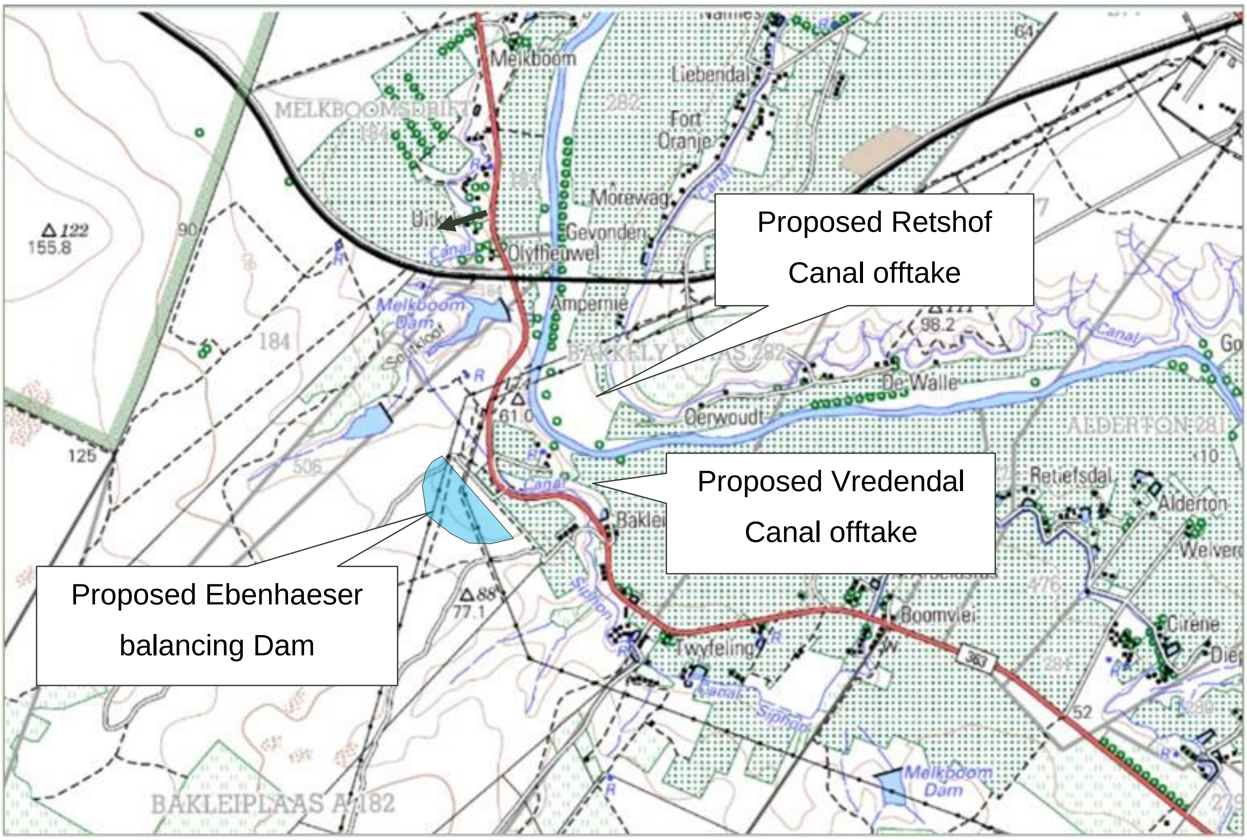

Figure 8-14:Locality plan of the proposed Ebenhaeser Balancing Dam

8.9.2.2 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.

8.9.2.3 Storage capacity

A Storage vs. Depth curve and a Surface Area vs. Depth curve for the dam basin were generated from the surveys at the proposed dam wall position. These curves are presented in **Figure** 8-15 below.

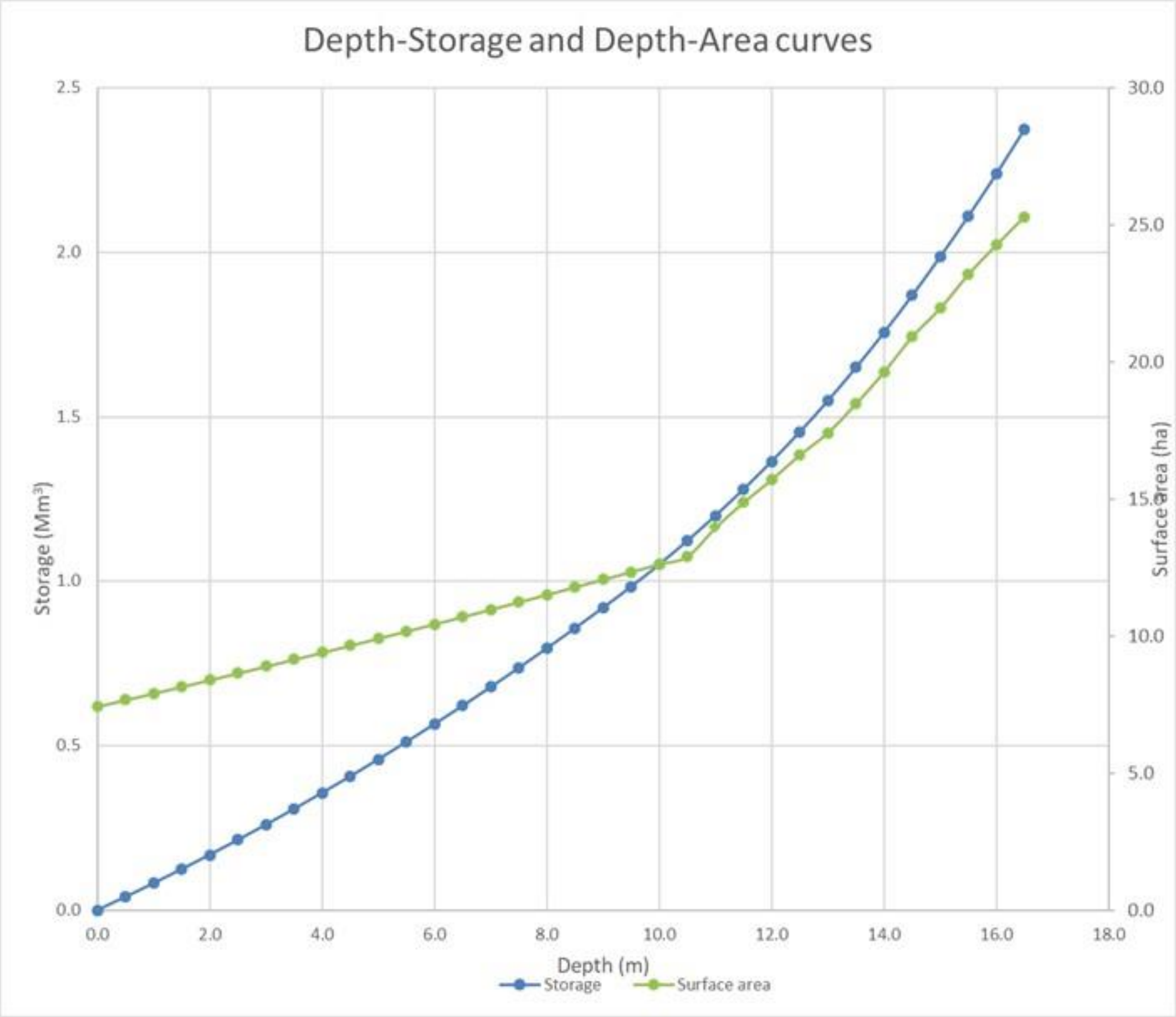

Figure 8-15:Depth-Storage and Depth-Area curves for Ebenhaeser Balancing Dam

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

8.9.3 Dam safety classification

The dam will be classified as a Category II dam. 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.

8.9.4 Flood hydrology

Based on the small size of the catchment area (0.9 km^2) and its drainage path, (**Figure 8-16**) 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 8-2**.

Table 8-2: Catchment parameters

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 %

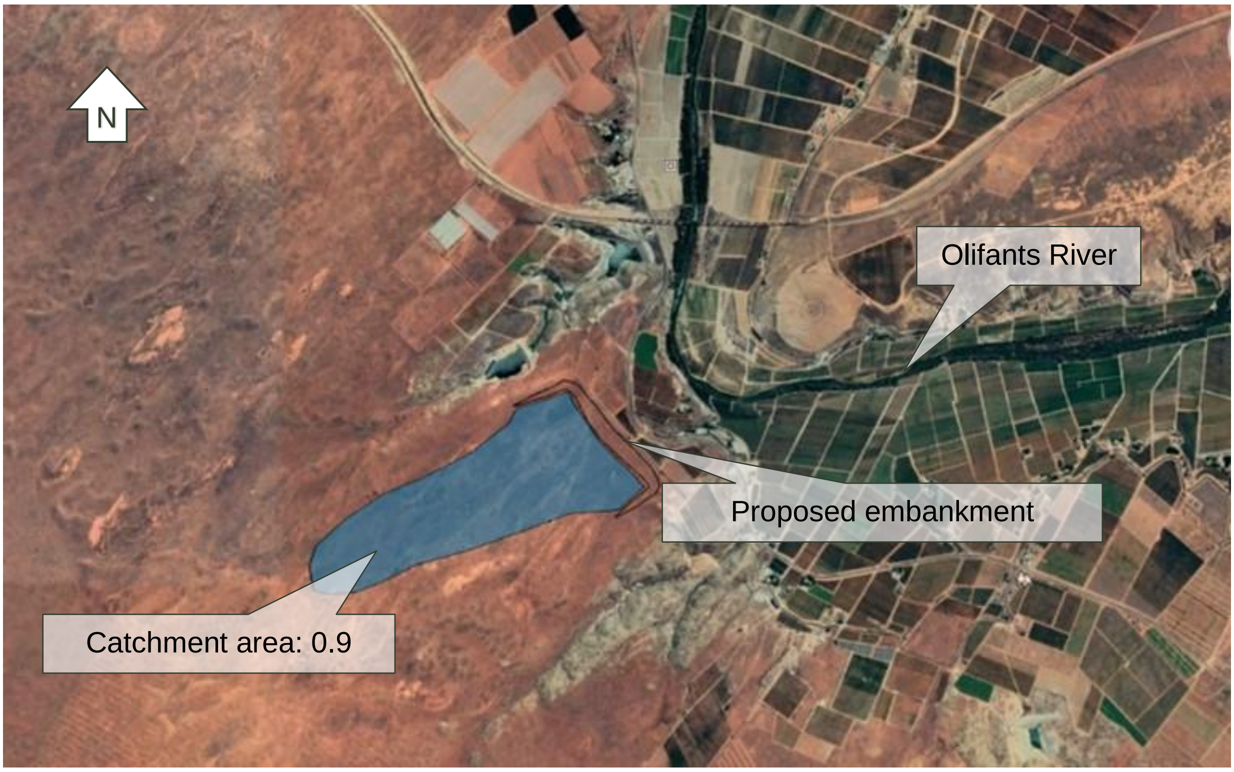

Figure 8-16:Ebenhaeser Balancing Dam catchment

The two methods resulted in a 1:100 year recurrence interval (1.0 % AEP) flood peak of 3.2 m^3/s and a PMF flow 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 SEF is equal to 70% of the Probable Maximum Flood, 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.

8.9.5 Embankment and Lining Design

8.9.5.1 Dam type selection

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

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

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

8.9.5.2 Embankment layout and detail

The embankment layout is typically U-shaped to account for the topography, which is more of a gentle incline than a broad valley. It is proposed that the embankment will be constructed with material excavated from the dam basin. 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 8-17**) 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.

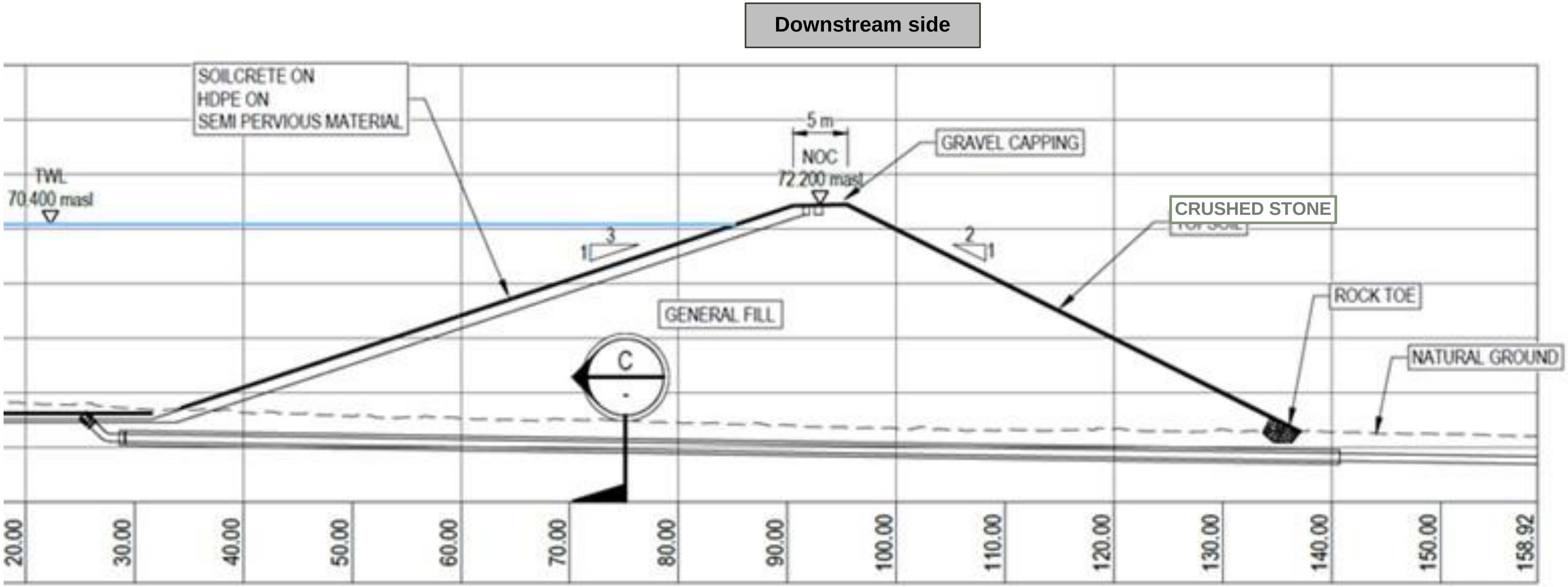

Figure 8-17:Illustrative cross section through the proposed balancing dam embankment

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 that daylights below the downstream toe.

8.9.5.3 Lining detail

The 1.5 mm HDPE liner will cover the entire basin up to the NOC contour and be anchored in the 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.

8.9.6 Spillway

8.9.6.1 Spillway design

The spillway will be located on the right abutment so that it can drain into the nearby natural drainage course. The spillway and embankment layout are shown in **Figure 8-18** 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.*

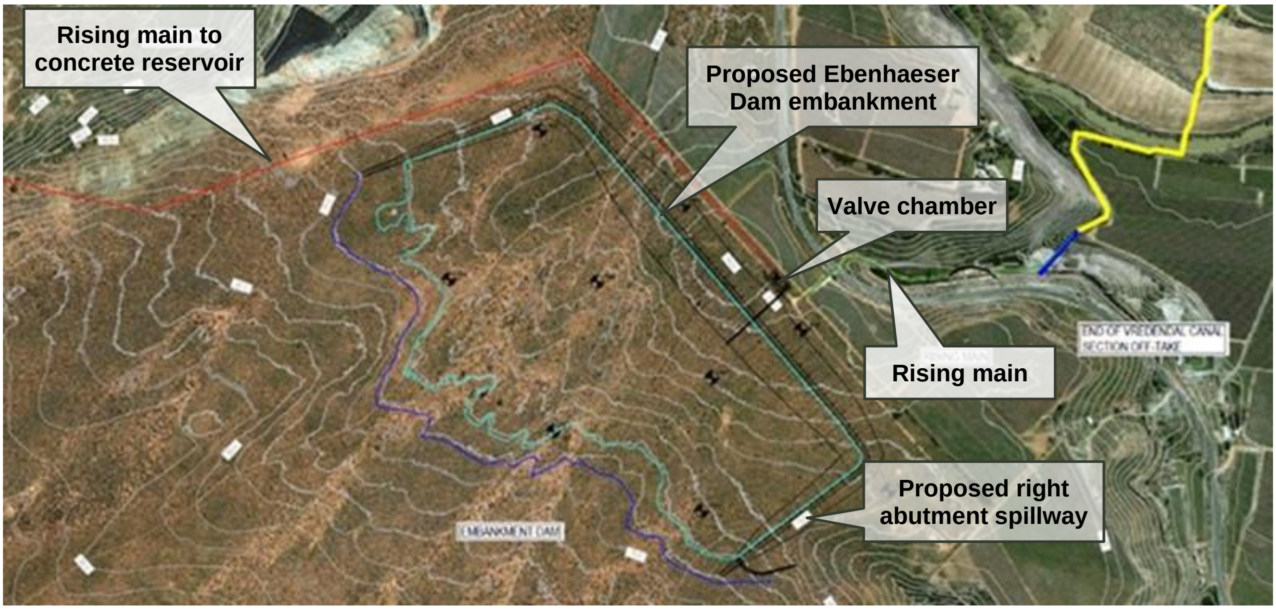

Figure 8-18:Plan view of the embankment showing proposed spillway location

8.9.6.2 Discharge channel

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

The channel is trapezoidal, has side slopes of 1V:1H and extends for 100 m. The base width narrows from 3.0 m to a nominal 1.0 m and has a longitudinal slope of 0.063 m/m (1:15). 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.*

8.9.6.3 Flood routing

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

8.9.7 Freeboard

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

8.9.8 Outlet works

8.9.8.1 Inlet/Outlet works configuration

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

The layout of the balancing dam and outlet works is shown in **Figure 8-19**. 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.*

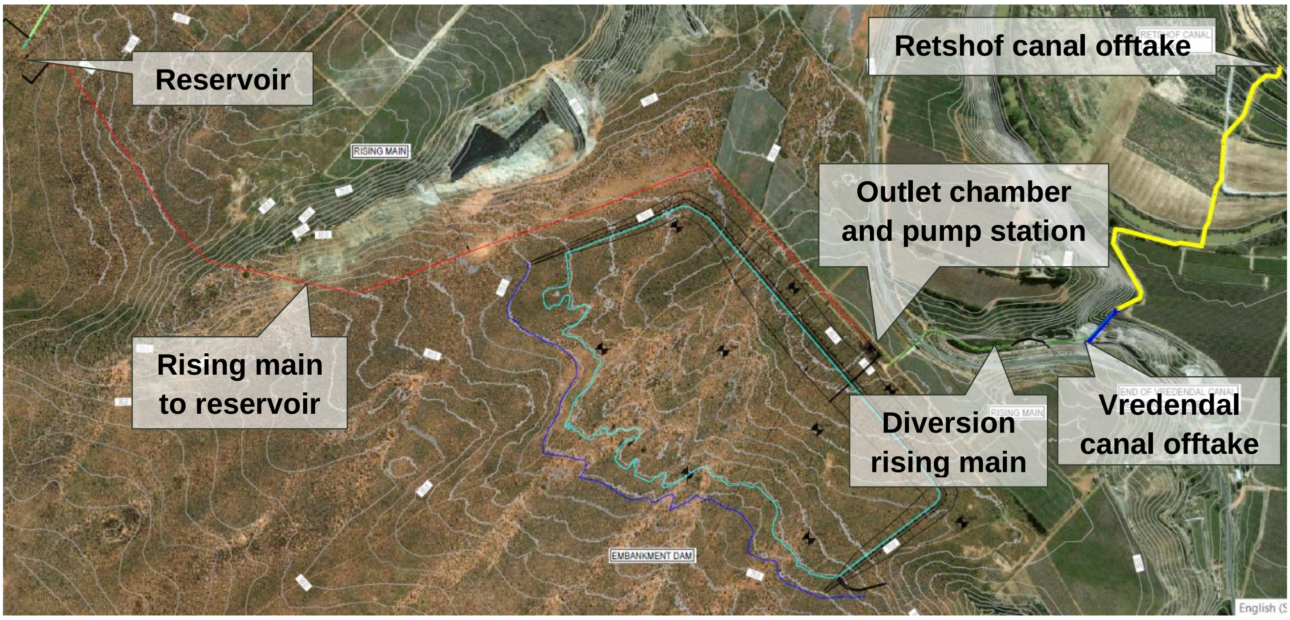

Figure 8-19:Ebenhaeser Balancing Dam and supply/connection pipe layout

The two 700 mm dia 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.

8.9.9 Associated infrastructure

8.9.9.1 Instrumentation

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

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

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

8.9.9.2 Storm water diversion

Due to the very small catchment and the fact that the dam is off-channel, river diversion during construction is not expected to cause problems.

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.

8.10 Ebenhaeser Balancing Dam Inlet/Outlet Chamber

The proposed dam will be supplied from the DN 710 diversion rising main, which will also be used to transfer water back to the canals when needed. Water from the balancing dam will also be pumped via a DN 560 rising main to a concrete balancing reservoir located to the west of the proposed balancing dam (refer to **Figure 8-1**).

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 8-20**. 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.*

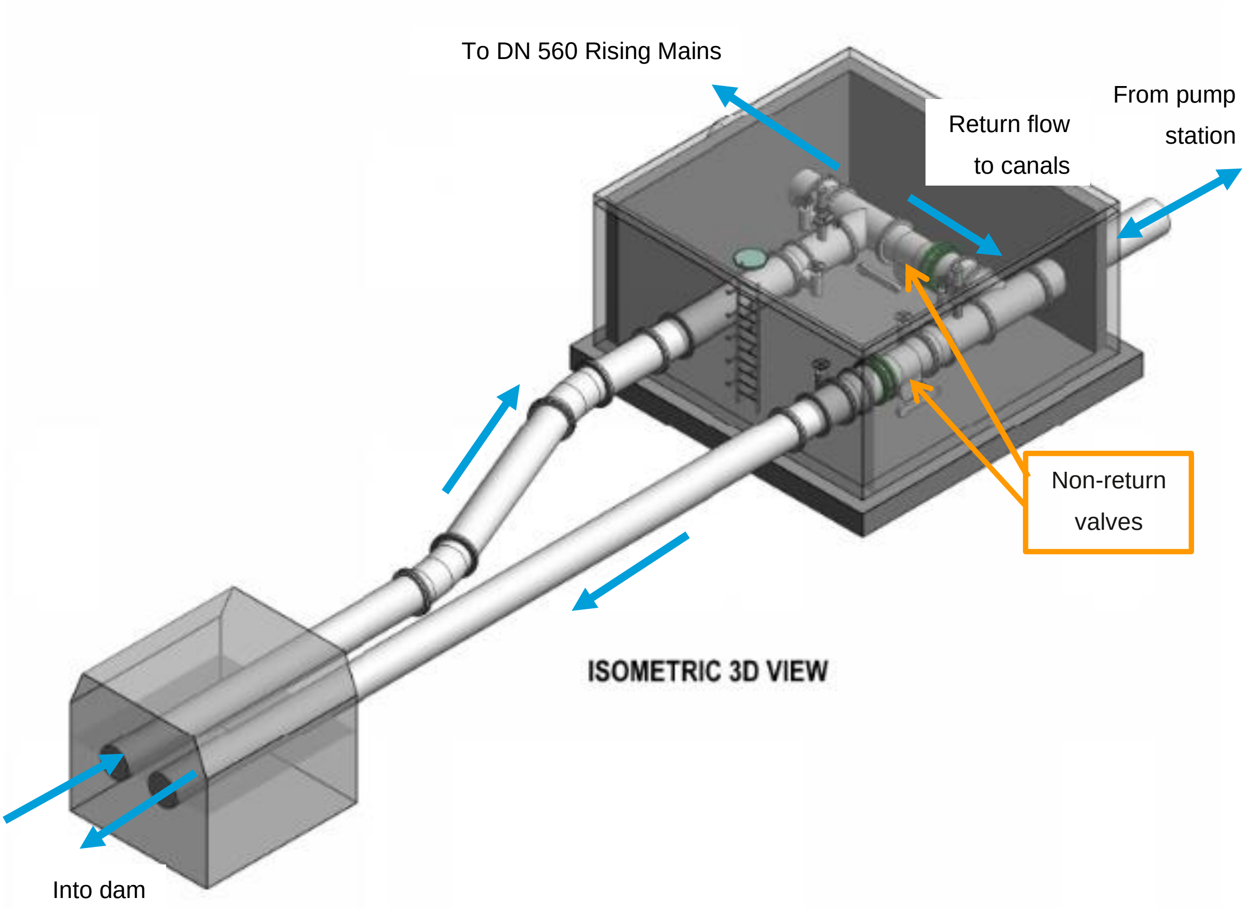

Figure 8-20:Isometric view of Ebenhaeser Balancing Dam Inlet/Outlet Chamber

8.11 Ebenhaeser Balancing Dam Pump Station

The Ebenhaeser Balancing Dam Pump Station will pump water from the Ebenhaeser balancing dam via a DN 560 rising main to a concrete balancing reservoir. 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 8-21 shows the characteristic and pump curves for the pump station.

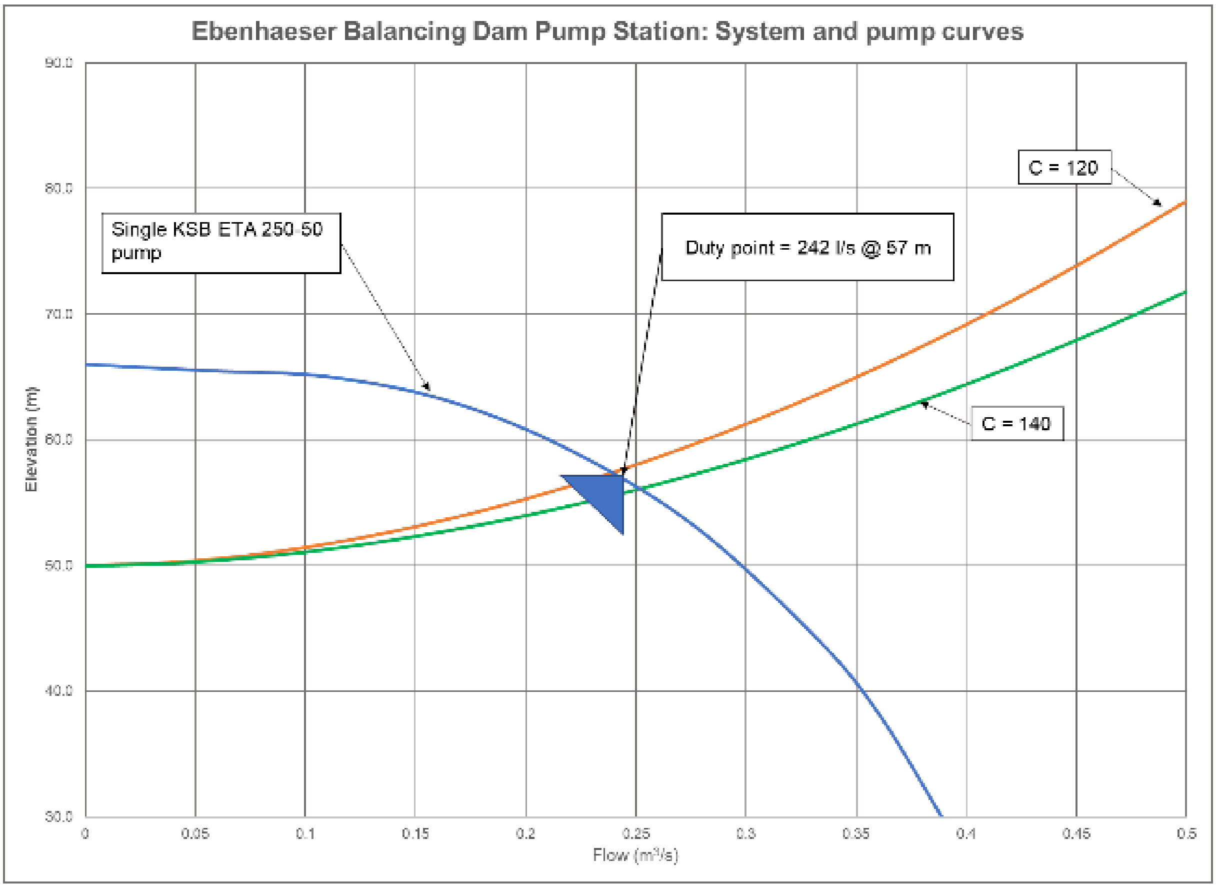

Figure 8-21:Characteristic and pump curve for Ebenhaeser Balancing Dam Pump Station

It is evident from **Figure 8-21** 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 8-22**Figure 8-22 and in the *Jan Dissels and Ebenhaeser Schemes Design Sub-Report* on drawing 11383-0000-DRG-CC-0111 in Appendix A2.

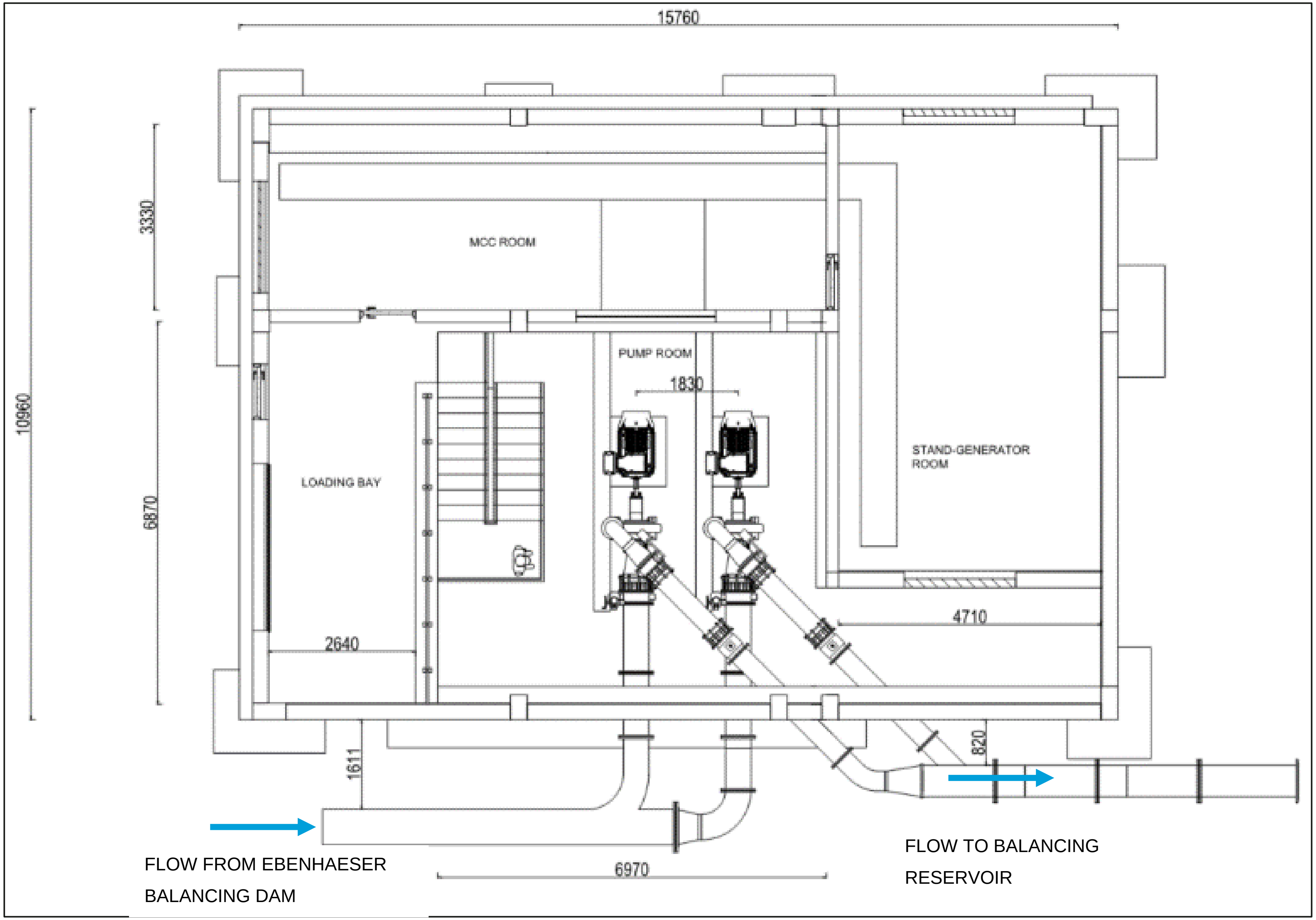

Figure 8-22:Plan view of Ebenhaeser Balancing Dam Pump Station

8.12 Rising Main to Concrete Balancing Reservoir

8.12.1 Description of pipeline

The proposed rising main will convey water from the Ebenhaeser Balancing Dam to the Concrete Balancing Reservoir (1 975 m in length). 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 8-23 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).

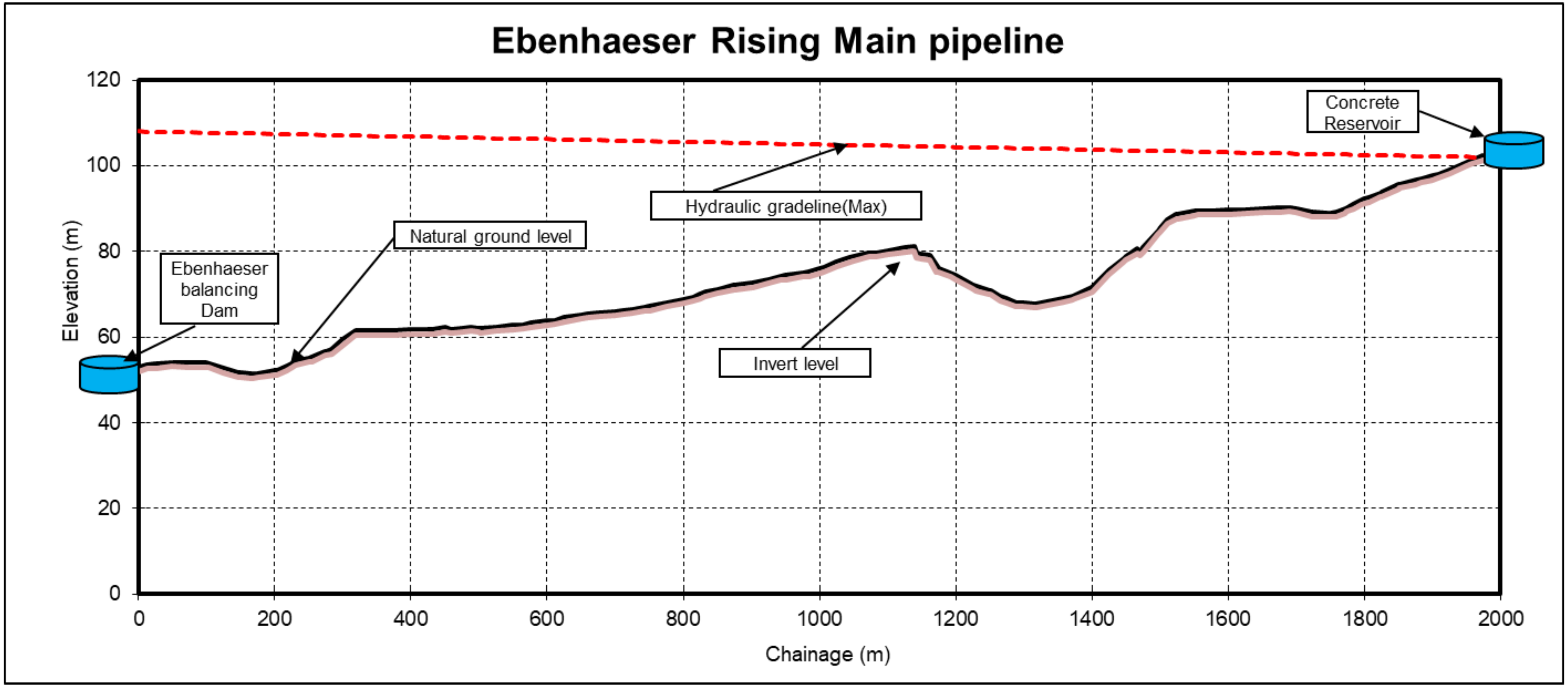

Figure 8-23:Rising Main to Concrete Reservoir: HGL for 20.9 Mℓ/d in aged DN 560 pipeline

8.13 Concrete Balancing Reservoir

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

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*.

8.14 Gravity Pipeline and Distribution Mains

8.14.1 Gravity Pipeline to Five Clusters

8.14.1.1 Description of the pipelines

The proposed gravity pipeline will convey water from the concrete balancing reservoir to the five water requirement clusters on 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 flows and proposed pipeline diameters are shown in **Table** 8-3.

Table 8-3: Gravity Pipeline to Five Clusters: Design flows and diameters

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

Figure 8-24 shows the hydraulic gradient line of the gravity pipeline to the five clusters for the flow rates and pipe diameters shown in **Table 8-3**.

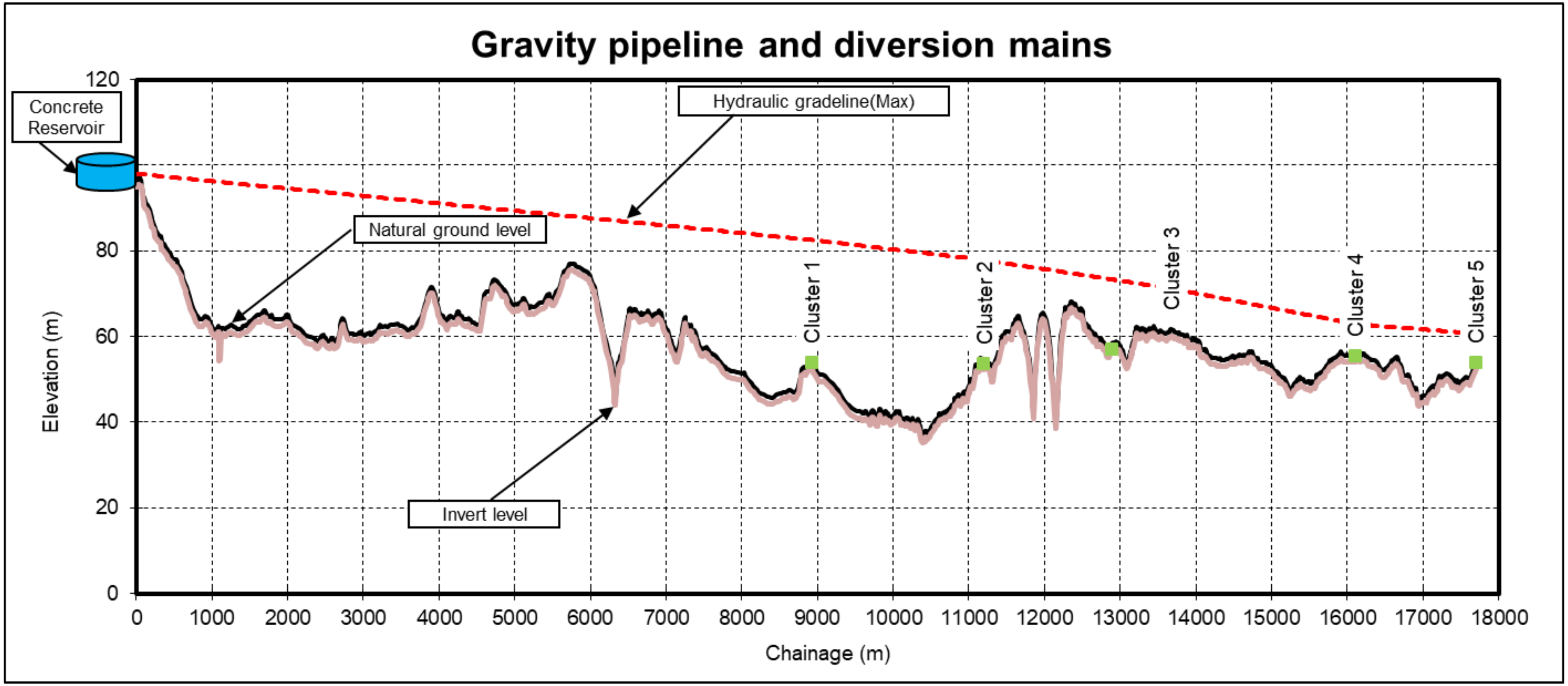

Figure 8-24:Gravity pipeline and diversion main offtakes at clusters: Hydraulic gradient line

8.14.1.2 Railway Crossing

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

8.14.1.3 Culvert Crossing near Railway

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.

8.14.1.4 Road Crossing

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

8.14.2 Distribution Mains for Clusters

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

Table 8-4 summarises the design flows at each off-take, the expected head range at the off-takes, as well as the proposed off-take diameter.

Table 8-4: 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 on drawing 113834-0000-DRG-CC-0113 in Appendix A2 and in **Figure 8-25**Figure 8-25.

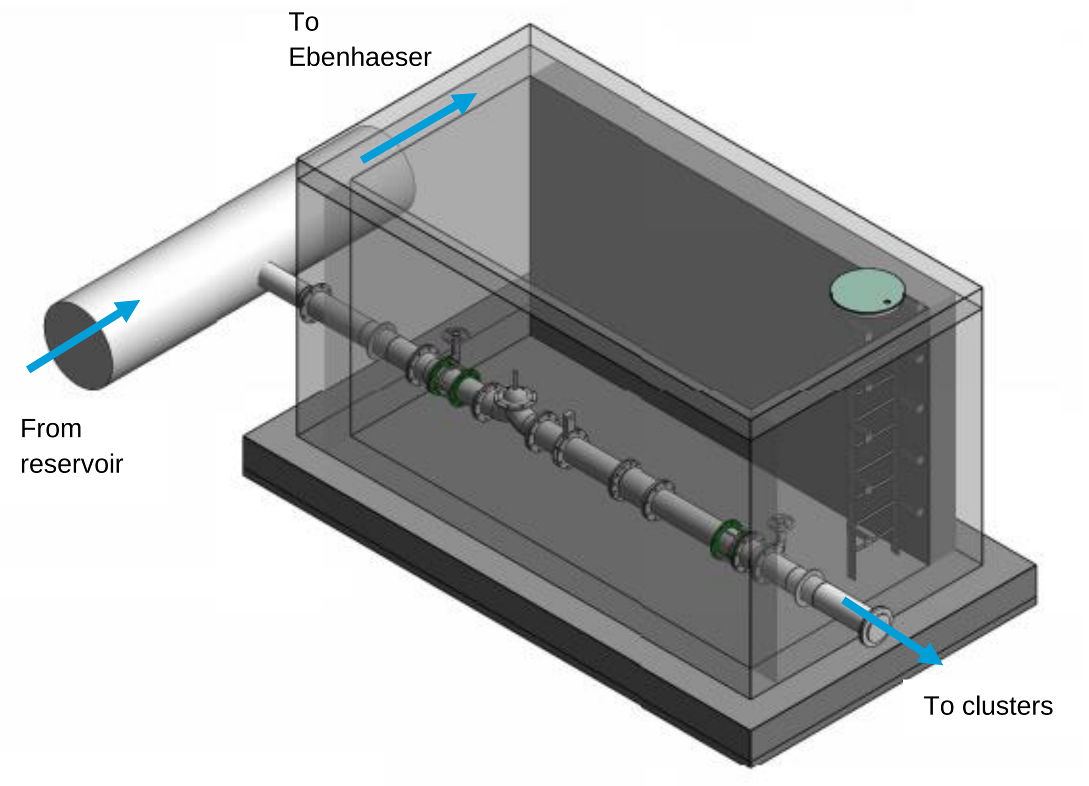

Figure 8-25:Isometric view of typical cluster offtake chamber

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 Cost Estimates

In this Chapter, the dimensions, assumptions and other factors affecting the costing of the various components of the three schemes are discussed and capital, operational and other estimated costs are presented. All cost estimates are at October 2020 prices.

Detailed bills of quantities have been included as Appendices in the *Jan Dissels and Ebenhaeser Schemes Feasibility Design Sub-Report* and the *Right Bank Canal Scheme Feasibility Design Sub-Report* respectively.

9.1 Jan Dissels Scheme

9.1.1 Capital Costs

Table 9-1 provides a summary of the costs for the various components of the Route 1 option (pumping from the lake of the raised Clanwilliam Dam). **Table 9-2** provides a summary of the costs for the Route 2 option (pumping from an outlet at the wall of the raised Clanwilliam Dam).

Table 9-1: Cost estimate summary for the Jan Dissels Scheme Rising Main Route 1 (excluding VAT)

No	Description	Amount (R million)
1	Main Pipelines	2.682
2	Pump Station and Sump	14.190
3	Balancing Reservoir	13.200
	Subtotal (a)	**30.072**
4	Preliminary and General Items (40%)	12.029
	Subtotal (b)	**42.101**
5	Contingencies (25%)	10.525
	Total (October 2020 prices)	**52.626**

Table 9-2: Cost estimate summary for the Jan Dissels Scheme Rising Main Route 2 (excluding 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)	**72.069**

9.1.2 Project Cost Estimate

The project cost estimates for the construction of the Jan Dissels Scheme options, including other miscellaneous costs, professional fees and land acquisition costs, are shown in **Table 9-3** and **Table 9-4** respectively.

Table 9-3: Jan Dissels Scheme Route 1 Project Cost Estimate, incl. VAT

No	Description	Amount (R million)
1	Rising Main Route 1	52.626
2	Access road (1 km long)	1.000
3	Electrical supply	3.000
	Total: Construction costs	**56.626**
4	Professional fees (10%)	5.663
	Value Added Tax (15%)	9.343
5	Land acquisition	0.013
	TOTAL (October 2020 prices, incl. VAT)	**71.700**

Table 9-4: Jan Dissels Scheme Route 2 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.

9.1.3 Operating and Maintenance Costs

The operation and maintenance costs (**Table 9-5** and **Table 9-6**) of the various Jan Dissels Scheme components have been included as an annual cost based on a percentage of the construction value.

The components are divided into two sections:

- Civil works, which includes the pipelines, pump stations, reservoirs and all concrete work at tie-ins and chambers; and
- Mechanical and electrical works, which includes the pumps, valves, motors, low voltage work, etc.

Table 9-5: Operation and maintenance costs for the Jan Dissels Scheme Route 1 (excluding VAT)

No	Description	Percentage	Construction value (R million)	Annual Amount (R)
1	Civil works	0.5%	27.082	135 000
2	Mechanical works	4.0%	2.990	120 000
Total O&M Costs Route 1			**30.072**	**255 000**

Table 9-6: Operation and maintenance costs for the Jan Dissels Scheme Route 2 (excluding VAT)

No	Description	Percentage	Construction value (R million)	Annual Amount (R)
1	Civil works	0.5%	39.742	199 000
2	Mechanical works	4.0%	1.440	58 000
Total O&M Costs Route 2			**41.182**	**256 000**

9.1.4 NPV and URV Comparison

A financial comparison (2020 prices, excluding VAT) has been done to compare the capital cost, net present value (NPV) and unit reference value (URV) of the bulk water infrastructure of the two sub-options, as indicated in **Table 9-7**. This evaluation excludes the cost of access roads, distribution pipes and on-farm reservoirs.

Table 9-7: Comparative costing of sub-options

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

9.2 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 from years between 2015 and 2020, and by contacting relevant manufacturers. All rates were then escalated to October 2020 values at 6% per annum for comparison.

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

The capital cost of the Right Bank canal and directly associated infrastructure (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 9-8** for the cost summary).

Table 9-8: 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		**819.611**
Preliminary & General (% of subtotal A)	40%	327.844
SUBTOTAL B		**1 147.455**
Contingencies (% of subtotal B)	25%	286.864
SUBTOTAL C		**1 434.319**
Professional Fees (% of subtotal C)	10%	143.432
Land Acquisition	BOQ-14	15.979
TOTAL COST (excl. VAT)		**1 593.730**
VAT	15%	239.059
TOTAL COST (incl. VAT) (2020 prices)		**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 Scheme 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.

The total annual operation and maintenance (O&M) costs estimated for the Civil and Mechanical Works is R 3. 6 million (excl. VAT), i.e. **R 4.1 million (incl. VAT)**. Refer to **Section 8** of the '*Right Bank Canal Design sub-report*' for additional details of the cost estimate.

9.2.1 Comparative Capital Costs (NPV and URV)

The full comparative capital cost (2020 prices, excluding VAT) of the Right Bank Canal Scheme is shown in **Table** 9-9. The capital cost of the required additional bulk water infrastructure for the abstraction of water from the new Right Bank canal (pump stations, pipelines, farm dams, etc.), for each of the four new irrigation areas was assessed at reconnaissance level.

Table 9-9: Right Bank Canal Scheme Comparative Capital Costs in million Rand, excl. VAT

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

Should a new Right Bank main canal not be constructed, then two small bulk water schemes would supply the same four irrigation areas. The estimated costs of these small schemes are described in Chapter 5.7 of the *Conceptual Design Sub-Report*.

The capital cost of the two small schemes to supply the four irrigation areas, which were evaluated at reconnaissance (desktop) level, is regarded as the attributable ‘Development’ capital cost component of the Right Bank Canal Scheme. The combined estimated October 2020 capital cost of the development component of the two small schemes is R 573.16 million, excluding VAT.

The difference between the development cost of the two small schemes and the full cost of the Right Bank Canal Scheme is deemed the ‘Betterment’ capital cost. The betterment cost component of the scheme is therefore R 1 421.5 million, excluding VAT. This is shown in **Table 9-10**.

Table 9-10: Right Bank Canal Scheme Capital Costs in million Rand, excl. VAT

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

The net present value (NPV) and unit reference value (URV) of the scheme are given in **Table 9-11**. The attributable betterment costs are the difference between the NPVs of the development costs (two small schemes) and the cost of the Right Bank Canal Scheme.

Table 9-11: NPV (R million) and URV (R/m^3)

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

9.2.2 Comparative long-term upgrade of the existing left bank main canal

9.2.2.1 Raising/ling of the existing left bank main canal

The *Right Bank Canal Scheme Cost Analysis Sub-Report* provides a comparative analysis of the long-term alternative to the construction of the Right Bank Canal Scheme. This long-term alternative assumes that the small schemes are built to supply the four irrigation areas in the vicinity of Trawal, and that the first 8 km of the existing left bank canal is lined/raised to convey additional flow for these schemes.

To reduce the risk of severe water disruptions due to a failure in the remainder of the left bank main canal (up to Verdeling - 24.6 km), structural improvements will be required. These improvements are subject to the limitations of access difficulties, the fact that water needs to flow almost continuously and available budget. This will entail relining the existing left bank main canal at an estimated cost of R 1 436.41 million (excl. VAT) at October 2020 prices. This would provide a comparative long-term alternative to the implementation of the Right Bank Canal Scheme.

The capacity of the remainder of the canal will stay as current. It is assumed that the consideration of risks to the Lower Olifants River supply area will lead to a decision to upgrade the rest of the left bank canal, but that implementation will take place over a long period (15 years) for practical reasons. Undertaking of the canal lining replacement during LORWUA's scheduled downtime is not feasible. It would therefore be necessary that temporary diversion works, consisting of a 600 m temporary pipeline bypass, be constructed to allow for replacement of the canal lining without interrupting the water supply to farmers. Other measures may include construction work done on different sections at the same time using different teams.

9.2.2.2 Comparison of the two long-term main canal alternatives

The resulting capital cost of the two options, i.e. upgrading the existing left bank main canal vs. building a new Right Bank Canal Scheme, are shown in **Table 9-12**:

Table 9-12: Comparative Capital Costs (million Rand, excl. VAT, 2020 prices)

Main canal long-term alternative	Development Component	Betterment Component	Total Cost (R million)
Upgrade left bank main canal	R 573.16	R 1 436.41	R 2 009.57
Right Bank Canal Scheme	R 573.16	R 1 421.50	R 1 994.66

From a capital cost point of view, the two alternatives for the main canal are the same.

There are many benefits of implementing the Right Bank Canal Scheme, which will not be matched by the lining/raising of the existing left-bank main canal. This is described in Chapter 2 of the *Scheme Betterment Costs Analysis Report*.

9.2.2.3 Benefits

The benefits of implementing the Right Bank Canal Scheme, in comparison with upgrading the existing left bank canal are as follows:

a) The Right Bank Canal will be built to current construction standards, with proper freeboard and additional capacity that allows for intra-month flexibility to meet water requirements and therefore improve production. While this, at first, will only be of immediate benefit for water users up to Verdeling, this presents the opportunity for the rest of the system to benefit later when the secondary canals are upgraded.
b) The Right Bank Canal will be more secure against failure than the re-lined left bank canal. In addition, this security will be achieved earlier.
c) The Right Bank Canal will present an opportunity for a subsequent upgrade of the system downstream, extending the benefit of greater flexibility and additional capacity. This in turn, along with the slightly increased capacity, will allow irrigators to plant a higher percentage of permanent crops, especially during the high summer period, with associated socio-economic benefits.
d) There is greater confidence in the estimation of the Right Bank Canal's construction costs and programme. For the upgrading of the left bank canal, the requirement to keep water flowing while construction takes place makes it a complex exercise, beset with operational difficulties and unforeseen issues that can increase costs and are likely to cause delays.
e) The Right Bank Canal Scheme makes provision to meet the future water requirements such as towns, industries and mines (initially only up to Verdeling, until further canals are upgraded). Upgrading the existing left bank canal does not make provision to meet the future water requirements, especially the potential to eventually increase the supply capacity up to Vredendal.
f) Should the left bank canal be re-lined, new irrigation schemes that rely on the construction of the Right Bank Canal cannot be developed, such as the Klawer Scheme Phase 2, which can be done if the Right Bank Canal Scheme is implemented.
g) There will be significant water savings should the Right Bank Canal be constructed, compared to re-lining the entire left bank main canal. The integrity of the Right Bank Canal will also be better than that of a re-lined left bank canal.

Whilst it is not possible to directly compare all the incremental benefits with the incremental costs, a strong argument can be made for implementing the Right Bank Canal Scheme. The benefits are described above, but in addition the opportunity to supply the new development areas is a once-off. If missed, that opportunity will be foregone forever.

9.3 Ebenhaeser Scheme

9.3.1 Capital Cost

9.3.1.1 Pipelines, Pump Stations and Canals

Table 9-13 provides a summary of the cost estimates for the various scheme components and types of work (excluding the balancing dam), excluding an allowance for Preliminary & General and Contingency costs.

Table 9-13: 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		
2	Canal Diversion Structures	2.531		
3	Diversion Pump Station and Sump	8.490		
4	Ebenhaeser Balancing Dam Return flow to canals		1.736	
5	Ebenhaeser Balancing Dam Inlet/Outlet Chamber	2.274		
6	Ebenhaeser Balancing Dam Pump Station	6.900		
7	Balancing Reservoir	13.200		
8	Distribution Mains Offtake Chambers	1.188		
Sub-total October 2020 prices		**174.238**	**1.736**	**175.974**

9.3.1.2 Balancing Dam

A capital cost estimate for the balancing dam was conducted based on the geotechnical information and detailed topographical survey data. This cost estimate is summarised in **Table** 9-14 below, excluding an allowance for Preliminary & General and Contingency costs. The 'LORWUA Betterment Cost' is the cost of an additional 150 000 m^3 balancing dam storage and required conveyance and other infrastructure.

Table 9-14: Capital Cost Estimate for the Balancing Dam (excl. VAT)

No	Description	Ebenhaeser Dam (2.17 Mm^3) (R million)	LORWUA Betterment Cost (0.15 Mm^3) (R million)	Combined Cost (2.32 Mm^3) (R million)
1	Earthworks	62.863	4.963	67.826
2	HDPE lining	23.791	1.878	25.669
3	Concrete works	1.815	0.143	1.958
4	Mechanical and other	1.373	0.108	1.481
	Sub-total October 2020 prices	**89.841**	**7.093**	**96.934**

9.3.1.3 Total Capital Cost for the Scheme

Table 9-15 provides a summary of the total capital cost estimate for the scheme, excluding an allowance for Preliminary & General and Contingency costs.

Table 9-15: Total Ebenhaeser Scheme Capital Cost Estimate (excl. VAT)

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Capital Cost (R million)
Pipelines, pumps and canals	174.238	. 736	175.974
Balancing dam	89.841	7.093	96.934
Total Capital Cost	**264.079**	**8.829**	**272.908**

9.3.2 Construction Cost

The construction cost of the scheme consists of the capital cost plus allowance for Preliminary and General Items and Contingencies, plus other miscellaneous project costs.

Table 9-17 shows the construction cost of the scheme, excluding miscellaneous project costs.

Table 9-16: Ebenhaeser Scheme Construction Cost Estimate (excl. VAT)

Description	Development Cost (R million)	LORWUA Betterment Cost (R million)	Total Cost (R million)
Total Capital Cost	264.079	8.829	272.908
Preliminary & General Items (40%)	105.632	3.532	109.163
Subtotal	**369.711**	**12.361**	**382.071**
Contingencies (25%)	92.428	3.090	95.518
Total Construction Cost	**462.138**	**15.451**	**477.589**

9.3.3 Total Project Cost Estimate

Table 9-17 shows a summary of the total project cost estimate, inclusive of other miscellaneous scheme costs.

Table 9-17: 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	**465.398**	**15.471**	**480.869**
Professional fees (10%)	46.540	1.547	48.087
Value Added Tax (15%)	69.810	2.321	72.130
Land acquisition	0.930	0.041	0.971
TOTAL (October 2020 prices, incl. VAT)	**582.678**	**19.380**	**601.086**

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

9.3.4 Operation and maintenance costs

The annual operation and maintenance costs (**Table 9-18**) of the various Ebenhaeser Scheme components have been included as an annual cost based on a percentage of the construction value. The components are divided into three sections, as follows:

- Civil works, which includes the pipelines, pump stations, reservoirs and all concrete work at tie-ins and chambers;
- The mechanical and electrical works, which includes pumps, valves, motors, low voltage supply, etc.; and
- Balancing Dam, which includes civil works (embankment, concrete work, HDPE lining and outlet pipe).

An annual operation and maintenance cost estimate for the categories has been determined, based on a percentage of the construction value.

Table 9-18: Operation and maintenance costs for the Ebenhaeser Scheme (excluding VAT)

No	Description	Percentage	Construction value (R million)	Annual Amount (R)
1	Civil works	0.5%	173.095	865 000
2	Mechanical and electrical works	4.0%	2.879	115 000
3	Balancing dam	0.5%	89.841	449 000
Total Annual O&M Costs			**175.974**	**1 429 000**

9.3.5 Comparative Capital Costs (NPV and URV)

The Development and Betterment capital costs (October 2020 prices, excluding VAT) of the Ebenhaeser Scheme are shown in **Table** 9-19. The NPV and URV value for the Development portion of the scheme are given in **Table** 9-20.

Table 9-19: Ebenhaeser Scheme Comparative Capital Costs in million Rand (2020 prices, excl. VAT)

Cost distribution	Canal & Bal Dam Structures	Balancing dams	Pump stations	Pipelines & syphon	Reser-voir	Purchase of land	Prof. design & support	Roads & Elec supply	Total Cost
Development	8.41	157.22	26.93	246.47	23.10	0.93	46.55	**3.33**	**512.94**
Betterment	3.04	12.42	-	-	-	0.04	1.54	**0.02**	**17.06**
Total	**11.45**	**169.64**	**26.93**	**246.47**	**23.10**	**0.97**	**48.09**	**3.35**	**530.00**

Table 9-20: Development NPV (R million) and URV (R/m^3)

Cost Item	Cost (R million, excl. VAT)	Value (R/m^3)
Total NPV Cost	R 536.71	
URV at 8% discount rate		R 12.77

10 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.

10.1 Water Use Licensing

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

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

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

10.1.1 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.

10.1.2 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.

10.1.3 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 schemes routes and sites are located within minor drainage lines, Section 21(c) and 21(i) applications for these may also be required.

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

10.2 WULA Process

The implementation of the proposed conveyance infrastructure and balancing dam will, where relevant trigger the requirement for a combined water use licence in accordance with Section 21 of the NWA for each scheme.

The WULAs will be submitted via the DWS online eWULAAS platform. The relevant Water Management Area is *Catchment E - Berg-Olifants*, which means that the application will be processed by the Bellville DWS office.

The issuing of a water use licence is based on an evaluation of the proposed activity in terms of the impact on the resource as well as the potential social, economic and environmental impacts of the proposed use. Supporting documentation and studies are required to show:

- The extent to which the proposed water use will impact on the resource;
- The steps that will be undertaken to mitigate this impact;
- The extent to which the proposed water use will contribute to the local and national economy; and
- The social benefits in terms of job creation and income generation in the area.

A strong emphasis is given to water use that supports water allocation reform, the re-dress of previous inequitable allocation of water use licences and the equitable use of the natural resource.

The information required for a Section 21(a), (b), (c) and (i) application is listed in **Table 10-1** below.

Table 10-1: Information requirements for Section 21(a), (b), (c) and (i) in terms of GN R267/2017 Annexure C

Description
Proof of Payment of Licence Application Processing Fee (Compulsory)
Copy of Identity Document of Applicant and Proponent (if applicable) (Compulsory)
Letter of Authority or Power of Attorney to Apply on behalf of Applicant
Letter of Consent if the Applicant is not the Property Owner (Compulsory)
*Applicant Information Form: Water Service Provider (DW 757 1 770)
*Applicant Information Form: Company, Partnership, Government (DW 7581771)
*Applicant Information Form: Water User Association (DW 759 1 772)
Property Details Form (DW 901)
Property Owner Details (DW 902)
Permission to Occupy (PTO), Title Deed, Lease Agreement, Community Resolution
A description of the location of the activity, including (aa) the 21-digit Surveyor General code of each cadastral land parcel, (bb) where available, the physical address or farm name, (cc) where the required information in sub -regulation (aa) and (bb) is not available, the coordinates of the boundary of the property or properties,
A plan which locates the proposed activity or activities applied for at an appropriate scale, or if it is- (aa) a linear activity, a description and coordinates of the corridor in which the proposed activity or activities is proposed; or (bb) on land where the property has not been defined, the coordinates of the area within which the activity is proposed
*Taking water from a water resource Form (DW 773)
Section 21(a) application
*Pump Technical Data Form (DW 784)
*Canal Technical Data Form (DW 786)
Irrigation Field and Crop Details (DW 787)
*Supplementary Info: Power Generation, Industrial or Mining (DW 788)
*Supplementary info: Domestic, Urban, Commercial or Industrial (DW 789)
Soil Suitability Report (for irrigation from Dept. Agriculture)
Section 21(b) application
*Storing water form (DW 774)

Description
'Dam and Basin Technical Data Form (DW 789)
*Dam Classification Form (DW 793) (for dams >5m and >50 000m^3)
Dam Location Map
Section 21(c) application
* Impeding or diverting the flow of water in a watercourse form (DW 763)
*Altering the bed, banks, course or characteristics of a watercourse (DW 789)
*Supplementary Information for 21 (c) & (i) form (DW775)

Because it is proposed that the embankment of the Ebenhaeser balancing dam will be constructed with material excavated from the dam basin, the **disposal of inert waste** is unlikely to require a Section 21 (g) application and is therefore currently excluded from the authorisations/licences/permits required.

10.3 Dam Safety Licence Requirements

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

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

10.4 Application for Licence for Borrow Area

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

10.5 Ecological Water Requirement

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 as the Ebenhaeser balancing dam wall 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.

10.6 Environmental Impact Assessment

10.6.1 Introduction

Following the completion of the Clanwilliam Bridging Study, the DWS will undertake separate EIA processes for the Jan Dissels, Right Bank Canal and Ebenhaeser Schemes, in terms of all applicable environmental legislation, in a combined EIA study with separate components. A detailed scope of services has been prepared by DWS to invite proposals from professional service providers, which includes the need to prepare and submit a WULA for the schemes in terms of Section 21 and Section 22(3) of the NWA.

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

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

10.6.2 Specialist studies

Various specialist studies will be required, as part of the EIA process, to quantify and assess social and environmental impacts of the proposed schemes and identify suitable mitigation measures. Specialist studies that are envisaged for this these schemes include:

- A terrestrial ecology and botanical study;
- An aquatic ecology and wetland assessment;
- A Phase 1 heritage impact and paleontological assessment; and
- A social impact assessment.

10.6.3 Applicable Legislation

The legislation applicable to the EIA process includes the following:

10.6.3.1 National Environmental Management Act (No. 107 of 1998, as amended)

The three schemes will require a Scoping-EIA process in terms of NEMA, as it will trigger *inter alia* activities 15 and 16 of GN R984 (2014, as amended). The schemes will also trigger various listed activities under GN R983 and R985 (2014, as amended).

10.6.3.2 Mineral and Petroleum Resources Development Act (No. 28 of 2002, as amended)

The schemes may require specific construction material to be sourced elsewhere if suitable material is not available from commercial sources. This will result in the need for a borrow pit close to the construction site(s). DWS has been exempted from the provisions of Sections 16, 20, 22 and 27 of the Mineral and Petroleum Resources Development Act (MPRDA), in terms of Section 106 of the Act. While the amended GN R983 and R984 now exclude Section 106 (mining activities), auxiliary activities such as vegetation clearance or access roads are not excluded.
At this stage it is therefore anticipated that borrow (mining) areas might trigger listed activities under GN R983 and R985. Appendices 1 of GN R983 to R985 specify that the Minister of Mineral Resources is the CA for listed activities that are directly related to the extraction or primary processing of a mineral. A separate application will thus be required to be submitted to the DMRE for the authorisation of any listed activities, which will be triggered as a direct result of the mining activities (borrow pit).

10.6.3.3 National Environmental Management: Biodiversity Act (No. 10 of 2004, as amended)

Based on the Post Feasibility Bridging study the study area encompasses a total of 28 threatened ecosystems with two categorised as Endangered, namely the Leipoldtville Sand Fynbos and Citrusdal Shale Renosterveld. There are a few areas mapped as CBA 2, in the study area. It is anticipated that the NEMBA will have to be consulted.

10.6.3.4 National Water Act (No. 36 of 1998, as amended)

The volume of water to be stored in the Ebenhaeser balancing dam is 2.3 million m^3. The dam will thus require a Water Use Licence Application in terms of Section 21 (b) of the NWA. Section 21(c) and 21(i) applications will most likely also be required for the balancing dam and conveyance infrastructure, such as syphons, diversion works and pipelines.

10.6.3.5 National Forests Act (No. 84 of 1998, as amended)

The Ebenhaeser balancing dam site is located within an 'Endangered' ecosystem, which is in a near natural state. It is therefore anticipated that a permit might be required for the destruction of any tree species that are protected under the National Forests Act (NFA). It may however be possible to relocate some of the protected species.

10.6.3.6 Nature and Environmental Conservation Ordinance (No. 19 of 1974)

The Ebenhaeser balancing dam site is located within an 'Endangered' ecosystem, which is in a near natural state. It is therefore anticipated that a permit might be required for the relocation, damage or destruction of species that are protected under the Nature and Environmental Conservation Ordinance.

10.6.3.7 National Heritage Resources Act (No. 25 of 1999)

The proposed project requires notification of Heritage Western Cape (HWC), in terms of Section 38(1)(b) and 38(c) of the NHRA. In the event of a heritage object and/or site being identified during the Phase 1 Archaeological and Paleontological study, an application for a permit for destruction or relocation will be required.

10.6.4 Competent Authority

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

11 Implementation Arrangements

This chapter briefly identifies the various legislative considerations required for effective implementation, identifies affected land, land acquisition and wayleaves, discusses operation and maintenance requirements, and institutional arrangements.

11.1 Affected Land, Land Acquisition and Wayleaves

11.1.1 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.

11.1.1.1 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.

11.1.1.2 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.

11.1.1.3 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.

11.1.1.4 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.

11.1.1.5 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.

11.1.1.6 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 WUA sub-committee, is also involved.

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

11.1.2 Right Bank Canal Scheme

Figure 11-1 shows the existing infrastructure that will be affected by the canal alignment, which includes the major components described below.

11.1.2.1 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.

11.1.2.2 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.

11.1.2.3 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 11-1**.

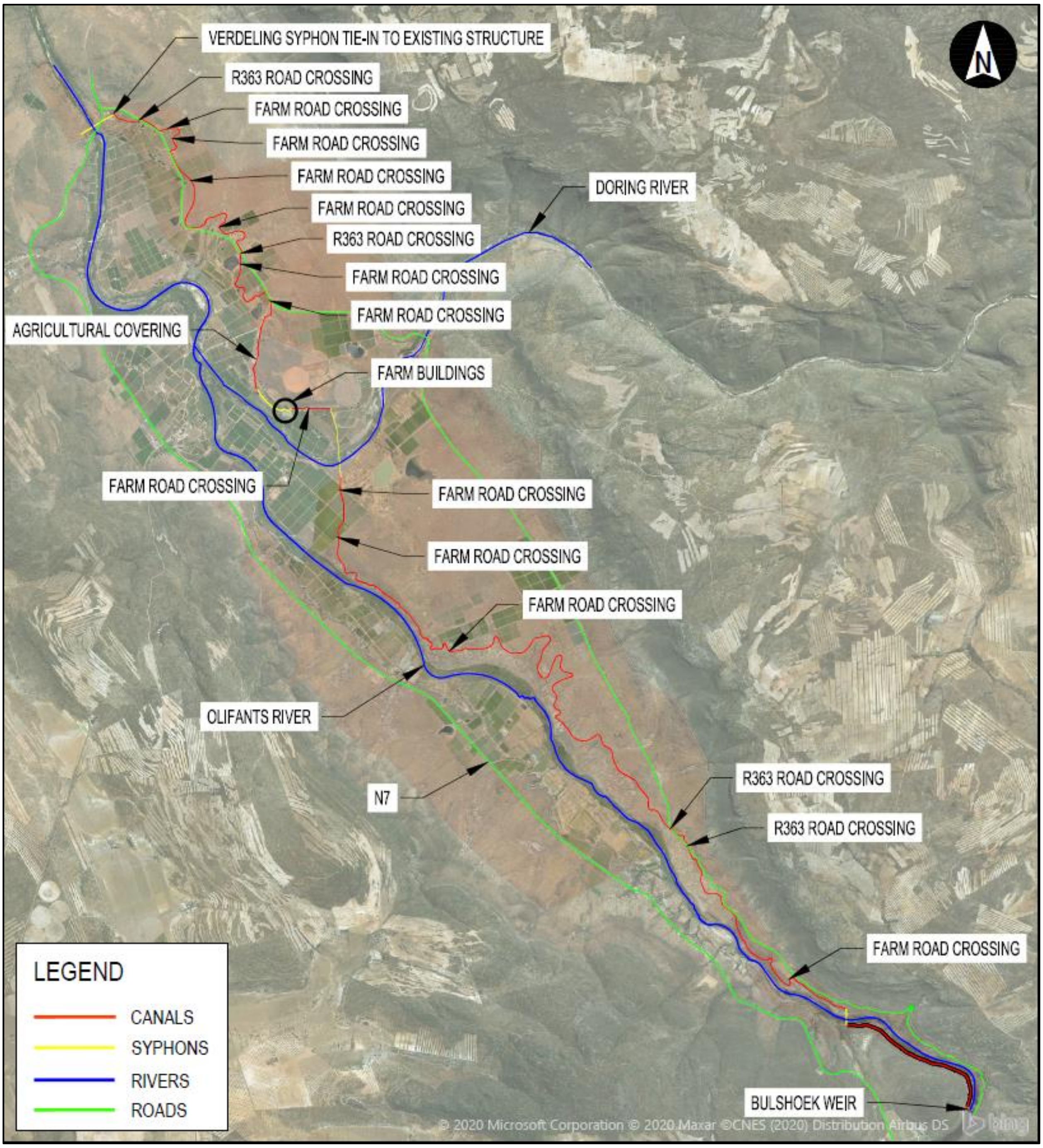

Figure 11-1:Existing infrastructure affected by the Right Bank Canal route

11.1.2.4 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.

11.1.2.5 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.

11.1.2.6 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.

11.1.3 Ebenhaeser Scheme

11.1.3.1 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 11-2 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 11-3** shows the main bulk infrastructure components that will be located on private land.

11.1.3.2 R362 & R363 Provincial Roads

The proposed diversion rising main (from diversion pump station to Ebenhaeser Balancing Dam) will cross the R363 road. The gravity pipeline (from the concrete balancing reservoir to 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.

11.1.3.3 Railway

The proposed gravity pipeline from the concrete balancing reservoir to 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.

11.1.3.4 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.

11.1.3.5 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.

11.1.4 Wayleaves

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

This process should be undertaken during the detailed design phase of the project.

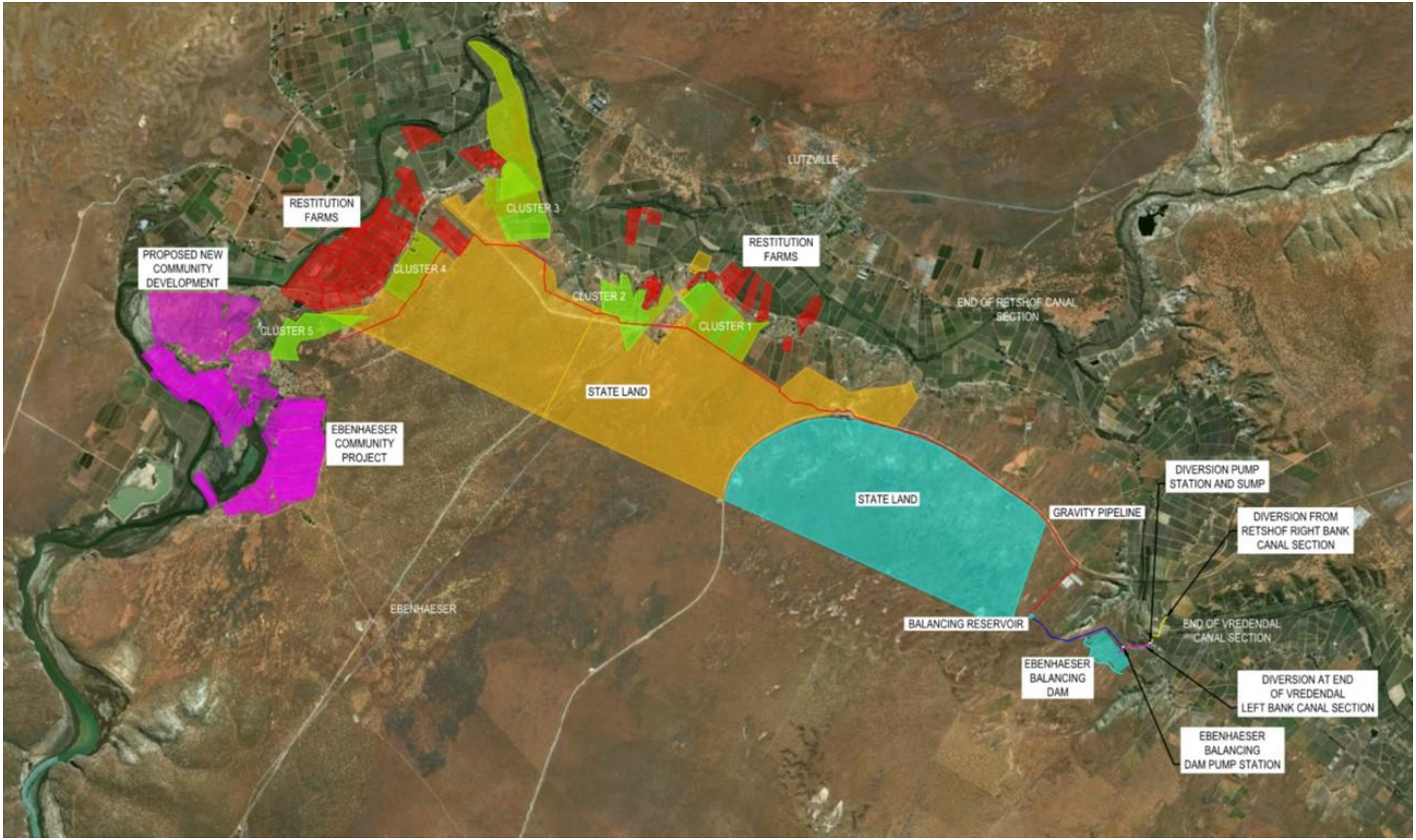

Figure 11-2: Remaining state land at the Ebenhaeser Scheme

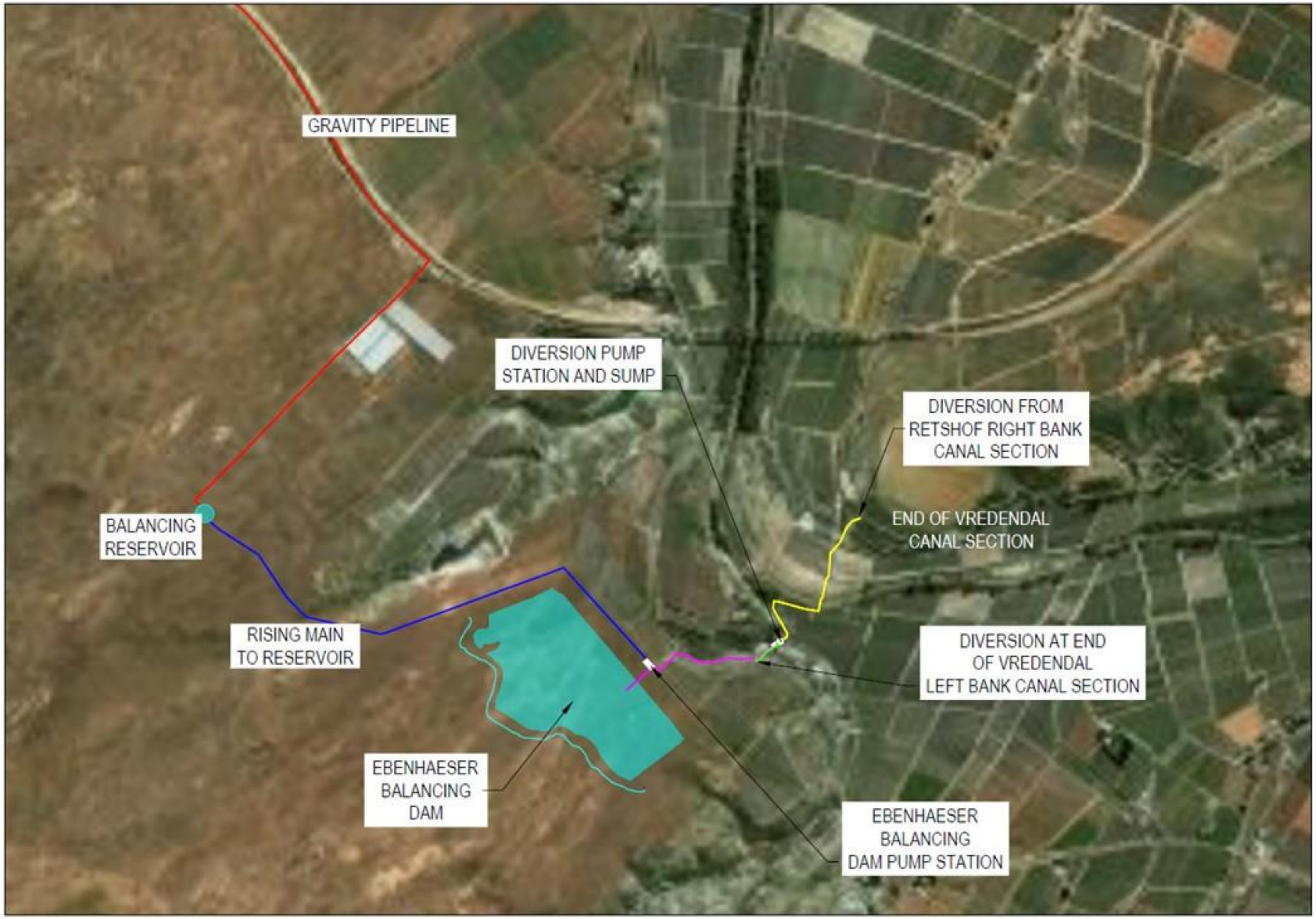

Figure 11-3:Ebenhaeser Scheme Bulk infrastructure components

11.2 Operation and Maintenance Requirements

11.2.1 Jan Dissels Scheme

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

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

11.2.2 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.

11.2.3 Ebenhaeser Scheme

11.2.3.1 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.

11.2.3.2 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.

11.3 Institutional Arrangements

11.3.1 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.

11.3.2 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. It is a possibility that the DWS construction team currently on site for the raising of Clanwilliam Dam, could implement the scheme.

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.

11.3.3 Right Bank Canal Scheme

It is expected that DWS will be the owner of the scheme and that it will be operated by the LORWUA, and therefore no issues are foreseen with additional water supply from the Bulshoek Weir. It is a possibility that the DWS construction team currently on site for the raising of Clanwilliam Dam, could implement the scheme. If this is not practical or feasible, a private contractor could be appointed via an open tender process.

11.3.4 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.

It is a possibility that a DWS construction team could implement the scheme.

12 Further Investigations for Detailed Design

This Chapter describes the further investigations that are required to successfully undertake the detailed design.

12.1 Jan Dissels Scheme

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

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) It is proposed that the selection of pump types be refined.

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

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 detailed design.

12.2 Right Bank Canal Scheme

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

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 would 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 should 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.

12.3 Ebenhaeser Scheme

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

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) It is proposed that the selection of pump types 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.

13 Project Implementation

This chapter provides information on the recommended implementation process, as well as the possible timeframe and milestones dates.

13.1 Implementation process

The recommended steps for the implementation of the recommended schemes (also referred to as 'the project') are discussed under the relevant headings below. The various actions are provided in chronological order, although some actions can be undertaken in parallel.

13.1.1 Record of Implementation Decisions

The Record of Implementation Decisions (RID) is the official internal DWS document to hand over the project for implementation, and will be compiled as part of this study. The RID describes the components of the project, design aspects, further investigations to be undertaken, institutional and funding arrangements, operational aspects and other pertinent information for implementation of the project.

The RID will be issued to DWS Chief Directorate Infrastructure Development for the implementation of the project after the Environmental Authorisation has been received.

13.1.2 Environmental Authorisation

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

13.1.3 Funding Arrangements

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

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

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

13.1.4 Detailed Design

DWS Chief Directorate Engineering Services can be requested to undertake the detailed design of the proposed Right Bank Canal Scheme and potentially the Jan Dissels and Ebenhaeser Schemes. It is however recommended that a PSP should rather be appointed to undertake the detailed design and construction supervision of the Right Bank Canal, the Jan Dissels and Ebenhaeser schemes. The Chief Directorate Engineering Services would then provide the required management and guidance of the PSP and contractors.

Detailed design will commence once the EIA has been concluded, and an Environmental Authorisation has been issued for each of the three schemes respectively.

13.1.5 Water use licences

The WULAs for storing water and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), National Water Act, 1998) is included in the scope of work for the EIA study.

The raising of Clanwilliam Dam and associated availability of additional water will determine when the licensing process for irrigation development (Section 21(a)) can get underway. This will be determined by DWS during implementation of the project.

13.1.6 Dam safety regulation requirements

Applications for licences to comply with the dam safety regulations will need to be completed as part of the detailed design and construction of the Ebenhaeser balancing dam. The requirements in terms of dam safety regulations are discussed in Chapter 10.3 of this report.

13.1.7 Borrow area regulation requirements

The use of a borrow area(s) to source construction material could trigger listed activities under GN R983 and R985. Before a borrow area is developed, authorisation must be obtained from DMRE for the listed activities.

13.2 Programme and Milestones

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

14 Conclusions

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

14.1 Requirements and Purpose of the Schemes

14.1.1 The Clanwilliam Dam on the Olifants River will be raised by 13 m, making an additional 81.4 million m3/a available for use, at a 91% assurance of supply. The raising of the dam is currently in the construction phase.

14.1.2 The additional dam yield will be used to augment the water supply to the existing scheduled irrigation area, towns and industrial use, to provide additional water for new irrigation areas to establish historically-disadvantaged farmers, as well as to supply other local water users, including water losses.

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

14.1.4 A preferred suite of proposed irrigation schemes have been identified and the prioritisation and phasing of the uptake of water is recommended. The future water requirements of other water users have also been determined.

14.1.5 The planning was done for 61.1 million m3 to be supplied to new HDI farmer development, 15.2 million m3/a to increase the reliability to existing users, and a remainder of 5.1 million m3/a to supply future domestic and industrial water requirements. An unallocated amount was retained for the short-term to medium-term to account for hydrological and other uncertainties.

14.1.6 The Jan Dissels Scheme, Right Bank Canal Scheme and Ebenhaeser Scheme have been identified for feasibility level design.

14.2 Overview of the Schemes

14.2.1 The **Jan Dissels Scheme** will pump water from an outlet of the raised Clanwilliam Dam, to a concrete balancing reservoir. The scheme is located on State land near Clanwilliam town, is very feasible from a cost perspective and offers a good opportunity for the inclusion of smallholder plots, given its proximity to the town.

14.2.2 The **Right Bank Canal Scheme** will replace the existing left bank main canal, and the Doring canal section on the right bank, with increased capacity on the right bank of the Olifants River. The new canal will have capacity to supply new downstream irrigation development and other future uses. This scheme is essential to ensure a secure future water supply to the lower Olifants River irrigators and other users, and to the prosperity of the region. There is currently a high risk of disruption and shortfall in supply due to the poor state of the existing canals, especially the existing main (Trawal section) canal.

14.2.3 The **Ebenhaeser Scheme** will make use of spare capacity in the existing canal sections, supplying a combination of Ebenhaeser restitution farms and augmenting the Ebenhaeser community scheme. Augmentation of the water supply to prioritised restitution farms has a high priority from a social and political perspective, to ensure that such restitution farms can be successfully farmed, by increasing their currently inadequate water allocations.

14.3 Topographical Survey

14.3.1 A LiDar topographical survey was completed by Southern Mapping for the three schemes designed at feasibility level.

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

14.3.3 The accuracy of the available survey data is considered sufficient to undertake the detailed designs of the proposed infrastructure.

14.4 Geotechnical and Materials Investigations

The findings of the geological and geotechnical evaluation are as follows:

14.4.1 Jan Dissels Scheme:

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

14.4.1.2 **Excavation considerations:** The hard rock quartzitic sandstone will require a track excavator and use of power tools for excavation. Any blasting near the dam wall and other structures will need to be carefully controlled.

14.4.1.3 **Slope stability and lateral support:** Excavation slopes being formed through the boulder colluvium and deeper than 1.50 m are likely to be unstable. These slopes will need to be battered back to safe slopes or shored. This is essential to ensure safe working conditions for workers in excavations.

14.4.1.4 **Soil corrosiveness:** Soils are considered moderately to highly corrosive for buried steel elements. Special consideration needs to be given in the design to the deterioration of buried steel and concrete structures.

14.4.1.5 **Foundations:** The colluvium is mainly suitable as bedding cradle and selected fill blanket, i.e. SC1 and SC2 bedding material types. The residual quartzitic sandstone is generally suitable for foundations. The founding material for the small reservoir is suitable for a reinforced concrete slab foundation.

14.4.1.6 **Access road**: Quartzitic sandstone from the Cape Supergroup and possibly shale can be used as crushed stone for construction / base material.

14.4.2 Right Bank Canal Scheme

14.4.2.1 **Geology:** The underlying geology comprises 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 characterized by folding and faulting. The project area is located in a zone of low seismicity, with Peak Ground Acceleration (PGA) values of roughly 0.05 g, with a 10% probability of being exceeded in a 50-year period.

14.4.2.2 The **test pit profiles** and surface observations were used to sub-divide the canal routing into zones of similar geological profiles. The materials encountered are of varied origin, and the following material types are identified:

- Sands of aeolian origin;
- Alluvial soils in the rivers;
- Colluvial sands;
- Colluvial (talus) deposits comprising gravels, cobbles and boulders in a sand matrix;
- Terrace gravels, comprising variable proportions of sand, gravels and cobbles, with a sandy matrix;
- Pedogenic materials that comprise variable sand and gravel soils that are cemented to varying degrees, from calcretised sand to hardpan;

- Residual soils derived from the weathering of the shales or siltstones; and
- Bedrock comprising quartzitic sandstone, shale or siltstone.

For each of the zones, a generalized ground profile was developed.

14.4.2.3 For each of these elements, the **geotechnical factors** that could impact on the design and are discussed. These factors include the general geological conditions and the founding implications. Also discussed are the excavation characteristics, slope stability (temporary cut slopes and permanent excavations), and the presence of shallow groundwater. The Olifants and Doring river crossings are expected to have different engineered solutions, comprising a pipe bridge and a syphon, respectively. Geotechnical factors specific to these expected solutions are discussed.

14.4.2.4 No targeted ground investigations have been conducted into potential sources of coarse and fine aggregates, and general comments are included on likely sources that might be considered. The suitability of the in situ soils for use in embankment construction is also assessed.

14.4.3 Ebenhaeser Scheme

14.4.3.1 **Geology:** The site is covered by aeolian sands. It is underlain by calcareous soils, and graphitic and sericitic schist, phyllite, greywacke, quartzite, impure dolomite, limestone and marble of the Aties Formation, Gariep Supergroup.

14.4.3.2 **Excavation considerations:** The stability of excavations during construction may be compromised and shoring or battering of excavations will be required. The presence of seepage and terrace gravels was observed and will require attention during construction. A stability assessment for deeper excavations left open for longer periods would be required to ensure safe working conditions during construction.

14.4.3.3 **Slope stability and lateral support:** Excavation slopes being formed through the boulder colluvium and deeper than 1.50 m are likely to be unstable. These slopes will need to be battered back to safe slopes or shored. This is essential to ensure safe working conditions for workers in excavations.

14.4.3.4 **Soil corrosiveness:** The soils along the Ebenhaeser scheme corridor are generally non-corrosive to extremely corrosive. This indicates that special consideration needs to be given to the buried steel and concrete elements, in particular the concrete reservoir, and inlet and outlet structure for the balancing dam.

14.4.3.5 **Groundwater seepage:** 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.

14.4.3.6 **Dispersivity of soils:** 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.

14.4.3.7 **Backfill materials:** The aeolian sands, pedogenic materials and terrace gravels along the pipeline route are suitable as backfill materials.

14.4.3.8 **Concrete reservoir:** The Concrete Reservoir should be founded on the very dense, calcretised and ferruginised sand (hardpan calcrete) to allow for adequate bearing capacity. Alternatively, compacted backfill below the structure could be considered on the eastern and southern sides of the reservoir.

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

14.5 Environmental Screening

The environmental screening of the schemes is documented in the *Environmental Screening Sub-Report* (Report No. P WMA 09/E10/00/0417/8). The relevant conclusions from this report are listed below.

14.5.1 Jan Dissels Scheme

14.5.1.1 Rising Main Route 1 (RM1) is located within an area mapped as a Critical Biodiversity Area (CBA). This option would include the removal of indigenous vegetation, but with the pipeline route being much shorter than the alternative, Rising Main Route 2.

14.5.1.2 Rising Main Route 2 (RM2) is not located in any CBA mapped areas, but does transect the Ramskop Nature Reserve, which is managed by the Cederberg Municipality.

14.5.1.3 There are indications that existing pipelines are present in the area of RM2 and that the construction of the pipeline could potentially be approved by the Management Authority, which would be the Municipality in this case.

14.5.1.4 The RM2 route does however include the removal of indigenous vegetation and would probably require temporary and permanent access tracks to be constructed.

14.5.1.5 The proposed scheme will be subject to further on-site specialist assessments by a botanical specialist.

14.5.1.6 The proposed infrastructure would require a Basic Assessment to obtain authorisation from DEFF.

14.5.1.7 If borrow pits are required, an application for authorisation should also be submitted to DMRE for mining activities.

14.5.1.8 The proposed infrastructure would also require heritage authorisation in terms of Section 38(a) and 38(c) of NHRA.

14.5.1.9 A water use authorisation in terms of Section 21(i) of the NWA is required.

14.5.2 Right Bank Canal Scheme

14.5.2.1 The upgrading of the existing Left Bank Canal should consider limiting vegetation clearance, since the site is located partly within a CBA, the Rondeberg Oord Private Nature Reserve and an endangered vegetation type.

14.5.2.2 The proposed works should be subject to further on-site specialist assessments by a freshwater and botanical specialist to determine the best environmental options within the sensitive areas and especially the watercourses.

14.5.2.3 The work to be undertaken as part of the Left Bank Canal upgrade, syphons through the Olifants and Doring rivers, construction of the Right Bank Canal and any other associated infrastructure would require a Basic Assessment to obtain authorisation from DEFF.

14.5.2.4 If borrow pits are required, an application for authorisation should also be submitted to Department of Mineral Resources and Energy (DMRE) for mining activities.

14.5.2.5 The proposed infrastructure would also require heritage authorisation in terms of Section 38(a) and 38(c) of the NHRA.

14.5.2.6 A water use authorisation in terms of Section 21(c) and 21(i) of the NWA is required.

14.5.3 Ebenhaeser Scheme

14.5.3.1 The proposed works should be subject to further on-site specialist assessments by a freshwater and botanical specialist to determine the best environmental options within the sensitive areas and especially the watercourses.

14.5.3.2 The work to be undertaken as part of the diversions, syphon through the Olifants River, construction of balancing reservoirs, a large earthfill dam and any other associated infrastructure would require an EIA to obtain authorisation from DEFF.

14.5.3.3 If borrow pits are required, an application for authorisation should also be submitted to the DMRE for mining activities.

14.5.3.4 Should the earthfill dam be removed from the scope of works, then only a Basic Assessment would be required for the authorisation of the remaining infrastructure.

14.5.3.5 The proposed infrastructure would also require heritage authorisation in terms of Section 38(a) and 38(c) of the NHRA.

14.5.3.6 A water use authorisation in terms of Section 21(b), 21(c) and 21(i) of the NWA is required.

14.6 Jan Dissels Scheme Feasibility Design

An assessment of two sub-options for the scheme was undertaken. The main features of the scheme include the final abstraction point and conveyance route, reservoir site and design flow. These features are indicated on the scheme layout map. .

The feasibility-level design of the Jan Dissels scheme has concluded the following:

14.6.1 The feasibility design was done for two route options, namely:

i. Route Option 1: Pumping from Clanwilliam Dam basin; comprising a rising main, low-lift and high-lift pump station, balancing tank and reservoir;
ii. Route Option 2: Pumping from below Clanwilliam Dam wall; comprising a rising main, high-lift pump station and reservoir.

14.6.2 The hydraulic calculations for both options are based on a design capacity of 23.2 Mℓ (0.269 m^3/s) and the raised Clanwilliam Dam water levels at MOL of 100.0 masl and a FSL of 118.25 masl.

14.6.3 A DN 500 HDPE pipe will be suitable for both rising main options.

14.6.4 For Route Option 1, submersible pumps will be suitable for the low-lift pump station and either end-suction centrifugal or horizontal split casing pumps for the high-lift pump station.

14.6.5 For Route Option 2, multi-stage or horizontal split-casing pumps are suitable pump types, with horizontal split-casing pumps being preferred for raw water applications, due to their better solids handling capabilities and ease of undertaking maintenance.

14.6.6 It is proposed that a 12 000 m^3 (12 Mℓ) reinforced concrete reservoir be provided for a 12 hour storage capacity. The reservoir's MOL and FSL are 202 masl and 208 masl, respectively.

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

14.6.8 The estimated total capital cost for the recommended scheme (Rising Main Route 2) is **R 95.7 million (incl. VAT)** at October 2020 prices.

14.7 Right Bank Canal Scheme Feasibility Design

An assessment of the starting point and conveyance route for this scheme was undertaken, and the design flow was determined. The features of the scheme are indicated on the scheme layout maps.

The feasibility design of the Right Bank Canal and supporting structures has concluded the following:

14.7.1 The Right Bank Canal Scheme is designed to replace the existing main canal with a new canal on the right bank of the Olifants River, transporting water from the existing Bulshoek Weir to the existing 2.0 m diameter syphon at Verdeling.

14.7.2 The *Conceptual Design Sub-report* describes the options analysis undertaken of the various components of the Right Bank Canal Scheme.

14.7.3 The canal routing, syphon types and infrastructure sizing were investigated and designed at feasibility level, as described in this report. The feasibility-level design is based on a design flow rate of 11.40 m/s.

14.7.4 The estimated total capital cost for the proposed scheme is **R 1 832.8 million (incl. VAT)** at October 2020 prices.

14.7.5 The total annual O&M costs estimated for the Civil and Mechanical Works is **R 4 141 610 (incl. VAT)**.

14.8 Ebenhaeser Scheme Feasibility Design

An assessment of the release and abstraction points, conveyance routes, balancing dam and reservoir sites was undertaken, and design flows were determined. The features of the scheme are indicated on scheme layout maps.

14.8.1 Pipelines, Pump Station and Canal Structures

The feasibility-level design of the Ebenhaeser Scheme has concluded the following:

14.8.1.1 The diversion infrastructure from the left and right bank canals comprises two diversion and discharge structures, two diversion gravity pipelines, a diversion pump station and sump, and a rising main to the Ebenhaeser Balancing Dam.

14.8.1.2 Further components of the scheme are the Ebenhaeser Balancing Dam with a pump station and rising main to a concrete reservoir, and a gravity pipeline to the five water requirement clusters.

14.8.1.3 The hydraulic calculations for the diversion gravity pipelines are based on a design capacity of 25.5 Mℓ/d (0.29 m^3/s) for the right bank canal and 30.8 Mℓ/d (0.36 m^3/s) for the left bank canal.

14.8.1.4 The right bank gravity pipeline will cross the Olifants River by means of a syphon.

14.8.1.5 A horizontal split casing or end-suction centrifugal pump will be suitable for the diversion pump station, which is combined with a 2 500 m^3 (2.5 Mℓ) sump.

14.8.1.6 The hydraulic calculations for the diversion rising main is based on a design capacity of 56 Mℓ/d (0.65 m^3/s), and the Ebenhaeser balancing dam water levels at MOL of 55.0 masl and FSL at 70.8 masl.

14.8.1.7 End-suction centrifugal pumps are best suited for the proposed Ebenhaeser balancing dam pump station duty point.

14.8.1.8 The hydraulic calculations for the rising main from the Ebenhaeser balancing dam to the reservoir are based on a design capacity of 20.9 Mℓ/d (0.242 m^3/s).

14.8.1.9 It is proposed that a 11 000 m^3 (11 Mℓ) reinforced concrete reservoir be provided for a 12 hour storage capacity. The reservoir's MOL and FSL are 99.5 masl and 105.5 masl, respectively.

14.8.1.10 The gravity pipeline diameters were optimised to ensure sufficient residual head at each irrigation cluster off-take.

14.8.2 Ebenhaeser Balancing Dam

The feasibility-level design of the proposed Ebenhaeser Balancing Dam has concluded the following:

14.8.2.1 The proposed location of the Ebenhaeser Balancing Dam is about 100 m west of the R363 road, and 11 km north west of Vredendal. The middle of the embankment is located 200 m west of the proposed Vredendal canal offtake. The main advantage of this site is that the offtakes are upstream enough of Ebenhaeser to allow a much higher assurance of supply and that the topography allows for more storage.

14.8.2.2 The dam will be filled from the Vredendal and Retshof canals via a short rising main. Another short rising main will convey the water from the dam to a concrete reservoir from where it will gravitate to the Ebenhaeser community.

14.8.2.3 The proposed dam is an HDPE lined earthfill embankment dam.

14.8.2.4 Sand-cement (soilcrete) is used on the upstream face of the dam and basin slopes for protection of the HDPE from mechanical damage. Crushed stone is used for erosion protection on the downstream face.

14.8.2.5 The dam has a crest width of 5.0 m, an upstream slope of 1V:3H and a downstream slope of 1V:2H.

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

14.8.2.7 The full supply level is 70.4 masl, which gives a maximum water depth of approximately 15.4 m and a storage capacity of 2.32 million m^3.

14.8.2.8 The wall height along with the expected *significant* hazard rating, results in a Category II dam safety classification.

14.8.2.9 The geotechnical investigations show that there is approximately sufficient "soft excavation" material in the basin to be used for the embankment, although some hard excavation may be needed to supplement this. The aeolian sand that is in plentiful supply will act well as the drainage layer under the HDPE lining.

14.8.2.10 Suitable sand and cohesionless gravel is not available on site for the pipe underdrains and will need to be imported.

14.8.2.11 The nominal spillway should be located on the right abutment from where it can gravitate into the adjacent eastern valley.

14.8.2.12 The bywash channel spillway has a trapezoidal cross-section with base width of 3 m, a depth of 1.8 m, and side slopes of 1V:1H.

14.8.2.13 The spillway channel narrows into a trapezoidal discharge channel with a base width of 1 m and slopes of 1V:1H, lined with gabions, Armorflex or rip-rap for the first 30 m, and with a depth of 0.4 m for ease of construction.

14.8.2.14 The discharge channel is 100 m long and terminates at the top of a small valley.

14.8.2.15 The required freeboard was determined for a Category II embankment dam, using the attenuated flood levels. The required freeboard is determined by the wave action combinations, which was found to be 1.8 m.

14.8.2.16 At the outlet chamber, at the toe of the dam, two concrete encased 700 mm diameter pipes will daylight. One will connect to the rising main supply and the other will gravitate to a pump station from where water will be pumped up to a concrete reservoir.

14.8.2.17 The gravity outlet pipe will be provided with an upstream steel bend and sieve inlet.

14.8.2.18 The dam will be accessed via the existing gravel road that runs below the toe of the main wall of the proposed embankment. The gravel road will be extended and realigned to run up and along the toe of the northern flank of the embankment to connect to the crest.

14.8.2.19 The estimated total capital cost for the proposed scheme (pipelines, pump stations, canal structures and balancing dam) is **R 601.1 million (incl. VAT)** at October 2020 prices.

14.9 Legislative Compliance

14.9.1 Water Use and Dam Safety Licences

14.9.1.1.1 The proposed schemes will require separate WULAs in terms of Section 21(b), 21(c) and 21(i) of the NWA.

14.9.1.1.2 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 processes for the implementation of the schemes.

14.9.1.2 Jan Dissels Scheme

14.9.1.2.1 If the rising main pipeline does cross any rivulets, a WULA would be required in terms of Section 21(i) of the NWA.

14.9.1.3 Right Bank Canal Scheme

14.9.1.3.1 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.

14.9.1.4 Ebenhaeser Scheme

14.9.1.4.1 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.

14.9.1.4.2 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.

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

14.9.2 Application for Licence for Borrow Area

14.9.2.1 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.

14.9.2.2 Provision should therefore be made for a separate application to be submitted to DMRE for the authorisation of these listed activities.

14.9.3 Ecological Water Requirement (EWR)

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

14.9.3.2 DWS Directorate: Resource Directed Measures should confirm whether it is necessary or not to undertake an EWR determination study. If required, a EWR determination could be included in the Environmental Impact Assessment.

14.9.4 Environmental Impact Assessment

14.9.4.1 The DWS will undertake the required EIA process for the proposed Jan Dissels, Right Bank Canal and Ebenhaeser schemes, in terms of all applicable environmental legislation. The EIA is expected to start in 2021/22. Separate Environmental Authorisations will be obtained for the three schemes.

14.9.4.2 Impact mitigation measures and environmental management are to be described in an EMPr and must address the life-cycle of the schemes. This will be compiled and submitted as part of the EIA process.

14.9.4.3 Specialist studies will be required as part of the EIA process.

14.9.4.4 Applicable legislation to consider in the EIA process is the National Environmental Management Act, Mineral and Petroleum Resources Development Act, National Environmental Management: Biodiversity Act, National Water Act, National Forests Act, Nature Environmental Conservation Ordinance and National Heritage Resources Act.

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

14.10 Implementation Arrangements

14.10.1 Affected Land, Land Acquisition and Wayleaves

The existing infrastructure that will be affected by the new infrastructure includes the major components described below.

14.10.1.1 Jan Dissels Scheme

14.10.1.1.1 The land on which the scheme will be located is State land. The Rising Main pump station at the dam wall is owned by DWS. 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.

14.10.1.1.2 The Cederberg Municipality will need to be consulted regarding the pipeline route and associated infrastructure over their property.

14.10.1.1.3 The construction of the pipeline through the Ramskop Nature Reserve, which is managed by the Cederberg Municipality, will need to be approved by the Municipality.

14.10.1.1.4 Approval will be required from the provincial roads department for the road crossings and possible construction works in the road reserve for the Deon Burger Road and the entrance/exit roads to the Clanwilliam Dam Resort.

14.10.1.1.5 An access road to the proposed concrete reservoir must be constructed from the “Ou Kaapse” Road or the township development located close by.

14.10.1.2 Right Bank Canal Scheme

14.10.1.2.1 The horizontal alignment for the proposed Right Bank Canal, including a 4.0 m wide canal service road next to the canal, runs through privately owned farms.

14.10.1.2.2 The private 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 scheme.

14.10.1.2.3 The proposed canal crosses the R363 Provincial Road 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. Approval will be required from the Western Cape Department of Transport and Public Works for construction of the road crossings and other possible construction works in the road reserve.

14.10.1.2.4 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.

14.10.1.2.5 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.

14.10.1.3 Ebenhaeser Scheme

14.10.1.3.1 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. The remainder of the land on which the scheme will be located is State land.

14.10.1.3.2 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.

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

14.10.1.3.4 The proposed gravity pipeline from the concrete balancing reservoir to 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.

14.10.1.3.5 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.

14.10.1.3.6 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.

14.10.2 Wayleaves

14.10.2.1 Wayleave applications will need to be submitted to all the relevant service authorities during the detailed design phase of the scheme in order to:

(a) Obtain information on the location of their existing services;

(b) Comment on the proposed pipeline alignments; and

(c) Obtain their requirements that must be adhered to during construction.

14.10.3 Scheme Operation and Maintenance

14.10.3.1 Jan Dissels Scheme

14.10.3.1.1 It is anticipated that DWS will operate the scheme to meet the agreed irrigation schedule.

14.10.3.2 Right Bank Canal Scheme

14.10.3.2.1 After the proposed Right Bank Canal has been completed, the existing main canal on the left bank of the Olifants River will continue to supply 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.

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

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

14.10.3.2.4 The syphons should be regularly drained.

14.10.3.3 Ebenhaeser Scheme

14.10.3.3.1 During weeks when there is spare flow capacity in the Vredendal and Retshof canal sections, and when the balancing dam is not full, additional flows need to be released from Bulshoek Weir, which are equal to the spare weekly capacity in the Vredendal and Retshof canal sections respectively (plus estimated canal losses).

14.10.3.3.2 The above rule needs to be revisited should the Klawer Phase 1 Scheme be implemented, to accommodate the flows required by the Klawer Phase 1 Scheme.

14.10.3.3.3 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.

14.10.3.3.4 Water needs to 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.

14.10.3.3.5 The Ebenhaeser balancing dam should be operated to be full just before the start of the irrigation peak season, likely in early November.

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

14.10.3.3.7 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.

14.10.4 Institutional Arrangements

The institutional arrangements for the schemes are described below.

14.10.4.1 Jan Dissels Scheme

14.10.4.1.1 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. An alternate operator to consider is the West Coast District Municipality.

14.10.4.1.2 It is a possibility that the DWS construction team, currently on site for the raising of Clanwilliam Dam, could implement the scheme. If this is not practical or feasible, a private contractor could be appointed via an open tender process.

14.10.4.2 Right Bank Canal Scheme

14.10.4.2.1 DWS will be the owner of the scheme and the scheme will be operated by LORWUA.

14.10.4.2.2 It is a possibility that the DWS construction team, currently on site for the raising of Clanwilliam Dam, could implement the scheme. If this is not practical or feasible, a private contractor could be appointed via an open tender process.

14.10.4.3 Ebenhaeser Scheme

14.10.4.3.1 DWS will be the owner of the scheme. It is recommended that the scheme be operated by LORWUA. 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.

14.10.4.3.2 It is a possibility that a DWS construction team could implement the scheme.

14.11Further Investigations for Detailed Design

14.11.1 Jan Dissels Scheme

14.11.1.1 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, environmental considerations and associated approvals.

14.11.1.2 Conduct follow-up geotechnical investigations, specifically where insufficient data was obtained for the recommended pump station site.

14.11.1.3 Conduct additional chemical testing to confirm the corrosiveness of the soils.

14.11.1.4 Undertake a ground centreline survey 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.

14.11.1.5 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.

14.11.1.6 Confirm pipeline routes and infrastructure locations, after discussions with affected landowners and authorities.

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

14.11.1.8 Confirm the choice of pipe material for pipelines.

14.11.1.9 Eskom should be engaged regarding electrical supplies to the pump stations.

14.11.1.10 Refine the selection of pump types.

14.11.1.11 Submit proposed road crossing details to the relevant road authority for their approval.

14.11.1.12 Reconsider the sizing of the concrete balancing reservoir.

14.11.1.13 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 project life cycle.

14.11.2 Right Bank Canal Scheme

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

14.11.2.2 Conduct a more detailed analysis and survey of the existing Bulshoek Weir Outlet to verify the capacity. This could influence the decision to increase the canal capacity, which would require alterations to the current outlet.

14.11.2.3 Undertake a ground centreline survey along the final chosen canal routes, prior to construction commencing.

14.11.2.4 Confirm the canal routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

14.11.2.5 Consider adjusted offtake points for the four new irrigation developments, should information be available, as well as for current abstractions from the existing Doring canal section.

14.11.2.6 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.

14.11.3 Ebenhaeser Scheme

14.11.3.1 Undertake a ground centreline survey 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.

14.11.3.2 Estimate the volume of suitable pipeline bedding material that will need to be imported, as well as locating suitable sources of this material.

14.11.3.3 Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities.

14.11.3.4 Include independent quality control inspections of the pipes, at the factory and on site, in the construction tender documents.

14.11.3.5 Confirm the choice of pipe material.

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

14.11.3.7 Refine the selection of pump types as part of the detailed design phase.

14.11.3.8 Reconsider the sizing of the concrete balancing reservoir.

14.11.3.9 Submit the proposed railway crossing details on the Ebenhaeser gravity main to the relevant railway authority for their approval.

14.11.3.10 Submit the proposed road crossing details to the relevant road authority for their approval.

14.11.3.11 Undertake a more site-specific survey for the railway and existing culvert crossings on the Ebenhaeser gravity pipeline.

14.11.3.12 Confirm the assumptions made in the determination of the desired balancing dam storage volume.

14.11.3.13 Design the zoning dimensions of the balancing dam based on the actual material properties and design constraints for the particular zones.

14.11.3.14 Undertake further investigation into the required thickness and other properties of the balancing dam lining. 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.

14.11.3.15 Investigate the relocation of three power lines affected by the position of the balancing dam.

14.11.3.16 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 project life cycle.

14.12 Project Implementation

14.12.1.1 The Record of Implementation Decisions (RID) is the official internal DWS document to hand over the schemes for implementation. The RID describes the components of the project, design aspects, further investigations to be undertaken, institutional and funding arrangements, operational aspects and other pertinent information for implementation of the project. The RID will be issued to DWS Chief Directorate Infrastructure Development for the implementation of the schemes after the Environmental Authorisation has been received.

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

14.12.1.3 The proposed Jan Dissels Scheme will be located on State-owned land. The Right Bank Canal Scheme and the Ebenhaeser Scheme will form part of the LORGWS. It is expected that all three schemes will be implemented as Government Waterworks and funded by National Treasury. This will enable each scheme to be implemented as soon as the detailed design and tender documentation are ready, and environmental authorisation has been received. Alternative funding and associated implementation arrangements can however not be excluded, especially in a post-Covid-19 situation.

14.12.1.4 The implementation of the Jan Dissels and Ebenhaeser schemes is dependent on when additional water will be available after the Clanwilliam Dam has been raised. The Right Bank Canal Scheme is a Betterment Works and can be implemented as soon as Environmental Authorisation has been issued and funding is available.

14.12.1.5 Given the significant challenges and delays being experienced with the DWS in-house implementation of projects, due to Supply Chain and other issues, an alternative tried-and-tested implementation model should be considered. Detailed design will commence once the EIA has been concluded, and an Environmental Authorisation has been issued for each of the three schemes respectively.

14.12.1.6 The WULAs for storing water and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), National Water Act, 1998) is included in the scope of work for the EIA study.

14.12.1.7 Progress with the raising of Clanwilliam Dam and associated availability of additional water will determine when the licensing process for irrigation development (Section 21(a)) can get underway. This will be determined by DWS during implementation of the project.

14.12.1.8 Applications for licences to comply with the dam safety regulations will need to be completed as part of the detailed design and construction of the Ebenhaeser balancing dam.

14.12.1.9 The use of a borrow area(s) to source construction material could trigger listed activities under GN R983 and R985. Before a borrow area is developed, authorisation must be obtained from DMRE for the listed activities.

15 Recommendations

This Chapter lists the recommendations emanating from the feasibility design.

The following recommendations are applicable to the detailed design and construction phases of the schemes.

15.1 Topographical Survey

15.1.1 The LiDar topographical survey was completed at a standard that is suitable to use for detailed design of the three schemes.

15.1.2 Undertake a ground centreline survey along the final chosen pipeline routes, prior to construction commencing. This will serve as a final check on the pipelines' vertical alignment and verification of the survey data.

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

15.2 Geotechnical and Materials Investigations

15.2.1 Conduct follow-up geotechnical investigations for the Jan Dissels Scheme, specifically where insufficient data was obtained for the recommended pump station site.

15.2.2 Conduct additional chemical testing to confirm the corrosiveness of the soils.

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

15.3 Jan Dissels Scheme Feasibility Design

The following recommendations are applicable:

15.3.1 It is recommended that the Rising Main Route 2 option be implemented for the Jan Dissels Scheme.

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

15.3.3 Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

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

15.3.5 Confirm the choice of pipe material during the detailed design phase of the project, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.

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

15.3.7 Refine the selection of pump types.

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

15.4 Right Bank Canal Scheme Feasibility Design

The following recommendations are applicable:

15.4.1 If the required design flow capacity is revised, the scheme routing and sizing of infrastructure should be amended during the detailed design stage.

15.4.2 Conduct a more detailed analysis and survey of the existing Bulshoek Weir Outlet to verify the capacity. This could influence the decision to alter the current outlet.

15.4.3 Confirm the canal routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

15.5 Ebenhaeser Scheme Feasibility Design

The following recommendations are applicable:

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

15.5.2 Confirm the pipeline routes and infrastructure locations, after discussions with affected landowners and authorities. Some refinements to the routes and locations may be required due to developments subsequent to the feasibility design.

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

15.5.4 Confirm the choice of pipe material, taking into account factors such as geotechnical conditions, type of bedding material required, soil resistivity, corrosion requirements, pipe material and construction costs.

15.5.5 Eskom should be engaged regarding electrical supplies to the pump stations.

15.5.6 Refine the selection of pump types;

15.5.7 Submit the proposed railway crossing details on the Ebenhaeser gravity main to the relevant railway authority for their approval during detailed design stage.

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

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

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

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

15.6 Legislative Compliance

15.6.1 The water use licence applications for storing water, and affecting and altering the banks of a river (Section 21(b), 21(c) and 21(i), NWA), as relevant for the three schemes, is included in the scope of work for the EIA study.

15.6.2 The application to DMRE for a Licence for a Borrow Area is included in the scope of work for the EIA study.

15.6.3 The Ebenhaeser Balancing Dam safety regulation requirements are as follows:

- Applications for licences for complying with the dam safety regulations will need to be completed before certain tasks may continue;
- A licence to construct must be issued by the Dam Safety Office (DSO) before any construction may commence. This application includes the relevant application forms, the Detailed Design Report for the dam with engineering drawings, the water use licence, and engineering specifications;

- Before the bottom outlets of the dam are closed, thereby commencing the impounding of water, the licence to impound must be obtained from the DSO. This application includes the relevant application forms, the operation and maintenance manual and the emergency preparedness plan.

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

15.7 Implementation Arrangements

15.7.1 The planned new irrigation developments and the implementation of the schemes need careful planning and coordination.

15.7.2 Further investigations for detailed design should be undertaken, inclusive of topographical surveys, geotechnical investigations, construction materials, electrical power supply, and road and railway crossings.

15.7.3 Obtain environmental authorisations for the schemes.

15.7.4 Finalise scheme layouts and sizing of components, and undertake detailed design.

15.7.5 Obtain the necessary licences for implementation of the schemes.

15.7.6 Undertake land acquisition and obtain servitudes, as required for the schemes, including compensation for affected land and infrastructure.

15.7.7 Obtain wayleaves from the relevant authorities for road and railway crossings.

15.7.8 Finalise institutional agreements for implementation of the schemes.

15.7.9 The revision of contractual arrangements with LORWUA should be considered, for the operation of the Right Bank Canal and Ebenhaeser schemes and the joint use of water from the Ebenhaeser balancing dam.

15.7.10 The RID should be finalised after the Environmental Authorisation has been received and issued to DWS Infrastructure Development to formalise the implementation of the schemes.

15.7.11 Funding needs to be secured from National Treasury to enable construction of the project to commence as soon as the detail design is complete and Environmental Authorisation has been received.

15.8 Further issues to address

Further issues to address are the following:

15.8.1 The principles of the splitting of capital costs and NPVs between new irrigation development and betterment costs (costs attributable to current irrigators) should be re-visited, to ensure equity.

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

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

15.8.4 The DWS should make a formal submission about the planned Clanwilliam Dam raising conveyance infrastructure development to the authorities involved with the gazetting of the critical biodiversity areas, following acceptance of the recommendations.

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

15.8.6 To obtain greater clarity on funding options, it is suggested that DWS provide a presentation to National Treasury to explain implementation approaches, and to request confirmation of National Treasury's view on this, as well as any concerns and required procedures. For this purpose, it will be necessary to have information at hand regarding economic and job creation implications of new investment. It would further be valuable to also provide the risks for the economy and labour of potential canal failures if betterments are not undertaken, although this is not currently part of this study.

16 References

Brink, A.B.A. (1983). *Engineering Geology of Southern Africa: Volume 3*. Pretoria: Building Publications Pretoria.

Chadwick, A; Morfett, J & Borthwick M. 2013. *Hydraulics in Civil and Environmental Engineering.* 5th Edition. Taylor & Francis Group. Boca Raton, FL

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

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

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

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

Department of Water Affairs and Forestry, 2008. *Clanwilliam Dam Raising Feasibility Study* prepared by Ninham Shand.

Department of Water and Sanitation, 2016. *Study on National Water Resource Infrastructure*, inclusive of the Lower Olifants River Government Water Scheme (LORGWS), undertaken by Pula Consulting.

Department of Water and Sanitation, 2017. *Validation and verification of existing lawful water uses within the Berg Olifants WMA*. Prepared by Aurecon. Unnumbered report.

Department of Water and Sanitation, South Africa. 2019. *Water Requirements Assessment.* Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/4.

Department of Water and Sanitation, South Africa. 2019. *Distribution of Additional Available Water*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/5.

Department of Water and Sanitation, South Africa. 2019. *Existing conveyance infrastructure and irrigated land.* Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/6.

Department of Water and Sanitation, South Africa. 2019. *Suitable Areas for Agricultural Development Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/10.

Department of Water and Sanitation, South Africa. 2019. *Topographical Survey Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Report number P WMA 09/E10/00/0417/7.

Department of Water and Sanitation, South Africa. 2020. *Post Feasibility Bridging Study for the Proposed Bulk Conveyance in Infrastructure from the Raised Clanwilliam Dam: Geotechnical Investigations Report. Vol I, II and III*, Report No. P WMA 09/E10/00/0417/8, 2020.

Department of Water and Sanitation, South Africa. 2020. *Post Feasibility Bridging Study for the Proposed Bulk Conveyance in Infrastructure from the Raised Clanwilliam Dam: Topographical Surveys Report* No. P WMA 09/E10/00/0417/7, 2020.

Department of Water and Sanitation, South Africa. 2020. *Conceptual Design Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered.

Department of Water and Sanitation, South Africa. 2020. *Environmental Screening Sub-Report*. Prepared by Zutari (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered

Department of Water and Sanitation, South Africa. 2021. *Jan Dissels and Ebenhaeser Schemes Design Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility

Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered.

Department of Water and Sanitation, South Africa. 2021. *Right Bank Canal Design Sub-Report*. Prepared by Aurecon South Africa (Pty) Ltd as part of the Post Feasibility Bridging Study for the Proposed Bulk Conveyance Infrastructure from the Raised Clanwilliam Dam. Unnumbered.

Design of Small Dams, 1987. United States Department of the Interior, Bureau of Reclamation.

LORWUA, 2004. *Investigation into the rehabilitation of the canal downstream of Bulshoek Dam*, prepared by Element Consulting Engineers.

LORWUA. Estimation of water use (pump abstractions from the riverbed) downstream of Bulshoek Weir from the Olifants River.

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

SANCOLD, 1990. Interim Guidelines on Freeboard for Dams, South African National Committee on Large Dams, Report No 3, August 1990.

SANCOLD, 1991. Guidelines on Safety in Relation to Floods, South African Committee on Large Dams, Report No 4, December 1991.

Swaziland Water and Agricultural Development Enterprise Ltd (SWADE). 2015. *Main Conveyance System Final Design Review Report.* Prepared by Aurecon South Africa in association with Bosch Stemele and Bicon Consulting Engineers as part of the Lower Usuthu II Extension Downstream Development. Aurecon Report No. 10288.

Western Cape Provincial Department of Agriculture, 2008. Western Cape Olifants/Doorn River Irrigation Study, 2006, prepared by Arcus Gibb.

Western Cape Provincial Department of Agriculture, 2013. *Mapping of agricultural activities, crop types and irrigation areas in the Western Cape Province.*

Western Cape Provincial Department of Agriculture, ongoing. *Water quality measurements undertaken in the lower Olifants River.*

Weinert, H.H. (1980). *The natural road construction materials of southern Africa*, Publisher: National Book Printers, Cape Town, South Africa.

Appendices

Appendix A: Technical Note: Comment on the Design Flow Capacity of the Right Bank Main Canal

1. APPROACHES

Two approaches were followed to indicate alternative design flow capacities, namely:

a) **Approach 1**: Determining the flow similarly to the way it was calculated in the study, considering the existing flows in more detail by separating irrigation from other water uses and taking into consideration the further variables of potential crop changes and losses. This does not take into account the unallocated volume of the increased assurance to existing irrigators from the raised Clanwilliam Dam of 5.1 million m^3/a.

b) **Approach 2**: Assuming that the full unallocated portion of the increased assurance from the raised Clanwilliam Dam of 5.1 million m^3/a is allocated for new development below Bulshoek Weir. The approach followed differs somewhat from that followed in option a) above. This is the recommended approach by Mr Peter Keuck of the Department of Agriculture, Western Cape.

2. STUDY DESIGN APPROACH

The capacity of the Right Bank canal (rounded to 11.4 m^3/s) was designed considering the following aspects, as also indicated in **Table 1**:

- Current flow capacity of the main canal, providing existing irrigators,
- Up to 20.35 million m^3/a (25% of 81.4 million m^3/a) may be used by existing irrigators for an increased assurance of supply of which a portion will receive water from the canals. An increased flow capacity for existing irrigators, to alleviate the bottleneck caused by the existing flow capacities of canal sections, taking a long-term view of incremental betterment / replacement of the existing canal sections,
- Flow requirement for new irrigation downstream of Bulshoek Weir, and
- Future, additional non-irrigation flows for (raw water) domestic and industrial supply,
- Adequate freeboard.

Table 1: Right Bank Canal peak design flows

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

It was noted that (existing) farmers may plant more permanent crops, and winter flows are also expected to increase. The canal will be required to accommodate the peak flow during the summer months. An aggregated peak factor (for January) for the irrigation development areas downstream of the Bulshoek Weir of 2.13 was applied to the average flows. The additional irrigation flow component took into account canal losses as well as balancing dam losses relevant to specific schemes.

3. APPROACH 1

3.1 Improved Flow Allowance For Existing Users

There is discomfort regarding the argument to use the increased assurance of supply to existing users to derive the required peak month flow at the start of the proposed new main canal. The increased assurance means there will be more years in future (after Clanwilliam Dam is raised) that the current irrigators will receive their full quota (9 out of 10 years roughly.) In the peak months, the restricted capacity of the main canal limits current irrigation only to cultivate permanent crops. After the raising of Clanwilliam Dam this restriction, if there is no increase in canal capacity, will still apply to the cultivation of permanent crops even though more water will be available for irrigation use during the year as a whole. Some, or even all, of the quota may be used, but the restriction on irrigating during the peak period will remain.

The determination of canal capacities would usually be derived from basics: determining crop water requirement during peak months (for the likely crop cultivated), and losses on-farm and in the canals etc. As this is an existing scheme with scheduling already determined the approach on at p. 45 of the Conceptual Design Report of this study seems appropriate:

According to the LORWUA, the current capacity of the main canal is 26 000 m^3/h (or 7.222 m^3/s). The current irrigated area, which receives scheduled water allocations from the Clanwilliam Dam via the LORWUA canal system, is 9 517 ha. If irrigators obtain their full scheduled allocation of 12 200 m^3/ha/a, this equates to total scheduled water allocations of approximately 116 million m^3/a (average flow of 3.682 m^3/s). With an average peak factor of 2.13 (refer Section 5.2.3), the canal is required to convey a peak flow of 7.842 m^3/s.

This may seem a logical approach, **but losses in the canals and balancing dams should be added** to the above figure.

The question then is what should the allowance for **losses** be?

The *Distribution of Additional Available Water Report* of this study, 2018, states on pg. 20 that "*Average percentages for losses of 27% for Bulshoek (LORWUA) canals and 30% for Clanwilliam Canal have been accepted for the determination of available yield*."

One can argue that, with the new main canal in place, and gradual upgrading of the secondary canals, the losses should be less than in the current, very much degraded, system. From the Zutari spreadsheet, *Reqmnts Dams Findings Phasing*, the following is gleaned:

Losses (according to LORWUA):
Main canal = 20% losses (current)
Left Bank canal from Verdeling = 35% losses (current)
Right Bank canal from Verdeling = 20% losses (current)
Assumed Losses for Design:
(New) Right Bank canal = 10% losses
Left Bank Canal abstraction (post RB canal) = 20% losses
Right Bank Canal abstraction (post RB canal) = 15% losses

It should be noted that Mr Nieuwoudt of DWS is of the opinion that aggregate losses in the canal system currently averages about 30%.

A point to consider is whether losses for the new Right Bank Canal should be regarded as more than 10% in the longer-term, as this canal section will also deteriorate over time.

For the sake of the argument, it has therefore been assumed that the aggregate system loss in the peak month of January would be 20% after upgrading of the main canal.

The required peak flow for the current irrigators would then be 7.842 m^3/s times 1.20 = 9.410 m^3/s.

The existing domestic and industrial water requirements are shown in **Table 2**. It should be noted that current water use by the Matzikama Municipality already exceeds their allocation as indicated in the table.

Table 2: Existing domestic, industrial and mining water requirements (2021)

Municipality	Water Demand		Month Peak Factor	Month Peak Flow	
	Annual (m^3/a)	Av / Month (m^3)		(m^3)	m^3/s
Matzikama Municipality incl. industries	5 151 000	429 250	1.50	643 875	0.240
Mining - Tronox	3 200 000	266 667	1.10	293 333	0.110
Total excluding losses					**0.350**
Total including 20% losses					**0.420**

Accepting the above, it is recommended that **Table 1** for the Right Bank Canal peak design flows should be revised as indicated in **Table 3**, with allowance for freeboard still to be added. This represents an increase of 10.8% in the peak design flow, relative to the 11.4 m^3/s.

Table 3: Recommended Right Bank Canal peak design flows

Flow component	Flow (m^3/s)
Current irrigation	9.410
Current domestic, industrial & mining	0.420
Future additional non-irrigation flows	0.079
Additional new irrigation	2.723
Total peak design capacity	**12.632**

3.2 Factors Further Influencing the Flow Determination

3.2.1 Influencing factors

The following factors may influence the above determination:

Factors that require an **increase** in capacity:

a. LORWUA future canal system losses greater than 20%,

b. Changes in crops grown by existing irrigators, including:
    - Future increase of land under permanent crops by existing irrigators (currently estimated at 83%,
    - Move from wine grapes to table grapes,
    - The worst-case scenario crop mix (P Keuck request),

c. Move towards less onerous irrigation hours e.g. from (current) 168 hours to 120 hours per week (note latter is standard for new schemes, but much depends on the design. In this case the canals are very long and it will not be easy to vary flows within the week),

d. If the unallocated portion of the increased assurance from the raised Clanwilliam Dam is allocated for new development below Bulshoek Weir, although this is an unlikely scenario, and has not been assessed.

Factors that will require a **lesser** capacity:

a. LORWUA canal system losses are reduced to less than 20%,
b. Cash crops being favoured on new irrigation development,
c. Greater uptake of irrigation above the Bulshoek Weir abstraction point.

Note that the peak month's flow may not be adequate for extreme (e.g. heat-wave) conditions (i.e. during the peak week flow the requirement may be quite a bit more), but that some encroachment of the canal freeboard are allowed under such conditions. This is not a luxury the current Main canal currently offers.

Evaluation of the factors that will require a lesser capacity is not needed.

3.2.2 Greater than 20% canal losses

Should it be accepted that the main canal will also deteriorate over time, the losses could be closer to 30% in the long-term, but this assumes that the existing canal sections on the left bank and right bank respectively is not upgraded / improved, following the replacement of the left bank main canal.

Should aggregate canal losses of say 25% be considered, the additional losses would then be 12.632 m^3/s divided by 1.20 = 10.527 m^3/s times 0.05 = 0.526 m^3/s, to account for the additional 5% losses.

Should aggregate canal losses of say 30% be considered, the additional losses would then be 12.632 m^3/s divided by 1.20 = 10.527 m^3/s times 0.1 = 1.053 m^3/s, to account for the additional 10% losses.

3.2.3 Worst-case Scenario Crop Mix

Primary principals

For planning purposes, the sizing and conveyance capacity of the canals need to support the maximum socio-economic benefit scenario that can be realised from the future available water. The following primary principals are applicable:

1) Bulk water storage is provided in the Clanwilliam Dam. No on-farm bulk water storage is provided for the purpose of seasonal water i.e. storing winter water for summer use, etc. (The very limited on-farm water storage is for the purpose to provide day to day flexibility to the farmer for on-farm irrigation scheduling, typically within a week.)
2) Economic market trends will determine the selection of crop types being cultivated in the region. The canals should therefore be sized to allow for the *worst case crop type scenario.*
3) A *worst case crop type scenario* would be the crop type with the highest irrigation peak, requiring the canals to operate at maximum design capacity.
4) Irrigation agriculture in the region will primarily be done during the summer irrigation season with the peak irrigation water requirements occurring during the month of January.
5) With reference to the monthly crop water requirements for the Vredendal region the *worst case crop type scenario* (highest nett irrigation water requirement) is that for *fruit medium* and *wine grapes intensive early*, which would require that 19% of the total agricultural allocation (current plus future) need to be conveyed during the month of January.
6) It can therefore be concluded that at any place along the canal, the canal need to be designed and sized to convey the total of: downstream water losses, 19% of the downstream agricultural allocation, current and future municipal, industrial and mining water use and freeboard.

The 19% January use of agricultural water translates to a crop monthly peak factor of 2.28.

Current irrigation

The current situation is that, in zones 4 and 5, i.e. below Bulshoek Weir, wine grapes account for 93.82% of permanent crops and fruit account for 1.34%. Permanent crops are currently 83% of the existing scheduling of 116.02 million m^3/s.

For existing irrigation, the assumption is that all the current crops will be converted to crops with the highest nett irrigation water requirement for this scenario, i.e. to *fruit medium* or *wine grapes* *intensive early*. This corresponds to about 2% of existing permanent cops in zones 4 and 5 (table grapes and other fruit) that will be converted to *fruit medium* or *wine grapes intensive early*.

This conversion of permanent crops would require 2% of 96.39 million m^3/a = 1.928 million m^3/a water requirement or 0.061 m^3/s average flow times ((19.0%-16.7%)/16.7%) = 0.007 m^3/s additional flow in January.

In addition, for this scenario the 17% of the total agricultural allocation non-permanent crops will then also be converted to *fruit medium* or *wine grapes intensive early*. It has been assumed that these non-permanent crops currently require an aggregate of 16% of the volume to be conveyed during the month of January.

The non-irrigation portion of the allocation is 116.02 million m^3/a times 17% = 19.723 million m^3/a.

The conversion of non-permanent crops to *fruit medium* or *wine grapes intensive early* permanent crops would require 19.723 times 16% = 3.156 m^3/a water requirement or 0.100 m^3/s average flow times ((19.0%-16.0%)/16.0%) = 0.019 m^3/s additional flow in January

For the existing irrigation the implication of increasing all the crop monthly peak factors of converting all permanent and non-permanent crops to *fruit medium* or *wine grapes intensive early*, is 0.007 + 0.019 = 0.026 m^3/s.

Future irrigation

For the determination of design flows for the new irrigation schemes, aggregated crop monthly peak factors of 2.17 was used in zone 4 (Olifants River below Bulshoek Weir to Trawal) and 2.09 in zone 5 (Olifants River from Klawer to Coast). Aggregate Water Demand of 8 680 $m^3/ha/a$ was used for zone 4 and 8 437 $m^3/ha/a$ for zone 5, as agreed with key stakeholders (and the sub-Committee formed to determine such values for the planning) during this study.

For the new irrigation the implication of increasing all the crop monthly peak factors of 2.17 and 2.09 as used for the design to 2.28, is 0.165 m^3/s as determined with the Zutari spreadsheet *Reqmnts Dams Findings Phasing.*

3.3 Summary

A summary of the influence of further factors on the proposed canal flow as indicated in **Table 4** is as follows:

Table 4: Influence of further factors on canal design flow

Flow component & influencing factor	Peak canal flow in m^3/s
Recommended peak design capacity as per Table 3 for current & new irrigation plus current & future domestic, industrial & mining use	12.632
- Canal losses increased to 25% - 5% additional losses	+0.526
- Canal losses increased to 30% - 10% additional losses	+1.053
- Worst-case scenario crop mix - additional (= 0.026 + 0.165)	+0.191

It is evident from the table that the assumed canal losses has a significant influence. The consideration of the worst-case scenario crop mix has a limited influence on existing crops as the bulk is wine grapes but will have a more marked influence on future planned crops.

3. APPROACH 2

The Second Approach, as conveyed by Mr Peter Keuck of the Department of Agriculture, Western Cape, in an email dated 4/4/2021 is as described below.

1. It has been shown that there are adequate irrigation opportunities, comprising of greenfield development options and expansion of existing irrigation farms, to utilise the additional allocations and the increased assurance of supply from the raised Clanwilliam – Bulshoek system.

   It is to be expected and not to be underestimated, with a higher assurance of supply and unrestrained conveyance capacity, that existing allocations would be utilised to irrigate substantial larger areas of permanent crops than the current scheduled allocation area of 9517ha.

2. The table as shown on the following page is handy and self-exploratory to determine the required main canal conveyance capacity. Please do not hesitate to adjust figures as appropriate. It is based on:

   a) The system yield (the balance after reasonable allowances for deductions applicable between Clanwilliam Dam and Bulshoek Dam, and deductions for environmental requirements as applicable),

   b) Conveyance losses which is an uncertain factor, provision for 10% to 35%, (….effectively at firm yield),

LORWUA: Proposed Right Bank Main Canal Design Flow

04 April 2021

Scenario	System Yield (Balance at Bulshoek Dam)	Conveyance Losses			Domestic & Industry		Balance of Yield for Agriculture		Main Canal
	10^6 m^3/a	%	m^3/s	10^6 m^3/a	10^6 m^3/a	peak m^3/s	10^6 m^3/a	peak m^3/s	peak m^3/s
1	213	10	0,79	18,04	8,35	0,35	186,61	12,60	13,74
2	213	15	1,18	27,06	8,35	0,35	177,59	11,99	13,52
3	213	20	1,57	36,08	8,35	0,35	168,57	11,39	13,31
4	213	25	1,96	45,10	8,35	0,35	159,55	10,78	13,09
5	213	30	2,36	54,12	8,35	0,35	150,53	10,17	12,87
6	213	35	2,75	63,14	8,35	0,35	141,51	9,56	12,66

Notes:							
	The 213 figure received from Rassie at time of commencement of discussion, July 2020. Change to alternate figure if required.	The 20% aggregate losses = 1,568 m^3/s is based on PvN's document "New main Canal: What capacity? (For discussion)" middle of page 2,- used as basis to calculate flows for other % losses (10%, 15%, 25%, 30%, 35%).	Total equivalent of losses for the year. Applicable only for the 38 weeks of the year that the canal is operational.	Figures from Rassie's addendum to PvN's document "New main Canal: What capacity? (For discussion)".	Balance of yield available for agriculture.	Peak flow based on Study's agriculture's annual average x 2,13 Peak Factor.	Main canal design flow (without utilising freeboard).

Additional Notes:

1. The canal will be operated during the peak period at full supply capacity 24/7 (without spare time or capacity provided for emergencies). However, in case of emergencies i.e. heat wave or canal failure etc, the option should be available to operate the canal at a higher emergency flow by utilising freeboard capacity. This require that the Bulshoek Dam's modified outlet works and the proposed main canal Syphon be sized accordingly, to accommodate the higher emergency flow requirements associated with utilising canal freeboard to its maximum.

2. RE Limited capacity of the existing syphon at 'Verdeling' to be used in reverse: By modifying the proposed right bank inlet of the syphon and elevating the vertical alignment of proposed right bank main canal, the capacity of the existing syphon, being operated in reverse, can be increased. The limitations would be the supply level ***within*** the Bulshoek Dam, head loss at Bulhoek's modified outlet works and the hydraulic grade losses of the proposed new syphon and main canal.

c) Long term domestic and industry supply demands with consideration of peak factors, (……effectively at 98% assurance of supply),

d) **That the balance of water be available for irrigation agriculture,** with additional considerations pertaining crop mix and irrigation peak factors, (……effectively at 91% assurance of supply).

3. From this the argument can be made that in order to achieve the full benefit of available water over the long term utilisation period, spanning up to 100 years and beyond, that the ***main canal design flow*** should be give or take 13.31 m^3/s, with additional flow capacity available should freeboard space be utilised in cases of emergency.

4. What additional flow can be conveyed within freeboard?

5. The design flow for the Bulshoek modified outlet works and the proposed syphon need to allow for the main canal design flow **plus** additional flow associated with maximum utilisation of the freeboard.

Appendix B: General layout arrangement of the Right Bank Canal Scheme

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CLIENT	REV	DATE	REVISION DETAILS	APPROVED
	A	31/07/20	FEASIBILITY STUDY - NOT FOR CONSTRUCTION	E.v.d. BERG

SCALE	SIZE
AS SHOWN	A1

DRAWN: S. DAKA
DESIGNED: G. CALITZ
CHECKED: A. CHANG

FEASIBILITY
NOT FOR CONSTRUCTION
APPROVED

PROJECT: CLANWILLIAM BRIDGING STUDY

TITLE: RIGHT BANK CANAL GENERAL LAYOUT SHEET 1 OF 1

DRAWING No.	PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
	113834	0000	DRG	CC	0001	A

Appendix C: Key Plan of the Ebenhaeser Scheme layout

REFERENCE DRAWINGS:

- 113834 - 0000 - DRG - CC - 0101 VREDENDAL - RETSHOF CANAL DIVERSION LAYOUT
- 113834 - 0000 - DRG - CC - 0102 RIGHT BANK CANAL DIVERSION STRUCTURE LAYOUT
- 113834 - 0000 - DRG - CC - 0103 RIGHT BANK CANAL DIVERSION STRUCTURE DETAIL
- 113834 - 0000 - DRG - CC - 0104 DIVERSION PUMP STATION AND SUMP
- 113834 - 0000 - DRG - CC - 0105 LEFT BANK CANAL DIVERSION STRUCTURE LAYOUT
- 113834 - 0000 - DRG - CC - 0106 LEFT BANK CANAL DIVERSION STRUCTURE DETAIL
- 113834 - 0000 - DRG - CC - 0107 RISING MAIN TO RESERVOIR
- 113834 - 0000 - DRG - CC - 0108 CONCRETE RESERVOIR
- 113834 - 0000 - DRG - CC - 0109 EBENHAESER GRAVITY PIPELINE (SHEET 1 F 2)
- 113834 - 0000 - DRG - CC - 0110 EBENHAESER GRAVITY PIPELINE (SHEET 2 OF 2)
- 113834 - 0000 - DRG - CC - 0111 EBENHAESER BALANCING DAM INLET/OUTLET CHAMBER & PUMP STATION LAYOUT
- 113834 - 0000 - DRG - CC - 0112 EBENHAESER BALANCING DAM INLET/OUTLET CHAMBER
- 113834 - 0000 - DRG - CC - 0113 TYPICAL CLUSTER OFFTAKE CHAMBER DETAIL
- 113834 - 0000 - DRG - CC - 0114 BALANCING DAM RESERVOIR DETAIL
- 113834 - 0000 - DRG - CC - 0115 EBENHAESER SCHEME SCHEMATIC LAYOUT
- 113834 - 0000 - DRG - CC - 0116 TYPICAL CANAL INTAKE DETAIL
- 113834 - 0000 - DRG - CC - 0117 MINOR STREAM/RIVER CROSSINGS TYPICAL DETAIL
- 113834 - 0000 - DRG - CC - 0118 MAJOR STREAM/RIVER CROSSING DIRECTION DRILLING
- 113834 - 0000 - DRG - CC - 0119 PIPELINES: TYPICAL ROAD CROSSING DETAIL
- 113834 - 0000 - DRG - CC - 0120 RAILWAY CROSSING DETAIL

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CLIENT

REV	DATE	REVISION DETAILS	APPROVED
A	10/2020	FOR DISCUSSION	E. vd BERG

SCALE	SIZE
1: 500 000	A1

DRAWN: A. KNOX
DESIGNED: A. KNOX
CHECKED: M. WAHL

PRELIMINARY
NOT FOR CONSTRUCTION

APPROVED: E vd BERG DATE

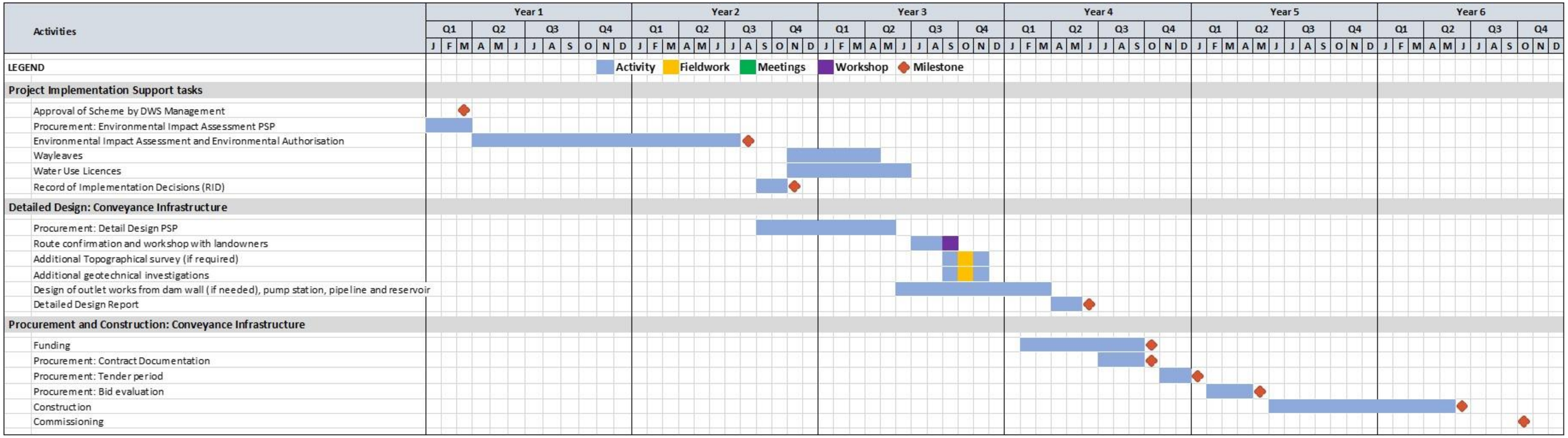
PROJECT: CLANWILLIAM BRIDGING STUDY EBENHAESER SCHEME

TITLE: EBENHAESER SCHEME KEY PLAN

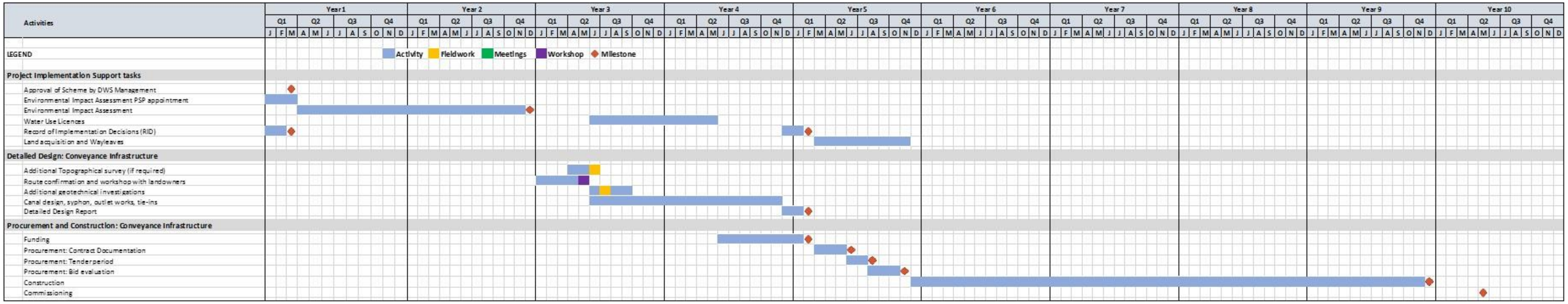
DRAWING No.	PROJECT No.	WBS	TYPE	DISC	NUMBER	REV
	113834	0000	DRG	CC	0100	A

Appendix D: Scheme implementation programmes

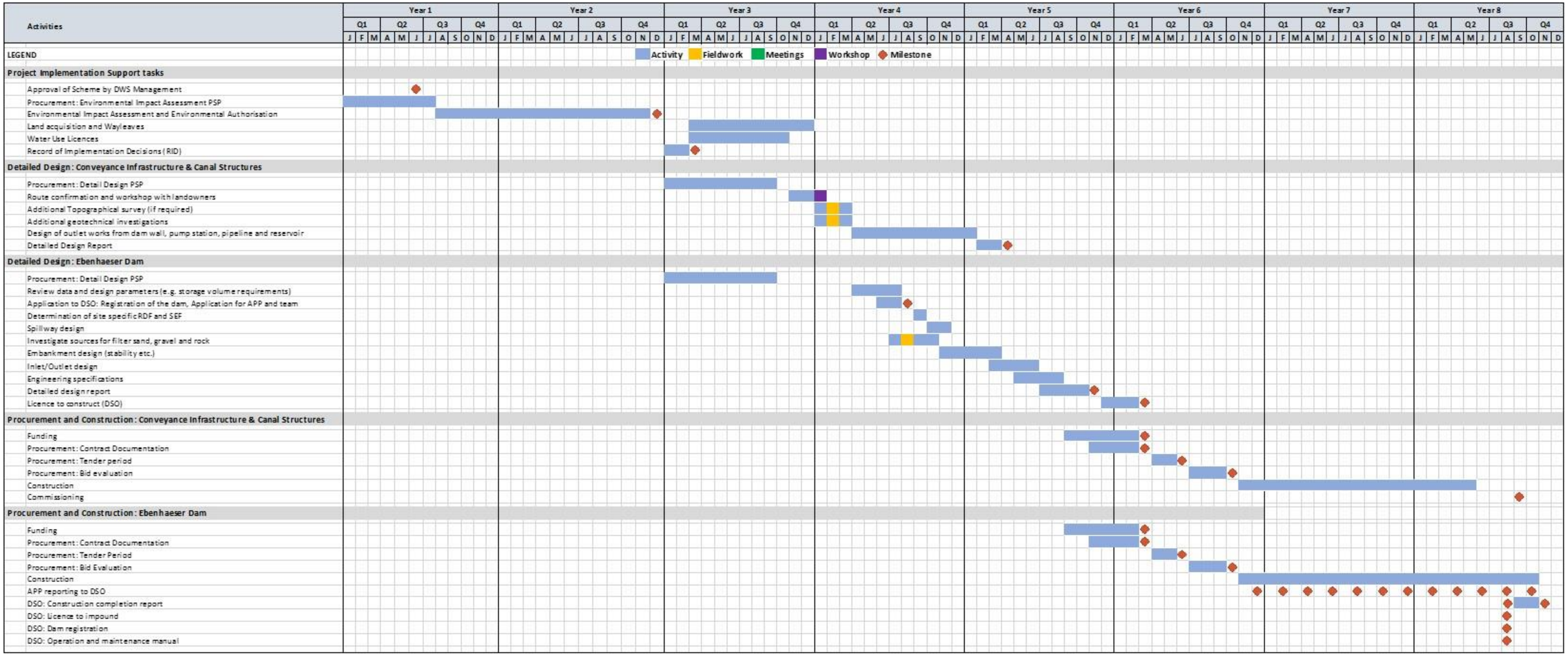
D1: IMPLEMENTATION PROGRAMME - Implementation Support, Detail Design and Construction of the Jan Dissels Scheme



D2: IMPLEMENTATION PROGRAMME - Implementation Support, Detail Design and Construction of the Right Bank Canal Scheme



D3: 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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