COVER PAGE

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AND SANITATION

Directorate: National Water Planning

Bloemfontein Reconciliation Strategy

ACCELERATED ACTION PLAN TO AUGMENT BLOEMFONTEIN'S WATER SUPPLY

August 2014

Prepared by:

Aurecon South Africa (Pty) Ltd
P O Box 494
Cape Town, 8000
South Africa

Tel: 021 526 5790
Fax: 086 526 9500
e-mail: mike.killick@aurecongroup.com

Prepared for:

Director: National Water Planning
Department of Water and Sanitation
Private Bag X313
Pretoria 0001
South Africa

Tel: 012 336 8358
Fax: 012 336 8295
E-mail: Rademeyer Seef (CE: NWP Central)
Rademeyers@dwa.gov.za

Contents

Tables

Figures

Acronyms

ACIP	Accelerated Community Infrastructure Program
BW	Bloem Water
CME	Compliance Monitoring Enforcement
DWA	(Previous) Department of Water Affairs
DWS	Department of Water and Sanitation
ELU	Existing Lawful Use
EWR	Ecological Water Requirement
GBWSS	Greater Bloemfontein Water Supply System
LHWP	Lesotho Highlands Water Project
Ml/d	Megaliter per day
MMM	Mangaung Metropolitan Municipality
m^3/a	Cubic meter per year
m^3/s	Cubic meter per second
$Mm^3/annum$	million cubic meters per year
PSP	Professional Service Provider
V & V	Verification and Validation
WC/WDM	Water Conservation and Water Demand Management
WSS	Water Supply System
WTP	Water Treatment Plant
WWTP	Waste Water Treatment Plant

1 Purpose of this Report

1.1 Introduction

At a meeting held on the 10th of July 2014 between the Minister of Water and Sanitation and stakeholders in Bloemfontein, it was suggested that a pipeline from Gariep Dam should be seriously considered as an option for augmenting Bloemfontein's water supply. This augmentation option was previously considered by the Bloemfontein Reconciliation Strategy Study as a longer term intervention, but given the current water shortages being experienced in the region it is considered prudent to study this augmentation option at feasibility level for possible earlier implementation. The Minister has requested her Department of Water and Sanitation (DWS) to inform her of the implications of such a plan for supplying Bloemfontein with water from the Gariep Dam.

1.2 The Bloemfontein Reconciliation Strategy Study

The Greater Bloemfontein Water Supply System (GBWSS) supplies water to the larger centres of Bloemfontein, Thaba Nchu and Botshabelo, as well as to the smaller towns of Wepener, Dewetsdorp, Reddersburg, Edenburg, and Excelsior.

A Water Reconciliation Strategy Study for the Greater Bloemfontein Area was developed in June 2012 by the then Department of Water Affairs (DWA), in cooperation with Bloem Water (BW), the Mangaung Metropolitan Municipality (MMM) and other stakeholders. The strategy was developed to determine when the next interventions (e.g. schemes) that will make additional water available will be required to meet future water requirements for at least the next 25 years. The Reconciliation Strategy Study identified actions, and responsibility and timing of such actions to ensure the adequate and sustainable reconciliation of future water requirements so as to prevent the risk of a water shortage becoming unacceptable.

A Greater Bloemfontein Water Reconciliation Strategy Steering Committee (SSC), representing all relevant government departments and statutory organisations whose planning depends on the availability of water, as well as Water Services Authorities (municipalities) which receive their water from the Greater Bloemfontein Water Supply System (GBWSS), was established towards the end of 2011. The SSC, which meets twice a year, monitors the implementation of the agreed strategies/actions, updates the Strategy as necessary, and informs all stakeholders and the public of progress with the implementation of the Strategy and the water balance situation in the System.

The implementation actions of the GBWSS are being continuously reviewed and updated as required. Much of the information in this report was drawn from the Bloemfontein Reconciliation Strategy.

1.3 Purpose of this Report

This report is aimed at providing an *Accelerated Water Supply Action Plan* for the Greater Bloemfontein Area to inform the Minister by providing the following supporting information:

i. Short Term actions to be taken to avert a crisis.

ii. Implementation actions with timelines that will indicate when the pipeline from Gariep Dam can deliver water to Bloemfontein in the future.

iii. Implementation actions with timelines that will indicate when the pipeline from an alternate Orange River abstraction point can deliver water to Bloemfontein in the future.

iv. An evaluation of the effect of this earlier implementation of the Gariep Dam pipeline, or alternate scheme, on the Strategy, i.e. how the order of the interventions will change.

v. Implementation actions with timelines for other recommended interventions.

1.4 Structure of this report

This Report is presented in six chapters. The contents of these chapters are as follows:

Chapter 1: Purpose of this Report (this Chapter) explains the objective of this report.

Chapter 2: Background introduces the reader to the GBWSS and the situation regarding the current water supply situation in the Greater Bloemfontein area.

Chapter 3: Potential Short Term Interventions discusses possible measures that could be taken immediately to relieve the potential water shortage.

Chapter 4: Bulk Water Augmentation Options discusses the various bulk water augmentation options to augment the GBWSS.

Chapter 5: The influence of Implementation Programmes on the Action Plan explains the implication of implementation timelines of the Gariep Dam pipeline, and alternate augmentation schemes.

Chapter 6: Accelerated Action Plan contains actions, timelines responsibilities and recommendations.

2 Background

2.1 The Greater Bloemfontein Water Supply System

The GBWSS provides the majority of the potable water requirements of the larger centres of Bloemfontein, Thaba Nchu and Botshabelo, as well as the smaller towns of Wepener, Dewetsdorp, Reddersburg, Edenburg, and Excelsior, which are also dependent to varying degrees on local water sources. In recent years Bloemfontein has been the focus of development resulting in a decline in many of the small rural towns. Migration from farms to towns by farm workers in search of employment opportunities has further placed increased burden on the water supplies to the towns. Currently approximately 66% of the treated water is supplied by BW, primarily through the Welbedacht and Rustfontein Water Treatment Plants (WTP) and the balance via MMM's Maselspoort WTP.

The strategy area comprising the catchment areas of the Caledon and Modder Rivers which currently supply the GBWSS is shown in **Figure 2-1** and the main components of the GBWSS are shown in **Figure 2-2**.

2.2 Bulk Water Supply Infrastructure

BW's Caledon – Bloemfontein transfer scheme (also referred to as the Welbedacht Scheme) supplies potable water from DWS's Welbedacht Dam to Bloemfontein, Botshabelo, Thaba Nchu, Dewetsdorp, Reddersburg, and Edenburg. Treated water is pumped via a 6.5 km pressure pipeline and a 106 km gravity pipeline to Bloemfontein. Siltation has significantly impacted on the yield of Welbedacht Dam requiring the construction of DWS' Knellpoort off-channel storage dam which is supplied with water transferred from the Caledon River via DWS' Tienfontein Pump station which is operated by BW.

BW's Novo Transfer Scheme is supplied with water abstracted from the Caledon River by the Tienfontein Pump Station, pipeline and canal which deliver the water to Knellpoort Dam. BW's Novo pump station transfers water from Knellpoort Dam via its 20 km pipeline and then via the upper reaches of the Modder River to DWS' Rustfontein Dam. Water is pumped from Rustfontein Dam to BW's Rustfontein WTP from which water is pumped to MMM's supply systems in Botshabelo/Thaba Nchu and Bloemfontein. Water is also released from Rustfontein Dam down the Modder River to Mockes Dam which supplies MMM's Maselspoort Scheme (Weir and WTP) which supplies approximately 25% of Bloemfontein's water needs.

Groundwater is currently not utilised as a water resource for the supply of potable water to Bloemfontein but the small towns and communities in the vicinity of Bloemfontein are partially dependent on groundwater, and sustainable use of this resource has potential.

Treated waste water is released to the rivers and mostly utilised by farmers for irrigation except for that which flows into Mockes Dam and is reused.

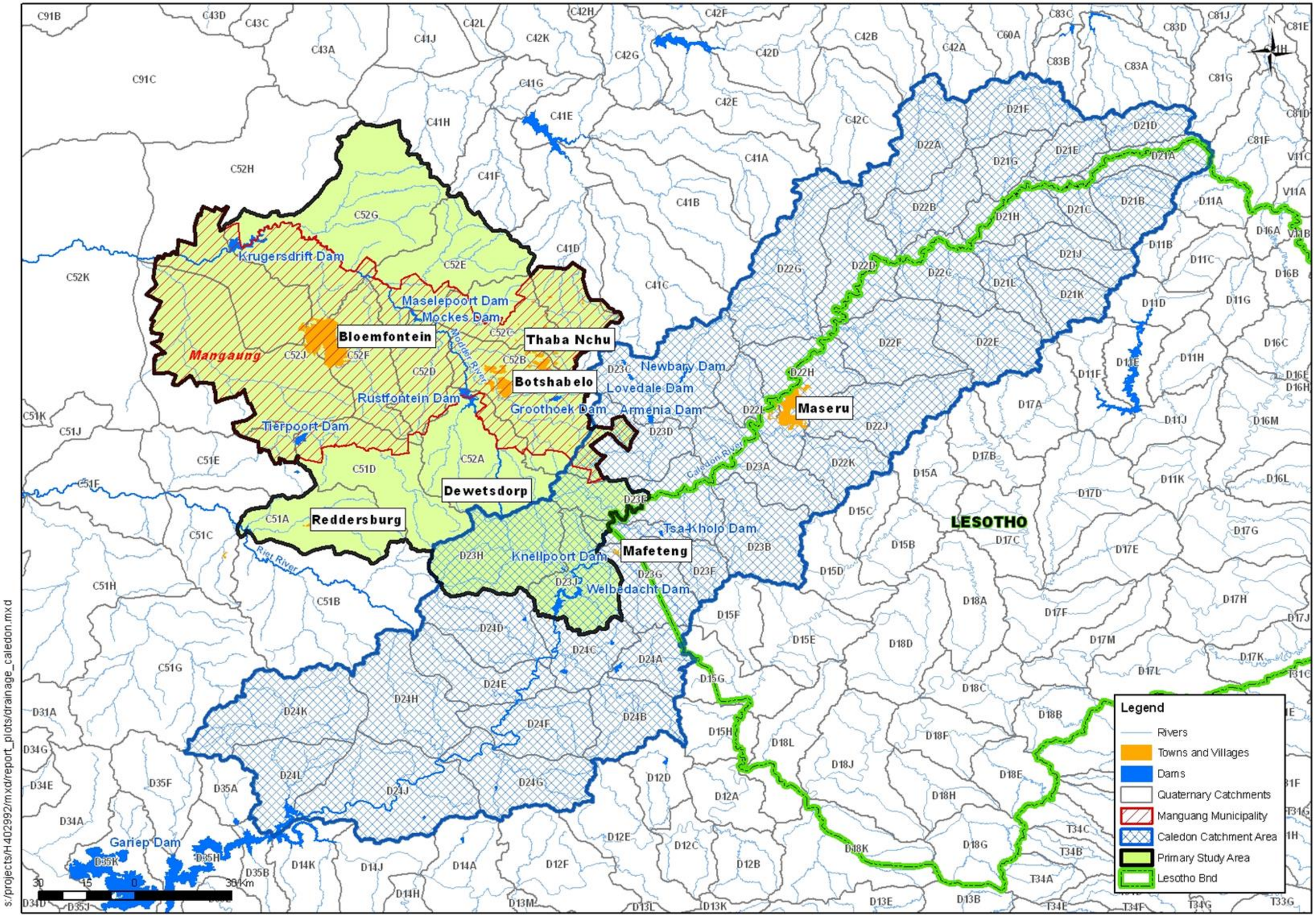

Figure 2-1 | The Greater Bloemfontein Bulk Water Supply System and the Caledon Catchment

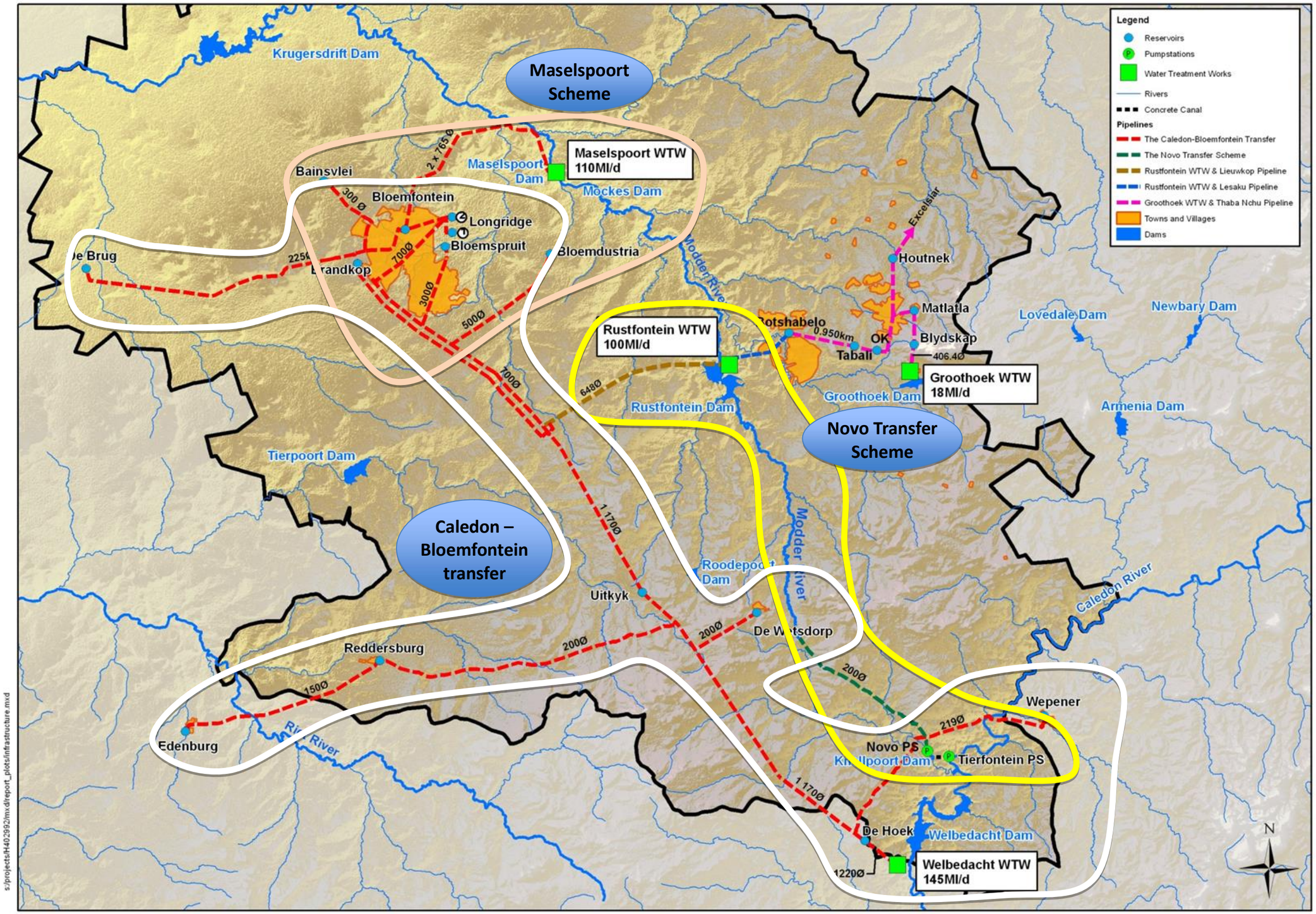

Figure 2-2 | **The Greater Bloemfontein Bulk Water Supply System**

2.3 Validation and verification

In August 2011 the DWS appointed a professional service provider (PSP) to undertake validation and verification (V&V) of water use in the Upper Orange catchment, inclusive of the Modder and Caledon River upstream catchments, which are of significance for the Bloemfontein area. This work has been completed and the V&V outputs show that generally in the Upper Caledon and Modder catchments, the existing lawful use (ELU) does not differ significantly from volumes registered by water users. Further independent analysis undertaken for quaternary C52A does not align precisely with the V&V results. The further analysis does concur with the overall findings of the V&V. It further suggests that current water use may be significantly greater than ELU and that unauthorised water use needs to be addressed. This may potentially be as a result of unauthorised water use along the Modder River above Rustfontein Dam.

As a result, the following actions have already been initiated by DWS:

- In-field confirmation of potential unauthorised use.
- Handover to the Compliance Monitoring Enforcement team for identified cases.
- Issuing of Directives to identified users and further steps taken as required.

The Water Resource Yield model was run for various scenarios of the existing lawful and current water use in the Upper Caledon and Modder River catchments based on results from the V&V study. Findings indicated that if water users utilised their full lawful allocation (i.e. the ELU) this would have a minor impact on the yield. However if the current water demands are as estimated by the V&V study then the available system yield reduces significantly from 83 million m^3/a to 68 million m^3/a, i.e. a reduction of 18% in the yield of the GBWSS, potentially as a result of extensive unauthorised water use. The implication is therefore that the possible unauthorised water use could be impacting severely on the water balance of the GBWSS.

2.4 State of water resources in the GBWSS

The anticipated water requirement will exceed the historical firm yield of the GBWSS until 2016, assuming that WC/WDM be successful, that the Tienfontein pump station capacity will be increased and that sedimentation control interventions will be successfully implemented. This is the earliest date any bulk water supply interventions can be implemented. In the short term however, water shortages are being experienced because of drought and operational problems, and this would need to be addressed through short term measures.

Rainfall in Bloemfontein has been very low over the past two years. This has increased the need for garden irrigation and has led to increased water demand.

The total accessible live storage in DWS's dams supplying the GBWSS is 170 million m^3, i.e. 63 million m^3 in Rustfontein Dam, 98 million m^3 in Knellpoort Dam and 9 million m^3 in Welbedacht Dam. On 22 July 2014 the remaining live storage was only 33 million m^3, i.e. 6 million m^3 in Rustfontein, 18 million m^3 in Knellpoort and about 9 million m^3 in Welbedacht Dam which was filled by the recent release from the LHWP. The total live storage in Mockes Dam is 5.5 million m^3; however the current storage is unknown.

The 2014/15 Orange River System Annual Operating Analysis has recently been completed by DWS.

Some of the key outcomes are described below:

- A 20% curtailment in urban water requirements is required to be imposed on water users in the Caledon Modder sub-system (Knellpoort, Welbedacht, Rustfontein and Mockes dams).

- The total abstraction for the greater Bloemfontein area was greater than had been targeted. The consumption from May 2013 to January 2014 was 73 million m^3 compared to a target of 65 million m^3 over this period.
- The projected storage capacities for Rustfontein Dam showed that if no restrictions were imposed there is an unacceptable risk that the dam capacities will fall below the minimum operating capacity and will run empty by December 2014.
- Even assuming that curtailments of 20% are applied, there is a high possibility that from October 2014 the water levels in Knellpoort Dam will drop below the minimum operating level of BW's pumps at Novo pump station.

2.5 Water restrictions

Following DWS' annual operational analysis of the GBWSS in October 2013, it became evident that water restrictions needed to be imposed, to avoid the risk of a shortfall in supply. DWS subsequently gazetted water restrictions for urban water consumers and farmers irrigating along the Modder River sub-catchment, as published in Government Gazette, 24 March 2014, No. 37421.

On 18 June 2014 the DWS Regional Chief Director requested MMM to impose Level 2 restrictions on its consumers. This requires the imposition of 20% restrictions on MMM's domestic and industrial consumers and 50% on irrigation by farmers in the Modder River sub-catchment upstream of Maselspoort Dam.

The MMM Council subsequently approved the following:

- Imposition of level 2 restrictions in terms of water restriction conditions, i.e. rules set by MMM Council in terms of water use by consumers as proposed by the Regional Office of DWS;
- Level 1 for water tariffs as approved by MMM Council.

Water Restrictions have since also been gazetted by MMM.

The reasons for restrictions to be imposed are the following (MMM):

- Very low rainfall in Bloemfontein during the past two years.
- Operational deficiencies arising from one of the two pumps at the Novo Pump Station being out of operation for seven months. As a result, sufficient water could not be pumped from Knellpoort Dam to the Modder River which supplies water to the Rustfontein and Mockes Dams.
- Operational deficiencies and the time taken to replace one of the four pumps at DWS' Tienfontein Pump Station also reduced the transfer of water from the Caledon River to Knellpoort Dam and therefore if BW's Novo pumps had been fully operational there would not have been sufficient water available in Knellpoort Dam to meet the full transfer requirements of the BW's Novo scheme.
- MMM is experiencing infrastructural challenges (old infrastructure which needs to be refurbished). This triggers water losses which further imposes severe strain on the availability of water resources.
- Consumers are not adequately utilising water in an effective and efficient manner.

2.6 Operation and Maintenance

The yield of the GBWSS is currently being negatively impacted by the problems associated with the ongoing high siltation being experienced at Welbedacht Dam, Welbedacht WTP and Tienfontein Pump Station, as follows:

- Ongoing operation and maintenance problems are experienced at the Tienfontein pump station that is owned by DWS but is operated and maintained by BW.
- DWS' Welbedacht Dam: The capacity of the dam will continue to decrease, unless scouring of the sediment takes place, and this will have a knock-on effect on BW's Welbedacht WTP and the Tienfontein pump station.
- BW's Welbedacht WTP: The plant is unable to deal with the high turbidity levels during the summer months.

The system yield is also influenced by the integrity of BW's Welbedacht pipeline and the reduced treatment capacity of the Welbedacht Scheme in the summer months, role-players not adhering to operating rules and the lack of standby capacity to be utilised while maintenance is undertaken on existing infrastructure. There are clearly defined operating rules for the GBWSS. If these are not complied with this will lead to a reduction in the yield of the GBWSS.

2.7 The importance of water augmentation planning

The planning and implementation of interventions takes time, often as long as 12 or more years for a large scheme. It is therefore imperative to clearly identify the steps to be taken in the process and to timeously plan for new longer term interventions.

2.8 Risks to Water Supply

The key risks to water supply have been identified as:

- Dealing with sedimentation problems in the Caledon River which affect the operation of the Tienfontein Pump Station, reduce the storage in Welbedacht Dam and affect the operation of the Welbedacht WTP.
- Operation of the GBWSS, and particularly the Welbedacht scheme and the Tienfontein and Novo Pump Stations which need to be operated in accordance with defined operating rules, otherwise the planned yield will not be achieved.
- High current water use, inclusive of high potential unauthorised water use.
- Lack of integrity of the Welbedacht pipeline.
- Insufficient budget to effectively implement WC/WDM.

The risks of not meeting the water supply requirements of the BGWSS and the mitigation measures currently being implemented are shown in **Table 2-1**.

Table 2-1 | Risks to Water Supply

Risks	Measures to be undertaken to mitigate risk
Tienfontein Pump Station: Capacity and Operation	DWS is currently replacing a damaged pump set and is considering installing 2 additional pump sets to provide 4 duty and 2 standby pumps.
Novo Pump Station: Capacity and Operation	BW has repaired the damaged pump and is currently installing additional capacity
Decreased production rate at Welbedacht WTP due to siltation. Ongoing Welbedacht siltation could put Tienfontein P/S at risk, as well as any further Caledon River Augmentation Schemes	BW is currently initiating a study to consider the design of desilting canals upstream of the Welbedacht WTP, potential redesign of the low lift pump station and increased diversion capacity.

Risks	Measures to be undertaken to mitigate risk
should this not be resolved.	BW has also initiated a study of a bidirectional pipeline from the Welbedacht WTP to Knellpoort Dam to deliver additional water to Knellpoort Dam and to supply water to the WTP during periods of high silt load.
Integrity of Welbedacht Pipeline	BW undertook a leak investigation study and has budgeted to re-lay sections of the pipeline
Insufficient Distribution Reservoir Storage Capacity	MMM currently increasing storage capacity
Current agricultural water use (in excess of legal use) in areas upstream of Rustfontein Dam could decrease system yield	DWS has embarked on a programme of compliance monitoring and enforcement
WC/WDM programme not successfully implemented	MMM proactively implementing WC/WDM. Budgetary constraints are a problem
Planning and Timing of new Augmentation Schemes	Studies need to be initiated

3 Potential Short-Term Interventions

3.1 Rapid Implementation of Maintenance and Repair

The current water supply crisis has arisen on account of the very low rainfall in Bloemfontein during the past two years and the long time that was required to repair one of the two pumps at the Novo scheme which resulted in the excess draw down of Rustfontein Dam. Similarly the long time that was required to replace the damaged pump at the Tienfontein Pump Station contributed to the current relatively low water level in Knellpoort Dam.

Effective maintenance and operation of the water supply system is very important, especially during the current water crisis. It is therefore strongly recommended that accelerated procurement measures are put in place to minimise delays in repairing any infrastructure until such time as the storages in the Rustfontein and Knellpoort Dams improve.

It is also essential that DWS, BW and MMM cooperate closely with each other in effectively managing the infrastructure so as to minimise the risk during the current potential water supply crisis and in the future.

3.2 Intensification of WC/WDM and Water Restrictions

Due to the imbalance between supply and requirements, it will be important to immediately implement a strategy of heightened consumer water awareness. Further water restriction measures should also be considered.

3.3 Releases from the LHWP

Should sufficient transfers into the Knellpoort Dam by the Tienfontein Pump Station not be achieved during the coming summer months, then during the winter of 2015 consideration should be given to making a further release from the LHWP for interception by the Tienfontein Pump Station as also discussed in **Section 4.4.2**. Such transfers may however influence the yield of the Vaal River System, which needs to be considered.

3.4 Management of Welbedacht, Knellpoort and Rustfontein Dams

The percentages of total storage in the Welbedacht, Knellpoort and Rustfontein dams in the period from 8 July to 22 July 2014 are shown in **Figure 3-1**, **Figure 3-2** and **Figure 3-3** respectively. These figures show that the recent release from the LHWP rapidly filled Welbedacht Dam and that this enabled the Tienfontein Pump Station to deliver water into the Knellpoort Dam. There has also been a slight improvement in the storage in Rustfontein Dam although the rate of increase in storage seems to be reducing.

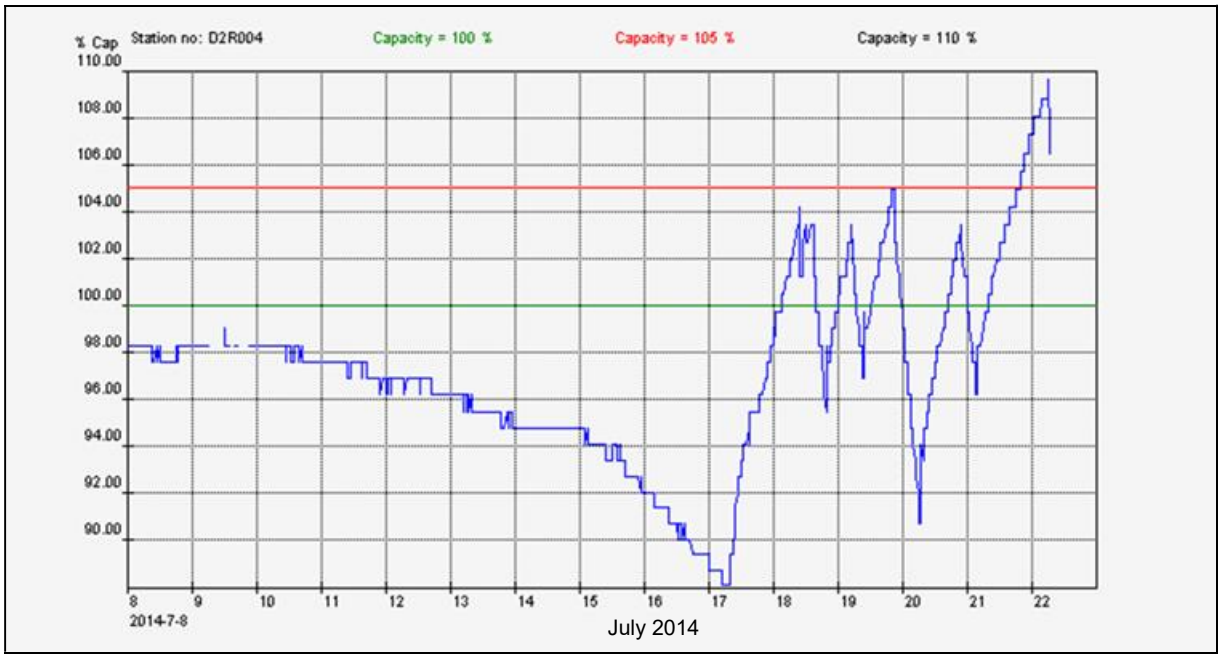

Figure 3-1 | Percentage Storage in Welbedacht Dam from 8 to 22 July 2014

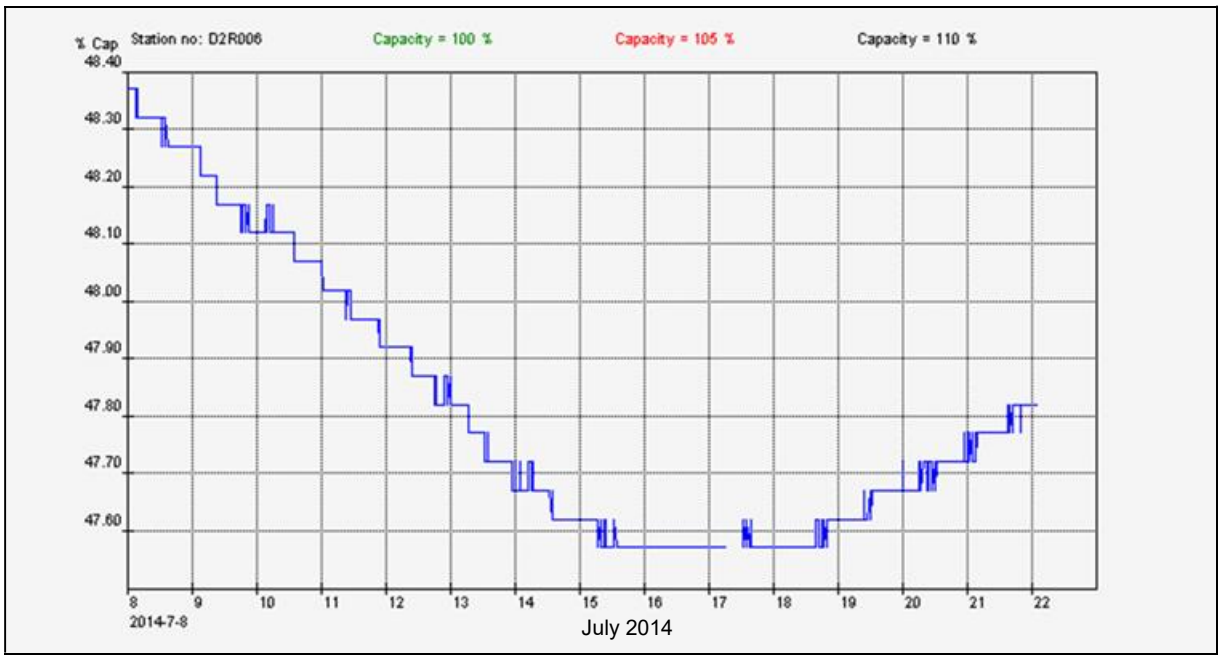

Figure 3-2 | Percentage Storage in Knellpoort Dam from 8 to 22 July 2014

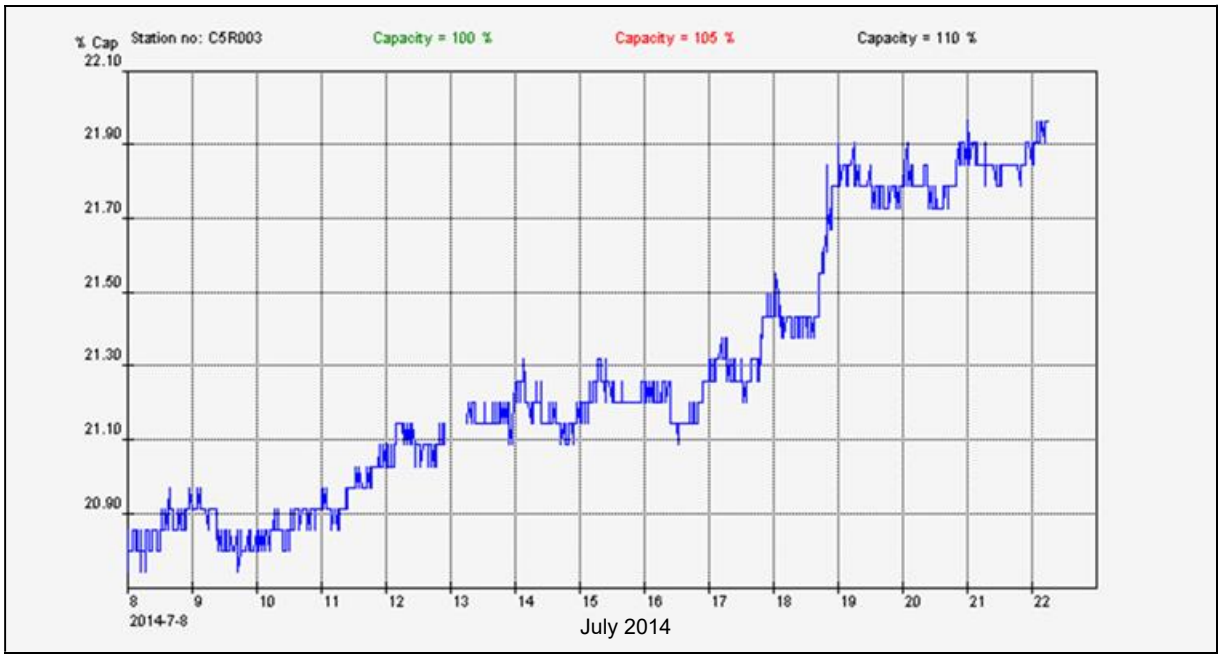

Figure 3-3 | Percentage Storage in Rustfontein Dam from 8 to 22 July 2014

These storages suggest that the operation of BWs infrastructure should be as follows in order to minimise the risk of water shortages:

- The utilisation of the Welbedacht scheme should be maximised as on 22 July 2014 the Welbedacht Dam was full and in an emergency water could be released from the LHWP into the Dam. This would impact on the Vaal System which may currently have a slight surplus, but this should be confirmed.
- Transfers from the Caledon River by the Tienfontein Pump Station into Knellpoort Dam should also be maximised as on 22 July there was only 18 million m^3 of storage that could be abstracted by the Novo Pump Station.
- Transfers by the Novo scheme from Knellpoort Dam into Rustfontein Dam should be maximised as on 22 July there was only about 6 million m^3 of utilisable storage in Rustfontein Dam. Therefore abstractions from Rustfontein Dam should be minimised as failure of the dam would impact immediately on consumers. Although Knellpoort Dam has a higher risk of failing the consequences would be less as no consumers are supplied directly from the dam.
- No information is available on the storage in Mockes Dam however it is suggested that arrangements should be made with the irrigators for the available storage to be allocated for urban use particularly if the drawdown of this dam is also critical. The possibility of providing compensation to the irrigators might also be considered.

3.5 Access to Low Level Storage in Rustfontein Dam

There is dead storage at Rustfontein Dam of about 6 million m^3 that cannot be accessed by the existing axial flow pumps which are located on the dam wall. Two options might be considered:

3.5.1 Extend Existing Axial Flow Pumps

It might be possible to access about 4 million m^3 of this dead storage by extending the existing pumps and their shafts shown in **Figure 3-4** by 3.5 m, if this would be feasible and provided that the configuration of the valley at the dam wall would permit this.

It is unlikely that this option could be rapidly implemented as the following investigations would be necessary and the implementation of the changes would also take some time.

- A check of the original survey of the reservoir basin configuration at the dam wall or preferably a new under water survey of the area where the existing pumps would be extended.
- An investigation together with the supplier of the original pumps on the practicality of extending the pumps to access the additional dead storage and whether this could be accommodated by the existing motors.

Lowering of the existing pumps by 3.5 m would increase the active storage from Rustfontein Dam from 63.3 million m^3 to 67.3 million m^3. In view of this relatively small potential gain in storage of only about 4 million m^3 that this option would provide and the time and cost of implementing this option it is unlikely to be viable as a short term option, although it would have the advantage of being permanent.

3.5.2 Suspended Submersible Pumps

An alternative for accessing this dead storage that could be implemented more rapidly would be to suspend one or more smaller submersible pumps from the dam wall and to utilize flexible hoses to connect these to the existing delivery pipework. These submersible pumps would deliver significantly less water to the treatment works but could probably be implemented more rapidly.

The suspended submersible pump option could probably access about 5 million m^3 of dead storage but because of their smaller pumping capacity this option should only be considered in the event of a potential long term failure of the pumps at the Novo Pump Station which might necessitate accessing this dead storage or if Knellpoort Dam drops below the minimum operating level.

The storages in the Rustfontein and Knellpoort Dams need to be closely monitored and arrangements to rapidly acquire suitable submersible pumps should be put in place so that these could be timeously installed if required.

3.6 Access Low Level Storage in Knellpoort Dam

The lined intake tunnel to the Novo Pump Station at Knellpoort Dam was constructed by the DWA at the time that the dam was constructed as were the shafts for the axial flow pumps which were subsequently installed by BW. The critical levels and their storage implications are as follows as shown in **Figure 3-5**:

- Lowest pump operating level: RL1439 m.
- Lowest level of intake channel 1431.5 m.
- Water level in intake channel leading to intake through which water could flow by gravity is about RL1435 m, which would allow access to about 18 million m^3 of dead storage, and increase the available active storage from 98 million m^3 to 116 million m^3.

A possible option for accessing this additional 18 million m^3 of currently dead storage is described below:

- Install a steel or concrete shaft to extend the existing inverted intake from RL1434.8 m to lowest pump operating level of 1439 m.

- Install submersible pumps in the intake channel next to the inverted intake to deliver water into the raised intake. Excess water not abstracted by the Novo Pumps would overflow the raised intake at RL1439 m.
- Power cables and switch gear would have to be provided.

This option could be installed in a relatively short time provided that procurement could be expedited and that suitable large capacity submersible pumps are available. However all work would have to be undertaken from a barge and as most of this would be under water the costs would be high. The barge should also be utilized to recover the pumps for storage and possible future use.

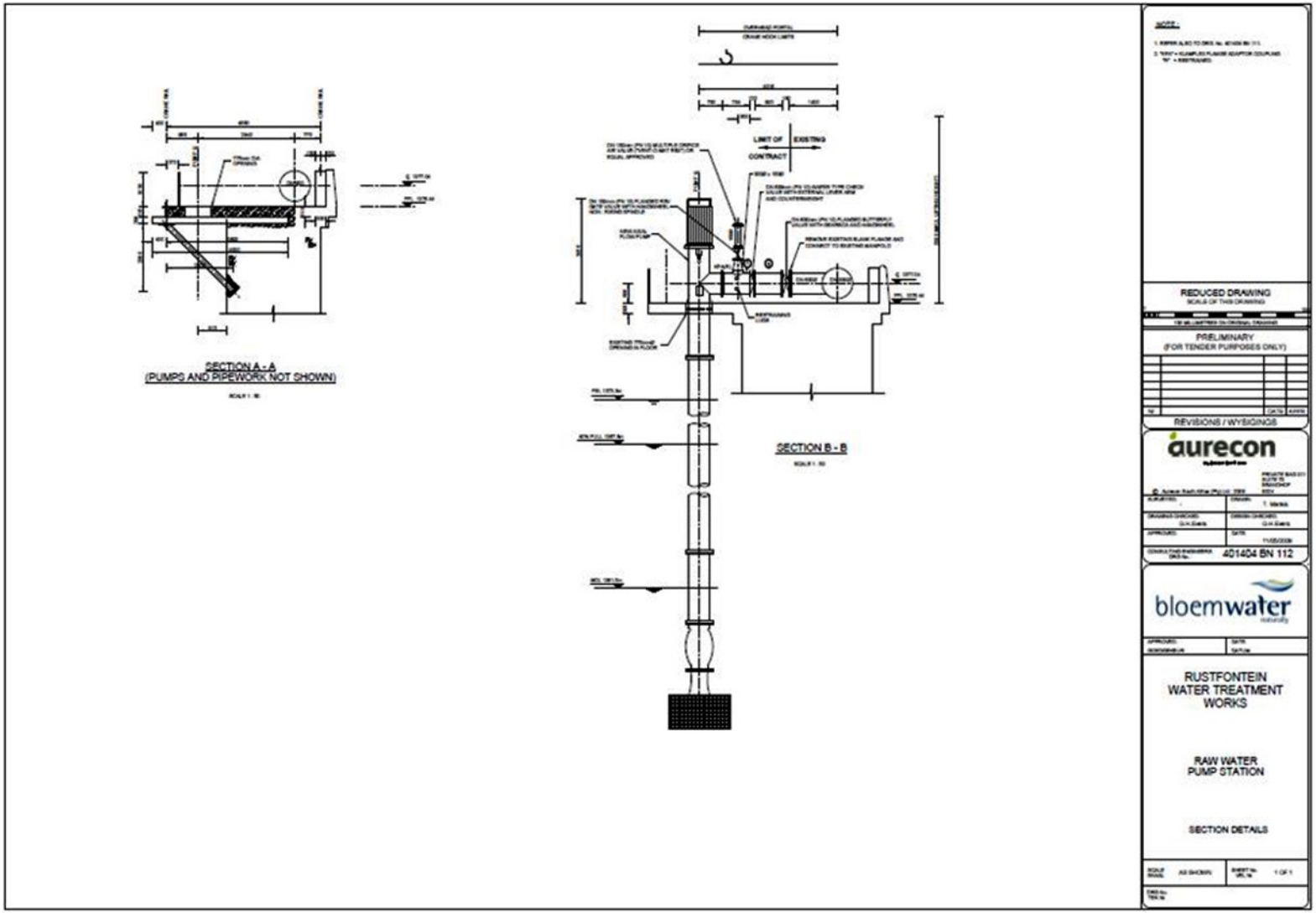

Figure 3-4 | **Rustfontein Pumps**

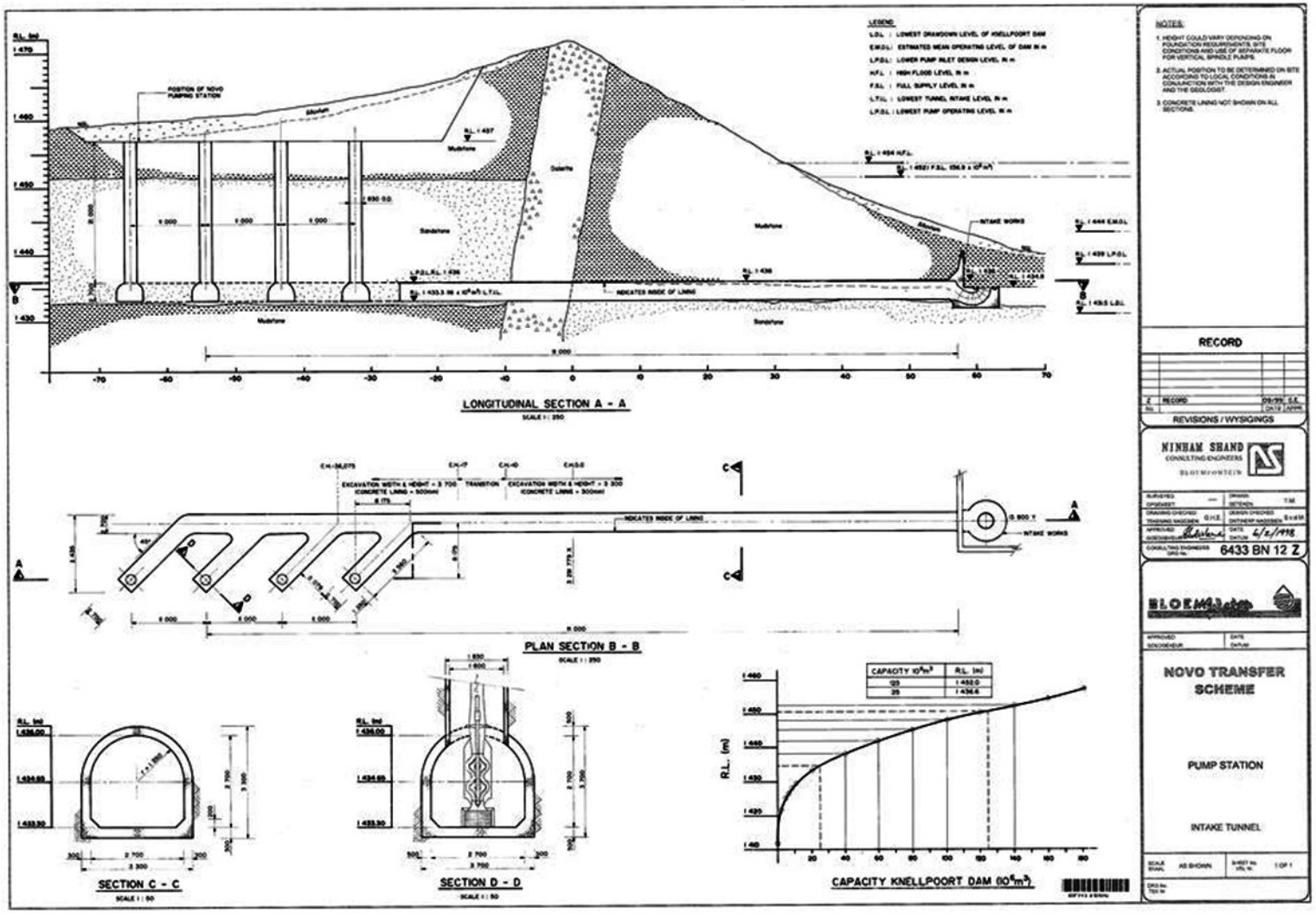

Figure 3-5 | Novo Pump Station Intake at Knellpoort Dam

4 Bulk Water Augmentation Options

4.1 Introduction

The Reconciliation Strategy Study for Large Bulk Water Supply Systems: Greater Bloemfontein Area dated June 2012 and subsequent investigations all identified the need to implement additional interventions from 2013 onwards in order meet the growing water demands on the GBWSS. The situation has been aggravated by breakdowns of equipment, the time taken to rectify these breakdowns, as well as the time taken to implement the recommended interventions for augmenting the supply from the Caledon River.

The situation has now become critical necessitating the imposition of water restrictions and the identification of options that could be rapidly implemented to relieve the situation. The following options have been screened for early implementation as described below and shown in **Figure 4-1**:

- Water from Gariep Dam:
  - 90 million m^3/annum scheme to supply Bloemfontein proposed by MMM.
  - 60 million m^3/annum scheme to supply Bloemfontein.
  - 60 million m^3/annum scheme to Rustfontein Dam.
- Water from the Upper Orange River:
  - 60 million m^3/annum scheme from Oranjedraai.
  - 60 million m^3/annum scheme from Aliwal North.
  - 60 million m^3/annum scheme from Verbeeldingskraal.
- Water from the Caledon River:
  - Releases from LHWP.
  - Tienfontein Pump Station Repair and Upgrading.
  - Novo Pump Scheme Upgrading.
  - Upgrading of Welbedacht Scheme.
  - Knellpoort Dam augmentation (Bidirectional Welbedacht Knellpoort Pipeline and possible Knellpoort Dam raising).

The capital costs of all the schemes have been determined. The operating and maintenance costs have not been calculated at this stage and would be determined in detail during detailed feasibility studies. The operating costs are significantly influenced by the cost of energy required for pumping and would therefore be the lowest for the schemes with the least pumping head required (i.e. schemes with the shortest pipeline length).

Both BW and MMM have independently undertaken investigative studies for obtaining water from Gariep Dam. It is imperative that such studies are undertaken in line with the Bloemfontein Reconciliation Strategy.

Appendix A contains *Programs for Prefeasibility and Feasibility Studies, Design and Construction*, while **Appendix B** contains *Tailored Programs for Prefeasibility and Feasibility Studies, Design and Construction*.

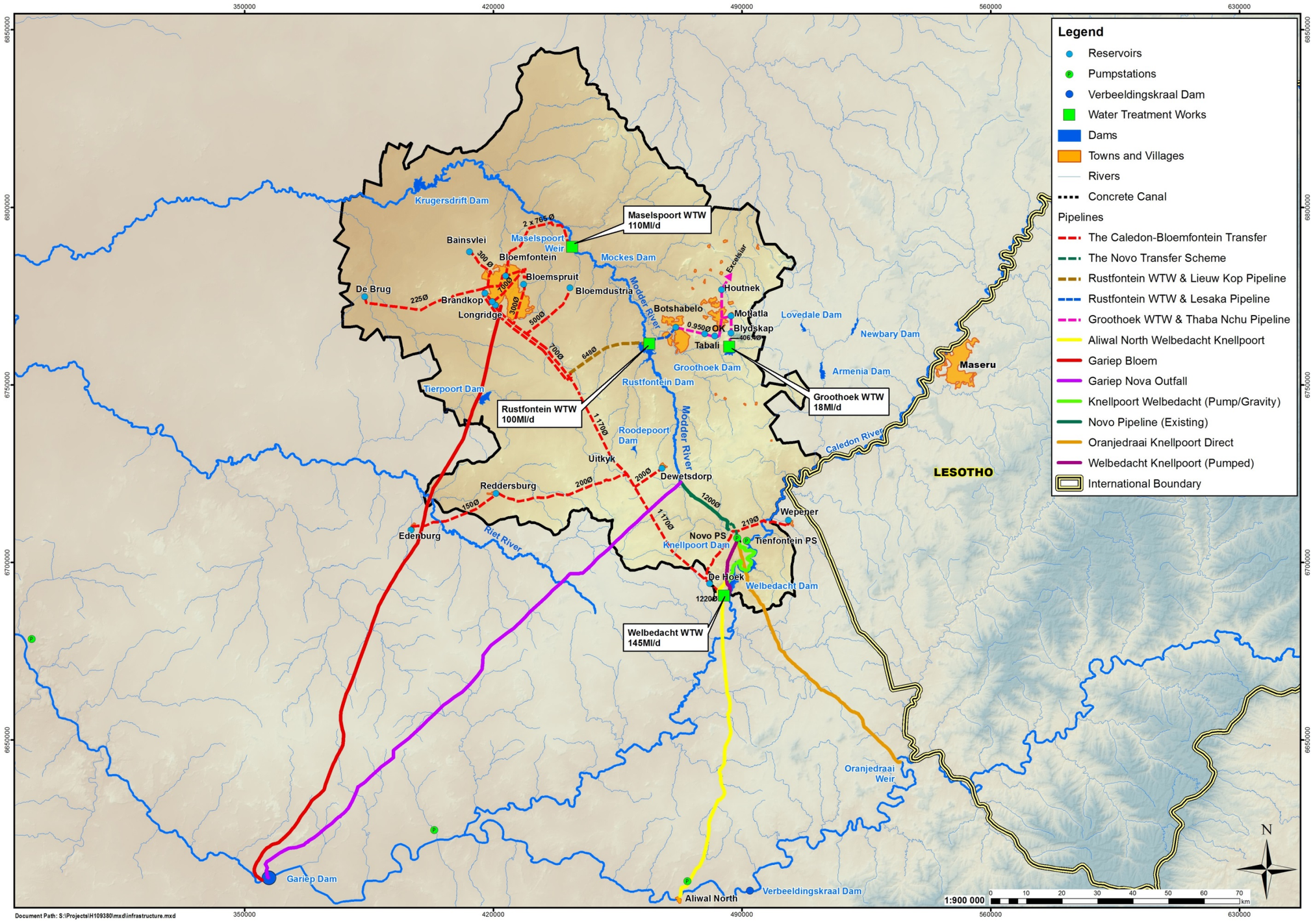

Figure 4-1 | Locations of Dams and Some Possible Schemes

4.2 Water from Gariep Dam

The limited investigation of options undertaken for this report only addressed some of the possible options for augmenting the water supply to MMM in order to provide an indication of the likely costs and times that would be taken for their implementation. The Section therefore focusses on the transfer of water from Gariep Dam to either Bloemfontein or the outfall of the Novo pipeline, and various options to transfer water from the upper Orange River.

In addition the transfer of Orange River water from Vanderkloof Dam could be considered. While not focussed on in this report, this is a possibility to take into account, and it is proposed that this be compared with the other transfer options for water from the Orange River. While the route may be slightly shorter, Vanderkloof Dam is located about 90m lower than Gariep Dam. A canal outlet for the Orange-Riet irrigation canal is located at Vanderkloof Dam.

It is therefore recommended that a prefeasibility study should identify all potential options for supplying water to MMM from the Caledon and Orange Rivers. Options from the Orange River should include schemes on the Upper Orange River, from Gariep Dam and from Van der Kloof Dam whereas the Caledon River options should be centered on the Welbedacht and Knellpoort dams schemes.

4.2.1 Pipeline from Gariep Dam to Bloemfontein: Bigen Africa Report for MMM

4.2.1.1 Description of 90 million m^3/annum Scheme

The Draft Report prepared by Bigen Africa for MMM dated July 2014 recommends a scheme to supply treated water from Gariep Dam directly to Bloemfontein, inclusive of peaking capacity. The existing supplies would provide the balance of the water requirements of the other users in the MMM that are supplied by Bloem Water (e.g. Botshabelo).

The scheme is planned to supply treated water to Bloemfontein to meet an average annual demand of 60 million m^3/annum and a peak demand equivalent to about 90 million m^3/annum.

This scheme would comprise the following components:

- A pump station at Gariep Dam which would abstract water from the existing outlet works at the dam.
- A 178 km long 1 500 mm diameter pipeline to supply a peak demand of 90 million m^3/a, average annual demand 60 million m^3/annum.
- A water treatment works at Bloemfontein to supply a peak demand 90 million m^3/annum.
- A second water pump station due to the high pumping head requirements.
- A storage reservoir.at Bloemfontein
- Power would be available at Gariep Dam.
- The pump stations would be close to Gariep Dam and the N1.

The maximum total pumping head would be about 525 m.

Bigen's report indicates that the scheme would be utilised to supply all the demands of Bloemfontein which are currently met from Maselspoort WTW but that further studies would be required to optimise the scheme and its integration into the existing supply system.

4.2.1.2 Cost Estimate for 90 million m^3/annum Pipelines

Bigen estimated the capital cost of the proposed scheme to be R 4 630 million excluding VAT, of which the capital cost of the pipeline and pump stations was estimated to be R 3 672 million. A very approximate check indicated a capital cost of R 3 980 million for the pipeline and pump station, which is similar to Bigen's estimate of R 3 672 million. None of these cost estimates makes provision for the costs of servitude acquisitions, professional fees and financing costs.

4.2.1.3 Program

Bigen estimated that the scheme could be completed in about 4.5 years by December 2018 whereas it is estimated in this evaluation that even if the scheme is fast tracked it would take 8 years to implement and that if normal procedures are followed then it would take about 12.5 years to implement the scheme. ***The implementation time for this scheme would take too long to resolve the current potential supply crisis***. The time frames proposed in this document are based on past experiences of implementing large projects. More refined timeframes can be determined during the feasibility studies.

4.2.2 Pipeline from Gariep Dam to Bloemfontein

4.2.2.1 Description of 60 million m^3/annum Pipeline

This scheme would have similar components to those of the 90 million m^3/annum pipeline described above but the pipeline would be designed to meet the average annual demand and the peak demands would be met by the existing infrastructure. This scheme would comprise the following:

- A pump station at Gariep Dam which would abstract water from the existing outlet works at the dam.
- A water treatment plant located near Gariep Dam to deliver a flow of 60 million m^3/annum.
- A 178 km long 1 300 mm pipeline to deliver 60 million m^3/annum.
- A second water pump station due to the high pumping head requirements. Power would be available at Gariep Dam.
- The pump stations would be located close to Gariep Dam and the N1.
- It has been assumed that if this scheme is to be equivalent to that proposed by Begin as described in **Section 4.2.1** then a new 22 km pipeline with a capacity of 30 million m^3/annum would be require to pump this flow from Maselspoort to Bloemfontein as explained in **Section 4.2.2.2**.

The total pumping head from Gariep Dam (for 60 million m^3/annum) would be about 370 m and from Maselspoort 190 m (for 30 million m^3/annum).

4.2.2.2 Cost Estimate for 60 million m^3/annum Pipeline

The estimated capital cost of this proposed 1 300 mm pipeline from Gariep Dam to Bloemfontein is R 2 950 million excluding VAT, professional fees, the cost of servitude acquisitions and finance costs, i.e. some R 1 030 million less than for the pipeline to supply 90 million m^3/annum.

If this scheme includes a water treatment works in the vicinity of Gariep Dam with a capacity of 60 million m^3/annum then it would be necessary, for peaking purposes to provide additional treatment capacity at Maselspoort of 30 million m^3/annum. The pipeline to convey this water to Bloemfontein would cost an additional R 170 million. Therefore the total comparable cost of the pipelines for this option would be about R 3 120 million (compared with the estimated cost of R 3 980 million for the 90 m^3/s pipeline described in **Section 4.2.1.2**).

4.2.2.3 Program

If normal procedures are followed then it would take about 12.5 years to implement the scheme and about 8 years if the scheme is fast tracked. ***These implementation times would be too long for the scheme to resolve the current potential supply crisis.***

4.2.3 Pipeline from Gariep Dam to Novo Pipeline Outfall

4.2.3.1 Description of 60 million m^3/annum Pipeline

This proposed 174 km long pipeline would also deliver about 60 million m^3/annum of water from Gariep Dam to the Novo Pipeline Outfall (or to another tributary of the Modder River above Rustfontein Dam) from where the water would flow down the stream which delivers water from

Knellpoort Dam and the Novo pipeline to Rustfontein Dam. The water would be abstracted from the existing outlet works at Gariep Dam. Some of the water that is released at the Novo pipeline outfall would be stored in Rustfontein Dam and some would be released from there and would flow to Mockes Dam via the river channel. MMM would be supplied from Rustfontein Dam and Mockes Dam via the existing water treatment works and pipelines which may require upgrading.

The main components of this scheme would be as follows:

- A pump station at Gariep Dam which would abstract water from the existing outlet works at the dam.
- A 174 km long 1 300 mm diameter pipeline.
- A second water pump station due to the high pumping head requirements.
- Power would be available at Gariep Dam.
- One of the pump stations would be located close to Gariep Dam.
- An additional water treatment plant located at Maselspoort to supply a peak demand of 90 million m^3/annum and a pump station and 22 km pipeline to deliver this water to Bloemfontein.

The total pumping head for delivering 60 million m^3/annum from Gariep Dam to Bloemfontein would be about 550 m and the head for delivering a peak demand of 90 million m^3/annum from Maselspoort to Bloemfontein about 200 m.

4.2.3.2 Cost Estimate for 60 million m^3/annum Pipeline

The estimated capital cost of this proposed 1 300mm pipeline from Gariep Dam to the Novo Pipeline Outfall is R 2 360 million excluding VAT, professional fees, the cost of servitude acquisitions and finance costs.

For this scheme the water would probably have to be released to Mockes Dam and treated at Maselspoort where additional treatment capacity of 90 million m^3/annum would have to be provided and a pipeline of the same capacity to Bloemfontein. This pipeline would cost an additional R 380 million. Therefore the total comparable cost of the pipelines for this option would be about R 2 740 million (compared with the estimated cost of R 3 980 million for a 90 m^3/s pipeline described in **Section 4.2.1.2**).

4.2.3.3 Program

This pipeline from Gariep Dam could be completed in about 9.5 years if a normal program of implementation is followed and in about 5.5 years if the project would be fast tracked. The implementation time for this scheme would also take too long to resolve the current potential supply crisis.

4.2.4 Other Previously Investigated Options from Gariep Dam

An undated report prepared for BW by Babareki Consulting Engineers entitled "*Pre-feasibility Investigation: Investigation for a Pipeline from Gariep Dam to Knellpoort Dam, Including Alternative Options*" describes five options for pipelines of 600 mm and 900 mm diameter to supply water from Gariep Dam to Knellpoort Dam as follows:

Option 1A: 180 km 600 mm raw water pipeline from Gariep Dam to Knellpoort Dam – R 1 452 million.

Option 1B: 130 km long 600 mm raw water pipeline from Bethulie to Knellpoort Dam – R 1 008 million.

Option 2: 190 km 900 mm raw water pipeline from Gariep Dam to Knellpoort Dam – R 2 660 million.

Option 3: 130 km 900 mm raw water pipeline from Bethulie to Knellpoort Dam with additional 10 km connection to Welbedacht Dam – R 1 960 million.

Option 4: 150 km 600 mm potable water pipeline from Bethulie to Brandkop Reservoir – R 1 650 million.

It is difficult to compare the alternatives identified by Bloem Water as the level of investigation undertaken and detail provided in the report, did not lend itself to an illustrative comparison with the other schemes identified. Note that the increases in yield that would be provided by these schemes are not provided in the report and that the costs may not be consistent with the other costs provided in this report.

4.3 Water from Upper Orange River

4.3.1 Pipeline from Oranjedraai

4.3.1.1 Description of 60 million m^3/annum Scheme

The proposed Oranjedraai scheme would abstract water from the Orange River at a pump station on the right bank at Oranjedraai and a pipeline would deliver this to Knellpoort Dam from where the water would be pumped by the Novo Scheme to Rustfontein Dam. The main components of this scheme would be as follows:

- A pump station on the right bank of the Orange River supplied by a flume from the original Oranjedraai gauging weir, that has been abandoned, or from the new gauging weir (D1H009), although the former would be preferable.
- A desilting works on the right bank of the Orange River.
- A high lift pump station with a capacity of 60 million m^3/annum.
- An 81 km steel pipeline, comprising 22 km of 1 300 mm pipe, 37 km of 1 200 mm pipe and 22 km of 1 000 mm steel pipe.
- Duplication of the Novo pump station at Knellpoort Dam.
- Electric power would have to be provided to Oranjedraai.
- The pump station and desilting works at Oranjedraai would be situated in a remote area and would be accessed from Zastron.
- An additional water treatment plant would be located at Maselspoort to supply a peak demand of 90 million m^3/annum and a pump station and 22 km pipeline to deliver this water to Bloemfontein.

The total pumping head would be about 470 m including the 160 m of head for the Novo scheme. The additional pumping head to deliver 90 million m^3/day from Maselspoort to Bloemfontein would be about 200 m.

The flow records developed for the Orange River at Oranjedraai with the assumed operation of the LHWP with Polihali Dam indicate that there may be sufficient flow to continuously abstract 60 million m^3/annum, while meeting the downstream irrigation requirements for most of the time. **It has not been established whether the remaining flow in the river would meet the requirements of the Reserve.**

If the proposed Verbeeldingskraal Dam is constructed its backwater would not affect Oranjedraai Weir, however the deposition of sediment in the headwaters of the reservoir is likely to impact on the proposed river pump station as has occurred at Welbedacht Dam. This may potentially influence the viability of this scheme.

4.3.1.2 Cost Estimate for 60 million m^3/annum Scheme

The very roughly estimated cost of this scheme is R 1 430 million including the cost of R 270 million for the duplication of the Novo Scheme, the greatest uncertainty being the cost of the river works, the

river pump station and the desilting works for which an amount of R 200 million is included in the estimate above.

For this scheme the water would probably have to be released to Mockes Dam and treated at Maselspoort where additional treatment capacity of 90 million m^3/annum would have to be provided and a pipeline of the same capacity to Bloemfontein. This pipeline would cost an additional R 380 million. Therefore the total comparable cost of the pipelines for this option would be about R 1 810 million (compared with the estimated cost of R 3 980 million for a 90 m^3/s pipeline described in **Section 4.2.1.2**).

4.3.1.3 Program

The Oranjedraai Scheme could be completed in about 11 years if a normal program of implementation is followed and in about 7 years if the project would be fast tracked. **The implementation time for this scheme would also take too long to resolve the current potential supply crisis.**

4.3.2 Pipeline from Aliwal North

4.3.2.1 Description of 60 million m^3/annum Scheme

The proposed Aliwal North scheme would abstract water from a pump station on the left bank of the Orange River at the existing diversion weir for irrigation purposes and a pipeline would deliver the water to Knellpoort Dam from where it would be delivered by the Novo Scheme to Rustfontein Dam. The main components of this scheme would be as follows:

- A river pump station on the left bank of the Orange River supplied by a flume from the existing diversion weir at Aliwal North which would have to be modified.
- A desilting works on the left bank of the Orange River.
- A high lift pump station.
- A 108 km steel pipeline, comprising 69 km of 1 200 mm pipe, 24 km of 1 300 mm pipe and 15 km of 1 000 mm pipe.
- Duplication of the Novo pump station at Knellpoort Dam.
- Electric power would probably be available.
- The site would be very close to Aliwal North with easy access.
- An additional water treatment plant would be located at Maselspoort to supply a peak demand of 90 million m^3/annum and a pump station and 22 km pipeline to deliver this water to Bloemfontein.

The total pumping head would be about 530 m including 160 m of head for the Novo scheme. The additional pumping head to deliver 90 million m^3/day from Maselspoort to Bloemfontein would be about 200 m.

The flow records developed for the Orange River at Oranjedraai with the assumed operation of the LHWP with Polihali Dam indicate that there would be sufficient flow to continuously abstract 60 million m^3/annum, while meeting the downstream irrigation requirements for most of the time. **It has not been established whether the remaining flow in the river would meet the requirements of the Reserve.**

The Orange River Reconciliation Strategy study has identified the proposed Verbeeldingskraal Dam on the Orange River as a potential new water resource. Feasibility studies on this scheme, however still need to be undertaken. Should the Verbeeldingskraal Dam eventually be constructed, then water would be released to supply the scheme or alternatively a new pump station could be provided at the dam and a new pipeline laid to join the existing pipeline from Aliwal North at Rouxville, which would add to the cost of the scheme. Although this would increase the cost the operation and maintenance in the vicinity of Aliwal North would be much easier. An alternative scheme at Verbeeldingskraal is described in Section 4.3.3.

4.3.2.2 Cost Estimate for 60 million m^3/annum Scheme

The very roughly estimated cost of this scheme is R 2 000 million, the greatest uncertainty being the cost of the river works, the river pump station and the desilting works.

For this scheme the water would probably have to be released to Mockes Dam and treated at Maselspoort where additional treatment capacity of 90 million m^3/annum would have to be provided and a pipeline of the same capacity to Bloemfontein. This pipeline would cost an additional R 380 million. Therefore the total comparable cost of the pipelines for this option would be about R 2 380 million (compared with the estimated cost of R 3 980 million for a 90 m^3/s pipeline described in **Section 4.2.1.2**).

4.3.2.3 Program

The Aliwal North Scheme could be completed in about 11.5 years if a normal program of implementation is followed and in about 7.25 years if the project would be fast tracked. **The implementation time for this scheme would also take too long to resolve the current potential supply crisis.**

4.3.3 Pipeline from Verbeeldingskraal

4.3.3.1 Description of 60 million m^3/annum Scheme

The proposed Verbeeldingskraal scheme would be similar to the scheme at Aliwal North as described in **Section 4.3.2**. Water would be abstracted from the Orange River at a pump station on the right bank at a weir to be constructed where a dolerite dyke crosses the river. This weir could be designed as a flow gauging weir for the future releases from the proposed Verbeeldingskraal Dam. A desilting works would also be provided on the right bank where the high lift pump station would be located. The pipeline would follow a different route to Rouxville, but beyond the town it would follow the same route to Knellpoort Dam as the Aliwal North pipeline.

The scheme would be located so that it could continue to function if the Verbeelingskraal Dam is constructed in the future and would draw water from the dam with increased assurance of supply. The proposed weir could be designed to serve as a gauging weir below the proposed dam.

The site is currently remote from roads and power lines.

4.3.3.2 Cost of 60 million m^3/annum Scheme

The capital cost of the scheme would probably be similar to that of the Aliwal North scheme described in **Section 4.3.2** but may be slightly higher because a new weir would have to be constructed.

4.3.3.3 Program

The program for the Verbeeldingskraal scheme would also be similar to that of the Aliwal North scheme described in **Section 4.3.2.3**. Therefore the scheme could be completed in about 11.5 years if a normal program of implementation is followed and in about 7.25 years if the project would be fast tracked. **The implementation time for this scheme would also take too long to resolve the current potential supply crisis.**

If augmentation of the BBWS scheme could be delayed until such time as the Verbeeldingskraal Dam is built, then this scheme would also draw water from a dam as would the proposed schemes from Gariep Dam. However the proposed Verbeeldingskraal Dam is only one of the options that have recently been identified by DWS and therefore it is very uncertain whether this dam will be constructed.

4.4 Water from the Caledon River

4.4.1 Introduction

The yield of the schemes on the Caledon River could be increased by one, many or a combination of interventions (**Figure 4-2**). These are listed below:

- Releases from the LHWP,
- Increasing the capacity of Tienfontein Pump Station,
- Augmentation of Knellpoort Dam with a bi-directional pipeline from Welbedacht Dam,
- Increasing the capacity of the Novo Pump Station for the bi-directional pipeline scheme (and also for the Upper Orange River schemes described in **Section 4.3**),
- Addressing siltation at Welbedacht Dam and the Water Treatment Plant,
- A combination of the abovementioned interventions.

These possible schemes are discussed in more detail in **Section 4.4.2** to **Section 4.4.7** of this report.

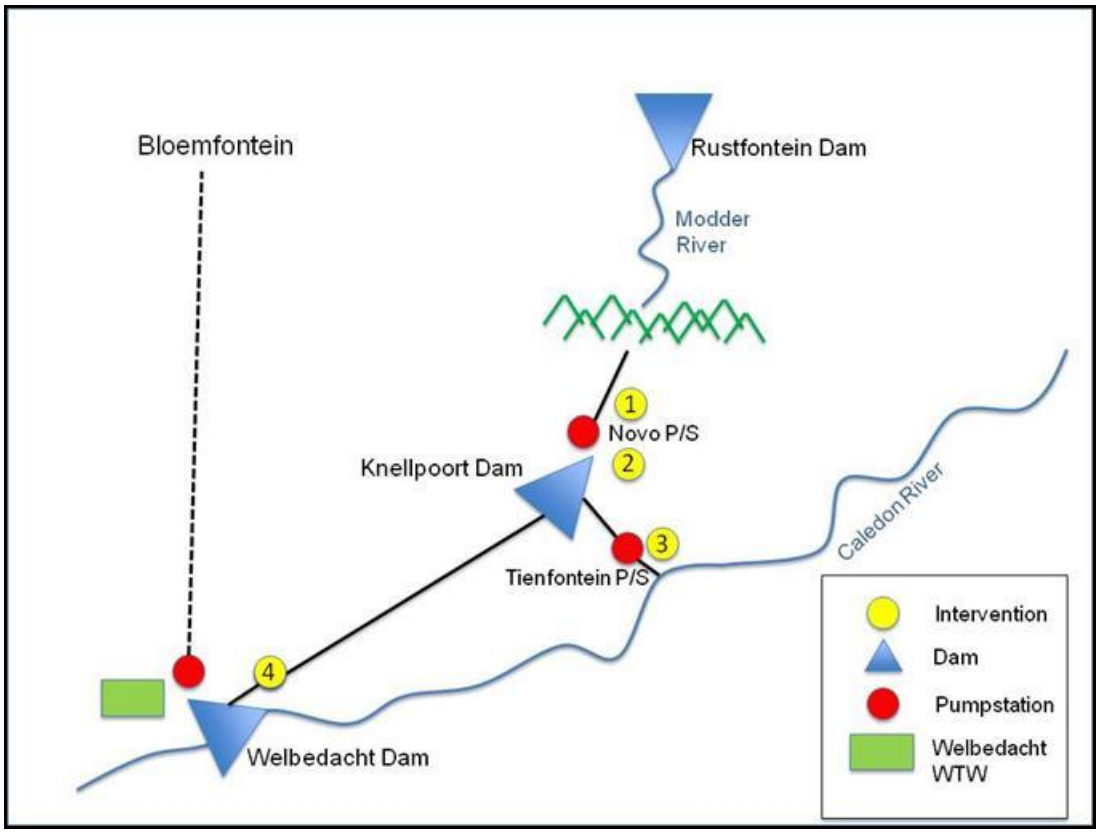

Figure 4-2 | Caledon-Bloemfontein Transfer Scheme Interventions

4.4.2 Releases from LHWP into the Little Caledon River

4.4.2.1 Description of Scheme

The LHWP Delivery Tunnel North can discharge water into the Little Caledon River, which flows into the Caledon River and past the Tienfontein Pump Station (which can pump water into the Knellpoort Dam) and from there into Welbedacht Dam. Along its course to Welbedacht Dam these rivers pass irrigated areas and various towns in South Africa and Lesotho which abstract water from the rivers and

riparian vegetation and evaporation results in other losses. Therefore it is very important to assess the losses that occurred during the recent release of water authorised by the Minister of DWS in order to gain a better understanding of these losses and the management of such releases so as to be able maximise their utilisation, should it be necessary to make additional releases to augment the bulk supply to Bloemfontein.

The abstraction of water at the Tienfontein Pump Station is limited by the ability to divert water into the Tienfontein pump station and by the capacity of the pumps. It is understood that sand bags were placed in the Caledon River to divert the recent LHWP releases into the pump station. The utilization of this water also depends on the pumping capacity available at the Tienfontein pump station.

The main advantage of such a release is that it can be implemented at very short notice whereas there are also the following disadvantages:

- River losses and losses in diverting the water from the Caledon River into the Tienfontein Pump Station.
- The limited available storage in Welbedacht Dam (the dam will fill very quickly and will then spill)
- The potential loss of yield of the Vaal Water Supply System. The economic value of water would need to be considered when deciding where best to utilise the water. (Refer also to 4.4.2.3 below).The cost of the raw water is reported to be about R2.20/m^3 before losses and assuming about 50% losses say R4.40/m^3 of water transferred into Knellpoort Dam. Should releases be considered as an option actual cost would still need to be quantified.

If further releases are made it is recommended that these are optimised based on the experience of the current release and that monitoring is also undertaken to further optimise the beneficial utilization of such releases.

4.4.2.2 Cost Estimate

Although the cost of water for this option appears to be high, if the releases are carefully managed, and preferably are only made when the storage level in Knellpoort Dam is very low, then this is probably one of the more economical short term options for augmenting the supplies from the Knellpoort and Welbedacht Dams.

Assuming that releases would only be made say 1 in 10 years to meet a shortfall of say 20 million m^3, taking account of river transfer losses, and that the average cost of water that would be pumped into Knellpoort dam would be R 4.40/m^3 (assuming that only 50% of the release can be utilised) then over a 40 year period the discounted cost would be equivalent to that of a scheme with a capital cost of about R 160 million for a discount rate of 8%.

4.4.2.3 Program

As mentioned above releases could be implemented at very short notice however their effectiveness will depend on the losses and on the operation of the Tienfontein Pump Station which is described below. Releases in the near future may not impact on the assurance of water supply from the Vaal System to Gauteng as there may be still be surplus yield available from this system, however this should be confirmed. The long term planning projections show that the Gauteng area will be in a water deficit and therefore the need for the construction of the Lesotho Highlands Phase 2 Scheme. Surplus water may be available on an annual basis dependent on the catchment rainfall and dam levels in that particular year.

4.4.3 Increasing Summer Supply from Welbedacht Water Treatment Works (WTW)

4.4.3.1 Description of Scheme

Due to the high turbidity of the raw water, especially during flood events, it is not possible to operate Welbedacht WTW at full capacity throughout the year. The WTW can be operated at its full capacity of 145 Ml/d in winter, but can only treat between 90 and 100 Ml/d in summer when the sediment load in the Caledon River is high. The operation of the Welbedacht WTW at full capacity throughout the year yield could potentially increase the yield of this scheme by about 7 million m^3/annum.

The storage capacity (and potential yield) of Welbedacht Dam could also potentially be improved through the scouring/flushing of Welbedacht Dam, however this would probably only be possible without reducing the flow to the water treatment works if the Bidirectional pipeline described in **Section 4.4.6** is implemented.

No cost estimate is available or has been prepared for this option.

4.4.3.2 Program

DWS has appointed a PSP and assuming that the main tasks will comprise the tender design, the tender process for the appointment of a contractor and the construction supervision then the upgraded works could probably be commissioned after about 3 years.

4.4.4 Increasing Capacity of Tienfontein Pump Station

4.4.4.1 Description of Schemes

The Tienfontein Pump Station is owned by DWS and operated by BW, however maintenance and the procurement thereof is undertaken by DWS. The pump station is situated on the Caledon River upstream of Welbedacht Dam and has been severely impacted by the sedimentation of the Caledon River upstream of the Dam. This and the ongoing maintenance problems limit the ability of the pump station to reliably deliver water to Knellpoort Dam.

The existing civil structure of the Tienfontein Pump Station consists of 7 pump bays, 4 of which normally have pump sets each with an installed capacity of 1 m^3/s, but one pump is currently being replaced. The Tienfontein Pump station has an operating capacity of 3 m^3/s (three duty pumps and one standby pump); however the capacity of the three remaining pumps is currently 2.8 m^3/s.

4.4.4.1.1 Upgrade to 4 m^3/s

The fourth pump at Tienfontein should be reinstalled by about December 2014. When this fourth pump is repaired or replaced the transfer capacity (excluding standby capacity) of the remaining three pumps will probably also be limited to about 2.8m^3/s.

DWS is proceeding with implementing the installation of two additional (1 m^3/s) pump sets at Tienfontein Pump Station. The first pump set would be utilised to increase the design capacity of the pump station to about 4 m^3/s and the second pump set to provide additional standby capacity. This would provide an additional yield of approximately 5 million m^3/a. The increase in the standby capacity (to 50% of design capacity) should facilitate maintenance of the pumps without impacting on the operating capacity of the pump station.

4.4.4.1.2 Upgrade from 4m^3/s to 7m^3/s

The replacement of the existing Tienfontein pump station with a new pump station designed for the high sediment load and with a pumping capacity of about 7 m^3/s has been proposed. This would provide an additional yield of 6 million m^3/annum compared with the 4 m^3/s capacity of the existing pump station after upgrading. It is intended that the proposed 7 m^3/s pump station and pumps would be designed for the local sedimentation circumstances and therefore should be more reliable than the existing pump station and pumps.

DWS is appointing a PSP to undertake the following:

- Double the pipeline at Tienfontein to the canal,
- Add another de-silting canal at Tienfontein,
- Add de-silting canals at the Welbedacht abstraction in order that water can be abstracted even when the Caledon River is in flood,
- Replace the low level pump station,
- Other Dam Safety related rehabilitation work.

The increases in yields described above are additional to the yields that would be provided by the upgrading of the Welbedacht WTW as described in **Section 4.4.3**.

4.4.4.2 Cost Estimates

4.4.4.2.1 Upgrade to 4 m^3/s

It is very roughly estimated that the cost of two additional pumps to increase the pumping capacity to 4m^3/s with two standby pump would be about R20 million, but this should be confirmed with DWS based on the current replacement of one pump.

4.4.4.2.2 Upgrade from 4m^3/s to 7 m^3/s

The replacement of the existing pump station, and the duplication of the pipeline, desilting works and canal to increase the capacity to 7 m^3/s is very roughly estimated to cost about R150 million.

4.4.4.3 Programs

4.4.4.3.1 Upgrade to 4 m^3/s

As mentioned above the new pump set to replace the existing pump set at Tienfontein will only be commissioned in about December 2014 which will limit the opportunity to deliver water to Knellpoort Dam during the coming summer months when the river flows will be higher.

DWS will be ordering the two additional pumps to upgrade the capacity of the pump station to 4 m^3/s and it is estimated that this will take approximately 2 years.

4.4.4.3.2 Upgrade from 4m^3/s to 7 m^3/s

Assuming that the PSPs appointed by DWA immediately commence designing the proposed new pump station and associated works, then the 7 m^3/s pump station could be implemented in about 3 years if the scheme is fast tracked.

4.4.5 Duplication of Novo Scheme (Pump Station and Pipeline)

4.4.5.1 Description of Scheme

BW's Novo Transfer Scheme pumps water from Knellpoort Dam via a 20 km long 1 200 mm steel pipeline into the upper reaches of the Modder River, to augment the flows into Rustfontein Dam.

The Novo Pump Station currently houses 2 pump sets with a capacity of 1.7 m^3/s (without standby capacity) when the water level in Knellpoort Dam is at full supply level. One of these pump sets was out of commission for 7 months and was recommissioned in June 2014. BW has let a contract for the installation of a third pump set to increase the capacity of the pump station to 2.4 m^3/s (without standby capacity).

It has been assumed that the Novo scheme would have to be duplicated (pipeline and pump station) to serve the proposed Knellpoort Dam augmentation by the proposed bidirectional pipeline between the Knellpoort and Welbedacht Dams/Knellpoort Dam raising described in **Section 4.4.6** and also to serve the possible schemes from the Orange River i.e. the Oranjedraai and Aliwal North schemes described in **Sections 4.3.1 and 4.3.2**. The total pumping head for the Novo scheme of 160 m has been included in the pumping head of all these schemes which would utilise Knellpoort Dam.

It is recommended that the raising of Knellpoort Dam should form part of any further investigations of the bi-directional pipeline and schemes from the Orange River. The scheme would require the duplication of the pump station and the 1 200 mm pipeline, but it has been assumed that it would be possible to utilise the existing intake works, however this would have to be confirmed.

4.4.5.2 Cost Estimate

The estimated cost of duplicating the Novo scheme is R 270 million.

4.4.5.3 Program

The Duplication of the Novo Scheme would be required should any one of the following schemes be implemented:

- Oranjedraai via Knellpoort and Novo.
- Aliwal North via Knellpoort and Novo.
- Knellpoort Dam augmentation (Welbedacht Knellpoort Bidirectional Pipeline/Knellpoort Dam raising).

The duplication of the Novo Scheme itself would take approximately 8.5 years if normal procedures are followed and 5.5 years if the scheme is fast tracked. These programs would be accommodated within the longer programs of the other schemes that the Novo scheme would serve, and it might be possible to phase the scheme slightly later as the existing transfer scheme may have spare capacity.

4.4.6 Augmentation of Knellpoort Dam with a Bidirectional Pipeline from Welbedacht Dam/Dam Raising

4.4.6.1 Description

BW has commissioned a PSP to design a bi-directional pipeline between Welbedacht and Knellpoort Dams and has instructed the PSP to also provide the design for a pre-treatment option (a horizontal flow sedimentation tank has been proposed).

The following need to be investigated as part of the feasibility study/design:

- Most suitable manner to augment Knellpoort Dam.
- Integration with other supply schemes and infrastructure.
- Incremental yield generated and total yield available.
- Environmental implications.
- Water quality.
- Cost estimates.
- Implementation programme.

Preliminary assessments of the additional yields that could be provided by a bidirectional pipeline with the Tienfontein Pump Station already upgraded to deliver 4 m^3/s are shown in **Table 4-1**.

Table 4-1 | Increase in Yield Provided by Bi-directional Pipeline

Bidirectional Pipeline Capacity (m^3/s)	Yield Additional to that with 4 m^3/s Pumps at Tienfontein (million m^3/annum)
3	27
6	34

The bi-directional pipeline would operate as follows:

- During periods of higher flow in the Caledon River additional water to that which would be intercepted by the Tienfontein Pump Station would be pumped from Welbedacht Dam into Knellpoort Dam.
- Most of this water would be pumped from Knellpoort Dam by the Novo Scheme to Rustfontein Dam.
- Water would also be released from Knellpoort via the pipeline to the Welbedacht WTP during periods while sediment is flushed from the Welbedacht Dam.

The PSP appointed by BW is investigating a smaller diameter pipeline which would provide small increases in yield and it is recommended that the larger schemes described above should also be investigated as the increases in potential yield are substantial.

It is also recommended that the bidirectional pipeline investigation should consider the possible additional yield that might be provided by the possible raising of Knellpoort Dam.

4.4.6.2 Cost Estimate

The following sets of alternatives for bidirectional pipelines between Welbedacht Dam and Knellpoort Dam, to augment Knellpoort Dam have been costed:

- A 32 km pipeline with pumps at Welbedacht to deliver water to Knellpoort and gravity flow from Knellpoort to Welbedacht.
- A 17.5 km pipeline with pumps at Welbedacht and Knellpoort to pump the flow in both directions.

In all cases it has been conservatively assumed that the Novo Transfer Scheme (Pump Station and Pipeline) would be duplicated and that the water would be released to Mockes Dam for delivery to Bloemfontein via Maselspoort.

The approximate capital costs and the total pumping heads of the various schemes that have been assessed are described below:

a) 32 km pipeline with pumping from Welbedacht to Knellpoort and gravity flow back to Knellpoort:
   - 1 500 mm pipeline to pump 3 m^3/s to Knellpoort Dam and to gravitate 2.3 m^3/s to 2.8 m^3/s back to Welbedacht Dam: R 980 million including R 270 million for the duplication of the Novo scheme and R 210 million for the Maselspoort pipeline.
     The total pumping head for the scheme would be about 470 m, 90 m for the bidirectional pipeline plus 160 m for the Novo scheme and 220 m for the Maselspoort pipeline.
   - 1 800 mm pipeline to pump 6 m^3/s to Knellpoort Dam and to gravitate 3.7 m^3/s to 4.5 m^3/s back to Welbedacht Dam: R 1 270 million including R 270 million for the duplication of the Novo scheme and R 210 million for the Maselspoort pipeline.
     The total pumping head for the scheme would be about 490 m, 110 m for the bidirectional pipeline plus 160 m for the Novo scheme and 220 m for the Maselspoort pipeline.

b) 17.5 km pipeline with pumping from Welbedacht to Knellpoort and back to Welbedacht:
   - 1 400 mm pipeline to pump 6 m^3/s to Knellpoort Dam and to pump 2.3 m^3/s to 2.8 m^3/s back to Welbedacht Dam: R 880 million including R 270 million for the duplication of the Novo scheme and R 210 million for the Maselspoort pipeline.
     The total pumping head for the scheme would be about 500 m, 110 m for the bidirectional pipeline plus 160 m for the Novo scheme and 220 m for the Maselspoort pipeline.
   - 1 800 mm pipeline to pump 6 m^3/s to Knellpoort Dam and to pump 3.7 m^3/s to 4.5 m^3/s back to Welbedacht Dam: R 1 090 million including R 270 million for the duplication of the Novo scheme and R 210 million for the Maselspoort pipeline.

The total pumping head for the scheme would be about 500 m, 120 m for the bidirectional pipeline plus 160 m for the Novo scheme and 220 m for the Maselspoort scheme.

The optimal scheme will depend on the pumping costs, yields and other operational constraints.

It has been assumed that the water delivered by the Novo scheme to Rustfontein Dam would be released to Mockes Dam and treated at Maselspoort where additional treatment capacity of about 30 million m^3/annum would have to be provided and from there would be pumped to Bloemfontein via a new pipeline. This pipeline would cost an additional R210 million as indicated. And the pumping head would be about 190 m.

4.4.6.3 Program

The time required to implement the Bidirectional Pipeline would be about 8.5 years and 5.5 years if the scheme is fast tracked.

4.4.7 Addressing Siltation at Welbedacht Dam and WTP

4.4.7.1 Description

On account of the high turbidity of the river water in Welbedacht Dam, especially during flood events it is not possible to operate Welbedacht WTP at full capacity throughout the year. The WTP can operate at its full capacity of 145 Ml/d in winter, but can only treat between 90 and 100 Ml/d in summer when the silt load in the Caledon River is high. It is estimated that the yield of the system could potentially be increased by about 7 million m^3/annum if the WTP would be operated at full capacity all year round.

The storage capacity (and potential yield) of Welbedacht Dam could also potentially be improved through the scouring/flushing of Welbedacht Dam, however if it is not feasible to interrupt the flow to the water treatment works then one option would be to supply the works via the bidirectional pipeline as described in **Section 4.4.6** .

The 2012 Reconciliation Strategy recommended that the best approach to these sediment control interventions should be investigated.

DWS are planning to issue a tender for a PSP to design desilting canals upstream of the Welbedacht WTP and for the potential redesign of the low lift pump station. This will address turbidity issues and allow the Welbedacht Water Treatment Plant to operate at full capacity throughout the year. The appointed PSP will also look at the need for the doubling up of existing pipelines and desilting canals between Tienfontein Pump Station and Knellpoort Dam. At this stage DWS are still in the process of appointing a PSP.

The following need to be investigated as part of feasibility study/design:

- Most suitable manner to augment Knellpoort Dam.
- Synergies with other supply schemes and infrastructure.
- Incremental yield generated and total yield available.
- Environmental implications.
- Water Quality.
- Cost Estimates.
- Implementation programme.

4.4.7.2 Cost Estimate

No cost estimate has been prepared.

4.4.7.3 Program

It has been assumed that scheme could be implemented within 3 years.

4.5 Other Implementation Actions

4.5.1 Water Conservation and Water Demand Management (WC/WDM)

MMM is in the process of implementing various water conservation and water demand management (WC/WDM) initiatives. The objective of these initiatives is to reduce non-revenue water (NRW), reduce water demand and improve efficiency of the water supply system. The work completed to date is covered by the following programs:

- Thaba Nchu rural villages leak repairs and pipe replacement.
- Accelerated Community Infrastructure Program (ACIP 1 and 2).
- Mangaung Real Water Loss Reduction Program.
- Replacement and Installation of water meters and associated works.

MMM is currently preparing a 10-year WC/WDM strategy. The content of this strategy will be presented to the next Strategy Steering Committee meeting scheduled to be held in November 2014.

Funding is currently a limiting factor in achieving the required targets.

4.5.2 Potential Unauthorised Use Compliance Monitoring Enforcement

DWS is currently also investigating unauthorised water use. The process entails in-field confirmation of potential unauthorised use followed by handover to the Compliance Monitoring Enforcement (CME) office. The CME office will issue directive to users to stop unlawful water use and is able to take further steps where necessary.

4.5.3 Water Re-use

Water reuse includes the direct or indirect re-use of treated effluent. Public resistance to this intervention may be encountered, possibly stemming from concerns of poor design or control of processes which may allow sub-standard water to be introduced into the potable water supply system, or for religious reasons.

Waste water treatment plant (WWTP) return flows from upstream of Mockes Dam flow into the dam where they are mixed with runoff and releases from Rustfontein Dam. Water is abstracted from Mockes dam for irrigation and for treatment at Maselspoort to supply Bloemfontein.

Other water available for re-use would only be that arising from the growth after 2009 in return flows from other WWTPs in the catchment area. The yield of this option, for the purposes of the scenario planning, was assumed to be 10.8 million m^3/a in the Reconciliation Strategy, but may ultimately be significantly more, depending on the growth in water use and return flows.

4.5.4 Groundwater

Should groundwater be developed to supply the full current and projected water requirements of Wepener, Dewetsdorp, Reddersburg, Edenburg and Excelsior, then the water demand on the Greater Bloemfontein system would be reduced by approximately 4%. This would reduce the risk of non-supply and also keep the system in balance until 2016 where after a new augmentation scheme would be required.

Groundwater to augment the greater Bloemfontein area itself was ruled out as a feasible large scale augmentation options due to current abstraction levels, high costs and low borehole yields.

4.6 Summary of Augmentation Options

Table 4-2 summarises the various augmentation options that have been identified and are described above. Bloem Water's identified schemes have not been included in the table as there is significant overlap in the schemes already presented below. With reference to the normal and fast track programs of implementation shown in the last two columns of the Table it is evident that none of these options, other than the release from the LHWP could be implemented at short notice to alleviate the current crisis which arises.

Table 4-2 | Summary of possible augmentation options

Scheme	Peak Capacity (Mm^3/annum)	Yield (Mm^3/annum)	Capital Cost (R million)	Normal Program (years)	Fast Track Program (years)
Tienfontein PS 4m^3/s		5	20		2
Increase Tienfontein Pump Station Capacity from 4m^3/s to 7m^3/s		12	150		3
Welbedacht WTP 145 Ml/day		7			3
Gariep Dam to Bloemfontein	90	60	3980	12.5	8
Gariep Dam to Bloemfontein	60	60	3120*	12.5	8
Gariep Dam to Novo Outfall	60	60	2360*	12.5	8
Oranjedraai via Knellpoort and Novo	60	60	1810**	11	7
Aliwal North via Knellpoort and Novo	60	60	2380**	11.5	7.5
Knellpoort Augmentation (Welbedacht Bidirectional Pipeline and Novo)	27/34	27/34	980/1270** 880/1090**	8.5	5.5
Duplication of Novo Scheme	75	75	270	8.5	5.5

* Includes Maselspoort Bloemfontein Pipeline
** Includes Novo Scheme Duplication and Maselspoort Bloemfontein Pipeline

The earliest dates that first water could be delivered from these schemes are as shown in **Table 4-3**.

Table 4-3 | Earliest delivery dates of schemes (year)

Scheme	Program (Normal / Fast Track)	
	Normal	Fast Track
Tienfontein PS 4m^3/s		2016
Increase Tienfontein Pump Station Capacity from 4m^3/s to 7 m^3/s		2017
Welbedacht WTP 145 Ml/day		2017
Gariep to Bloemfontein 60Ml/d / Gariep to Novo Outfall	2027	2022
Oranjedraai via Knellpoort and Novo	2025	2021
Aliwal North via Knellpoort and Novo	2026	2022
Knellpoort augmentation (Welbedacht Bidirectional Pipeline and Novo)	2023	2020
Duplication of Novo Scheme	2022	2019

5 The Influence of Implementation Programmes on the Action Plan

5.1 Assessment of Implementation Programmes

The 2012 Greater Bloemfontein Reconciliation Strategy recommended that feasible schemes (in terms of costs and environmental/social impacts) be assessed in order of mainly cost, but taking other factors into account as well. Similar criteria have been adopted for this assessment and particularly the times taken to implement schemes for both normal and fast track approaches.

A range of implementation programmes for bulk water augmentation schemes to ensure a water balance for the GBWSS, for various water balance scenarios have been determined for the future water requirements Probable Scenario.

Note that the baseline for all the scenarios evaluated includes the following three interventions which it has been assumed would be implemented in all cases:

- WC/WDM measures for the first 5 years of the evaluation.
- Capacity of the pumps at Tienfontein Pump Station increased to 4 m^3/s.
- Capacity of Welbedacht WTP increased to 145Ml/d.

The following additional schemes have been considered in various combinations:

- Pipeline from Gariep Dam to Bloemfontein, typical and fast-tracked programmes (several variations of this pipeline were evaluated). Alternate schemes from the Orange River are not shown.
- Knellpoort Dam augmentation (Welbedacht to Knellpoort Bidirectional Pipeline/Knellpoort Dam raising), typical and fast-tracked programmes.
- Capacity of the pumps at Tienfontein Pump Station increased from 4 m^3/s to 7 m^3/s.

Four scenarios were considered to evaluate the implications of implementing certain schemes first, as shown in **Error! Reference source not found.Figure 5-1 to** Error! Reference source not found. and described in **Table 5-1 to Table 5-4.**

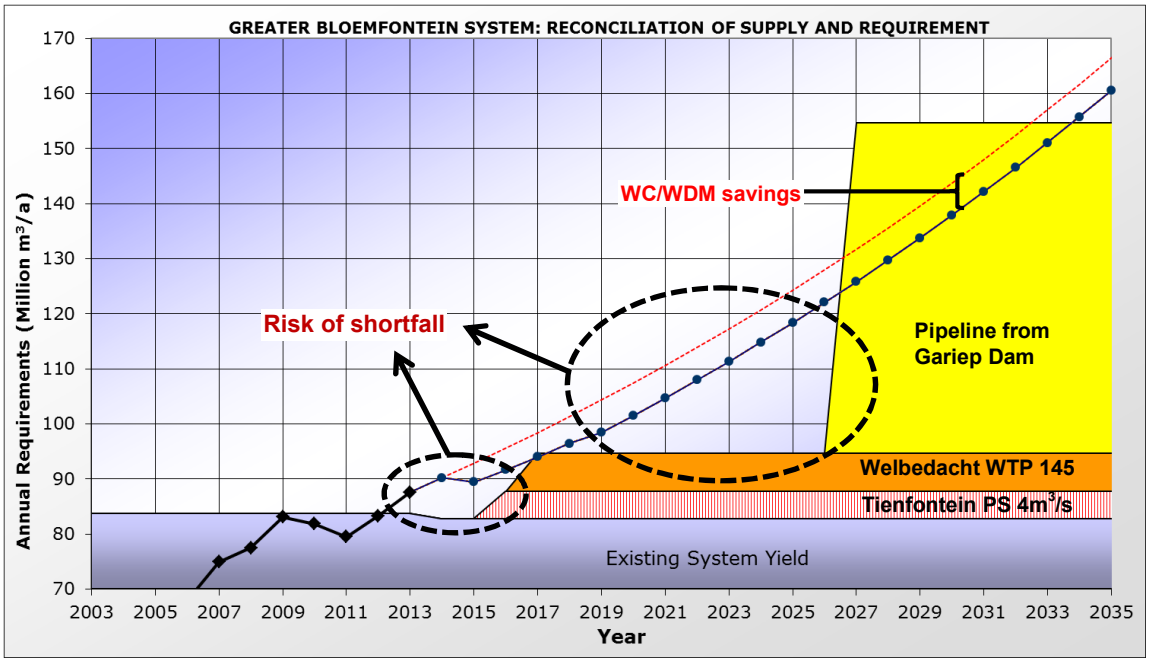

Figure 5-1 | Scenario Implementation Programme 1

The interventions for the 1st scenario shown in Error! Reference source not found. above would be implemented as shown in the following **Table 5-1**.

From **Error! Reference source not found.** it is evident that until the Tienfontein 4 m^3/s scheme and the upgrading of the Welbedacht WTP to 145 Ml/d are complete the GBWSS is at risk of not meeting the full water demands under drought conditions.

Table 5-1 | Scenario Implementation Programme 1

Baseline interventions	Further Interventions	Year of First Water or Saving	Yield Mm^3/a)
WC/WDM: Years 1-5		2015	5.8
Tienfontein 4 m^3/s		2016	5.0
Welbedacht WTP 145		2017	7.0
	Gariep (178 km Raw Water 2 m^3/s)	2027	60.0

This illustrates the quickest implementation of a typical program to bring water by pipeline from Gariep Dam to Bloemfontein. It is evident that, **because of the long implementation program, this scheme would be too late as the next intervention if implemented according to its typical implementation program**, following the baseline interventions being implemented.

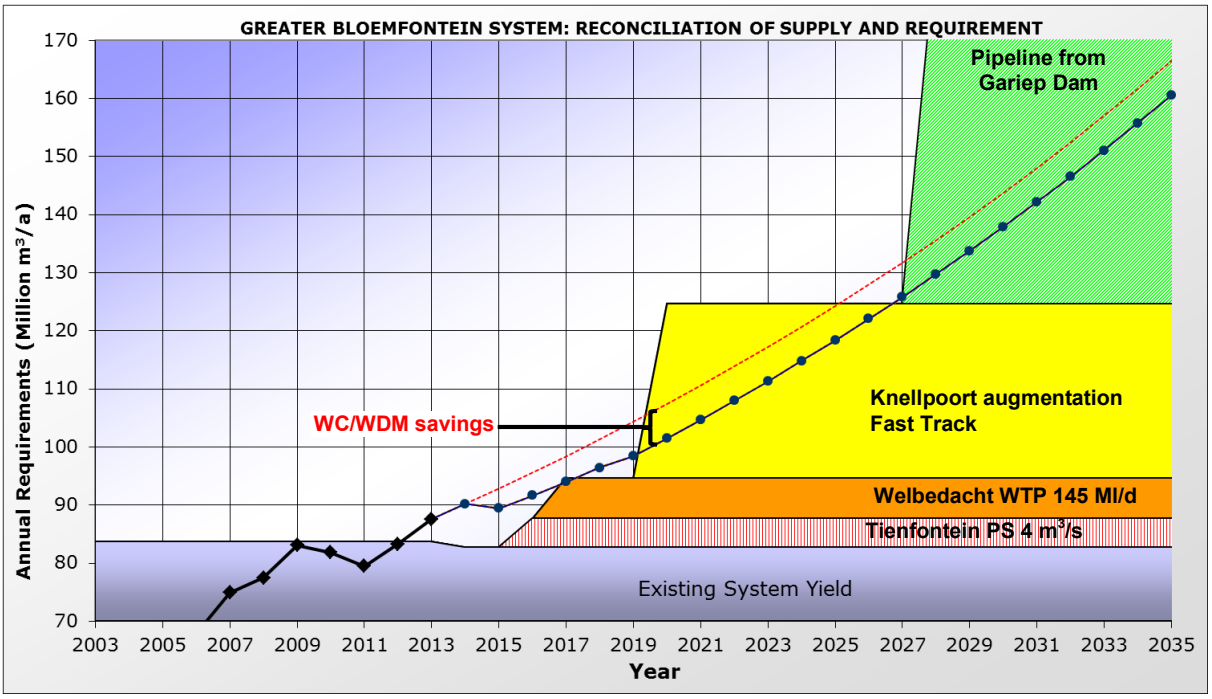

Figure 5-2 | Scenario Implementation Programme 2

The interventions for the 2nd scenario as shown in **Error! Reference source not found.** above are implemented as shown in the following **Table 5-2**.

Table 5-2 | Scenario Implementation Programme 2

Baseline interventions	Further Interventions	Year of First Water or Saving	Yield Mm^3/a)
WC/WDM: Years 1-5		2015	5.8
Tienfontein 4 m^3/s		2016	5.0
Welbedacht WTP 145		2017	7.0
	Knellpoort augmentation (Welbedacht Bidirectional pipeline) Fast Track	2020	30.0
	Gariep (178 km Raw Water 2 m^3/s)	2028	60.0

This scenario shows the potential for implementing the Fast Track Knellpoort Augmentation Scheme (Bi-Directional Pipeline) before the pipeline from Gariep Dam to Bloemfontein. The Knellpoort Augmentation Scheme can be implemented 2 years later than required, even if fast tracked. This would provide adequate time to implement the pipeline from Gariep Dam to Bloemfontein (one year later than its typical implementation program), without having to fast-track the pipeline scheme from Gariep Dam to Bloemfontein. Some interim measure providing a small additional yield may then still be required.

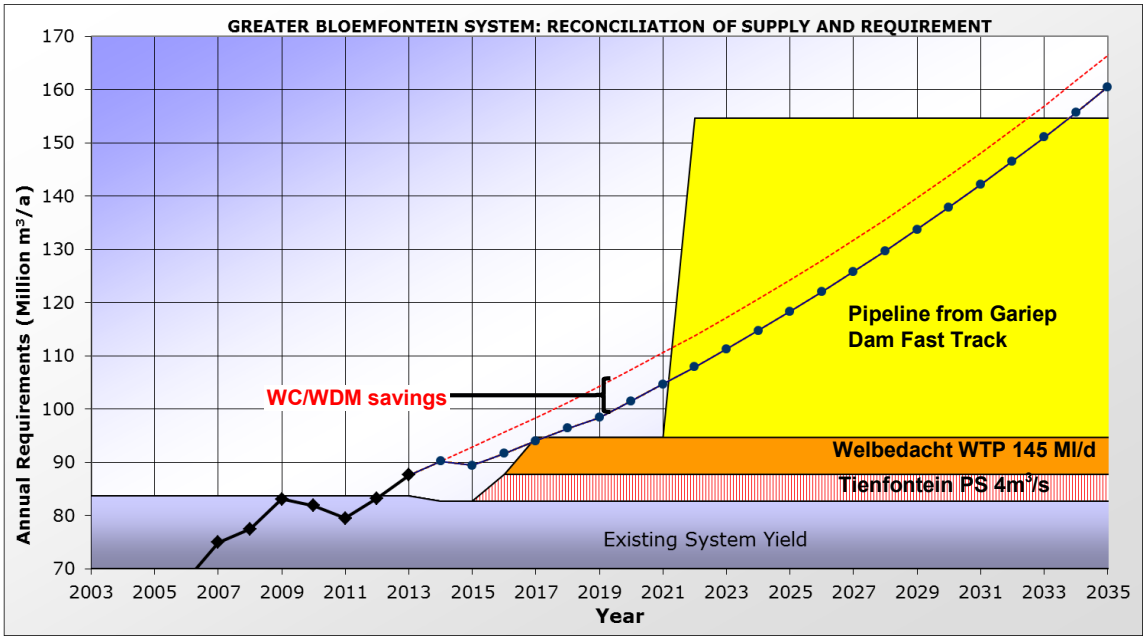

Figure 5-3 | Scenario Implementation Programme 3

The interventions for the 3rd scenario as shown in **Error! Reference source not found.** above are implemented as shown in the following **Table 5-3**.

Table 5-3 | Scenario Implementation Programme 3

Baseline interventions	Further Interventions	Year of First Water or Saving	Yield Mm^3/a)
WC/WDM: Years 1-5		2015	5.8
Tienfontein 4 m^3/s		2016	5.0
Welbedacht WTP 145		2017	7.0
	Gariep (178 km) Fast Track	2022	60.0

This scenario shows the potential for fast tracking the pipeline from Gariep Dam, as the next bulk water augmentation scheme following implementation of the baseline interventions. It is evident that such a scheme could only be implemented about 4 years later than required, even if fast tracked. An interim measure would be required.

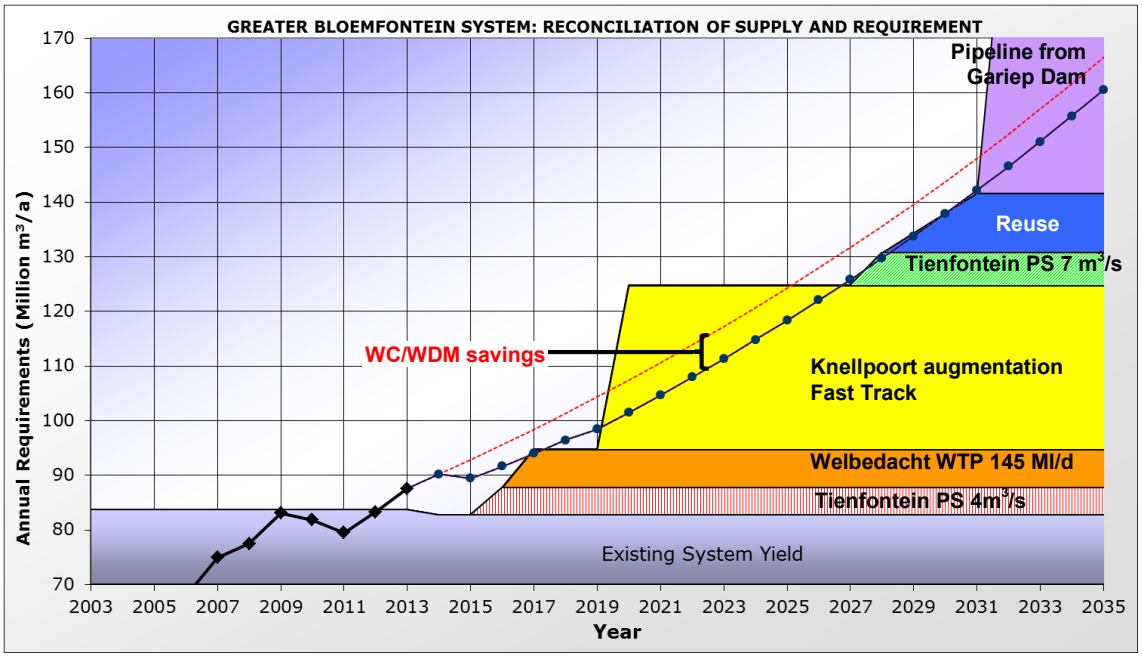

Figure 5-4 | Scenario Implementation Programme 4

The interventions for the 4th scenario as shown in Error! Reference source not found. above are implemented as shown in the following **Table 5-4Error! Reference source not found.**

Table 5-4 | Scenario Implementation Programme 4

Baseline interventions	Further Interventions	Year of First Water or Saving	Yield Mm^3/a)
WC/WDM: Years 1-5		2015	5.8
Tienfontein 4 m^3/s		2016	5.0
Welbedacht WTP 145		2017	7.0
	Knellpoort Augmentation (Welbedacht Bidirectional/Dam Raising) Fast Track	2017	30.0
	Tienfontein PS 4 m^3/s to7 m^3/s	2027	6.0
	Reuse of treated effluent	2029	10.9
	Gariep (178 km Raw Water 2 m^3/s)	2032	60

This scenario shows alternative intervention options which are available for implementation before transferring water from the Orange River. It shows that it is possible to delay transfers from the Orange River up to 2032, should this scenario be implemented.

5.2 Implications of scenario options for the Implementation Programme

The upgrading of the capacity of Tienfontein Pump Station to 4m^3/s and the increase in the treatment capacity of Welbedacht WTP to 145 Ml/d is both already scheduled for completion by 2016.

Following that, the following possible bulk water schemes could be considered for implementation, apart from other mutually exclusive options:

i. Pipeline from Gariep Dam to Bloemfontein, implemented according to either a typical or fast-tracked program (variations of this pipeline were evaluated).

ii. Pipeline from Vanderkloof Dam to Bloemfontein, an option that has not been discussed in more detail in this report. This option would have a similar implementation program to the pipeline from Gariep Dam to Bloemfontein.

iii. Alternate Orange River transfer: Oranjedraai 'run-of-river' pipeline Scheme from the upper Orange River, implemented according to either a typical or fast-tracked program (variations of this pipeline were evaluated).

iv. Increased use of the Caledon River:
   - Knellpoort Dam augmentation (Welbedacht to Knellpoort Bidirectional Pipeline), implemented according to either a typical or fast-tracked program.
   - Increasing the capacity of Tienfontein Pump Station from 4m^3/s to 7m^3/s.

v. Reuse of water.

Figure 5-1 Error! Reference source not found.shows that it will take too long to implement a pipeline from Gariep Dam as the next augmentation scheme, following the baseline schemes, according to a typical implementation programme, and that another augmentation measure would first be required. The fast track programme for a pipeline from Gariep Dam could be implemented four years later than required, as indicated in **Figure 5-3Error! Reference source not found.**.

The Knellpoort Dam Augmentation Scheme could be implemented two years later than required according to a fast track implementation program as indicated in **Figure 5-2Error! Reference source not found.**.

Error! Reference source not found. represents a scenario where both Caledon River schemes as well as a reuse scheme are implemented first, delaying the need for water from the Orange River up to 2032.

It is however very important to take into consideration that the fast track options have inherent risks of not meeting the short deadlines associated with their accelerated programmes. The consequences of unexpected delays can be significant.

6 Accelerated Action Plan

This Action Plan firstly recommends and prioritises the Short Term Measures described in **Section 3** and recommends the Accelerated Longer Term actions to be taken to provide sufficient supply to meet the growing water demands of the MMM and other areas served by BW and MMM.

6.1 Short Term Action Plan

The short term measures described in **Table 6-1** are recommended to minimise the risk that there will be insufficient water available in the short term, particularly from Rustfontein Dam, to supply some areas of MMM.

Table 6-1 | Short Term Action Plan

Short Term Measures	Responsibility	Programme
Obtain **authority to expedite procurement procedures** so as to be able **to rapidly undertake maintenance, repairs** and any other **urgent measures** necessary, possibly by **declaring an Emergency situation in terms of Section 3.5 of the NWA.** This pertains to: • Tienfontein Pump Station: capacity and operation • Novo Pump Station: capacity and operation • Decreased production rate at Welbedacht WTP due to siltation. Ongoing Welbedacht siltation could put Tienfontein P/S at risk • Integrity of Welbedacht Pipeline • Insufficient Distribution Reservoir Storage Capacity in WSS	DWS, BW, MMM	August 2014
Hold **regular** (at least monthly) **meetings** to update actions and progress with urgent measures as well as monthly usage and storage of dams	DWS,BW,MMM	Monthly
Implement **short term WC/WDM measures**, which can include a publicity campaign and a hot line to report leaks etc.	MMM	August 2014
Engage with high water users to try and limit their short term water demand	MMM	Ongoing
Review the water tariff structure and amend if deemed necessary	MMM	August 2014
Maximise transfers from the Caledon to Knellpoort Dam and from Knellpoort Dam to Rustfontein Dam	DWS, BW	Ongoing
If necessary plan and manage more releases from the LHWP to the Caledon River	DWS, BW	As required
Minimise demand on Rustfontein Dam and	BW, MMM	Ongoing

Short Term Measures	Responsibility	Programme
maximise utilisation of Welbedacht and Mockes Dams (if storage is available in the latter).		
Review the restrictions on irrigators, particularly those that irrigate **from Mockes Dam** and **explore** the possible **temporary purchase of their allocations**	DWS, MMM	August 2014
Plan short term measures to access **dead storage in Rustfontein Dam** and prepare for rapid implementation	DWS, BW	August 2014
Plan short term measures to access **dead storage in Knellpoort Dam**	DWS, BW	September 2014

6.2 Accelerated Longer Term Action Plan

The priority actions in the Accelerated Longer Term Action Plan **Table 6-2** are necessary for planning and implementing schemes to meet the growing water requirements of the areas served by BW and MMM. Actions relating to the management of water use are equally (if not more) important and have been included.

Table 6-2 | Accelerated Longer Term Action Plan

Priority Actions	Responsibility	Programme
Once scheme yields are known, commission a **pre-feasibility study of** the following options: • Transfer from Gariep Dam • Transfer from Vanderkloof Dam • Oranjedraai and Aliwal North Transfer Schemes on Orange River • Knellpoort Dam augmentation (Welbedacht / Knellpoort dams bi-directional pipeline, Knellpoort Dam Raising) • Increasing Tienfontein Pump Station capacity from 4m^3/s to 7 m^3/s • Novo Scheme Augmentation (pump station, pipeline and WTP) • Water Reuse This includes a system analysis for the various bulk water augmentation options to confirm potential allocations and scheme yields and to optimise water supply systems. Financial evaluation should include full life-cycle costing, inclusive of O&M costs. Prioritise the most favourable option/s for a feasibility study.	DWS, BW	September 2014-December 2014
Undertake a **feasibility study** of measures to improve the reliability of the Welbedacht pipeline and	BW, MMM	September 2014-December 2014

Priority Actions	Responsibility	Programme
the flexibility of supply from the existing bulk WSS.		
Undertake a **Feasibility Study** of the scheme/s prioritised by the prefeasibility study, once complete. This should include the following: • Evaluation of technical, social, environmental, economic and financial aspects and impacts. • Identification and evaluation of all scheme components. • Conceptual design of the scheme. • Geotechnical and geological investigations. • Full Environmental Impact Assessment.	DWS, BW	October 2015-December 2015
Programme of compliance monitoring and enforcement for current agricultural water use (in excess of legal use) in areas upstream of Rustfontein Dam, which possibly decreases the yield of the GBWSS	DWS, FS DOA	Ongoing
Implementation of WC/WDM Programme (funding constraint needs to be overcome)	MMM	Ongoing

6.3 Implementation of the Action Plans

The following recommendations are made for implementation of the Action Plans defined:

i. Immediately implement the Short Term Action Plan, the implementation of which is recommended to be actively managed and reported on by a team comprised of representatives of DWS, MMM and BW. The first task would be to agree on representatives for an Implementation Committee for the Action Plan, who should undertake a review of the Action Plan, update it if necessary and source commitment to responsibilities, and timelines.

ii. Implement the Accelerated Longer Term Action Plan under the auspices of the Greater Bloemfontein Reconciliation Strategy. This initiative has structures at management and technical level in place that comprises representatives of the key water organisations. These are the:

   a. Strategy Steering Committee (SSC), representing all relevant government departments and statutory organisations whose planning depends on the availability of water, as well as Water Services Authorities (municipalities) who receive their water from the GBWSS,

   b. Administrative and Technical Support Group (ATSG), responsible for general administrative and technical support that provides support to the SSC, and implements the decisions of the SSC.

7 References

1. Bloem Water, 2011. Extension of the Capacity of the Novo Transfer Scheme Study (EB/2009/5). Prepared by V&V Consulting Engineers Pty (Ltd) et al for Bloem Water.
2. Bloem Water, 2014. Pre Feasibility Investigation: Investigation for a Pipeline from Gariep Dam to Knellpoort Dam including Alternative Options Report. Prepared by Babereki Consulting Engineers for Bloem Water
3. Department of Water Affairs, South Africa. 2012. Reconciliation Strategy Report for the Large Bulk Water Supply Systems of the Greater Bloemfontein Area. Prepared by Aurecon in association with GHT Consulting Scientists and ILISO Consulting as part of the Water Reconciliation Strategy Study for the Large Bulk Water Supply Systems: Greater Bloemfontein Area. DWA Report No. P WMA 14/C520/00/0910/05
4. Department of Water Affairs, South Africa. June 2014. Progress Report of the Strategy Steering Committee meeting 5 held on the 19th June 2014. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area
5. Department of Water Affairs, South Africa. May 2014. Minutes of the Technical Support Committee Meeting held on the 8th May 2014. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area
6. Department of Water Affairs, South Africa. November 2013. Progress Report of the Strategy Steering Committee Meeting. Prepared by Aurecon as part of the Support to the Continuation of the Water Reconciliation Strategy for Large Bulk Water Supply Systems: Greater Bloemfontein Area
7. Department of Water Affairs, South Africa, 2014. Final Reconciliation Strategy (July 2014) – internal draft. Being prepared by WRP Consulting Engineer *set al*as part of the Development of Reconciliation Strategies for Large Bulk Water Supply Systems: Orange River
8. Mangaung Metro Municipality, July 2014. Draft Pre-Feasibility Study Report - Bulk Water Supply to the Greater Bloemfontein Area from Gariep Dam. Prepared by BIGEN AFRICA Services (Pty) Ltd for Mangaung Metro Municipality
9. Mangaung Metro Municipality, 23 June 2014. Caledon Modder Sub System: Limiting of Water Use in terms of Item 6 of Schedule 3 of the National Water Act of 1998 (Act 36 of 1998): Implementation of Water Restriction. Internal Letter to the City Manager from Directorate Engineering Services.

Appendix A
Programs for Prefeasibility and Feasibility Studies, Design and Construction

APPENDIX A: PROGRAMS FOR PREFEASIBILITY AND FEASIBILITY STUDIES, DESIGN AND CONSTRUCTION

A1: Program for Typical and Fast Track Prefeasibility Study

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration (months)**	**Programme Item**	**Duration (months)**
Prefeasibility Study	**27**	**Prefeasibility Study**	**15**
1. Decision, Budget and Appointment of PSP for Prefeasibility Study	**9.5**	**1. Decision, Budget and Appointment of Engineering/Reserve and Environmental PSPs for Prefeasibility and Feasibility Studies**	**5**
a) DWS Decision and Budget:		**a) DWS Decision and Budget:**	
(i) DWS decides to proceed with project	**1**	(i) DWS decides to proceed with project	**0.5**
(ii) The budget for PSP's services has usually been allocated by DWS well in advance		(ii) The budget for PSP's services has usually been allocated by DWS well in advance	
b) DWS Appointment of PSP for Prefeasibility:	**8.5**	**b) DWS Appointment of PSP for Prefeasibility and Feasibility and Environmental PSP:**	**4.5**
(i) DWS prepares terms of reference	1.5	(i) DWS prepares separate terms of reference for separate engineering and environmental PSPs for a limited number of alternatives selected by DWS	1
(ii) DWS places an invitation in newspapers inviting PSPs to submit proposals	1	(ii) DWS selects separate engineering and environmental PSPs from its panels and requests the PSPs to submit proposals.	0.5
(iii) PSPs prepare and submit proposals to DWS	1.5	(iii) PSPs prepare and submit proposals	1
(iv) DWS adjudicates proposals	3	(iv) DWS reviews proposals	1
(v) DWS advises PSP that proposal is accepted and submits Agreement to PSP for signature	1	(v) DWS advises PSPs that proposals are accepted and submits Agreements to PSPs for signature	0.5
(vi) PSP signs Agreement	0.5	(vi) PSP signs Agreement	0.5
2. Undertaking Prefeasibility Study	**17.5**	**2. Undertaking Prefeasibility Study**	**10**
(i) PSP meets with DWS and prepares Inception Report	1.5	(i) PSPs meet separately with DWS and prepare Inception Reports	1
(ii) PSP reviews all alternatives (from engineering, environmental and Reserve perspectives) and suggests additional options, gathers data and visits sites together with Engineers		(ii) PSPs reviews limited number of alternatives selected by DWS, gathers data and visit sites	2
(iii) The PSP analyses alternatives including system yield analyses, prepares concept designs, costs alternatives, reviews future	4	(iii) Engineering PSP analyses the limited number of alternatives selected by DWS including system yield analyses, prepares	

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration (months)**	**Programme Item**	**Duration (months)**
Prefeasibility Study	**27**	**Prefeasibility Study**	**15**
water demands, assesses environmental impacts and probable Reserve requirements, and prepares URVs for phased development	8	concept designs, cost alternatives, review future water demands and prepare URVs for phased development	4
(iv) PSP prepares material, arrange workshop and document results of selection of alternative or alternatives to be studied at Feasibility level	2	(iv) PSPs prepares material, arranges workshop and documents results for selection of alternative to be studied at Feasibility level	1.5
(v) PSP prepares Prefeasibility Report	2	(v) Engineering and Environmental PSP prepare prefeasibility Reports	1.5

A2: Program for Typical and Fast Track Feasibility Study

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration (months)**	**Programme Item**	**Duration (months)**
Feasibility Study	**43.5**	**Feasibility Study**	**20.5**
1. Decision, Budget and Appointment of Separate Engineering/Reserve and Environmental (EIA) PSPs	**11.5**	**1. Decision and Budget**	**2**
a) DWS Decision and Budget	**3**	**a) DWS Decision and Budget**	**1**
(i) DWS Reviews Prefeasibility Report and decides whether to proceed with Feasibility Study	3	(i) DWS Reviews Prefeasibility Report and decides whether to proceed with Feasibility Study	1
(ii) The budget for PSPs' services would be allocated by DWS well in advance		(ii) The budget for PSPs' services would be allocated by DWS well in advance	
b) DWS Appointment of Separate Engineering/Reserve and, EIA PSPs	**8.5**	**b) DWS Appointment of Separate Engineering/Reserve and, EIA PSPs**	**1**
(i) DWS prepares separate terms of reference for engineering/Reserve, environmental PSPs	1.5	(i) DWS refine TORs of Environmental (EIA) PSP	1
(ii) DWS places an invitation in newspapers inviting PSPs to submit proposals	1		
(iii) PSPs prepare and submit proposals to DWS	1.5		
(iv) DWS adjudicates proposals	3		
(v) DWS advises PSPs that proposals are accepted and submits Agreements to PSPs for signature	1		
(vi) PSPs sign Agreements	0.5		

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration (months)**	**Programme Item**	**Duration (months)**
2. Feasibility Study and Reserve	**32**	**2. Feasibility Study and Reserve**	**18.5**
a) Engineering/Reserve PSP	**19**	**a) Engineering/Reserve PSP**	**10.5**
(i) PSP meets with DWS, reviews relevant aspects of Prefeasibility Study and prepares Inception Report	2	(i) Engineering PSP arranges for topographical and geotechnical surveys to be undertaken as a parallel activity	1
(ii) PSP reviews all available information and visits site/s	1	(ii) Engineering PSP formulates options for selected alternative, including phasing and analyses these in terms of yield, phasing and unit reference values	6
(iii) Engineering PSP arranges for topographical and geotechnical surveys to be undertaken as a parallel activity	1	(iii) Engineering PSP arranges material for workshop to select option	1
(iv) Engineering PSP formulates options for selected alternative, including phasing and analyses these in terms of yield, phasing and unit reference values	9	(iv) Engineering PSP prepares Preliminary Design and detailed costing thereof	1
(v) Engineering PSP arranges material for workshop to select option	1	(v) Engineering PSP prepares final report	1
(vi) Engineering PSP prepares Preliminary Design and detailed costing thereof	2	(vi) DWS reviews Final Report and Engineering incorporates amendments and issues Final Report	0.5
(vii) Engineering PSP prepares final report	2		
(viii) DWS reviews Final Report and Engineering incorporates amendments and issues Final Report	1		
b) EIA PSP (initially in parallel with Engineering PSP but approvals could result in delays): Additional time	**13**	**b) EIA PSP (initially in parallel with Engineering PSP but approvals could result in delays): Additional time**	**8**
(i) PSP meets with DWS, reviews relevant aspects of Prefeasibility Study and prepares Inception Report		(i) PSP meets with DWS, reviews relevant aspects of Prefeasibility Study and prepares Inception Report	
(ii) PSP reviews all available information and visits site/s.		(ii) PSP reviews all available information and visits site/s.	
(iii) PSP prepares data base of key stakeholders and invites IAPs to register.		(iii) PSP prepares data base of key stakeholders and invites IAPs to register.	
(iv) PSP issues information sheets.		(iv) PSP issues information sheets.	
(v) PSP holds two sets of public meetings		(v) PSP holds two sets of public meetings	
(vi) PSP prepares EIA Scoping Report		(vi) PSP prepares EIA Scoping Report	
(vii) PSP prepares EIA Report, once Feasibility Study recommendations are known	2	(vii) PSP prepares EIA report, once Feasibility Study recommendations are known	1
(viii) PSP applies for approvals from various authorities	2	(viii) PSP applies for approvals from various authorities	1
(ix) Approval granted from relevant authorities	9	(ix) Approval granted from relevant authorities	6

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration** (months)	**Programme Item**	**Duration** (months)
c) Reserve PSP (if required then in parallel with Engineering and Environmental PSPs, but if a Comprehensive Reserve determination is required this could cause delay) (i) PSP determines Reserve requirements and issues report.	-	**c) Reserve PSP (if required then in parallel with Engineering and Environmental PSPs, but if a Comprehensive Reserve determination is required this could cause delay)** (i) PSP determines Reserve requirements and issues report	-

A3: Program for Typical and Fast Track Design and Construction

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration (months)**	**Programme Item**	**Duration (months)**
Design and Construction	**49.5 to 85.5**	**Design and Construction**	**41.5 to 59.5**
1. Decision, Budget and Appointment of PSP for Design and Construction Supervision	**9.5**	**1. Decision, Budget and Appointment of PSP for Design and Construction Supervision**	**5.5**
a) DWS Decision and Budget	**1**	**a) DWS Decision and Budget**	**1**
(i) DWS decides to proceed with project	1	(i) DWS decides to proceed with project	1
(ii) The budget for PSP's services has usually been allocated by DWS well in advance however acquisition of funds for construction may take longer but it is assumed that this would proceed during the design phase		(ii) The budget for PSP's services has usually been allocated by DWS well in advance however acquisition of funds for construction may take longer but it is assumed that this would proceed during the design phase	
b) DWS Appointment of PSP	**8.5**	**b) DWS Appointment of PSP**	**4.5**
(i) DWS prepares terms of reference for engineering PSP	1.5	(i) DWS prepares terms of reference for engineering PSP	1
(ii) DWS places an invitation in newspapers inviting PSPs to submit proposals	1	(ii) DWS selects PSP from its panel and requests the PSPs to submit proposals	0.5
(iii) PSPs prepare and submit proposals to DWS	1.5	(iii) PSPs prepare and submit proposals	1
(iv) DWS adjudicates proposals	3	(iv) DWS reviews proposals	1
(v) DWS advises PSP that proposals are accepted and submits Agreements to PSP for signature	1	(v) DWS advises PSP that proposal is accepted and submits Agreement to PSP for signature	0.5
(vi) PSP sign Agreements	0.5	(vi) PSP signs Agreement	0.5
2. Tender Design and Document	**22**	**2. Tender Design and Document**	**18**
a) Additional investigations	**15**	**a) Additional investigations**	**12**
(i) Additional topographical and geotechnical surveys done in parallel with detailed tender designs.		(i) Additional topographical and geotechnical surveys done in parallel with detailed tender designs.	
(ii) Undertake detailed tender designs, prepare tender drawings and specifications.	15	(iii) Undertake detailed tender designs, prepare tender drawings and specifications.	12
(iv) Design period will be slightly reduced for smaller schemes.		(v) Design period will be slightly reduced for smaller schemes.	
(vi) Expropriation, Servitudes and other authorisations assumed to take place in parallel with Tender Adjudication and Award.		(iii) Expropriation, Servitudes and other authorisations assumed to take place in parallel with Tender Adjudication and Award	

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration (months)**	**Programme Item**	**Duration (months)**
Design and Construction	**49.5 to 85.5**	**Design and Construction**	**41.5 to 59.5**
b) Tender, Adjudication and Award	**7**	**b) Tender Adjudication and Award**	**6**
(i) Advertise tender and hold site inspection	1.5	(i) Advertise tender and hold site inspection	1.5
(ii) Tender Period	1.5	(ii) Tender Period	1.5
(iii) Tender adjudication and award	4	(iii) Tender adjudication and award	4
3. Construction	**18 to 54**	**3. Construction**	**18 to 36**
(iv) Construction period varies depending on size and scope of project, and particularly projects which could be delayed by higher summer flows in rivers, by summer rainfalls or on account of delays in the supply of materials such as large diameter steel pipes, pumps and equipment.	**18 to 54**	(iv) Construction period varies depending on size and scope of project, and particularly projects which could be delayed by higher summer flows in rivers, by summer rainfalls or on account of delays in the supply of materials such as large diameter steel pipes, pumps and equipment. Some acceleration of the program may be possible at additional cost as would arise for a long pipeline if a Contractor works on say 8 pipeline fronts instead of 4 or 5 fronts.	**18 to 36**
Assumed Construction Periods:		Assumed Construction Periods:	
• Gariep to Bloemfontein (90 Ml/day proposed by Bigen)	54	• Gariep to Bloemfontein (90 Ml/day proposed by Bigen)	36
• Gariep to Bloemfontein (60 Ml/day)	54	• Gariep to Bloemfontein (60 Ml/day)	36
• Gariep to Novo Pipeline Outfall	54	• Gariep to Novo Pipeline Outfall	36
• Oranjedraai Knellpoort**	30	• Oranjedraai Knellpoort**	24
• Aliwal North Gariep**	36	• Aliwal North Gariep**	27
• Verbeeldingskraal**	36	• Verbeeldingskraal**	36
• Welbedacht Knellpoort Bidirectional Pipeline**	24	• Welbedacht Knellpoort Bidirectional Pipeline**	21
• Tienfontein Upgrading to 7 m^3/s	24	• Tienfontein Upgrading to 7 m^3/s	24
• Tienfontein Capacity Increase to 4 m^3/s	18	• Tienfontein Capacity Increase to 4 m^3/s	18
*** Includes Novo Duplication to be constructed later*		*** Includes Novo Duplication to be constructed later*	

A4: Program for Typical and Fast Track: Full Program to First Water

TYPICAL PROCEDURE		FAST TRACK PROCEDURE	
Programme Item	**Duration** (months)	**Programme Item**	**Duration** (months)
Prefeasibility Study	27	Prefeasibility Study	15
Feasibility Study	43.5	Feasibility Study	20.5
Design and Construction	49.5 to 85.5	Design and Construction	41.5 to 59.5
TOTAL IMPLEMENTATION PERIOD (months)	**120 to 156**	**TOTAL IMPLEMENTATION PERIOD (months)**	**87 to 95**
TOTAL IMPLEMENTATION PERIOD (years)	**10 to 13**	**TOTAL IMPLEMENTATION PERIOD (years)**	**7.25 to 9**

Appendix B
Tailored Programs for Prefeasibility and Feasibility Studies, Design and Construction

APPENDIX B: TAILORED PROGRAMS FOR PREFEASIBILITY AND FEASIBILITY STUDIES, DESIGN AND CONSTRUCTION

Months per Activity

ACTIVITY	Aliwal North (108 km Raw Water 2 m3/s)	Aliwal North Fast Track	Oranjedraai (80 km Raw Water 2 m3/s)	Oranjedraai Fast Track	Gariep Novo (174 km Raw Water 2 mm3/s)	Gariep Novo Fast Track	Begin Gariep (178 km Treated Water 3 m3/s)	Begin Gariep Fast Track	Welbedacht Knellpoort Bidirectional: Gravity from Knellpoort	Welbedacht Knellpoort Bidirectional Gravity from Knellpoort Fast Track	Knellpoort Welbedacht Bidirectional: Pumped	Knellpoort Welbedacht Bidirectional: Pumped Fast Track	Novo Duplication	Novo Fast Track	New Tienfontein 7 m3/s	New Tienfontein 7 m3/s Fast Track	Existing Tienfontein 4 m3/s	Existing Tienfontein 4 m3/s Fast Track	Welbedacht Treatment Works Upgrade	Welbedacht Treatment Works Upgrade Fast Track	Mazelspoort Bloem 22 km Pumped	Mazelspoort Bloem 22 km Pumped Fast Track
Prefeasibility Study																						
Budget, Decision and Appoint PSP	9.5	5.0	9.5	5.0	9.5	5.0	9.5	5.0	9.5	5.0	9.5	5.0	9.5	5.0							9.5	5.0
Prefeasibility Study	17.5	10.0	17.5	10.0	17.5	10.0	17.5	10.0	17.5	10.0	17.5	10.0	17.5	10.0							17.5	10.0
Total Prefeasibility	**27.0**	**15.0**	**27.0**	**15.0**	**27.0**	**15.0**	**27.0**	**15.0**	**27.0**	**15.0**	**27.0**	**15.0**	**27.0**	**15.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**27.0**	**15.0**
Feasibility Study, EIA and Reserve																						
Budget, Decision and Appoint PSP	11.5	2.0	11.5	2.0	11.5	2.0	11.5	2.0	11.5	2.0	11.5	2.0	11.5	2.0							11.5	2.0
Feasibility Study and Preliminary Design	32.0	18.5	32.0	18.5	32.0	18.5	32.0	18.5	16.0	9.0	16.0	9.0	16.0	9.0	16.0	9.0					16.0	9.0
Additional for EIA, Reserve, DMR approval and Licence	*13.0*	*8.0*	*13.0*	*8.0*	*13.0*	*8.0*	*13.0*	*8.0*	*13.0*	*8.0*	*13.0*	*8.0*	*13.0*	*8.0*	*13.0*	*8.0*					*13.0*	*8.0*
Total Feasibility	**43.5**	**20.5**	**43.5**	**20.5**	**43.5**	**20.5**	**43.5**	**20.5**	**27.5**	**11.0**	**27.5**	**11.0**	**27.5**	**11.0**	**16.0**	**9.0**	**0.0**	**0.0**	**0.0**	**0.0**	**27.5**	**11.0**
Design and Construction																						
Budget, Decision and Appoint PSP	9.5	5.5	9.5	5.5	9.5	5.5	9.5	5.5	9.5	5.5	9.5	5.5	9.5	5.5	9.5	5.5					9.5	5.5
Design	15.0	12.0	15.0	12.0	15.0	12.0	15.0	12.0	10.0	8.0	10.0	8.0	10.0	8.0	10.0	8.0			10.0	8.0	10.0	8.0
Tender and Award	7.0	6.0	7.0	6.0	7.0	6.0	7.0	6.0	7.0	6.0	7.0	6.0	7.0	6.0	7.0	6.0	5.0	4.0	5.0	4.0	7.0	6.0
Construction and Commissioning	36.0	27.0	30.0	24.0	48.0	36.0	48.0	36.0	21.0	21.0	21.0	21.0	21.0	21.0	24.0	24.0	18.0	18.0	21.0	21.0	21.0	21.0
Concurrent Expropriation/Servitude	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*	*12.0*
Total Design and Construction	**67.5**	**50.5**	**61.5**	**47.5**	**79.5**	**59.5**	**79.5**	**59.5**	**47.5**	**40.5**	**47.5**	**40.5**	**47.5**	**40.5**	**50.5**	**43.5**	**23.0**	**22.0**	**36.0**	**33.0**	**47.5**	**40.5**
TOTAL months	**138.0**	**86.0**	**132.0**	**83.0**	**150.0**	**95.0**	**150.0**	**95.0**	**102.0**	**66.5**	**102.0**	**66.5**	**102.0**	**66.5**	**66.5**	**52.5**	**23.0**	**22.0**	**36.0**	**33.0**	**102.0**	**66.5**
TOTAL years	**11.5**	**7.2**	**11.0**	**6.9**	**12.5**	**7.9**	**12.5**	**7.9**	**8.5**	**5.5**	**8.5**	**5.5**	**8.5**	**5.5**	**5.5**	**4.4**	**1.9**	**1.8**	**3.0**	**2.8**	**8.5**	**5.5**

WORKS REQUIRED	Design Capacity 2 m3/s 60 million m3/a		Design Capacity 2 m3/s 60 million m3/a		Design Capacity 2 m3/s 60 million m3/a		Design Capacity 3 m3/s 90 million m3/a		Design Capacity 3 m3/s 30-40 million m3/a		Design Capacity 3 m3/s 30-40 million m3/a		Design Capacity 2.4 m3/s		Design Capacity 7 m3/s 12 million m3/a		Design Capacity 4 m3/s 4 million m3/a		Design Capacity 4 m3/s 4 million m3/a		Design Capacity 1-3 m3/s	
	Modify Original/New Oranjedraai Weir		Modify Original/New Oranjedraai Weir		Utilise Existing Outlet Pipeline		Utilise Existing Outlet Pipeline		Utilise Existing Dam Outlet?		Utilise Existing Dam Outlet?		Utilise Existing Outlet Pipeline		Utilise Existing Outlet Pipeline		Utilise Existing Tienfontein Pipeline		Utilise Existing Tienfontein Pipeline			
	Low Lift River Water :Pump Station		Low Lift River Water :Pump Station						Desilting Works		Desilting Works											
	Desilting Works		Desilting Works		Dam Water Pump Station		Dam Water Pump Station		1 Raw Water Pump Station		2 Raw Water Pump Stations		Raw Water Pump Station		New Raw Water Pump Station		2 Additional Raw Water Pumps		2 Additional Raw Water Pumps		Raw Water Pump Station	
	Raw water High Lift Pump Station/s		Raw water High Lift Pump Station/s		Dam Water High Lift Pump Stations		Water Treatment Works		Pumped/Gravity Pipeline		Pumped Both Ways Pipeline		20 km Pipeline		Desilting Works						Water Treatment Works	
	New Powerline		New Powerline		Existing Powerline		Existing Powerline														Treated Water Pump Station	
	108 Kilometer Pipeline to Knelpoort		108 Kilometer Pipeline to Knelpoort		174 Kilometer Pipeline		Treated Water Pump Station		27 km Kilometer Pipeline		27 km Kilometer Pipeline				3 km Pipeline to Knellpoort		Existing pipeline to Knellpoort		Existing pipeline to Knellpoort		22 km Pipeline	
	Future Duplication of Novo Pumps		Future Duplication of Novo Pumps				178 km Kilometer Pipeline														Clear Water Reservoir	
	Mazelspoort 22 km Pipeline Scheme		Mazelspoort 22 km Pipeline Scheme		Mazelspoort 22 km Pipeline Scheme				Mazelspoort 22 km Pipeline Scheme		Mazelspoort 22 km Pipeline Scheme		Mazelspoort 22 km Pipeline Scheme									
Total pipeline length m	108000	108000	80000	80000	174000	174000	174000	174000	27000	27000	17000	17000	20000	20000	2500	2500	0	0	0	0	22000	22000
Metres per day	**200**	**300**	**200**	**300**	**250**	**350**	**250**	**250**	**100**	**100**	**100**	**100**	**100**	**100**	**50**	**50**	**1**	**1**	**1**	**1**	**100**	**100**
Working days per annum	220.00	220.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00	220.00	300.00
Total years	2.45	1.64	1.82	0.89	3.16	1.66	3.16	2.32	1.23	0.90	0.77	0.57	0.91	0.67	0.23	0.17	0.00	0.00	0.00	0.00	1.00	0.73
Additional time years	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
TOTAL TIME years	**3.0**	**2.1**	**2.3**	**1.4**	**3.7**	**2.2**	**3.7**	**2.8**	**1.7**	**1.4**	**1.3**	**1.1**	**1.4**	**1.2**	**0.7**	**0.7**	**0.5**	**0.5**	**0.5**	**0.5**	**1.5**	**1.2**
Pump Stations/River Works	**2.0**	**2.0**	**2.0**	**2.0**	**2**	**2**	**2**	**2**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**2**	**2**	**1.5**	**1.5**	**1.5**	**1.5**	**1.75**	**1.75**
Years	**3.00**	**2.25**	**2.50**	**2**	**4.00**	**3**	**4.00**	**3**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**1.75**	**2.00**	**2.00**	**1.50**	**1.5**	**1.50**	**1.5**	**1.75**	**1.75**
Months	**36**	**27**	**30**	**24**	**48**	**36**	**48**	**36**	**21**	**21**	**21**	**21**	**21**	**21**	**24**	**24**	**18**	**18**	**18**	**18**	**21**	**21**

Percentage of Months Compared with Gariep

ACTIVITY	Aliwal North (108 km Raw Water 2 m3/s)	Aliwal North Fast Track	Oranjedraai (80 km Raw Water 2 m3/s)	Oranjedraai Fast Track	Gariep Novo (174 km Raw Water 2 mm3/s)	Gariep Novo Fast Track	Begin Gariep (178 km Treated Water 3 m3/s)	Begin Gariep Fast Track	Welbedacht Knellpoort Bidirectional: Gravity from Knellpoort	Welbedacht Knellpoort Bidirectional Gravity from Knellpoort Fast Track	Knellpoort Welbedacht Bidirectional: Pumped	Knellpoort Welbedacht Bidirectional: Pumped Fast Track	Novo Duplication	Novo Fast Track	New Tienfontein 7 m3/s	New Tienfontein 7 m3/s Fast Track	Existing Tienfontein 4 m3/s	Existing Tienfontein 4 m3/s Fast Track	Existing Tienfontein 4 m3/s	Existing Tienfontein 4 m3/s Fast Track	Mazelspoort Bloem 22 km Pumped	Mazelspoort Bloem 22 km Pumped Fast Track
Prefeasibility Study																						
Budget, Decision and Appoint PSP	100%	53%	100%	53%	100%	53%	100%	53%	100%	53%	100%	53%	100%	53%	0%	0%	0%	0%	0%	0%	100%	53%
Prefeasibility Study	100%	57%	100%	57%	100%	57%	100%	57%	100%	57%	100%	57%	100%	57%	0%	0%	0%	0%	0%	0%	100%	57%
Total Prefeasibility	**100%**	**56%**	**100%**	**56%**	**100%**	**56%**	**100%**	**56%**	**100%**	**56%**	**100%**	**56%**	**100%**	**56%**	**0%**	**0%**	**0%**	**0%**	**0%**	**0%**	**100%**	**56%**
Feasibility Study, EIA and Reserve																						
Budget, Decision and Appoint PSP	100%	17%	100%	17%	100%	17%	100%	17%	100%	17%	100%	17%	100%	17%	0%	0%	0%	0%	0%	0%	100%	17%
Feasibility Study and Preliminary Design	100%	58%	100%	58%	100%	58%	100%	58%	50%	28%	50%	28%	50%	28%	50%	28%	0%	0%	0%	0%	50%	28%
Additional for EIA, Reserve, DMR approval and Licence	100%	62%	100%	62%	100%	62%	100%	62%	100%	62%	100%	62%	100%	62%	100%	62%	0%	0%	0%	0%	100%	62%
Total Feasibility	**100%**	**47%**	**100%**	**47%**	**100%**	**47%**	**100%**	**47%**	**63%**	**25%**	**63%**	**25%**	**63%**	**25%**	**37%**	**21%**	**0%**	**0%**	**0%**	**0%**	**63%**	**25%**
Design and Construction																						
Budget, Decision and Appoint PSP	100%	58%	100%	58%	100%	58%	100%	58%	100%	58%	100%	58%	100%	58%	100%	58%	0%	0%	0%	0%	100%	58%
Design	100%	80%	100%	80%	100%	80%	100%	80%	67%	53%	67%	53%	67%	53%	67%	53%	0%	0%	67%	53%	67%	53%
Tender and Award	100%	86%	100%	86%	100%	86%	100%	86%	100%	86%	100%	86%	100%	86%	100%	86%	71%	57%	71%	57%	100%	86%
Construction and Commissioning	75%	56%	63%	50%	100%	75%	100%	75%	44%	44%	44%	44%	44%	44%	50%	50%	38%	38%	44%	44%	44%	44%
Concurrent Expropriation/Servitude	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Total Design and Construction	**85%**	**64%**	**77%**	**60%**	**100%**	**75%**	**100%**	**75%**	**60%**	**51%**	**60%**	**51%**	**60%**	**51%**	**64%**	**55%**	**29%**	**28%**	**45%**	**42%**	**60%**	**51%**
TOTAL	**92%**	**57%**	**88%**	**55%**	**100%**	**63%**	**100%**	**63%**	**68%**	**44%**	**68%**	**44%**	**68%**	**44%**	**44%**	**35%**	**15%**	**15%**	**24%**	**22%**	**68%**	**44%**