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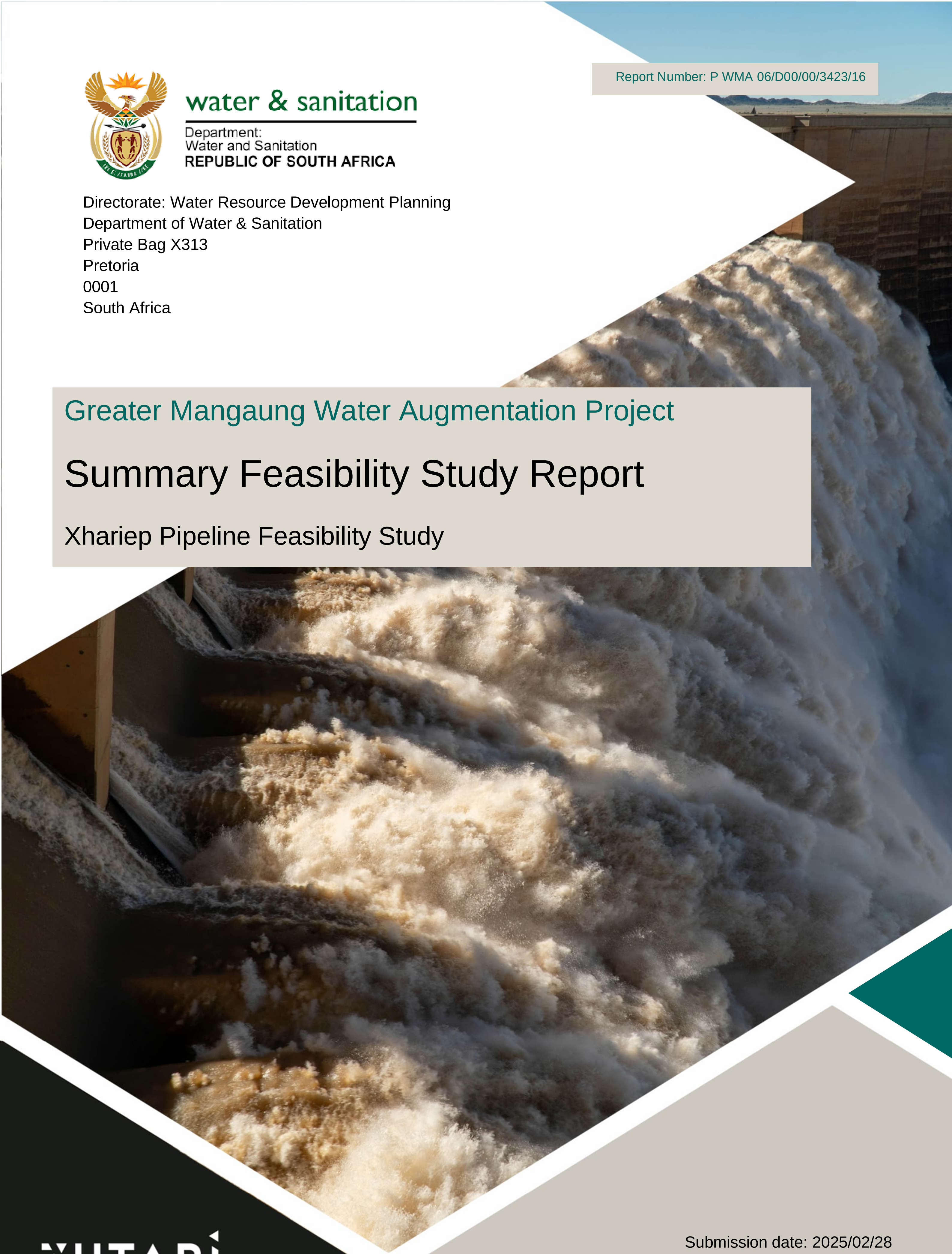

Greater Mangaung Water Augmentation Project

Summary Feasibility Study Report

Xhariep Pipeline Feasibility Study

ZUTARI
IMPACT. ENGINEERED.

Submission date: 2025/02/28

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water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

Directorate Water Resource Development Planning

Summary Feasibility Study Report

APPROVAL

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Project Name	:	Xhariep Pipeline Feasibility Study
DWS Report Number	:	P WMA 06/D00/00/3423/16
PSP Name	:	Zutari (Pty) Ltd
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Report Structure

This report forms part of the following suite for the study:

REPORT INDEX	REPORT NAME	DWS NUMBER
1	Inception Report	P WMA 06/D00/00/3423/1
2	Site Visit Report	P WMA 06/D00/00/3423/2
3	Stakeholder Management Report	P WMA 06/D00/00/3423/3
4	Data Analysis and Collection Report	P WMA 06/D00/00/3423/4
5	Pre-feasibility Study Report	P WMA 06/D00/00/3423/5
6	Main Feasibility Study Report	P WMA 06/D00/00/3423/6
7	Geological and Materials Investigations Report	P WMA 06/D00/00/3423/7
8	Topographical Survey and Mapping Report	P WMA 06/D00/00/3423/8
9	Feasibility Design Report – Pipeline, Pump Stations and Reservoirs	P WMA 06/D00/00/3423/9
10	Socio-Economic Impact Assessment and Legal, Institutional and Financing Arrangements Report	P WMA 06/D00/00/3423/10
11	Feasibility Design Report – Water Treatment Works	P WMA 06/D00/00/3423/11
12	Land Matters	P WMA 06/D00/00/3423/12
13	DFFE Application Submission	P WMA 06/D00/00/3423/13
14	Public Participation Report	P WMA 06/D00/00/3423/14
15	DFFE BAR Submission	P WMA 06/D00/00/3423/15
16	**Summary Feasibility Study Report**	**P WMA 06/D00/00/3423/16**
17	Water Use License Application Summary Report	P WMA 06/D00/00/3423/17
18	Integrated Water and Waste Management Plan	P WMA 06/D00/00/3423/18
19	Water Resource Analysis Report	P WMA 06/D00/00/3423/19

Reference

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa. 2023. *Greater Manguang Water Augmentation Project – Xhariep Pipeline Feasibility Study: Summary Feasibility Study Report*.

DWS Report Number: P WMA 06/D00/00/3423/16

Prepared by Zutari (Pty) Ltd

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Abbreviations

Acronyms

Acronym	Description
AOA	Annual Operating Analysis
BAR	Basic Assessment Report
CAPEX	Capital Expenditure
DFFE	Department of Forestry, Fisheries and Environment
DOC	Dissolved Organic Carbon
DWS	Department of Water & Sanitation
ECSA	Engineering Council of South Africa
GBWSS	Greater Bloemfontein Water Supply System
GDP	Gross Domestic Product
LiDAR	Light Detection and Ranging
LRA	Land Rights Administration
MMM	Mangaung Metropolitan Municipality
NEMA	National Environmental Management Act
NPV	Net Present Value
NWRP	DWS Directorate: National Water Resource Planning
O&M	Operations & Maintenance
OPEX	Operational Expenditure
P&G	Preliminary and General
PPP	Public Participation Process
SANRAL	South African National Roads Agency Limited
URV	Unit Reference Values
VCWB	Vaal Central Water Board
VSD	Variable Speed Drive
WRYM	Water Resource Yield Model
WTW	Water Treatment Works
WULA	Water Use License Application

Measurement Units

Symbol	Description
km	Kilometres
m	Meters
m^3/s	Cubic meters per second
million m^3	Million cubic meters
million m^3/a	Million cubic meters per annum
Mℓ/d	Megalitres per day

1 Introduction

1.1 Background

The Water Reconciliation Strategy Study for the Larger Bulk Water Supply Systems: Greater Bloemfontein Area (DWS, 2012), henceforth referred to as the “2012 Reconciliation Strategy”, identified that the Greater Bloemfontein Water Supply System (GBWSS) would need to secure a sustainable water supply for the future water demands in the area. The 2012 Reconciliation Strategy recommended that the development of a major surface water augmentation scheme should be given consideration as a possible option in conjunction with the implementation of various other interventions.

Following the 2012 Reconciliation Strategy, the area experienced water shortages and the major surface water augmentation scheme, now called the Greater Mangaung Water Augmentation Project – Xhariep Pipeline, was accelerated. Vaal Central Water Board (VCWB), previously known as Bloem Water, and Mangaung Metropolitan Municipality (MMM) independently investigated the same three route options from Gariep Dam to tie-in points within the GBWSS area (see Figure 1-1). Each institution reached a different conclusion as to which of the three was the best route/scheme.

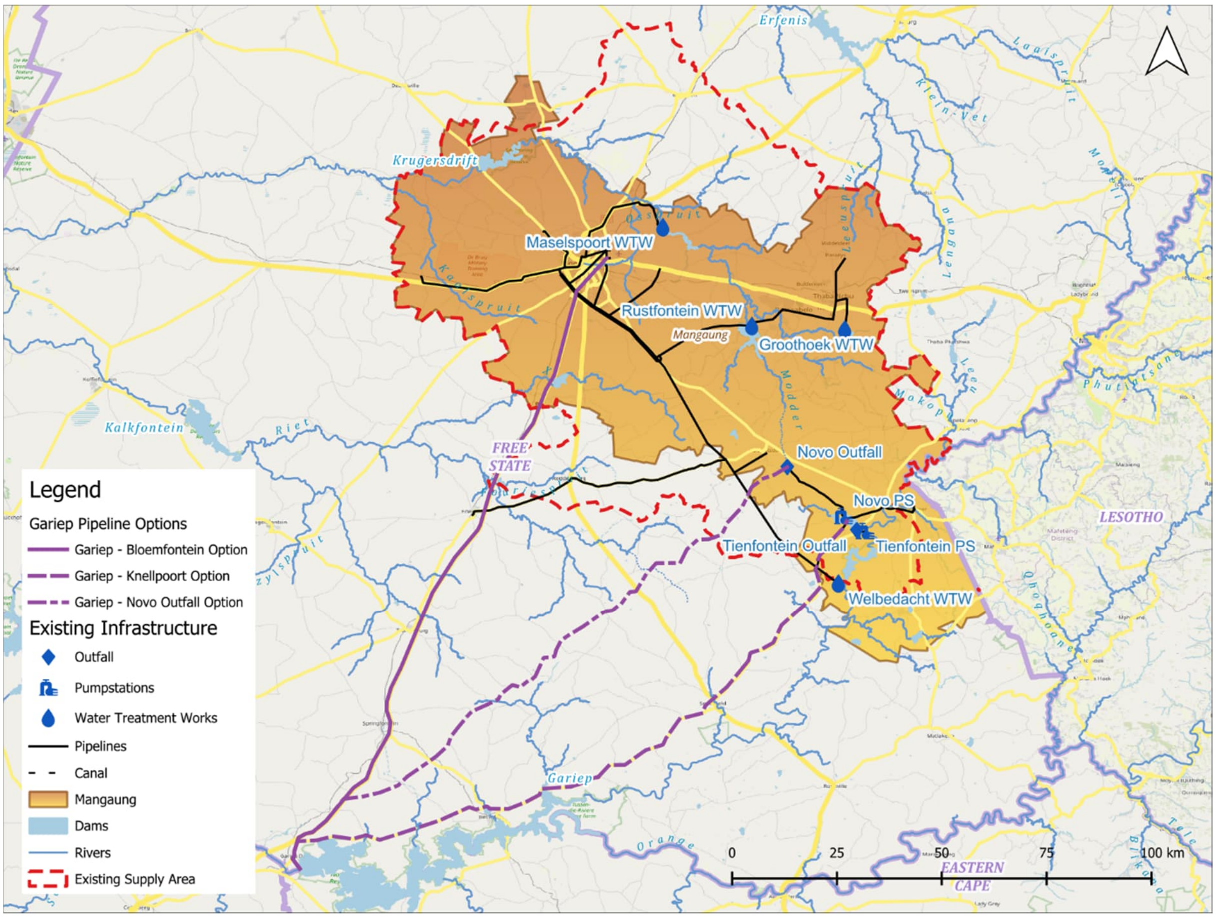

Figure 1-1: Previously studied route options from Gariep Dam to the GBWSS

The Xhariep Pipeline project was and remains of critical importance to address growing water demands on a regional basis; thus the Department of Water and Sanitation (DWS) appointed Zutari to complete the pre-feasibility study, which included reviewing all previous studies, and recommending the optimal scheme from a national and regional perspective. This included determining routing and sizing to be taken forward to a detailed feasibility stage. Upon completion of the pre-feasibility stage, DWS approved the preferred option, whereafter Zutari carried out the detailed feasibility study, the water use license application and the environmental authorisation process. The detailed design of the Xhariep Pipeline project, and the preparation of the procurement documentation, will be the subject of a future appointment and did not form part of this project.

1.2 Study Objectives

The pre-feasibility study conducted an independent investigation that built on the information collected and analysed in previous work. After DWS approved the preferred option as identified in the pre-feasibility stage, the detailed feasibility stage proceeded. As the study was complex, additional factors were considered in the detailed feasibility stage. The objectives are listed in Table 1-1.

Table 1-1: Objectives of the Xhariep Pipeline Feasibility Study

Prefeasibility Study	Detailed Feasibility Study	Additional Feasibility Considerations
1. Evaluate options for the Greater Mangaung Water Augmentation Project with Gariep Dam as the source. 2. Conduct additional pre-feasibility level investigations. 3. Select the optimal size, phasing, and configuration of the best water conveyance infrastructure option. 4. Present to PSC and DWS for approval to take forward into the Detailed Feasibility Study.	1. Assess the technical, financial, economic, and environmental aspects at detailed feasibility level. 2. Assess the risks and redundancy of the proposed bulk infrastructure system when operated in conjunction with the existing bulk infrastructure. 3. Assess the impact of the project on existing systems including the Orange River System (ORS). 4. Maximise the integration and utilisation of the available capacities in the existing infrastructure. 5. Conduct stakeholder engagement workshops.	1. Institutional arrangements for ownership and operation. 2. Financing options. 3. Affordability and bankability in line with the National Treasury guidelines. 4. Opportunities for phased implementation. 5. Stakeholder preferences.

The pre-feasibility and detailed feasibility study was a continuation of the 2012 Reconciliation Strategy and focused specifically on the recommendation that a major surface water augmentation scheme was required, in addition to the implementation of various other interventions, to ensure a sustainable water supply to the GBWSS until at least 2050.

This study did not address but assumed the other interventions identified in the 2012 Reconciliation Strategy (e.g. construction of a bi-directional pipeline between Knellpoort and Welbedacht Dams, increasing the Tienfontein pump station's pumping capacity, implementation of a re-use of treated effluent scheme, etc.) will be implemented. It is, however, important to note that these other interventions are still required in addition to the Xhariep Pipeline project to satisfy the projected 2050 water demands. It was therefore assumed that the interventions will be implemented prior to the Xhariep Pipeline becoming operational.

1.3 Report Structure

The purpose of this Summary Feasibility Study Report is to present the findings from the detailed feasibility design in a concise and non-technical document. The report is structured as follows:

Chapter 1 presents the background and objectives of the study.

Chapter 2 summarises the pre-feasibility study findings to provide context for the feasibility study.

Chapter 3 describes the site investigations undertaken.

Chapter 4 summarises the feasibility design of the pipelines, pump stations and reservoirs.

Chapter 5 contains a summary of the water treatment works design.

Chapter 6 describes the Authorisation processes and status.

Chapter 7 presents the findings of the socio-economic impact assessments and the legal, institutional and financing arrangements.

Chapter 8 presents the estimated project cost for implementation.

Chapter 9 contains the estimated implementation programme.

Chapter 10 describes the conclusions and recommendations from the study.

2 Pre-Feasibility Study Findings

2.1 Water Requirements

A water requirement projection was conducted to determine the required supply needed to meet the water requirements of the GBWSS up to the year 2050. This study assessed water requirements using two approaches:

1. Historic Trend Analysis – this method estimated future requirements by analysing past water consumption and assuming a similar growth rate over time.
2. Population-Based Analysis – the approach used population data from Stats SA and considered an improvement in level of service, assuming that by 2050, all households in the project area will have a house connection.

The analysis projected a 2050 water requirement of 180 million m³/a using the historic trend approach and 186 million m³/a for the population-based approach. These estimates aligned well with previous projections from the 2018 MMM study and the DWS 2022/23 Annual Operating Analysis (AOA). The population-based estimate of 186 million m³/a was adopted as the 2050 water requirement target for the GBWSS. This analysis also included potential future water requirements from towns and villages within 10km of the proposed pipeline route, should these towns wish to connect to the Xhariep Pipeline in future.

2.2 Water Resources Analysis

The Water Resource Yield Model (WRYM) was used to determine the potential increase in the yield of the GBWSS due to abstraction of water from the Gariep Dam. Various scenarios were analysed and operating rules adjusted to determine the minimum volume that can be transferred from the Gariep Dam that will ensure that the 2050 water requirements can be satisfied.

It was determined that, for the preferred scheme selected at the end of the pre-feasibility phase, a transfer capacity of 101 million m³/a was required from Gariep Dam to meet the 2050 water requirements. This transfer capacity was based on the following additional interventions being implemented timeously by MMM and VCWB:

- The bi-directional pipelines between Knellpoort and Welbedacht Dams,
- Upgrading the Tienfontein Pump Station capacity to 7 m³/s,
- A re-use scheme with a yield of 12.9 million m³/a, and,
- Raising the full supply levels of Knellpoort and Rustfontein Dams by 2 m.

The raising of Knellpoort and Rustfontein Dams was not considered as part of the 2012 Reconciliation Strategy but was identified as an intervention during this study to improve the operational flexibility of the overall system and to marginally reduce the volumes to be transferred from Gariep Dam. It was recommended in the Water Resource Analysis Report that the operating rules be further refined and that the impact of operational recommendations from earlier Annual Operating Analyses (AOA) be evaluated, which would inform the need to implement the raising of the two dams and if so, the timing thereof.

A long-term stochastic analysis confirmed that the proposed potable water transfer scheme at a capacity of 101 million m³/a can meet the GBWSS requirements at least 98% assurance of supply assuming the above additional interventions are implemented timeously.

Description	Additional Yield (million m³/a)	Cumulative Yield (million m³/a)
Current System Yield	-	65

Description	Additional Yield (million m³/a)	Cumulative Yield (million m³/a)
Bi-directional Pipeline	17	82
Tienfontein Pump Station Upgrade	8	90
Re-use Scheme	12	102
Raising Knellpoort and Rustfontein Dams	7	109
Impact of developments in Upper Caledon catchment by 2035	-14	95
Further impact of developments in Upper Caledon catchment by 2050	-10	85
Xhariep Pipeline	101	186[1]

[1] – calculated system yield for 2050, factoring reduction in system yield due to upstream developments.

2.3 Scheme Development

The yield modelling results were used as a basis for the development of feasible bulk water and water treatment infrastructure schemes that could meet the 2050 demands. To develop technically feasible schemes for costing, the required flows from the yield model were compared with the existing bulk water and water treatment infrastructure. The capacity shortfalls were identified to quantify the required upgrades for inclusion in the proposed schemes.

To kick off the pre-feasibility study, four schemes were investigated and included one potable water scheme (Scheme 1) and three raw water schemes (Schemes 2, 3 & 4), see Figure 2-1, with a maximum transfer volume of 60 million m³/a. The ability of each scheme to satisfy the 2050 demands to Bloemfontein and the towns of Botshabelo and Thaba Nchu was based on the yield model outflows at the respective water treatment works (WTWs). While none of the original four schemes were able to fulfil the 2050 demand projections, Schemes 1 and 4 were shown to be the most economical potable and raw water options respectively. Therefore, additional yield modelling was recommended for these schemes to determine the flows from Gariep Dam that would satisfy the 2050 water demands.

It was shown that the potable water Scheme 1A and raw water Scheme 4B, shown in Figure 2-1 below, required a maximum transfer volume of 120 million m³/a and 142 million m³/a respectively to produce historic firm yields of 186 million m³/a in the system. The increased transfer volume showed that Scheme 4B could, for the most part, satisfy the demands. However, Scheme 1A still had a 23% shortfall in supplying the 2050 demands to the towns of Botshabelo and Thaba Nchu.

Upon consultation with DWS, MMM and VCWB, it was evident that neither Scheme 1A nor 4B would enable efficient distribution of water throughout the GBWSS. Scheme 1B, a hybrid of 1 and 4, was developed to distribute the water from Gariep Dam to Bloemfontein, Botshabelo and Thaba Nchu more efficiently. Scheme 1B (hybrid) is a potable water transfer scheme that comprises of a modified Scheme 4B pipeline alignment which terminates at a command reservoir. This arrangement optimises the distribution characteristics of Scheme 4B whilst retaining the resilience of supply in the system from the proposed new WTW in Scheme 1A. Scheme 1B can supply all 2050 water demands and was technically preferred for its optimisation potential and operating flexibility. Additionally, it was shown to be economically comparable to Schemes 1A and 4B. Therefore, Scheme 1B was presented to DWS and the Project Steering Committee and was subsequently recommended as the preferred solution to be taken forward in the detailed feasibility design.

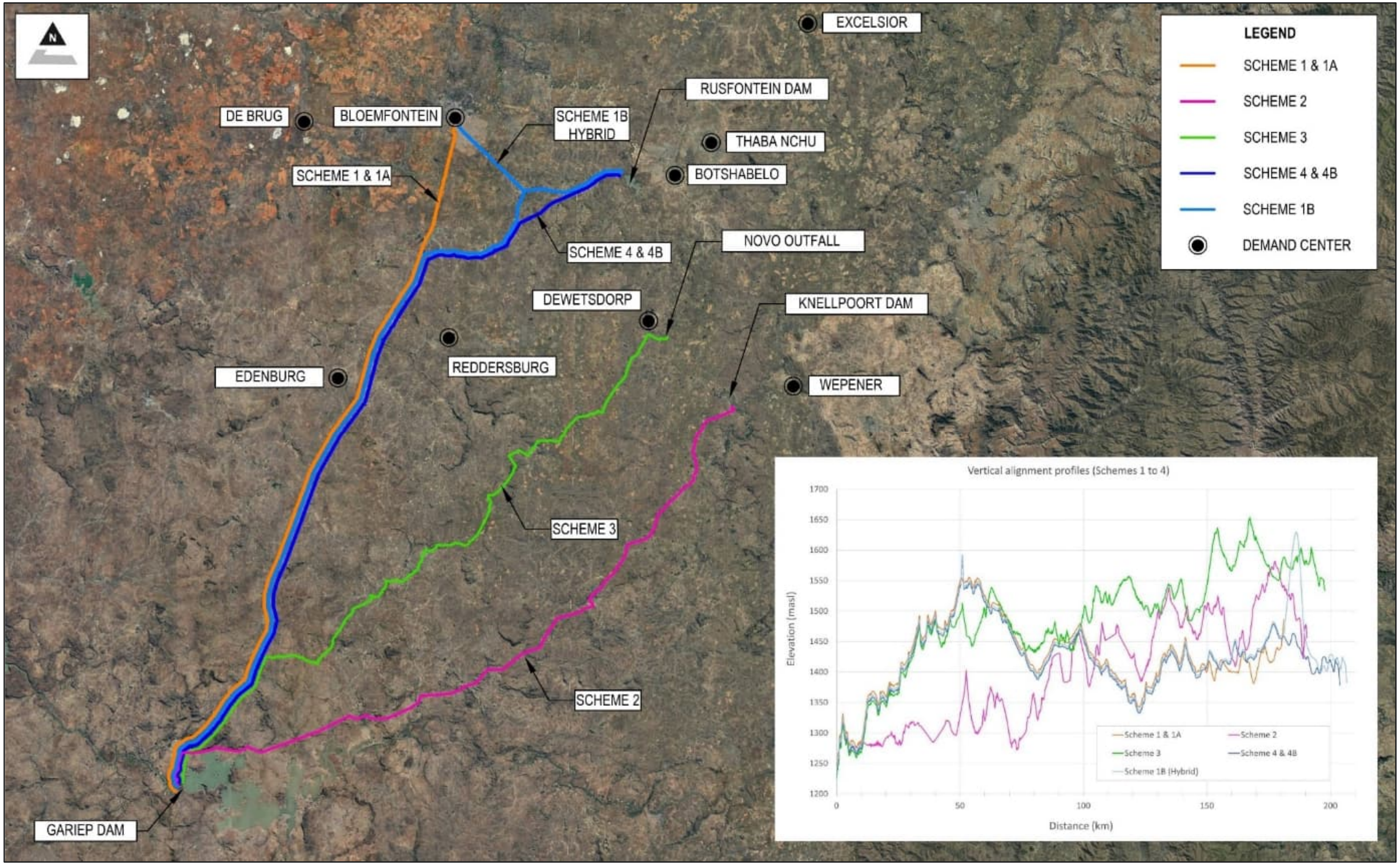

Figure 2-1: Plan layout of bulk water pipeline routes and vertical profiles for all schemes

2.4 Proposed Bulk Water Infrastructure for Scheme 1B

Three alternative configurations were assessed as part of the design optimisation of Scheme 1B. These alternative configurations mainly evaluated different locations for the booster pump station, different elevations for the second command reservoir, and connecting pipeline sizes between the second command reservoir and Bloemfontein as well as the second command reservoir and Rustfontein WTW. The Net Present Values (NPVs) and the Unit Reference Values (URVs) for the three configurations were calculated. The URVs of the three configurations differed by less than 2%, meaning that the configurations were comparable from a financial perspective. The configuration with the gravity supply from a command reservoir to Longridge Reservoir (Bloemfontein) and Rustfontein WTW was recommended.

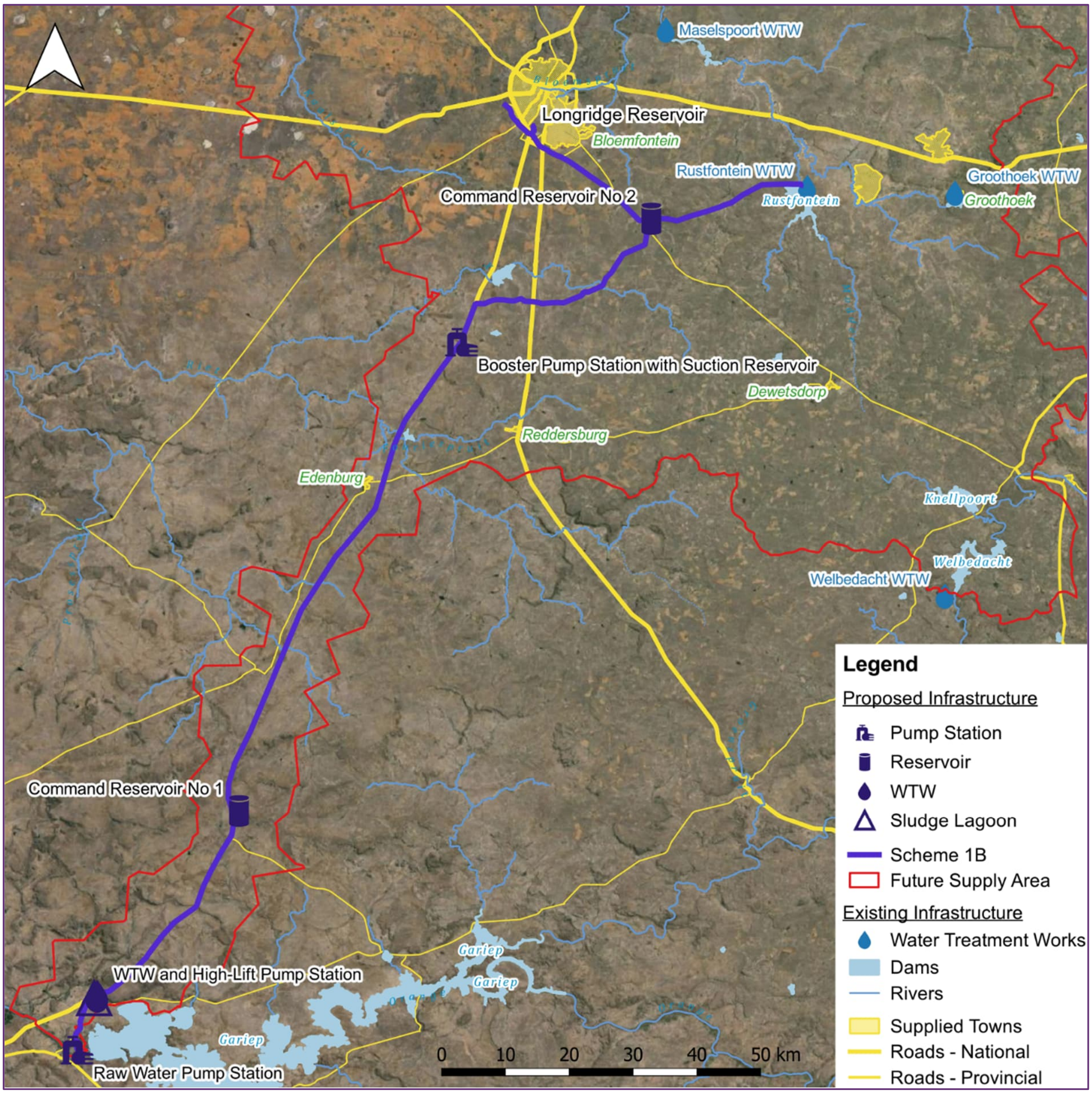

Figure 2-2: Schematic of optimised Xhariep Pipeline Scheme 1B

The detailed feasibility design was based on DWS "Technical Guidelines for the Development of Water and Sanitation Infrastructure", see Section 2.2 of the Feasibility Design Report – Pipelines, Pump Stations and Reservoirs (Ref No.: P WMA 06/D00/00/3423/9) for additional detail. It was determined, from the design flow calculations, that the raw water infrastructure had to be sized for a peak week flow of 3.797 m³/s (329 Mℓ/d), whereas the potable infrastructure, including the WTW, had to be sized for a peak week flow of 3.616 m³/s (312 Mℓ/d). The two command reservoirs were sized for 6 hours storage at the peak week flow rate of 3.616 m³/s (312 Mℓ/d), equating to a storage capacity of 80 Mℓ per reservoir.

A summary of the design capacity of the main infrastructure components are provided in Table 2-1.

Table 2-1: Summary of design capacity of main infrastructure components of Scheme 1B

Infrastructure component	Capacity / Size
Low-lift pump station	3,797 m³/s
Water treatment works	312 Mℓ/d
High-lift pump station	3,616 m³/s
1st command reservoir	80 Mℓ (1)
Booster pump station	3,616 m³/s
2nd command reservoir	80 Mℓ (1)

(1) 6 hours x pump rate of 312 Mℓ/d = 78 Mℓ storage. Reservoir sizes designed for 80 Mℓ storage.

3 Site Investigations

3.1 Topographical Survey

Details of the topographical survey undertaken for the project are contained in the Topographical Survey and Mapping Report (Ref No.: P WMA 06/D00/00/3423/8). A summary of the salient aspects from the report is provided below.

The topographical survey comprised:

- A Light Detection and Ranging (LiDAR) survey complete with installation of ground control points;
- Digital colour images of the project area;
- Installation and surveying of control points; and
- Field topographical in-fill surveys at streams, rivers and culverts.

Access to certain sections of the project was not granted by the respective landowners and/or authorities and the affected sections had to be excluded from the scope. This included the area where Command Reservoir No 2 is to be located and where the proposed pipeline infrastructure needs to tie in at Longridge and Brandkop Reservoirs in Bloemfontein. It is important that access to these areas be resolved and that the survey for these sections be completed during the detailed design phase.

The following is a summary of the topograhical survey deliverables produced under this project:

- CAD design files in Microstation DGN, DWG and DXF format showing:
  - Orthophoto tiles and LiDAR point block layout
  - The surveyed project area with boundaries
  - Contours at 0.5m, 1m and 2m intervals (Note – these contours have been smoothed and are merely an aesthetic representation of the ground shape)
- Ortho-rectified aerial images in GEOTIFF and ECW format with an 10cm pixel resolution.
- Composite Image in ECW format at 0.5m
- 1m Raster DEM
- 1m Elevation Grid
- Google Earth Overlay in KMZ format at 0.5m
- Full LiDAR points in LAS1.4 format

3.2 Geotechnical Field Investigations

Details of the geotechnical field investigations undertaken for the project are contained in the Geological and Materials Investigation Report (Ref No.: P WMA 06/D00/00/3423/7). A summary of the salient aspects from the report is provided below.

The fieldwork investigation included:

- Test pits at 400 m intervals;
- In-situ DCP and DPSH tests;
- An electrical resistivity survey at 200 m intervals;
- Rotary core drilling, with in-situ SPT tests at 1.5 m intervals within the soil profile at the proposed structure positions, road / railway crossings and major river / stream crossings; and
- Laboratory testing.

As per the topographical survey, access was not available to certain sections of the project. The geotechnical field investigations need to be completed for these sections during the detailed design phase, especially for Command Reservoir No 2.

The investigation along the proposed pipeline route and at the major structures (i.e. pump stations, reservoirs and water treatment plant) found that:

- The ground conditions are generally characterized by shallow bedrock (0.1 m to 3.8 m below ground level) that is covered by a combination of silty sand, clayey silt and silty to sandy clay that has calcrete formation towards the bottom of the transported deposits. Occasional hardpan calcrete was also encountered. The bedrock mostly consists of interbedded sandstone, mudstone and shale from the Karoo Supergroup, that is locally intruded by dolerite.
- Deeper rock levels were noted along approximately 7% of the pipeline route which is generally related to wetlands, rivers and streams.
- Groundwater levels typically vary across the pipeline route, with seepage noted within 2 % of the test pits, ranging between 0.5 m to 3.8 m below surface. Here seepage was generally found within bedrock at stream and river crossings.
- The electrical resistivity survey found that approximately 83% of the surveyed sections along the pipeline route traverse soils which range from mildly corrosive to extremely corrosive to buried steel, which was confirmed by the pH and conductivity test results. Therefore, cathodic protection will be required. It is highly recommended that BRE/DIN chemical testing be done during the detailed design phase to be more accurate in determining the corrosivity of the soil towards steel and aggressiveness towards buried concrete.
- Samples taken were from test pits to determine the material quality to be considered for use during construction. The results showed that all of the excavatable material over the area generally classifies as G9 – >G9 according to COLTO specifications and was not suitable for use as bedding or engineered fill. Locally some of the colluvium, residual dolerite and residual sandstone tested as G7 - G6, but it was variable and good quality control would be required should this material be considered.

With the pipe invert level between 3.0 – 4.5 m below surface, most of the pipeline will be situated within bedrock. Localised blasting is anticipated through hard rock dolerite.

3.3 Land Matters

The proposed Xhariep Pipeline Project traverses multiple properties which some are privately owned agricultural land and to a lesser extent on land owned by the Government of South Africa, the South African National Roads Agency Limited (SANRAL), Eskom servitudes, the Free State Department of Community Safety, Roads and Transport, and Transnet.

A comprehensive public participation process (PPP) was undertaken as part of the environmental authorisation and the water use licence process, see Section 6. The findings from the PPP are documented in the Public Participation Report (Ref. No. P WMA 06/D00/00/3423/14). This report contains all the comments received, as well as the responses shared to these comments, which require consideration during the detailed design phase of the project. It is important to note that no appeal was received against the environmental authorisation.

During the detailed design phase, servitudes will need to be registered to facilitate the future operation and maintenance of the Xhariep Pipeline Project. The registration of these servitudes and the associated financial compensation is handled by the Sub Directorate: Land Rights Administration (LRA), which is the unit within DWS responsible for all land related matters for the DWS water infrastructure, country wide. The LRA needs to be engaged as soon as the detailed design phase has progressed to a point where communication with affected landowners can commence.

4 Xhariep Pipeline Feasibility Design

4.1 Infrastructure Components

The main infrastructure components of Scheme 1B, as shown in Figure 2-2, include the following:

- Tie-in at the existing DN2100 pipeline downstream of the Gariep Dam wall,
- A pipeline from the Gariep Dam to the Raw Water Pump Station (± 2 km long),
- The Raw Water Pump Station,
- A pipeline from the Raw Water Pump Station to a break pressure tank (± 2 km long),
- A pipeline from the break pressure tank to the Xhariep WTW (± 9 km long),
- The Xhariep WTW, designed for a capacity of 312 Mℓ/d of which 208 Mℓ/d will be constructed as Phase 1, with a future 104 Mℓ/d to be constructure later. The site will, however, be planned for an ultimate capacity of 416 Mℓ/d,
- The High Lift Pump Station located at the WTW site, which will pump water to Command Reservoir No 1,
- The pipeline from the High Lift Pump Station to Command Reservoir No 1 (± 43 km long),
- Command Reservoir No 1 (80 Mℓ storage),
- A pipeline from Command Reservoir No 1 to the Booster Pump Station (± 95 km long),
- A Booster Pump Station with Suction Reservoir (10 Mℓ storage),
- A pipeline from the Booster Pump Station to Command Reservoir No 2 (± 44 km long),
- Command Reservoir No 2 (80 Mℓ storage),
- A pipeline from Command Reservoir No 2 to the existing Rustfontein WTW (± 25 km long), and,
- A pipeline from Command Reservoir No 2 to the existing Longridge Reservoirs (± 28 km long).

4.2 Pipeline Diameter Optimisation

The pipeline diameters of the pumping mains were optimised based on NPV calculations that considered capital, maintenance and operational costs. Various sensitivity analyses were undertaken that considered different discount rates, growth patterns in water demand, inflation rates for energy costs, etc. The recommended optimum diameters for the pumping mains are:

- Pipeline from the Raw Water Pump Station to a break pressure tank = DN 1800,
- Pipeline from the High Lift Pump Station to Command Reservoir No 1 = DN 1800, and,
- Pipeline from the Booster Pump Station to Command Reservoir No 2 = DN 1800.

The pipeline diameters for the gravity pipelines were determined based on the available head and the design flow rates. The recommended optimum diameters for the gravity pipelines are:

- Pipeline from Gariep Dam to the Raw Water Pump Station = DN 1800,
- Pipeline from the break pressure tank to the Xhariep WTW = DN 2000,
- Pipeline from Command Reservoir No 1 to the Booster Pump Station = DN 1800,
- Pipeline from Command Reservoir No 2 to the existing Rustfontein WTW = DN 1400, and,
- Pipeline from Command Reservoir No 2 to the existing Longridge Reservoirs = DN 2000.

4.3 Pump Station Design

4.3.1 Pump Selection

The duty points for the three pump stations (i.e. raw water pump station, high-lift pump station and booster pump station) were calculated based on the optimised pipe diameters. The pump types available to achieve the required duty points were evaluated, concluding that horizontal split-casing and vertical turbine pumps were the only pump options that could deliver the required flows and heads. The horizontal split-casing pumps were, however, preferred as they are more economical and easier to operate and maintain.

All three pump stations were designed with a three duty, one standby, pump configuration. Critical aspects such as operating speed, hydraulic efficiency, net positive suction head required, and head rise to shut-off head were evaluated for each pump selection.

The Raw Water Pump Station pump sets will be fitted with variable speed drives (VSDs), whereas the other two pump stations will operate at fixed speed. The VSDs are required due to the large fluctuation in water levels within Gariep Dam and to ensure that the raw water flow matches the flow to be treated at the proposed Xhariep WTW.

4.3.2 Pump Station Layout

The pump station layouts were based on the sizes of the mechanical and electrical equipment required. Provision was made for storage rooms, offices, loading bays and control rooms at each pump station. Refer to the Feasibility Design Report – Pipeline, Pump Stations and Reservoirs Report (Ref No.: P WMA 06/D00/00/3423/9) for details, including renderings of the building and mechanical works.

4.4 Pipeline Design

A hydraulic and water hammer analysis was undertaken to determine the maximum working and surge pressures. To mitigate excessive surge pressures during a pump trip event, non-return valves were recommended at the following locations:

- Pipeline from Raw Water Pump Station to break pressure tank = at chainage 4,100 m, approximately 100 m upstream of the break pressure tank,
- Pipeline from High Lift Pump Station to Command Reservoir No 1 = at chainage 38,500 m, and,
- Pipeline from Booster Pump Station to Command Reservoir No 2 = at chainage 43,000 m.

The maximum design and field test pressure for each pipeline was determined in accordance with DWS1110, which states that “Test pressures will generally be 1.25 times the pipeline design pressure for design pressures up to and including 3.2 MPa and 1.1 times the design pressure for higher pressures”.

Based on the pipe diameters and operating pressures, steel was considered the only feasible pipe material for the project. Grade X52 steel, with a yield strength of 358 MPa, is recommended. The pipeline structural design was based on AWWA M11 guidelines, but using the factors of safety recommended by DWS, i.e. a factor of safety of 1.67 for both the working and surge pressures. It was calculated that wall thicknesses will vary from 8 mm on the DN 1400 pipelines up to 22 mm on the DN 1800 pipeline, immediately downstream of the high-lift pump station.

Various options are available for the pipe lining (e.g. cement mortar, epoxy) and coating (e.g. polymer modified bitumen, fusion bonded medium density polyethylene, trilaminate polyethylene, rigid polyurethane, etc.). The preferred lining and coating need to be selected during the detailed design phase in consultation with the entity responsible for the operation and maintenance of the pipelines.

Other pipeline aspects considered, included the sizing of air valves and scour valves, the installation of inline isolation valves, the provision of off-takes to end-users from the bulk pipelines, river and stream crossings, road crossings and dealing with existing services.

4.5 Reservoir Design

Three types of reservoirs were considered for command reservoirs with a storage capacity of 80 Mℓ, namely:

(a) Conventional above ground post-tensioned circular reinforced concrete reservoirs,
(b) Conventional above ground circular or rectangular reinforced concrete reservoirs, and,
(c) Earth-fill embankment type reinforced concrete lined reservoirs.

It was established that earth-fill embankment type reinforced concrete lined reservoirs will be the most economical of the three reservoir types.

5 Xhariep Water Treatment Works Design

5.1 WTW Capacity

The capacity of the plant was dictated by the requirements of the scheme as defined in the Pre-feasibility Study Report (Ref No.: P WMA 06/D00/00/3423/5). The required plant capacity is 312 Mℓ/d. The site planning however provides for an additional 104 Mℓ/d to facilitate future plant expansion. The total planned site capacity is therefore 416 Mℓ/d. The sizing horizon for the WTW is 30 years.

The design of the WTW was based on the establishment of two clusters of treatment infrastructure, each consisting of two semi-independent trains of 104 Mℓ/d each. Each cluster then has a capacity of 208 Mℓ/d. It was anticipated that the site will be developed to deliver 208 Mℓ/d at first and then to be augmented with a further 104 Mℓ/d around 10 years later at which time the capacity of the WTW will be 312 Mℓ/d. The further provision of 104 Mℓ/d was not scheduled but will allow for consideration of delivery to the south of the proposed WTW as well as further distribution into the southern Free State Province. The plant design will reach the target daily production capacity in 22 hours per day.

5.2 Raw Water Quality Assessment

Several sources of data were consulted to define the quality of raw water to be treated at the proposed WTW. These included historical data for the Gariep Dam from the archives of DWS, historical data for the existing Gariep Dam WTW which was obtained from VCWB, and an in-depth monitoring programme which was undertaken as part of this study. The latter consisted of 12 samples over the period spanning March 2024 to August 2024 (6 months) and which focussed on gaps identified in the DWS and VCWB data.

The analysis of the raw water quality indicates the following treatment requirements after evaluation and consideration of the errant data:

- Turbidity levels are moderately high and require treatment intervention.
- Total aluminium levels are high. The dissolved aluminium levels are very low and do not require treatment. The non-dissolved fraction will be removed along with general turbidity if care is taken not to re-dissolve the aluminium through extensive pH manipulation.
- The microbiological indicators will be removed adequately through normal disinfection protocols. No positive results were noted for chlorine resistant cysts or oocysts in any of the water qualty data sets.
- A small number of datapoints reflected very high dissolved organic carbon (DOC) levels. All the high values were however reported prior to 2003. Subsequent reports all indicated DOC levels below the national standard. No specific treatment regimes are included to address organic carbon removal.
- Both the Ryznar index as well as Calcium Carbonate Precipitation Potential (CCPP) indicate that the water is aggressive and will require stabilisation.
- The additional sampling of the water source and analysis for a significantly expanded set of parameters indicated little to no risk associated with chlorophyll-a or contaminants of emerging concern at the proposed treatment plant.
- Some historical data sets indicate a number of determinands are present at levels of concern. The high initial values are likely the result of laboratory detection limits exceeding the specified water quality targets.The latest data sets indicate that these values, when appropriately analysed, are below levels of concern.

Based on the available water quality data the water can be described as of very good quality. Turbidity, microbiology, and stability are the only determinants requiring particular attention. Conventional flocculation, settling and filtration are proposed. A comparable process is currently successfully employed at the Gariep Dam WTW. The new Xhariep WTW will additionally focus on stabilisation and a suitable disinfection strategy.

Laboratory tests indicate that the preferred flocculant for treatment of the source water was a poli-aluminium chloride flocculant. The average design dosage of 12 mg/ℓ and maximum of 35 mg/ℓ are informed by laboratory tests as well as current operational experience at the existing Gariep Dam WTW.

Water quality data and laboratory tests indicate that stabilisation was required to achieve the required CCPP target of 2 to 5 mg/ℓ. An options analysis indicates that hydrated lime at around 5 to 10 mg/ℓ was the most economical approach to stabilisation.

A chlorine demand study was undertaken that indicated a single chlorine dose at the treatment plant would not be sufficient to sustain chlorine levels in the transfer system. Chloramination cannot be considered as MMM does not presently receive chloraminated water from its other sources and the mixing of chloraminated and non-chloraminated water cannot be permitted. The system will therefore be chlorinated with a booster injection of chlorine at the Booster Pump Station at which time the water will have been in the transfer system for around 48 hours. Chlorine decay models indicate that this approach will result in a chlorine residual being present in the water when it reaches the receiving reservoirs in Mangaung. A comparison of chlorination systems indicated that chlorine gas systems are more economical than on-site chlorine generation systems. This report is based on the use of 1 tonne chlorine gas drums. More economical gas delivery approaches may be available, but this can only be confirmed following direct negotiation with chlorine gas suppliers.

Main disinfection will take place in the on-site storage reservoir. The reservoir will be partitioned to allow for 30 minutes of contact time. At a residual level of 4 mg/ℓ chlorine the CT-requirement for Giardia, Cryptosporidium as well as viruses will be satisfied. The stated chlorine level was required to ensure a residual of chlorine remains present when the water reaches the chlorine booster station. The total chlorine dose at the WTW was estimated to be in the order of 6.7 mg/ℓ on average and 7.9 mg/ℓ at maximum. The booster dosage requirement was estimated to be 3 mg/ℓ.

The chlorine dosing requirements are high and suggest that trihalomethane production may be a risk. Laboratory tests indicate a marginal risk for this albeit at higher chlorine dosages and on untreated water. Trihalomethanes will have to be monitored as a risk determinand once the WTW is in operation.

5.3 Treatment Technology

The treatment technology proposed for the WTW can be described as conventional:

- Flocculation and clarification will take place in a pulsator clarifier. Experience at other treatment sites along the Orange River indicate that pulsators operate acceptably if routine maintenance is in place. The pulsators also typically operate at higher rates than horizontal settlers and radial flow clarifiers resulting in a smaller footprint and lower costs. The proposed design was based on a loading rate of 2.5 m/h which was conservative for pulsators but will be appropriate for the occasional turbidity peaks that may exceed 200 NTU in extreme cases. A total of 12 separate pulsators will be required to deliver 312 Mℓ/d. The modular design will allow for diversion of flow to the remaining units if a unit is to be removed from operation for maintenance purposes.
- The rapid gravity sand filters are designed for deep penetration of floc into the filter bed. The filter beds are 1 m deep and the effective media size (d_{10}) is 0.9 mm. The filter will be cleaned using a combined air and water scour to facilitate collapse pulsing which will be followed by a water rinse. A total of 30 filters, with a surface area of 84.7 m^2 each, are required to deliver 312 Mℓ/d. The filter loading rate is 6 m/hr with all 30 filters operational and 6.67 m/hr if three filters have been removed from operation for maintenance purposes.

Treatment residuals will be thickened in sludge ponds. Mechanical thickening was not considered as an alternative due to the additional operational complexity that this brings to a WTW as well as the fact that sufficient land is available to allow for consideration of the low cost and effort alternative of ponds. Pond supernatant will be returned to the inlet works to ensure efficient use of the water resource. An options analysis was undertaken to compare various pond construction approaches. A Hyson cell lined pond was found to be most cost effective. The lining will allow for mechanical cleaning of the pond at a higher frequency than for clay lined ponds, hence a smaller pond area can be specified, and at a lower cost than comparably sized concrete lined ponds.

5.4 Support Buildings

The following support buildings have been included in the feasibility design:

- Administration and control building with a laboratory, meeting rooms, control offices and staff facilities;
- A maintance workshop with workshop floor area supported by overhead cranes, store areas, offices, meeting rooms and facilities for maintenance personnel; and
- Chemical storage areas for bulk chemical storage and housing of dosing equipment. Chlorine is stored and controlled from separate facilities that can be developed in a phased manner.

All structures, services and installed plant shall be designed and constructed to meet DWS standards as well as the WTW owner's standards where these exceed the requirement of DWS.

5.5 Mechanical and Electronic Works

The mechanical equipment selections, power ratings and capacities are preliminary, and will be finalised during detailed design. The estimated rated power consumptions required for Phase 1 (208 Mℓ/d) and Phase 1 and 2 (312 Mℓ/d) was 664 kW and 1152 kW respectively. This excludes the High Lift Pump Station.

The design approach for the electronic works shall achieve the following:

- Centralised control of the WTW allowing for easy and convenient operation.
- The installation can be controlled and monitored remotely from the administration building's SCADA, the Xhariep scheme's remote command centre or in the field at the Human Machine Interfaces (HMI) at various possible locations, like filters and dosing systems.

6 Authorisation Processes

6.1 Environmental Authorisation

The Xhariep Pipeline entails certain activities that require authorisation in terms of the National Environmental Management Act (Act No. 107 of 1998) (NEMA). The process for seeking authorisation for Xhariep Pipeline was undertaken in accordance with the EIA Regulations (Government Notices No. R385, R386 and R387 of 21 April 2006), promulgated in terms of Chapter 5 of NEMA. This process incorporated the following:

- Environmental Screening (part of Pre-feasibility Study),
- Public Participation,
- Basic Assessment Application, and,
- Basic Assessment Report (BAR, part of the Feasibility Study).

The BA Application, Public Participation Report and BAR Submission are part of the suite of public reports available for this project (Ref. No.: P WMA 06/D00/00/3423/13, P WMA 06/D00/00/3423/14 and P WMA 06/D00/00/3423/15 respectively).

Authorisation for the project was received on 26 September 2024, with DFFE Ref. No. 14/12/16/3/3/1/2996 and is valid for a period of 10 years.

6.2 Water Use License Application

All water use licences required in terms of Section 27 of the NWA during construction and operation of the Project must be obtained for the authorisation of such use. A Water Use License Application Summary Report and Integrated Water and Waste Management Plan (Ref. No. P WMA 06/D00/00/3423/17 and P WMA 06/D00/00/3423/18) have been drafted for inclusion in the online Water Use License Application (WULA) process.

The WULA must be submitted by the implementing entity which was not confirmed at the time of the study end.

7 Socio-Economic Impact Assessment and Legal, Institutional and Financial Arrangements

7.1 Socio-Economic Assessment

The socio-economic assessment reiterated that the implementation of the Xhariep Pipeline was essential to ensure long-term water security and economic stability in the GBWSS region.

From the socio-economic impact assessment, the following are key takeaways:

- The implementation of the Xhariep Pipeline Project would allow economic activities to continue at both the 2035 and 2050 horizons.
- The projected socio-economic impacts by 2050 (in 2023 prices) of the Xhariep Pipeline are:
    - Total Gross Domestic Product (GDP) = R416,665 million,
    - Capital generated = R892,574 million,
    - Employment Opportunities Maintained = 948,040,
    - Annual Household Income Generated = R158,013 million, with,
        - R23,892 million to low-income households, and,
    - Additional taxes paid to the different authorities = R107,236 million.
- The Xhariep Pipeline Scheme 1B was found to be economically viable as it would contribute to the socio-economic circumstances in the GBWSS and would improve security of supply of water of the system.
- The affordability analysis concluded that the total capital and interest repayment over a 30-year periods was not affordable for the paying households or the business and industrial sectors.
    - The paying households cannot afford the additional R28/m^3.
- If alternative funding options are considered, the option of a 75% capital grant and a loan for the balance of the capital costs at a low interest rate was probably the first of the different funding options that will ensure that the project was affordable to households.
- A concern raised through the socio-economic impact assessment was the financial management of MMM.

7.2 Financing Arrangements

The financing of the Xhariep Pipeline project is critical to its long-term success and sustainability. The financing model must balance the capital expenditure, operational costs and the affordability for the end-users. As there was limited opportunity for implementation phasing, the project requires substantial upfront investment, which will require a mix of public funding, concessional loans and potential private sector involvement.

The key takeaways from the financing arrangements assessment are:

- Various implementation scenarios were analysed. The project was split into three components and several implementation combinations were explored – with each entity implementing one, two or all three components. The components were namely:
    - Component A (encompassing the infrastructure from the Gariep Dam to the 2nd Command Reservoir),
    - Component B (encompassing the infrastructure from the 2nd Command Reservoir to Longridge Reservoir) and,

- Component C (encompassing the infrastructure from the 2nd Command Reservoir to Rustfontein water treatment works).

- The financial information required to accurately assess the implementation capacity of the entities was not available, however, financial information about previous projects implemented in the past 10 years by the entities was assessed as a proxy indicator.
- Five sources of financing are available for a public infrastructure project of this nature, i.e., (a) grants from central government, (b) the public delivery agency's own resources, (c) equity, (d) commercial debt, and (e) concessionary debt. The share of the financing sources **assumed** to be available to the implementation entities were presented in the report.
- The cost of capital from each financing source was assessed for each implementing entity. It should be noted that MMM and VCWB are expected to have to pay a premium above market rate for loans, given their vulnerable financial positions.
- For each implementation scenario considered, the projected bulk tariff was calculated taking into account the direct costs, long-term operational expenses and debt repayment obligations.
- Options 1C (where the project is implemented entirely by a DWS entity) and Option 3B (where components A and B are implemented by DWS and component C by VCWB) were found to have similar bulk tariff implications, R16.57/kl and R16.44/kl, respectively.
- Introducing a public-private partnership in Option 3B did not result in any savings, as the private sector efficiencies were not sufficient to overcome the public entities' access to lower financing cost.
- An affordable tariff structure, particularly for the lower income households is crucial to ensuring that the socio-economic benefits of the project are shared across the population.
- The project can achieve financial sustainability, provided that cost recovery is effectively implemented thorugh a carefully structured bulk water tariff system.

7.3 Legal and Institutional Arrangements

The legal and institutional arrangements analysis explained that the chosen institutional arrangement should be based on a cooperative framework that involves all relevant institutions with a mandate and responsibility to provide water.

Key takeaways from the legal and institutional arrangements include:

- The same implementation scenarios were assessed from a legal and institutional mandate perspective as were assessed from a financing perspective.
- The analysis described the mandates of the three spheres of government involved in the Xhariep Pipeline Project implementation process, the national (DWS), water board (VCWB) and the water service authority (MMM and the local municipalities), highlighting that neither sphere has hierarchy over another but that there is interdependency and interrelation between them.
- From the Constitution, the Municipal Systems Act, the Municipal Structures Act and the Water Services Act, the following has been deduced:
  - There is a duty on all spheres of government to ensure that water supply services are provided in a manner that is efficient, equitable and sustainable.
  - The water service authorities, i.e., MMM and the local municipalities, have the mandate to ensure provision of water supply services within their area of jurisdiction.
- Therefore, the municipalities can decide how best to fulfill their consitutional mandate of providing access to water supply services and should decide on who should be the implementing entity for the Xhariep Pipeline. In doing so, these municipalities must take into account, among others:
  - Alternative ways of providing access to the services,
  - The need for regional efficiency,
  - The need to achieve benefit of scale,
  - The need for low costs,

- The requirements of equity,
- The availability of resources from neighbouring authorities,
- Institutional capacity,
- Financial capacity,
- Technical competency,
- Manpower, etc.

- ► If necessary, the municipalities may request VCWB to be the implementing entity of the scheme and VCWB may only refuse the request if, for sound technical and financial reasons, they would not be able to provide those services.
- ► If the municipalities fail to take up their responsibilities, the organs of State in the provincial and national sphere of Government may intervene to resolve the matter.
- ► It should be noted that there is potentially an inability by MMM to take up this responsibility. Their current administration and infrastructure management are poor, but they are also constrained by inadequate support from the other spheres of government and a critical shortage of funds. The other local municipalities may face similar challenges though these were not specifically examined as they would use about 3% of the water produced by the scheme with MMM using 97%.

This assessment highlights that, while various institutional options exist, the financial sustainability of the pipeline project will be dependent on the chosen implementing entity's capacity to manage operations and maintenance effectively. The report findings underscores that the project's success hinges on collaboration between national, provincial and local governments, and a clear delineation of responsibilities among entities.

From an economic perspective, the project is expected to generate substantial socio-economic benefits through direct, indirect, and induced impacts. This includes job creation during the construction and operational phases and an improvement in water security, which is critical for supporting regional economic activities, particularly in the agriculture and manufacturing sectors. The financial viability of the project is achievable if tariff structures are well managed, ensuring affordability for households while maintaining financial sustainability.

7.4 Recommendations

Based on the finding of the assessments the following recommendations are made:

- ► The findings should be presented and discussed at a Working Group Committee meeting to all the relevant stakeholders, which should be initiated by DWS and attendees must include MMM, Kopanong Local Municipality, Mantsopa Local Municipality and VCWB;
- ► The project success hinges on collaboration and cooperation between national, provincial and local governments. DWS should initiate the establishment of and lead a **Working Group** that involves all the relevant stakeholders, with representation at an executive and strategic level, so that agreement can be reached on:
    - Responsibilities with respect to the implementation, operation and maintenance of the scheme, e.g. MMM (as they should take a leading role) can request VCWB (legally) or DWS (administratively) (including TCTA or the NWRIA) to implement the project on their behalf,
    - Financing options, taking consideration that at least a 75% capital grant and a loan for the balance of the capital costs at a low interest rate would be required to result in affordable bulk water tariff increases. The creditworthiness of each institution must be considered as part of the financing options to minimise the cost impact on the end-users, and,
    - Development of an implementation timeframe.

8 Financial Considerations

8.1 Capital Cost Estimate

The capital expenditure (CAPEX) estimate was prepared based on historical data collected from projects of a similar nature and complexity and is summarised in Table 8-1 including the WTW. Table 8-2 provides an expanded capital cost estimate for the WTW, including future phases. The cost estimate base date was November 2024, and the construction commencement date was assumed to be November 2028.

The assumptions used for the capital costing were as follows:

- Rates and unit costs (civil, mechanical, electrical and electronic) were adopted from projects of a similar nature in terms of size and capacity.
- Capital cost estimates for civil works, mechanical equipment, electrical and electronic equipment based on dated quotes were escalated at 8% per annum (p.a.) to allow for market related inflation.
- Civil works preliminary and general (P&G) expenses were based on 25% allowance, while the mechanical, electrical and electronic works P&G expenses were based on 30%.
- Contract Price adjustment of 7% p.a. was assumed for the construction period.
- Foreign exchange adjustment was calculated for specific mechanical and electrical WTW components that may be imported. Exchange rates at the time of tender and at the time of order were considered and the resultant foreign exchange adjustment was determined.
- Allowance for foreign exchange variation of 5% p.a. was assumed for the construction period.
- Contingencies of 15% were assumed to account for unforeseen items.
- Professional Fees were calculated based on ECSA 2021 Fee Scales gazetted on 26 March 2021 for each scenario based on the CAPEX and engineering discipline.
- Site Supervision was not included as part of the CAPEX
- Cost estimates can be assumed to be at an accuracy of 25 – 30% as part of detailed feasibility studies, which should improve to 10 – 15% at the end of the detailed design phase.

Table 8-1: Estimated Capital Expenditure for the Xhariep Pipeline Project

Description	Estimated CAPEX (ZAR)
Preliminary and General	3,939,328,274
Raw Water Pump Station	162,443,508
High-Lift Pump Station	359,650,870
Command Reservoir No 1	137,008,420
Booster Pump Station and Suction Reservoir	292,708,069
Command Reservoir No 2	304,276,170
Pipelines	14,385,273,022
Water Treatment Works (Phase 1)	2,248,730,000
Subtotal Capital Cost (Excl. VAT)	**21,829,418,333**
Contract Price Adjustment (CPA) @ 7% p.a.	4,912,557,790
Allowance for Foreign Exchange Variation @ 5% p.a.	434,230,000
Contingency @ 15%	4,076,430,918
Project Cost (Excl. VAT)	**31,252,637,041**
Engineering Design Fees @ 8%	2,500,210,963
Disbursements and Recoverable Costs	124,960,856
Professional Fees (Excl. VAT)	**2,625,171,819**

Description	Estimated CAPEX (ZAR)
Total Project Cost (Excl. VAT)	**33,877,808,861**
Total Project Cost (Incl. VAT)	**38,959,480,190**

Table 8-2: Estimated Capital Expenditure for the WTW

Description	Estimated CAPEX (ZAR)		
	Complete Phase	Phase 1	Phase 2
	312 Mℓ/d	208 Mℓ/d	+104 Mℓ/d
Preliminary and General	619,300,000	463,060,000	323,230,000
Civil works	1,811,570,000	1,425,630,000	836,900,000
Mechanical works	542,740,000	347,860,000	371,830,000
Electrical Works	11,880,000	7,610,000	8,140,000
Electronic works	7,130,000	4,570,000	4,890,000
Subtotal capital cost (excl. VAT)	**2,992,620,000**	**2,248,730,000**	**1,544,990,000**
Contract Price Adjustment (CPA) @ 7% p.a.	673,470,000	506,070,000	347,690,000
Allowance for Foreign Exchange Variation @ 5% p.a.	577,870,000	434,230,000	298,340,000
Contingency @ 15%	636,600,000	478,360,000	328,660,000
Project Cost (Excl. VAT)	**4,880,560,000**	**3,667,390,000**	**2,519,680,000**
Professional Fees (Excl. VAT)	**311,240,000**	**233,870,000**	**160,680,000**
Total Project Cost (Excl. VAT)	**5,191,800,000**	**3,901,260,000**	**2,680,360,000**
Total Project Cost (Incl. VAT)	**5,970,570,000**	**4,486,449,000**	**3,082,414,000**
Cost per Mega Liter (R/Mℓ)	16,640,000	18,760,000	25,770,000

8.2 Operation and Maintenance Cost

The estimated operation and maintenance budget required for the first year of operation is summarised in Table 8-3, showing an estimated minimum operations and maintenance (O&M) requirement.

Table 8-3: Estimated Annual O&M Budget for the Xhariep Pipeline Project

Description	Estimated Annual Maintenance and Operating Budget (ZAR)	
	Complete Phase	Phase1
	312Mℓ/d	208Mℓ/d
Maintenance	200,782,452	184,932,452
Labour	24,180,000	21,160,000
Energy	82,533,048	53,752,032
Chemicals	71,590,000	47,730,000
Sludge Disposal	13,940,000	9,300,000
Total OPEX (excl. VAT)	**393,025,500**	**316,874,484**
Plant Cost (Amortised @ 20 years)	633,040,000	475,680,000
Total Annual Cost of Ownership (excl. VAT)	**1,026,065,500**	**792,554,484**
Total Annual Cost of Ownership (incl. VAT)	**1,179,975,325**	**911,437,657**

9 Project Programme

Table 9-1 shows an indicative programme for the implementation of Phase 1 of the Xhariep Pipeline Project infrastructure. Figure 9-1 shows the programme in Gantt chart form.

Table 9-1: Xhariep Pipeline Project implementation programme (Phase 1)

Task description	Start date	Duration (days)	End date
End of Feasibility Study	2025/02/28	1	2025/03/01
Finalisation of Institutional Arrangements	2025/03/01	150	2025/07/29
Funding approval	2025/07/29	120	2025/11/26
Procure PSP[1] for Detailed Design	2025/04/30	210	2025/11/26
Detailed Design & Tender Documentation	2025/11/26	540	2027/05/20
Procure Contractor	2027/05/20	300	2028/03/15
Section 33 process	2028/03/15	360	2029/03/10
Pipeline construction (250 km)	2029/06/08	1260	2032/11/19
Water Treatment Works construction	2029/03/10	1440	2033/02/17
Pump stations (x 3)	2029/03/10	900	2031/08/27
Command Reservoirs (x2)	2029/03/10	720	2031/02/28
Testing and commissioning	2033/02/17	120	2033/06/17
Commencement of Defects Liability Period	2033/06/17	1	2033/06/18

[1] – Professional Service Provider

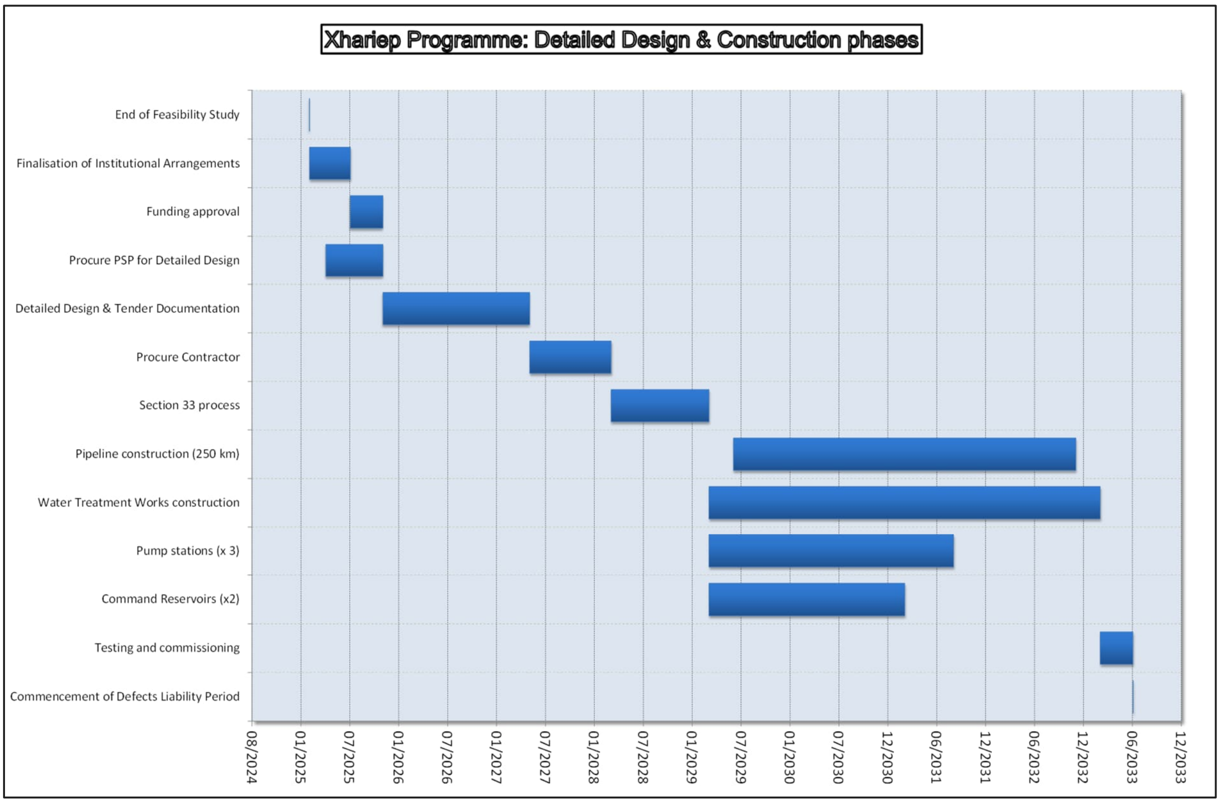

Figure 9-1: Xhariep Pipeline Project implementation programme (Phase 1)

Based on the indicative programme, the detailed design needs to commence towards the end of 2025 for construction to commence towards the end of 2028. The commissioning should be completed towards the end of 2032 with the scheme being fully operational by early 2033.

10 Conclusions and Recommendations

10.1 Conclusions

The following are the high-level conclusions from the summary report:

- Water Requirements and Resource Availability
  - The projected 2050 water demand of 186 million m³/a for the GBWSS was adopted.
  - A transfer capacity of 101 million m³/a from Gariep Dam was required to meet demand, assuming additional interventions such as raising dam levels and infrastructure upgrades are implemented.
- Scheme Selection and Design
  - Scheme 1B, a hybrid potable water transfer scheme, was identified as the preferred option due to its efficiency in distributing water and its technical and economic viability.
  - The scheme includes key infrastructure such as pump stations, command reservoirs, and a WTW with an ultimate planned capacity of 312 Mℓ/d with potential to expand to 416 Mℓ/d.
  - Hydraulic modelling confirmed that steel pipelines with optimised diameters and appropriate surge protection measures are required.
- Site Investigations
  - The geotechnical field investigations identified shallow bedrock, variable groundwater conditions, and corrosive soil conditions along sections of the route, necessitating protective measures.
  - Limited land access prevented full investigations in some areas, which must be completed in the detailed design phase.
- Water Treatment Works Design
  - The raw water quality assessment confirmed the need for turbidity removal, stabilisation, and disinfection.
  - The proposed treatment technology includes pulsator clarifiers, rapid gravity sand filtration, and chlorine-based disinfection.
  - Sludge handling will be managed via thickening ponds, and a booster chlorine dosing system will be implemented to maintain residual levels in the pipeline.
- Authorisation Processes
  - Environmental Authorisation was granted on 26 September 2024 and is valid for 10 years.
  - A WULA must be submitted by the implementing entity, which was not confirmed before this study concluded.
- Socio-Economic and Financial Considerations
  - The project is expected to generate significant socio-economic benefits, including job creation and improved water security.
  - The affordability analysis determined that a full loan-based funding model is not affordable for paying households, and at least 75% of capital costs must be grant-funded.
  - The financial sustainability of the project depends on an appropriate bulk tariff structure and effective cost recovery.
- Legal and Institutional Arrangements

- MMM is responsible for ensuring water supply services but may not have the financial or technical capacity to implement the project alone.
- Various implementation scenarios were analysed, with options involving DWS, VCWB, or a combination of both.
- A cooperative institutional arrangement is required to ensure long-term sustainability.

10.2 Recommendations

The following are the high-level recommendations from the summary report:

► Water Requirements and Resource Availability

- DWS should engage with ORASECOM to ensure the water supply for Gariep Dam and downstream users is secure as this involves negotiation with bordering countries.
- DWS should finalise operating rules for Gariep Dam and DWS, MMM and VCWS must implement the identified interventions to ensure the required 101 million m³/a transfer capacity.

► Site Investigations

- Additional geotechnical and topographical surveys must be conducted in inaccessible areas, particularly around Command Reservoir No. 2 and tie-in points.
- DWS, MMM and VCWB should coordinate with landowners to secure required access.

► Authorisation Processes

- The implementing entity must submit the WULA and ensure compliance with environmental conditions.
- DWS should liaise with relevant authorities to prevent project delays.

► Socio-Economic and Financial Considerations

- National Treasury should be engaged to secure the capital grant funding.

► Legal and Institutional Arrangements

- DWS must establish a Working Group with MMM, VCWB, and the other local municipalities to formalise implementation roles, with representation at an executive and strategic level.