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The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water

MAIN REPORT

FINAL

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PREAMBLE

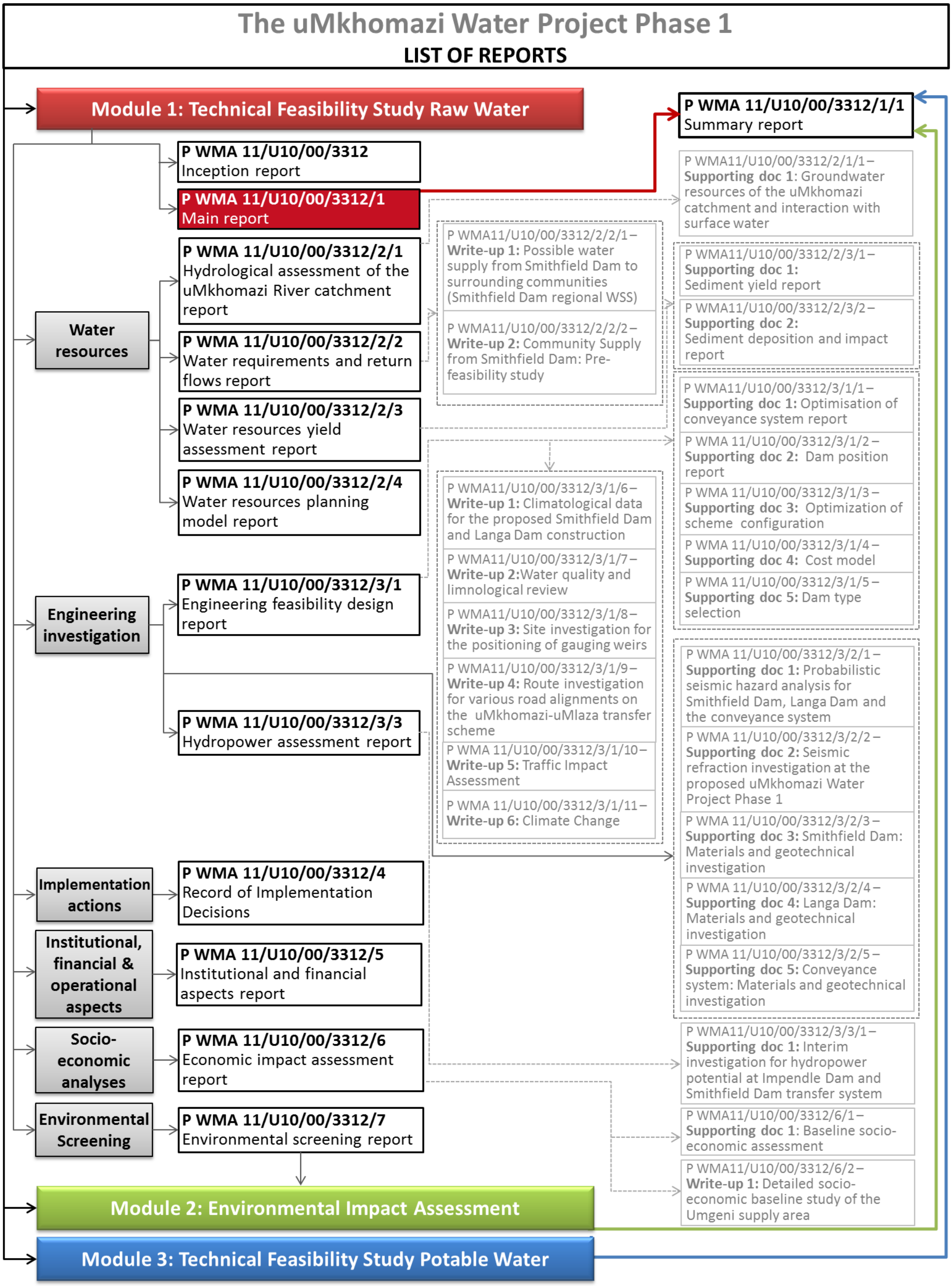
Department of Water Affairs vs Department Water and Sanitation

In June 2014, two years after the commencement of the uMkhomazi Water Project Phase 1 Feasibility Study, a new Department of Water and Sanitation was formed by Cabinet, including the formerly known Department of Water Affairs.

In order to maintain consistent reporting, all reports emanating from Module 1 of the study will be published under the Department of Water Affairs' (DWA) name.

BKS (Pty) Ltd vs AECOM

On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**. As a result of the change in name and ownership of the company during the study period, all the final study reports will be published under the AECOM name.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Executive Summary

BACKGROUND

The Department of Water Affairs (DWA) undertook the uMkhomazi Water Project (uMWP) Feasibility Study, as part of exploring options to meet the long-term water requirements of the approximately five million domestic and industrial water users in the eThekwini and Pietermaritzburg regions of KwaZulu-Natal. This area is the economic hub of KwaZulu-Natal, and needs reliable, efficient and sustainable long-term water supplies.

The objective of the study was to undertake a feasibility study to finalise the planning of the proposed uMWP at a detailed level. This feasibility study follows on from other investigations into the water resources of the Mgeni Water Supply System (WSS), including the KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy, *and these are regarded as part of the motivation for the uMWP.*

The feasibility study had been divided into the following modules, which ran concurrently:

- *Module 1: Technical Feasibility Raw Water (DWA) (this water resource study);*
- *Module 2: Environmental Impact Assessment (DWA); and*
- *Module 3: Technical Feasibility Potable Water (UW) (ranging from the Water Treatment Works to the tie-in point with the eThekwini pipe distribution system).*

NEED FOR ADDITIONAL AUGMENTATION FOR THE MGENI WSS

The Mgeni WSS is the main water source that supplies about five million people and industries in the eThekwini Metro Municipality, Msunduzi Local Municipality, and Ilembe, Ugu and Umgungundlovu District Municipalities' areas of jurisdiction.

There are four major dams in the Mgeni WSS, comprising Nagle, Midmar, Albert Falls and Inanda dams on the uMngeni River. Further it is augmented by the Mooi-Mgeni Transfer Scheme (MMTS), comprising of the Mearns Weir and Spring Grove Dam, both on the Mooi River.

*The water requirements projection shows that the Mgeni System may experience a deficit from **2016**, therefore the need for new water resources is imminent.*

OPTIONS TO AUGMENT THE MGENI WSS

Pre-feasibility investigations, undertaken by the DWA in 1998 and confirmed by the ***KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy****, indicated that the uMWP, which entails the transfer of water from the uMkhomazi River (a combination of dams at Smithfield and Impendle) to the Mgeni WSS, is the scheme most likely to fulfil this requirement.*

Other augmentation options, such as re-use and desalination, were also investigated. However, it was confirmed by the ***KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy*** *that these options would not be viable long-term alternatives for the uMWP, either due to cost, insufficient quantity or technical difficulties.*

Due to the location and the design of a gravity system, the uMWP is the only augmentation option that will supply water under gravitation, using almost no energy. Implementation of two hydropower plants should be considered for development as part of the system.

WATER AVAILABILITY AND USE IN THE UMKHOMAZI RIVER CATCHMENT

The uMkhomazi River, south west of the uMngeni Catchment, rises from the Drakensberg at levels of more than 3 200 masl with mean annual precipitation of around 1 200 mm, discharges into the Indian Ocean in the east and has a catchment area of 4 387 km². This catchment has an annual natural runoff of 1 078 million m³, 67% of which is generated upstream of the proposed Impendle and Smithfield dam sites.

The groundwater yield analysis indicated that the upper catchments, U10A to U10G have utilisable groundwater available in the order of 10 million m³/a or more.

The catchment is currently fairly undeveloped and only about 15% (159 million m³/a) of the runoff is currently being used, mostly for agricultural purposes and for the industrial user SAPPI-SAICCOR near the mouth of the uMkhomazi River at the town of Umkomaas.

Another 32% (350 million m³/a) of the catchment runoff is earmarked for ecological water requirements (EWR) to sustain the system's riverine health at a desirable level after the uMWP has been completed.

The proposed Smithfield Dam site is located on the uMkhomazi River, about 34 km north west from the town Richmond and about 14 km south west of the little village of Boston *in the KwaZulu-Natal midlands. From the optimization studies of this feasibility study a full supply level (FSL) of 930 masl was selected for the feasibility design of Smithfield Dam. This dam size corresponds to a live storage capacity of 226 million m^3 (a 31% MAR dam) and provides a 1:100-year yield (i.e. at an annual assurance of supply of 99%) of 220 million m^3/a, at the 2050-development level.*

An assessment of the total yield for the long term system, including a future Impendle Dam, indicated that the combined yield curve flattens towards a larger Impendle Dam, indicating that a combination of Smithfield Dam and a 1 MAR Impendle Dam will probably be the optimum system size. This needs to be confirmed in future studies.

LAYOUT OF SCHEME

From the Technical Feasibility Study the proposed layout of the first phase of the uMWP would comprise:

- *A new dam at Smithfield on the uMkhomazi River, and associated infrastructure;*
- *Raw water conveyance infrastructure (tunnel and pipeline) to the uMlaza River valley, including a balancing dam; and*
- *A water treatment works (WTW) in the uMlaza River valley, followed by a gravity pipeline to the Umgeni Water bulk distribution system, connecting in the area of the Umlaas Road reservoir. (The potable water infrastructure forms part of Module 3 of the Feasibility Study undertaken by Umgeni Water.)*

Phase two of the uMWP is planned for implementation in 2042, and will comprise the construction of a second large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam. An additional tunnel should then be constructed.

SMITHFIELD DAM

Various positions for the proposed Smithfield Dam were considered and the lowest cost option at site B (the pre-feasibility study site) was selected, which also conforms to the requirement of the transfer of water through a pressure tunnel and pipeline. The dam type and position was not only guided by the best dam site, but also by the operating levels required for a gravity scheme, all the way to Umlaas Road.

A detailed dam type selection analysis, considering cost, spoil of construction materials, time to construct and other aspects indicated that the preferred type for Smithfield Dam is an 81 m high zoned earth core rockfill dam, with a 26 m high earthfill embankment saddle dam. The geotechnical investigation identified three earthfill borrow areas.

The following components of the proposed Smithfield Dam and appurtenant structures will be implemented:

- *An 81 m high earth core rockfill dam (main dam) constructed with a residual dolerite earthfill core, dolerite rockfill outer zones and an inner shale rockfill zone;*
- *A primary side channel spillway with a gravity weir structure, chute and ski jump structure;*
- *A bottom outlet with a permanent double pipe multi-draw off in an intake structure connected to a pipe in one of the two 8 m diameter tunnels (used initially for river diversion). An access bridge from the main dam crest to the Intake Tower will be provided.*
- *A zoned earthfill embankment saddle dam of 26 m high.*
- *A secondary fuse plug spillway.*
- *Access roads for construction and operations.*
- *Deviation of the R617 necessitated by flooding of the dam basin, and new access roads to communities that will be cut-off by the reservoir.*
- *Provision to support the Eskom high voltage power line across the new reservoir.*
- *River diversion using two 8 m diameter tunnels and an array of six cofferdams to accommodate construction during varying flooding conditions of the mighty uMkhomazi River.*
- *Material to be obtained from the excavations, as well as specific quarries.*

UMKHOMAZI-UMLAZA TUNNEL

The transfer tunnel extends from the left side of Smithfield Dam Reservoir to the upper reaches of the Mbangweni Dam in the Mbangweni River. The shortest route through the mountain range between the two valleys was identified based on a comparison analysis between pumping schemes and the selected gravity conveyance system. The tunnel is 32.5 km long and the selected optimum inside diameter for a discharge at peak demand of 8.65 m^3/s is 3.5 m diameter. This pressure tunnel has to be driven through hard quality shales and dolerites (the latter about 40% of the distance) and is connected with a pressure pipeline from the tunnel end to the site of the Baynesfield Water Treatment Works. This system is sized to accommodate design flows with Smithfield Dam at the minimum operating level (MOL).

Based on lower cost and limiting the critical construction path of the project, the tunnel was costed for two Tunnel Boring Machines (TBMs). The tunnel was laid out with a slope towards the east and the TBMs have to bore in the upstream direction (west) accommodating encountered ground water in gravity flow requirements. The tunnel was designed for drainage during construction as seepage from groundwater is expected.

Some parts of the tunnel, e.g. a central access adit with a 5 m diameter, are to be excavated using drill and blast techniques.

Based on cost considerations and to ensure stable rock portals the inlet (for both uMWP phases) and outlet portals of the tunnel are to be formed through excavation of weathered rock materials. These excavated materials will be available for construction purposes.

Air entrainment of the tunnels to accommodate flowing water will be facilitated through two shafts, a central access adit and a shaft and pipe through the intake structure. The central 5 m diameter adit is also necessary for construction and later maintenance purposes.

LANGA DAM

The Langa Dam site is located in the uMlaza Catchment on the Mbangweni River at the downstream end of the tunnel outlet portal on the farm Nooitgedacht 903. This dam is required for storing water and for supply to Umgeni Water during emergency and maintenance periods of the tunnel. It is connected to the Baynesfield Raw Water Pipeline. At the FSL of 923 masl, it has a live storage capacity of 14.82 million m³ that can supply the uMWP direct supply area for 24 days at the maximum supply rate of the conveyance system. The DWA Directorate Strategic Asset Management requested two months' storage of the maximum demand to maintain the tunnel. The rest of the required two months' supply can be obtained from the existing Mgeni WSS. The need for Langa Dam and its storage volume were motivated through planning model water resources studies as well as comparisons with other options like the supply through water supply systems from the Mgeni Water Resources.

A dam type selection study indicated a Concrete Faced Rockfill Dam (CFRD) to be the optimum cost dam type. The rockfill will consist of shales from the reservoir (dam basin) of the dam. Finer bored rockfill from the tunnel will be used on its downstream toe section and the rest of the excavations from the outlet portal will be accommodated in a berm on the downstream side of the dam. A dolerite rockfill layer will be used as protection of the shale rockfill on the downstream face.

Furthermore, a side spillway on the left flank would ensure that the dam cannot be overtopped during flood events. A single level draw-off but double pipe intake system in an intake tower and bottom outlet would facilitate water to fill the dam from Smithfield Dam under gravitation, to release the required reserve water to accommodate wetlands and to release water for supply when required.

RAW WATER PIPELINE

The pressure pipeline from the tunnel outlet to the WTW has an internal diameter of 2.6 m and length of 5.2 km, and connects to the Langa Dam with a 1.6 m diameter and 1.3 km long pipeline. Bedding materials for laying the pipeline would probably be imported from commercial sources, although it is advised to consider using some of the tunnel spoils, where appropriate.

A stilling basin (or possible hydropower plant) is provided at the end of the pipeline for dissipating the energy of the water from the Smithfield Dam before it is routed through the WTW.

ASSOCIATED INFRASTRUCTURE

GAUGING WEIRS

Three gauging weirs are required to measure river flows at the following positions, as shown on ***Figure 8.1****:*

- *Location 1: Downstream of Impendle Dam to measure inflow to Smithfield dam,*
- *Location 2: Downstream of Smithfield Dam to determine the discharges from Smithfield dam required for the dam balance, and*
- *Location 3: Further downstream of Smithfield dam to determine the run-off from the incremental catchment downstream of Smithfield Dam to assist with the operation of the ecological water requirement.*

The three gauging weirs were designed as Crump weirs to accommodate monitoring of 80% of the flows.

ROADS INFRASTRUCTURE

The R617, a public road between Pietermaritzburg / Howick and Underberg, will be inundated by the new proposed Smithfield reservoir and should be deviated.

Furthermore, the following access roads to the project components are needed during and after construction, and also to provide access for communities that will be cut-off due to the inundation of the dam:

- *Access road to Nonguqa;*
- *Access road to tunnel inlet portal;*
- *Access road to dam wall;*
- *Access road to ventilation/air shafts;*

- *Access road to centre tunnel adit entry;*
- *Access road to tunnel outlet portal and Langa Dam;*
- *Access road to the WTW; and*
- *Access roads to gauging weirs.*

WASTE DISPOSAL SITES

The tunnel muck and excavated material will be disposed at two waste disposal sites, one near the tunnel inlet portal and one midway along the tunnel length near the central tunnel access adits, and material from the downstream outlet portal will be used for the construction of Langa Dam. The waste disposal sites will only be operational for the construction period of uMWP-1 and will be rehabilitated afterwards.

HYDROPOWER ASSESSMENT

A pre-feasibility viability assessment of hydropower generation as a secondary, but potential major benefit to the uMWP-1 was undertaken at the entrance to the Baynesfield WTW, and on the outlet works of Smithfield Dam. The proposed Baynesfield HPP was conceptually designed for a flow rate of 8.65 m³/s flow and 41.7 m net head, which has the potential of 3 MW power. The Smithfield Dam HPP was conceptually designed for a potential of 2.6 MW for a flow rate of 5.0 m³/s flow and 64.0 m net head.

INSTITUTIONAL AND FINANCIAL ARRANGEMENTS

Although the institutional arrangements will only be finalised during the implementation phase, various institutional options were considered, also addressing financial arrangements related to the mega bulk water supply scheme.

The uMWP's raw water components will form part of the national water resource infrastructure and therefore ownership and control will be vested in the Government of the Republic of South Africa, and thus administered by the Department of Water Affairs.

In recent years the Trans-Caledon Tunnel Authority (TCTA) implemented and obtained off-budget funding for the DWA's projects, and it is proposed that uMWP should follow a similar process, with similar contractual arrangements. This appointment of the TCTA is to be finalised.

The uMWP will supplement the Mgeni WSS and as such will form an integral component of this system. The uMWP is to be operated by Umgeni Water (UW), as is currently standard practice for all DWA dams in the Mgeni WSS. The operational aspects need to be negotiated between UW and DWA.

UW will fund and implement the uMWP potable bulk water component, as per their masterplan.

The uMWP-1's estimated feasibility capital cost is R16.5 billion (excl. VAT, 2014)[1], of which R12.8 billion is estimated for the raw water component. If the uMWP is fully funded off-budget, the bulk potable tariff would need to be increased by R2.70/kℓ by UW to recover the debt and operating cost of the uMWP-1. Obtaining government/grant funding for a portion of up to 25% of the cost, and phasing in of the tariff, is recommended.

LEGISLATIVE REQUIREMENTS

ENVIRONMENTAL IMPACT ASSESSMENT

An environmental screening process investigated the different options proposed by identifying environmental "red flags" and "fatal flaws" that would render an option unsuitable and not worthy of further investigation during the feasibility study. Subsequently, a comprehensive Environmental Impact Assessment (EIA), was conducted to obtain approval for the uMWP-1. Detail of the EIA process is contained in a separate study, uMWP-1 Module 2 EIA*.*

The feasibility study complemented the EIA's public participation programme through the workings of the Project Steering Committee (PSC) and ongoing consultations with key stakeholders, specifically also the Water Services Authorities (WSAs) that will be signatories to the off-take agreements.

ECONOMIC IMPACT ASSESSMENT

An Economic Impact Assessment was undertaken and aimed to provide the economic motivation for the uMWP-1.

This uMWP-1 will have an impact on the regional and local economies during the construction (short-term) and operational and refurbishment (long-term) phases. Total additional production (new business sales) anticipated to be generated by the project equates to R86 661 million (direct, indirect and induced). Gross domestic product (GDP) is anticipated to increase by R30 305 million (direct, indirect and induced). The analysis shows that the uMWP-1 development has the potential to generate high levels of employment creation (directly up to 9 670 annualised job opportunities). This will

[1] *Funding cost and interest excluded.*

stimulate business and human capital development and assist in raising living standards.

IMPLEMENTATION PROGRAMME

The imminent deficit in the Mgeni System requires the fast-tracking of this large project, supplying water by no later than 2023. A realistic construction programme for this comprehensive multidisciplinary project was drafted, with the milestones shown as follows:

- *Completion of all feasibility activities – end 2015;*
- *Environmental authorisation – end 2016;*
- *Decision making phase – 2016 to 2018;*
- *Design and documentation phase – Jan 2017 to early 2019;*
- *Construction – Sept 2018 to 2023; and*
- *First delivery of water – end 2023.*

To provide water by 2023, it is of utmost importance to stay on track, especially with the implementation readiness activities and the activities associated with the critical path.

CONCLUSION

The following can be concluded:

- *With the current water requirements projections of the Mgeni System, based on the National Basic Water Supply strategy and economic development, the system will be in deficit by 2016.*
- *The Mgeni System provides water to the economic hub of KwaZulu-Natal.*
- *The uMWP is the preferred long term scheme to augment the Mgeni System.*
- *The layout and infrastructure components of the uMWP-1 were defined in the feasibility study, as follows:*
    - *An 81 m high, 251 million m³ gross storage dam at Smithfield in the uMkhomazi River;*
    - *A 32.5 km, 3.5 m internal diameter tunnel between the uMkhomazi and uMlaza;*
    - *A 5.2 km long, 2.6 m internal diameter raw water pipeline to the WTW; and a 1.3 km long, 1.6 m internal diameter pipeline to the balancing dam; and*
    - *A 46.6 m high, 15.7 million m³ gross storage [balancing dam on the Mbangweni River.*

- *The 2014 capital cost of the uMWP Phase 1 is R16.5 billion (raw and potable water infrastructure).*
- *The project needs to be fast-tracked, to provide the Mgeni System with water as soon as possible, at the latest by 2023. As this project will be one of the largest transfer schemes in South Africa, comparable to the Lesotho Highlands Phase 2 Scheme, the management of the scheme along its critical path is of utmost importance.*
- *Without water, the economy of KZN will be constrained.*

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LIST OF ABBREVIATIONS

AECOM	AECOM SA (Pty) Ltd
AGEP	Average Groundwater Exploitation Potential
AGES	Africa Geo-Environmental Services
BKS	BKS (Pty) Ltd
CAPEX	Capital Expenditure
CFRD	Concrete faced rockfill dam
DBT	Drill and blast technique
DM	District Municipality
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation (previously Water Affairs)
ECA	Environmental Conservation Act
ECBA	Economic Cost-Benefit Analysis
ECRD	Earth Core Rockfill Dam
EIA	Environmental Impact Assessment

EWR	Ecological water requirement
FDCO	Finance, Design, Construct and Operate
FSC	Full supply capacity
FSL	Full supply level
GDP	Gross domestic product
GRIP	Groundwater Resource Information Programme
GYMR	Groundwater Yield Model for the Reserve
KZN	KwaZulu-Natal
LHWP	Lesotho Highlands Water Project
LM	Local Municipality
MAP	Mean annual precipitation
MAR	Mean annual runoff
MCE	Maximum Credible Earthquake
MDE	Maximum Design Earthquake
MM&A	Mogoba Maphuthi and Associates
MMTS	Mooi Mgeni Transfer Scheme
MOL	Minimum operating level
NEMA	National Environmental Management Act
NOC	Non-overspill crest
NPV	Net present value
NWIA	National Water Infrastructure Agency
OBE	Operating Basis Earthquake
OPEX	operating expenditure
PMC	Project Management Committee
PMF	Probable Maximum Flood
PSC	Project Steering Committee
PSHA	Probabilistic Seismic Hazard Analysis
PSP	Professional Service Provider
RCC	Roller compacted concrete
RDF	Recommended design flood
RID	Record of implementation decisions
RMF	Regional maximum flood
SAM	Social Accounting Matrix
SEF	Safety evaluation flood
TBM	tunnel bore machine
TCTA	Trans Caledon Tunnel Authority
ToR	Terms of Reference
UGEP	Utilisable Groundwater Exploitation Potential
uMWP	uMkhomazi Water Project
uMWP-1	uMkhomazi Water Project – Phase 1
uMWP-2	uMkhomazi Water Project – Phase 2

URV	unit reference values
UW	Umgeni Water
WRPM	Water Resources Planning Model
WRYM	Water Resources Yield Model
WSS	Water Supply System
WTW	Water Treatment Works
WwTW	Wastewater treatment works

LIST OF UNITS

Ha	Hectare
kℓ	kilolitre
km^2	square kilometre
ℓ/c/d	litre per capita per day
m	metre
m^3	cubic meter
m^3/a	cubic meter per annum
m^3/s	cubic metres per second
masl	metres above sea level
R	Rand
$t/km^2/a$	tons per square kilometre per annum

1 INTRODUCTION

The Department of Water Affairs (DWA) appointed **BKS (Pty) Ltd**[2] in association with three sub-consultants **Africa Geo-Environmental Services (AGES), Mogoba Maphuthi and Associates (MM&A)** and **Urban-Econ** with effect from 1 December 2011 to undertake the **uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study Raw Water study**.

1.1 BACKGROUND TO THE PROJECT

The current water resources of the Mgeni Water Supply System (WSS) are insufficient to meet the long-term water demands of the system. The Mgeni System is the main water source that supplies about six million people and industries in the eThekwini Municipality, uMgungundlovu District Municipality (DM) and Msunduzi Local Municipality (LM), all of which comprise the economic powerhouse of the KwaZulu-Natal (KZN) Province.

The resources of the Mgeni WSS have a stochastic yield of 334 million m^3/a at a 99% assurance of supply and are augmented from the Mooi River catchment with about 60 million m^3/a. However, this will not be sufficient to meet the current and long-term requirements of the system, and pre-feasibility investigations proposed the development of the uMkhomazi River to augment the Mgeni WSS.

Eight possible schemes were initially identified to augment the Mgeni WSS, and the Impendle and Smithfield scheme configurations emerged as preferred options for further investigation. The pre-feasibility investigation, concluded in 1998, recommended that the Smithfield to Baynesfield scheme be taken to a detailed feasibility-level investigation. This is due to the magnitude of the untapped resources, the proximity of the uMkhomazi River to the Mgeni and because the conveyances of water would be independent of the existing Mgeni System. This would thus reduce the risk of limited or non-supply to eThekwini Municipality and in essence provide a back up to the Mgeni System.

[2] *On 1 November 2012, BKS (Pty) Ltd was acquired by **AECOM Technology Corporation**.*

The "*Mkomazi-Mgeni Transfer Pre-feasibility Study*" (1998) concluded that the first phase of the uMkhomazi Water Project (uMWP) should comprise the following:

- A new dam at Smithfield on the uMkhomazi River near Richmond;
- A multi-level intake tower from the reservoir, with a water transfer pump/pipeline/tunnel system to a balancing dam at Baynesfield Dam or a similar in-stream dam;
- A water treatment works (WTW) at Baynesfield in the uMlaza River valley;
- A gravity pipeline to Umgeni Water's (UW) bulk distribution reservoir system, below the reservoir at Umlaas Road; and
- From the Umlaas Road reservoir, water should be distributed under gravity to eThekwini and possibly also low-lying areas of Pietermaritzburg.

Phase two of the uMWP would be implemented when needed, and could comprise the construction of a large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam.

1.2 STUDY AREA

The study focus and key objective of Module 1: Technical Feasibility Study Raw Water was related to the feasibility investigation of the Smithfield Dam and raw water conveyance infrastructure to the intake of the WTW in the uMlaza River valley. However, this is a multi-disciplinary project with the study area defined as the uMkhomazi River catchment, stretching to the north to include the uMngeni River catchment (refer to **Figure 1.1**). The various tasks had specific focus areas, defined as:

- Water resources: uMkhomazi and uMngeni River catchments;
- Water requirements: water users in the Mgeni WSS and the uMkhomazi River catchment;
- Engineering investigations: proposed dams at Impendle (only for costing purposes) and Smithfield, and the raw water conveyance infrastructure between Smithfield Dam and the WTW of UW;
- Environmental screening for all the proposed raw water components as input to the Environmental Impact Assessment (EIA); and
- Socio-economic impact assessment of the project on the regional and provincial (KZN) economy.

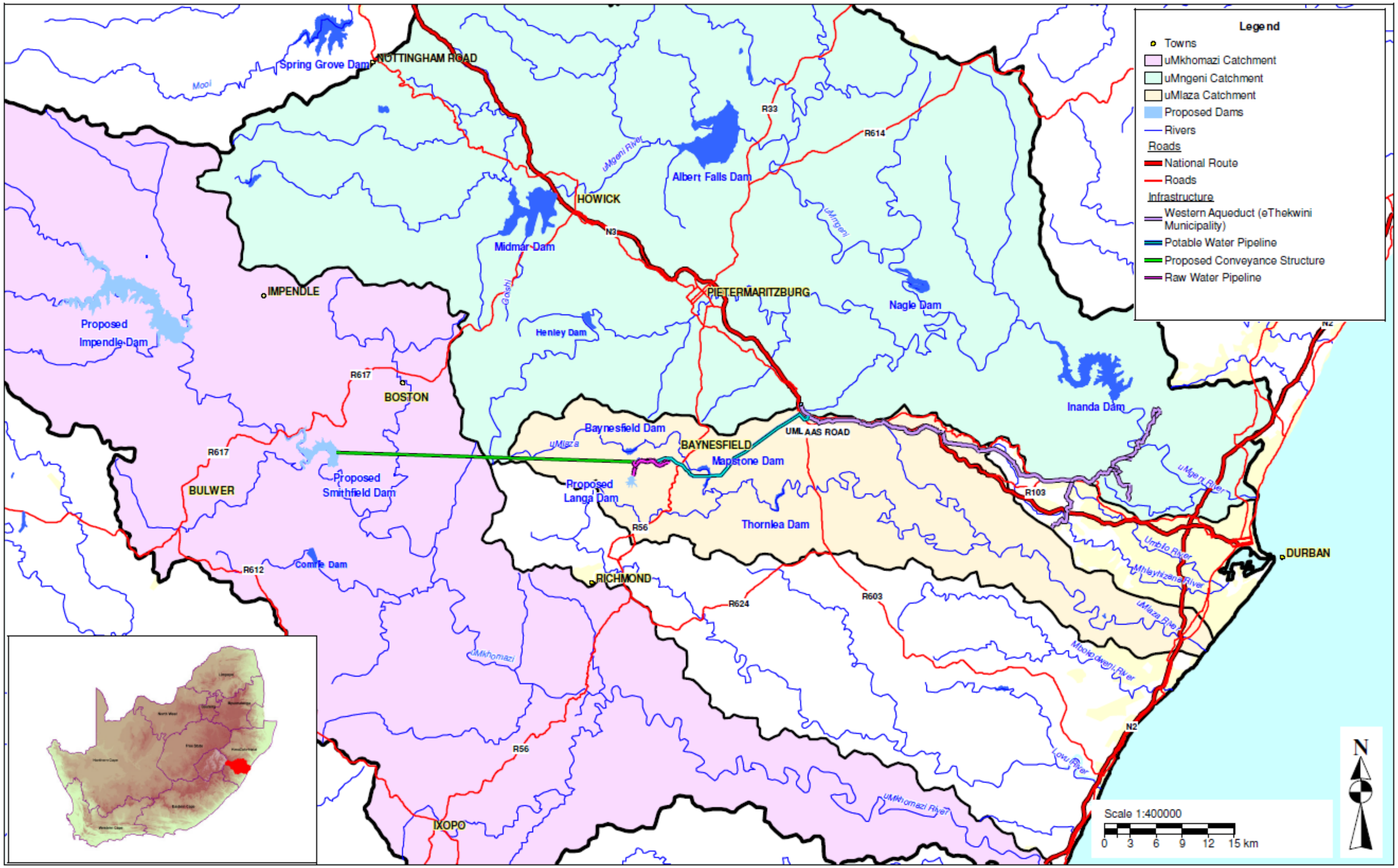


Figure 1.1: Locality map of the study area of the uMWP

1.3 OBJECTIVE OF THE FEASIBILITY STUDY

According to the Terms of Reference (ToR) (November 2010), the objective was to undertake a feasibility study to finalise the planning of the proposed uMWP at a detailed level for the scheme to be accurately compared with other possible alternatives and be ready for implementation (detailed design and construction) on completion of the study. This feasibility study follows on other investigations into the water resources of the Mgeni WSS, including the *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy* (WRP, et al., 2010), and these are regarded as part of the motivation for the uMWP.

The feasibility study had been divided into the following modules, which ran concurrently:

- Module 1: Technical Feasibility Raw Water (DWA) (*defined below*);
- Module 2: Environmental Impact Assessment (DWA); and
- Module 3: Technical Feasibility Potable Water (UW) (*ranging from the WTW to the tie-in point with the eThekwini distribution system*).

The layout according to these modules is shown in **Figure 1.2**.

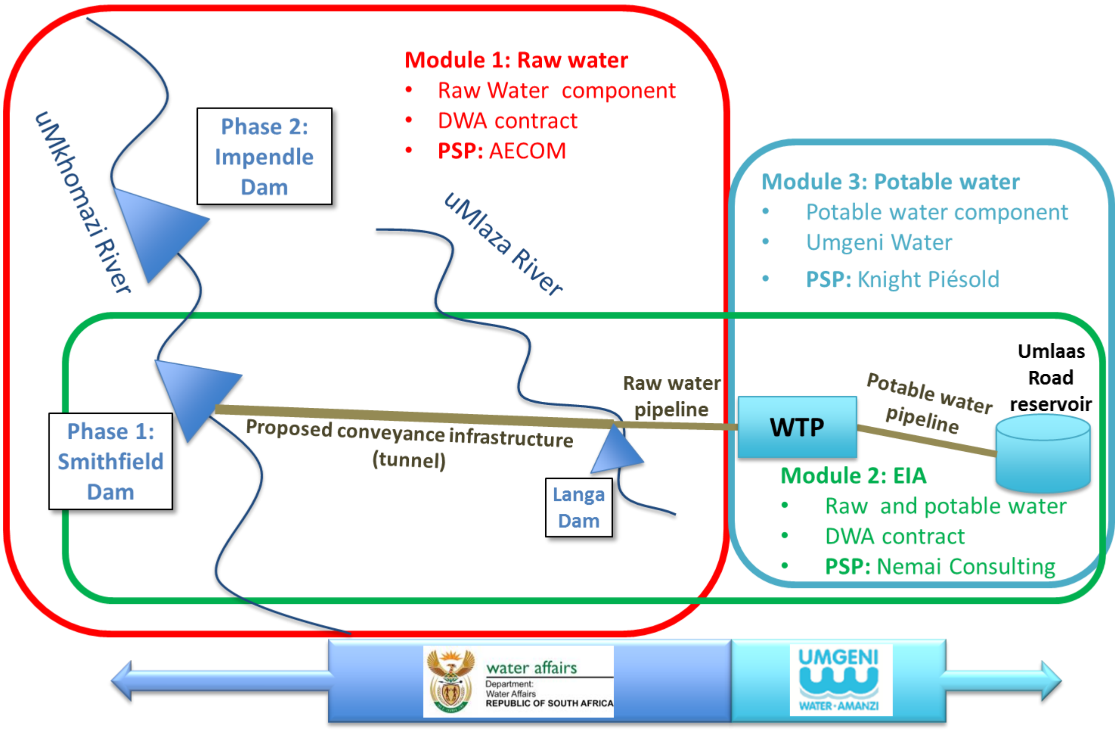


Figure 1.2: Organisation of the uMWP feasibility study modules

1.3.1 Module 1: Raw Water Technical Feasibility Study

This module, the Raw Water Technical Feasibility Study, considered the water resources aspects, engineering investigations and project planning and scheduling and implementation tasks, as well as an environmental screening and assessment of socio-economic impacts of the proposed project.

Some specific objectives identified for the Module 1 study, recommended in the *Mkomazi-Mgeni Transfer Scheme Pre-feasibility Study* (Ninham Shand Consulting Engineers, May 1999a) are listed below:

- Smithfield Dam (Phase 1) to be investigated to a detailed feasibility level;
- Investigate the availability of water from Impendle Dam (Phase 2) as a future resource to release to Smithfield Dam, and refine the phasing of the selected schemes;
- Optimise the conveyance system between Smithfield Dam and the proposed Baynesfield WTW;
- Undertake a water resources assessment of the uMkhomazi River Catchment, including water availability to the lower uMkhomazi;
- Evaluate the use of Baynesfield Dam as a balancing dam; and
- Investigate the social and economic impact of the uMWP.

This main report is a summary of the feasibility of the complete uMWP-1 Module 1: Technical Feasibility Study Raw Water and covers the various tasks carried out as part of the *uMkhomazi Water Project Phase 1*, as listed below:

Task	Reference of section in this report
• Environmental Screening	Section 10
• Project Management, including Project Coordination and a risk assessment	Sections 1, 11
• Water Resources	Sections 2, 3 and 4
• Engineering Investigation	Sections 5, 6, 7 and 8
• Implementation actions, such as an implementation programme for the project, Project Summary Report and Record of Implementation Decisions (RID)	Section 11
• Institutional, Financial and Operational Aspects	Section 9
• Socio-Economic Analyses	Section 10

Descriptions of all these tasks are included in the relevant detail reports, as listed in the report schematic before the Executive Summary.

This study, being one of three modules, was undertaken in close collaboration with the DWA, UW and the Professional Services Providers (PSPs) of the other modules.

1.3.2 Module 2: Environmental Impact Assessment

A full Environmental Impact Assessment (EIA), according to the requirements of the National Environmental Management Act (NEMA), was undertaken as Module 2, and included a comprehensive Public Participation process.

Regular liaising took place between the Module 1 and 2 study teams to align the EIA and the technical work. The outcome of Module 2 is not discussed further in this report; however, for more information on Module 2, refer to the Module 2 documents on the project website, accessible from **https://www.dwa.gov.za/Projects/uMkhomazi/documents.aspx**.

1.3.3 Module 3: Potable Water Technical Feasibility Study

The potable water technical feasibility study, Module 3, addressed engineering aspects and scheduling aspects of water treatment and pipeline conveyance. It included the following specific tasks:

- Investigate required sizing and possible locations for the WTW and water reservoirs;
- Determine the diameter and pipeline routes for water pipelines between Baynesfield and the Umlaas Road precinct;
- Reconcile infrastructure sizing and timing with the projected growth in downstream water demands.
- Undertake geotechnical investigations at the proposed WTW site and along the proposed pipeline route; and
- Undertake engineering surveys at the proposed WTW site and along the proposed pipeline routes (this included determining the extent of public and privately owned land that may be affected).

Regular liaising took place between the Module 1 and 3 study teams to align the raw and potable water components, specifically regarding the location of the WTW and the available yield from Smithfield Dam. The outcome of Module 3 is not discussed further in this report; however, for more information on Module 3, refer to the Module 3 documents on the project website, accessible from **https://www.dwa.gov.za/Projects/uMkhomazi/documents.aspx**.

1.4 GOVERNANCE AND ORGANISATION OF THE STUDY

The main objective of the project is to augment water supply to the Mgeni WSS. This supply area falls within the jurisdiction of UW. Ninety percent of the water in this area is concentrated mainly in the eThekwini and Msunduzi municipalities and the study therefore required the participation from the three spheres of government. Liaison with the Client, key stakeholders, interested and affected parties and team members were managed through various committees, as shown in the governance structure in **Figure 1.3**.

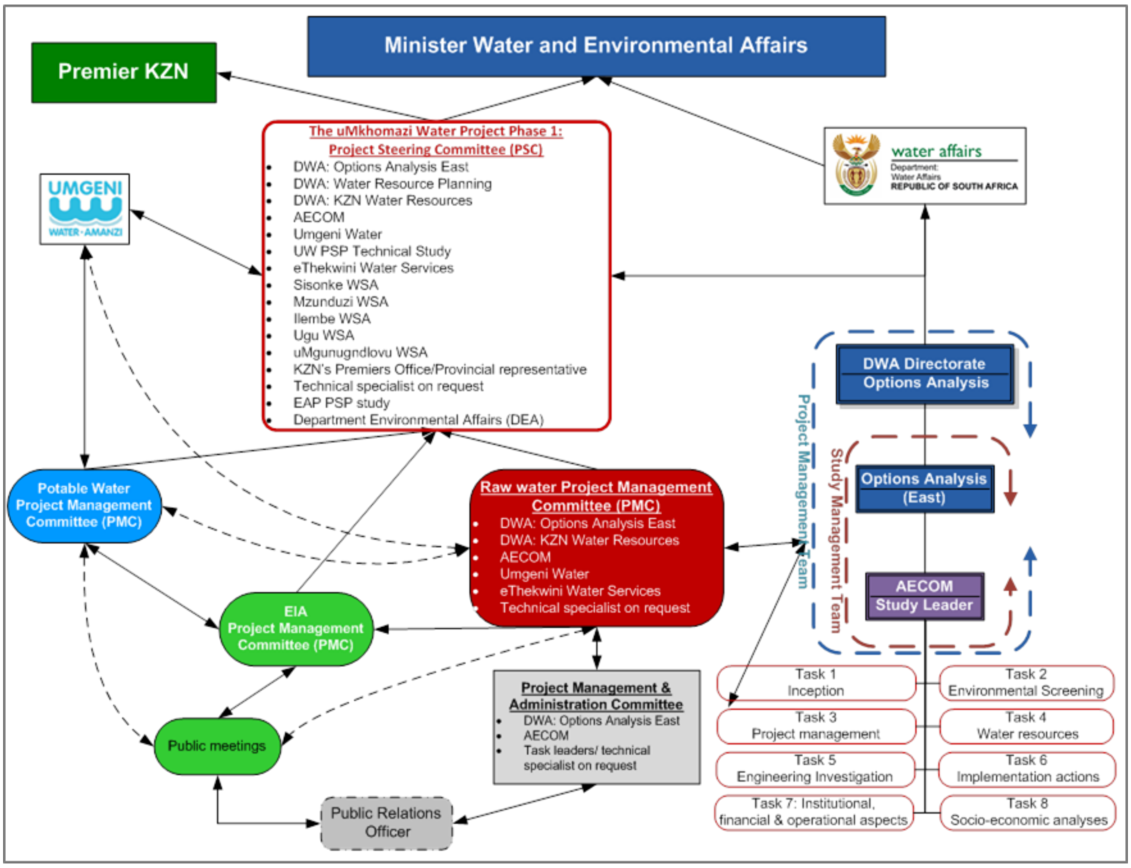


Figure 1.3: uMWP governance structure

This study's ***Project Steering Committee's*** (PSC) main function was to assist the DWA with strategic matters and to coordinate the contributions of other authorities, including UW and the affected Water Services Authorities (WSAs). This committee, as directed by the PSC ToR, oversaw the total project, including the Raw Water, Potable Water and Environmental Impact Assessment project modules.

Six PSCs, including an information session and site visit for Senior Officials, were held in the study area. The PSC chair was alternated between the DWA and UW.

The ***Project Management Committee*** (PMC) was responsible for governing and driving the feasibility study, and comprised the DWA Project Manager, UW, the PSP Study Leader (supported by technical specialists) and representatives of any DWA Directorate wishing to participate at any stage of the project. eThekwini Municipality was an *ad hoc* member, to ensure that the local considerations and situation of interested and affected parties were also accounted for at the appropriate level. Eleven PMC meetings were held in either Pretoria or Durban.

1.5 NAME CHANGE CLARIFICATIONS

- In 2010, the Department of Arts and Culture published a list of name changes in the Government Gazette (GG No 33584, 1 October 2010). In this list several river names were changed. The published spelling of these names, listed below, will therefore be used throughout this technical feasibility study:
    - The Mkomazi River's name changed to "***uMkhomazi***";
    - The Mgeni River's name changed to "***uMngeni***"; and
    - The Mlazi River's name changed to "***uMlaza***".
- The "uMngeni vs Mgeni WSS vs Umgeni Water" concepts are often misunderstood, and are explained as follows, with reference to **Figure 1.4**:
    - The ***uMngeni River*** is the river that rises in the Drakensberg and drains east in the Indian Ocean just north of the Moses Mabhida Stadium in Durban North.
    - The ***Mgeni Water Supply System (WSS)*** is an integrated water system comprising several resources in the uMngeni River catchment (Midmar, Albert Falls, Nagle and Inanda Dams) and augmented from the Mooi River catchment (Spring Grove Dam and the Mearns Weir). It supplies water through a system of bulk water infrastructure to the users mostly in the uMngeni River catchment (eThekwini and Msunduzi municipalities), but also through system links to Ugu and iLembe DMs.
    - ***Umgeni Water*** is a water board that supplies bulk potable water to eThekwini Municipality, iLembe District Municipality (DM), Harry Gwala DM, uMgungundlovu DM, Ugu DM and Msunduzi Municipality in the KZN Province.

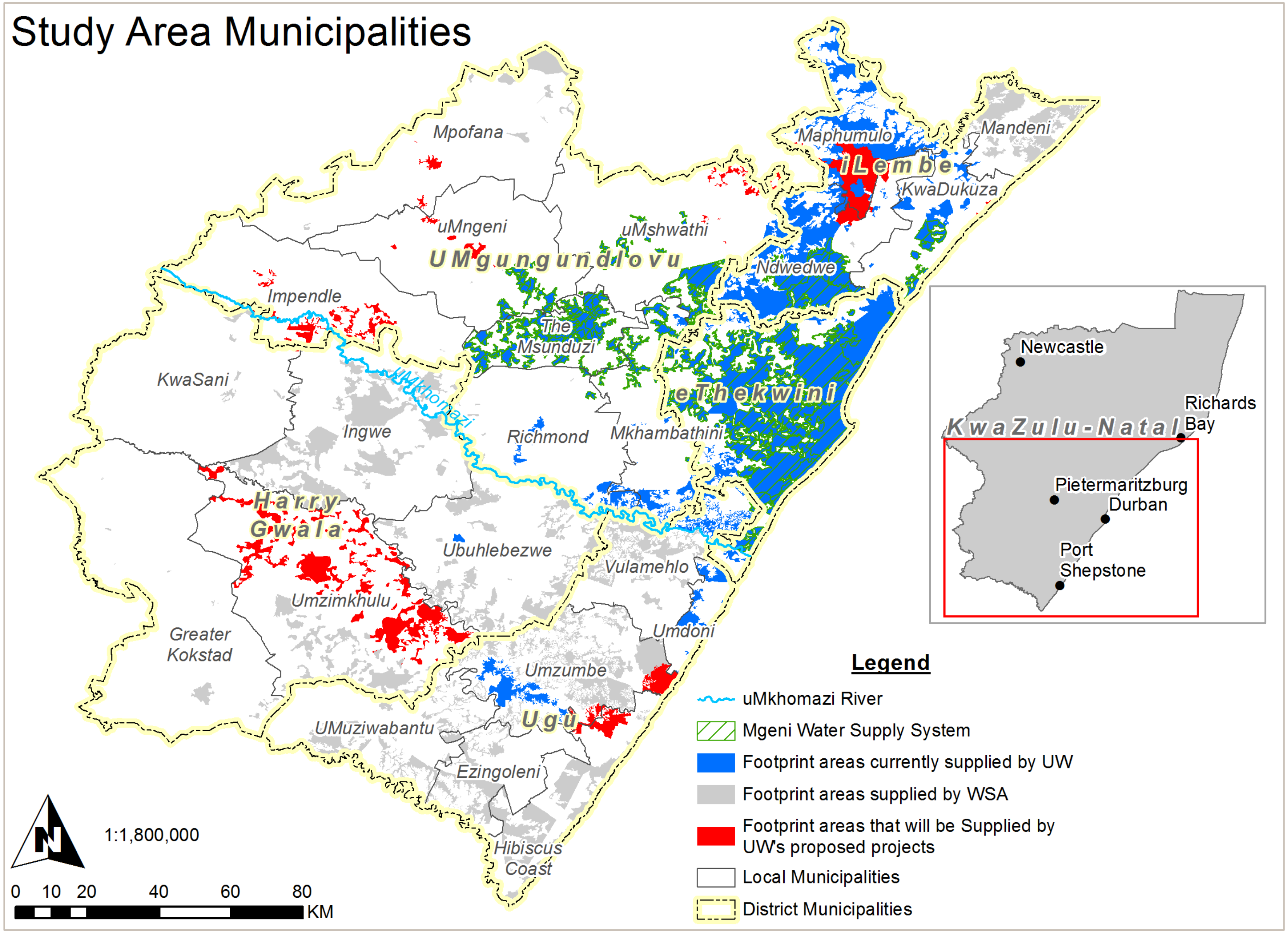


Figure 1.4: Mgeni WSS and Umgeni Water supply areas

2 NEED FOR ADDITIONAL AUGMENTATION FOR THE MGENI WATER SUPPLY SYSTEM

The eThekwini and Msunduzi municipalities are the two largest in the province of KZN, the first being at a major port and the latter the current administrative capital. Urban and industrial development in this area is extensive and has a major impact on water demand. Surrounding areas (north and south coast) are also developing at a significant rate and require water for growth. The shortage of water in the region is a limitation on economic growth.

2.1 CURRENT RESOURCES OF THE MGENI WSS

The principal source of water supply for the region is the uMngeni River, rising in the lower foothills of the Drakensberg at an altitude of 1 500 m. The uMngeni River is 257 km long, and has a moderately steep average gradient of 1:172.

The mean annual precipitation in the area varies between 700 mm and 1 400 mm, with most rainfall occurring in summer, although winter showers also occur. High rainfall areas are found mainly in the higher lying areas to the north of Albert Falls Dam and in the coastal zone, with a significant drop in rainfall at the central regions of the area. Rainfall patterns are also occasionally influenced by tropical cyclones, often resulting in devastating flooding. The hydrological characteristics of the uMngeni River catchment are shown in **Table 2.1**.

Table 2.1 Hydrological characteristics of the uMngeni Catchment (WR90)

Catchment	Area (km²)	Annual average			
		Evaporation (mm)	Rainfall (mm)	Natural runoff (million m³/a)	Natural runoff (mm)
uMngeni (U20)	4 439	1 214	921	674.0	152

There are four major dams on the uMngeni River with Nagle Dam being the oldest (completed in 1950), Midmar Dam (completed in 1963) in the upper catchment, Albert Falls Dam (completed in 1974) between Midmar and Nagle dams, and Inanda Dam (completed in 1988) in the lower catchment. The current system has a stochastic yield of 334 million m³/a (measured at Inanda Dam) at a 99% assurance of supply.

Further to its own resources, the Mgeni WSS is augmented by the Mooi-Mgeni Transfer Scheme (MMTS), comprising of the Mearns Weir and Spring Grove Dam, both on the Mooi River. Augmentation from the Mooi River catchment increases the yield of the Mgeni system by 60 million m³/a.

Figure 2.1 shows the uMngeni River Catchment, surrounding catchments and the locality of all the dams.

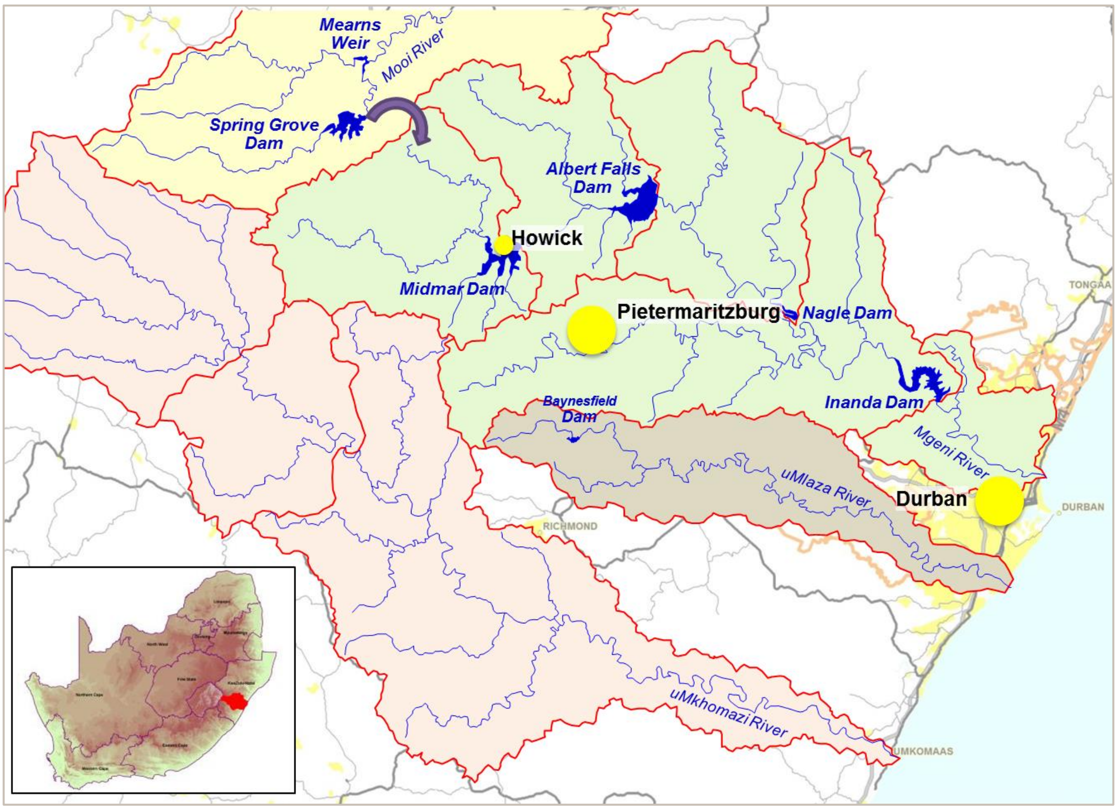


Figure 2.1: uMngeni River Catchment and surrounding catchment

2.2 FUTURE WATER REQUIREMENTS OF THE MGENI WSS

Assessment of the current water use and future water requirements formed part of *Module 3: Potable Water* conducted by UW. Hence, the supply areas and associated water requirement projections are covered in detail in the *uMkhomazi Water Project Phase 1: Module 3: Bulk Water Study – Water Demand Projections and Phasing of Infrastructure Report* (Knight Piésold, 2014). Key information and the findings from the Module 3 report are summarised in this report along with interpretation of the water requirements for the Mgeni WSS.

The water supply areas of the Mgeni WSS shown in **Figure 2.2** are defined as follows:

- ***Midmar WTW:*** Areas such as the Upper Mgeni (Pietermaritzburg and Howick) and the Outer West (Umlaas Road reservoir) fall within the supply area of

Midmar Dam. The water requirements projection was developed based on an annual growth rate of 1.5% and recorded sales figures obtained from UW for the area.

- ***Wiggins WTW:*** Low-lying areas in southern and central eThekwini supplied from Wiggins WTW, including supply to the northern areas of the South Coast. The water requirement projection was obtained from the *Module 3 Report* (Knight Piésold Consulting, 2014).
- ***Durban Heights WTW:*** Defined as the area supplied from Durban Heights WTW, including areas supplied by the Western and Northern aqueducts.
- ***Industrial re-use***: Industrial users that make use of treated effluent. These were kept unchanged and capped at 8.8 million m^3/a.

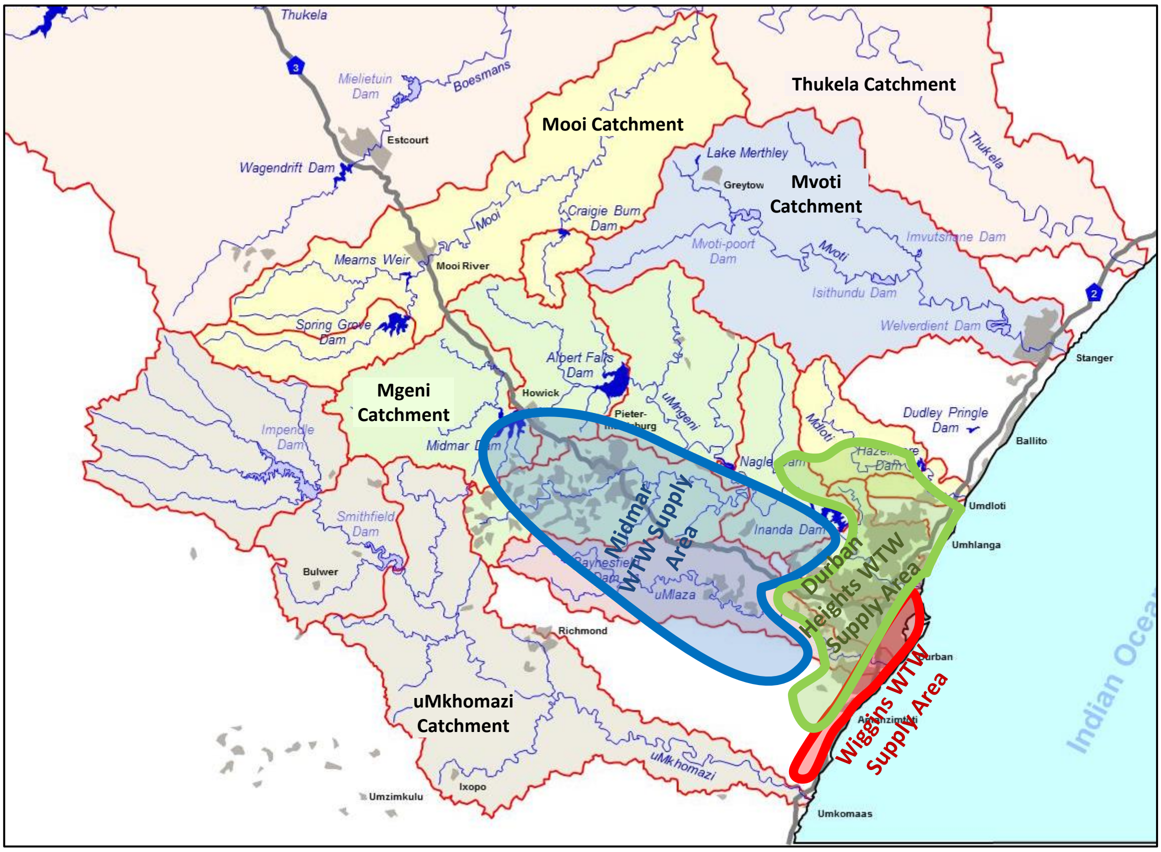


Figure 2.2: Schematic of water supply areas in the Mgeni WSS

The water requirement projection for the Mgeni WSS was developed based on the individual projections for each of the defined sub-areas of the system and the results are presented in both **Table 2.2** and **Figure 2.3**.

Table 2.2: Long-term water requirement projection for the Mgeni WSS

Supply area	Water requirement (million m³/a) for indicated time horizon								
	2013	2015	2020	2025	2030	2035	2040	2045	2050
Midmar WTW									
• Upper Mgeni	80.6	83.0	89.4	96.2	103.0	109.8	116.7	123.7	130.7
• Outer West Area	29.0	31.0	36.1	41.2	46.3	51.4	56.5	61.6	66.7
Durban Heights WTW									
• Western Aqueduct	57.8	58.4	67.2	68.7	70.2	71.7	73.2	74.7	76.1
• Northern Aqueduct	24.1	26.5	34.1	43.7	53.9	64.1	74.4	84.5	94.5
• Durban Heights Rem.	104.0	106.0	118.3	123.2	128.1	133.0	137.9	142.9	148.1
Wiggins WTW									
• Wiggins	81.4	83.1	89.5	96.5	103.9	111.9	120.6	129.6	138.5
• South Coast	12.2	13.7	23.6	23.8	23.8	23.8	23.8	23.8	23.8
Industrial re-use	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8	8.8
Total	**397.9**	**410.6**	**467.2**	**502.0**	**537.9**	**574.5**	**611.8**	**649.5**	**687.1**

From **Table 2.2**, the updated water requirement projections for the Mgeni WSS, including the expanded supply area along the North and South Coast, are shown to grow from the current (2013) 398 million m^3/a to about 480 million m^3/a in 2023 and 612 million m^3/a in 2040.

2.3 WATER BALANCE OF THE MGENI SYSTEM

Water balances for the resources and water requirements for the integrated Mgeni WSS have been developed as part of the ongoing DWS planning process contained in the *Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas* and were updated with the latest water requirement projections, shown **Table 2.2** (DWA, 2012).

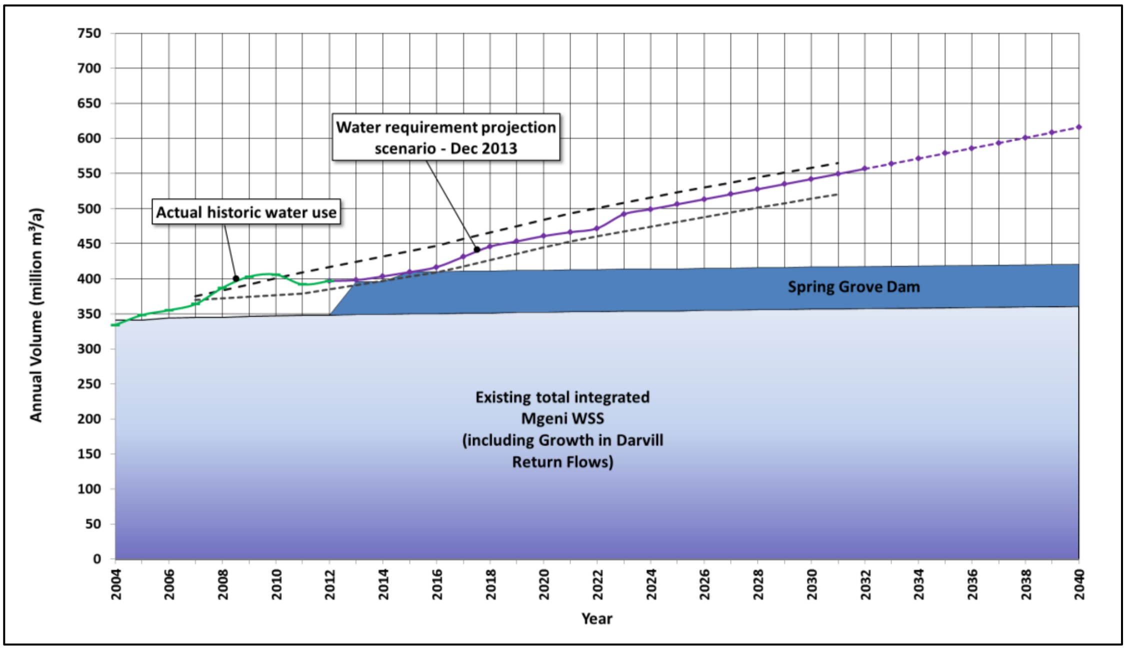


Figure 2.3: Long-term balance between available yield and water requirements for the integrated Mgeni WSS, also showing the completed Spring Grove Dam

The projected future water balance between the available yield and water requirements for the Mgeni WSS is shown in **Figure 2.3** and represents a selected scenario which is based on:

- The actual total historical water use in the system, from 2004 to 2011 (represented by the green line).
- The projected total Mgeni WSS water requirements, from 2012 to 2040 (represented by the purple line), based on the scenario developed in December 2013.
- The yield of the **existing integrated Mgeni WSS**, including MMTS-1 and projected growth in Darvil return flows (shaded in a gradient of purple).
- The incremental yield of the Mgeni WSS from the recently completed **Spring Grove Dam**, including the pumping station and pipeline of the MMTS-2 (shaded in dark blue).

The water balance indicates that the current Mooi-Mgeni WSS is able to assure water supply at acceptable levels of risk to ***2016***. Thus, the current system will not be adequate to meet the medium to long-term water requirements and therefore augmentation of the system is crucial. The water balance also shows that the Mgeni WSS experienced a theoretical deficit between 2004 and 2012, but a period of high rainfall over the catchment reduced the risks of shortfalls. The water balance shows that the water supply for the region is under stress and urgent augmentation is required.

2.4 SOCIO-ECONOMIC PROFILE FOR THE MGENI WSS

The Mgeni WSS, as defined in **Section 1.5**, comprises water supply to some or the whole of the municipalities of eThekwini, Msunduzi, iLembe, Ugu and uMgungundlovu. **Table 2.3** indicates the estimated population and number of households in the both the UW and Mgeni WSS supply areas in 2015.

Table 2.3: Demographics

Estimated 2015	Unit	UW supply area	Mgeni WSS
Population	Number	5 388 804	4 951 222
Households	Number	1 449 894	1 348 912
Household size (average)	People per household	3.7	3.7
Population density	People per km²	885	1 157
Household density	People per km²	238	315

The following map (**Figure 2.4**) gives an indication of the population density within this supply area.

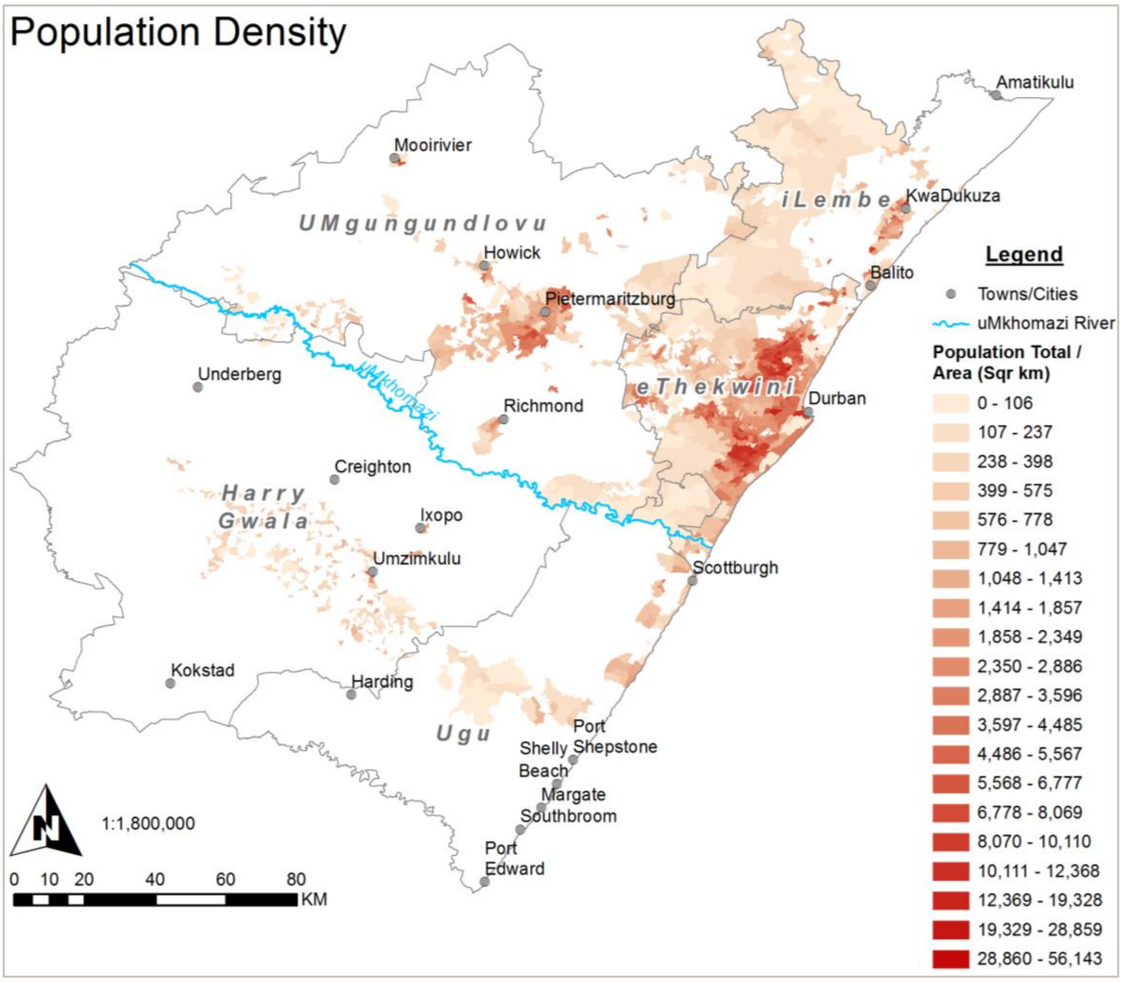


Figure 2.4: Population density in the study area

From this population of five million, about 48% of the population is male and 52% is female, with the age distribution shown in **Figure 2.5**. The potentially economically active population of a specific population is defined as the component of the local population that has the potential to perform labour. This definition excludes individuals below the age of 15 and over the age of 65. Approximately 68% of the population are part of the economically active population.

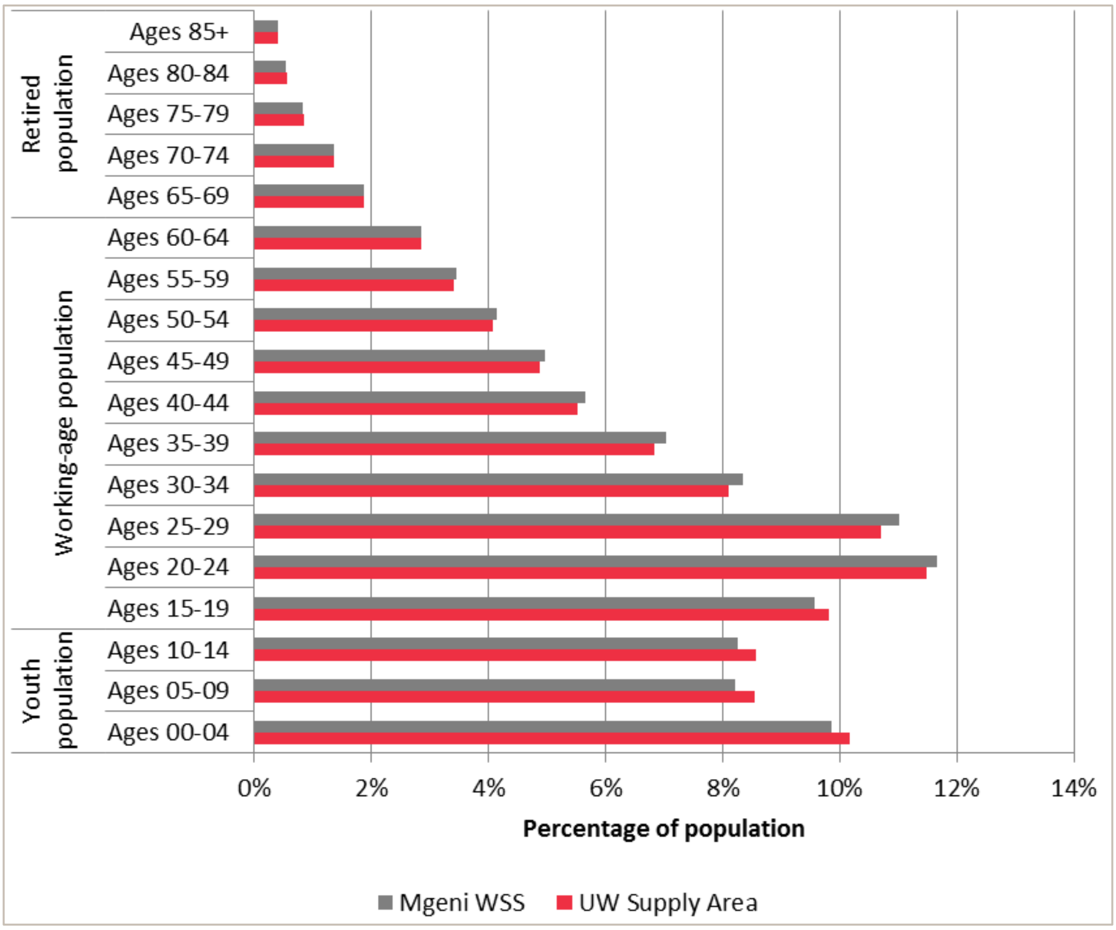


Figure 2.5: Age profile

The unemployment and employment levels within the supply area are indicative of the ability of residents to earn household income (which is generated from economic activities and used to purchase goods and services), and ultimately the ***ability to pay for water services*** received. **Table 2.4** indicates the expanded employment profile for the UW and Mgeni WSS supply areas.

Table 2.4: Employment profile

Employment Profile		UW supply area	Mgeni WSS
Labour force	Employed	61.2%	63.0%
	Unemployed	28.5%	28.3%
	Discouraged work-seeker	10.3%	8.7%
Labour force participation rate*		60.8%	62.0%
Labour absorption rate#		37.8%	39.1%

**Labour force as a percentage of the working age population*

#Employed persons as a percentage of the working age population

It can be highlighted that the unemployment rate for this area is approximately 28%.

Figure 2.6 indicates the employment density within the supply area as employed persons per square kilometre.

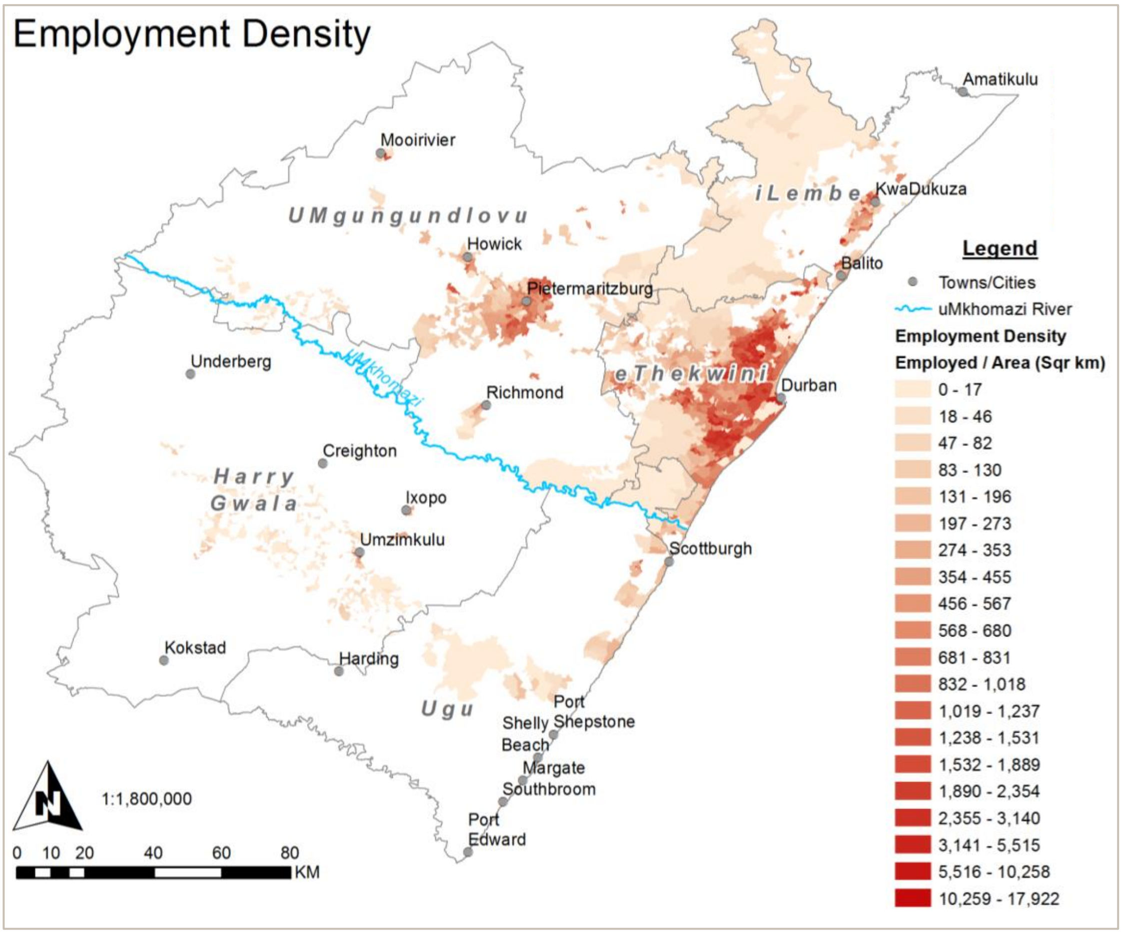


Figure 2.6: Employment density

It is evident that eThekwini has the highest employment density and is the economic hub of the KZN province. eThekwini drives economic growth in the province and will require additional water in order to sustain this economic growth.

The Census 2011 provides data on the household income of the various municipalities that are supplied by UW (see **Table 2.5**).

Table 2.5: Household income in the UW supply area (2015)

Local Municipality	Total number of households apportioned to the UW supply area	Households with annual household income below and equal to R 38 400 per annum		Households with annual household income above R 38 400 per annum	
		Number	Percentage	Number	Percentage
Ugu	48 948	35 966	73.5%	12 981	26.5%
uMgungundlovu	251 544	160 381	63.8%	91 162	36.2%
iLembe	114 403	83 933	73.4%	30 470	26.6%
Harry Gwala	37 857	31 760	83.9%	6 097	16.1%
eThekwini	997 143	584 161	58.6%	412 982	41.4%
Total	**1 449 894**	**896 201**	**61.8%**	**553 693**	**38.2%**

Although this area has the third largest economy in South Africa, it was found that a large portion of the population in the UW supply area – 62% (about 900 000 of the 1.45 million) – earns below the poverty line[3] of about R 3 200 per month in 2015. This has implications for recovery of infrastructure and provisioning costs, and identifies a need for some measure of support funding towards the provision of water infrastructure for these poor households.

The almost 900 000 poor households in the Mgeni WSS will use an estimated total of 98 million m³/a, which is 25% of the total water use of UW of 414 million m³/a. These households are therefore eligible for free basic water supply in accordance with eThekwini's current water supply policy.

[3] *Statistics South Africa: Poverty Trends in South Africa 2006 – 2011, Report No. 03-10-06, March 2014: Per capita poverty is measured at the income level of an individual earning under R443 per month or R5 316 per annum. This translates into household income of R3 200 per month and below.*

3 OPTIONS TO AUGMENT THE MGENI WSS

The need for the long-term augmentation of the Mgeni WSS area, as identified in **Section 2.3**, was previously investigated in pre-feasibility studies and the *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy*. Some of the current and long-term interventions identified are schematically shown in **Figure 3.1**, starting with the in-catchment interventions such as Water Conservation Demand Management (WCDM), desalination and re-use. Although WCDM initiatives are important and should be continuously implemented by the relevant WSAs, it is not discussed further in this study.

Figure 3.1: Reconciliation intervention options for augmentation

Current and future intervention options, identified in the *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy* (DWA, 2012), are shown in **Figure 3.1** and are as follows:

1. Water from Nagle Dam on the uMngeni River;
2. Water from Inanda Dam on the uMngeni River;
3. Water from Midmar Dam on the uMngeni River;
4. Water is released from Spring Grove Dam and abstracted from Mearns Weir on the Mooi River and transferred to the uMngeni River catchment;
5. Water from Hazelmere Dam on the uMdloti River;

6. Water pumped from Spring Grove Dam to the uMngeni River catchment;
7. Proposed implementation of the off-channel storage dam, Ngwadini Dam, on the lower uMkhomazi River;
8. Current implementation of abstraction works on the lower Thukela River;
9. Proposed implementation of the lower Mvoti Bulk Water Supply Scheme (BWSS);
10. Proposed implementation of the uMWP-1's Smithfield Dam;
11. Proposed implementation of the upper Mvoti River Scheme;
12. Proposed implementation of the upper Thukela Scheme;
13. Proposed implementation of the uMWP-2's Impendle Dam;

A. Proposed KwaMashu Wastewater Treatment Works (WwTW) re-use;
B. Proposed Northern WwTW re-use;
C. Proposed North Coast (Tongaat) desalination; and
D. Proposed South Coast (Lovu) desalination plant.

Although all WCDM initiatives are crucial and should be implemented, **alternative augmentation measures should still be developed**.

3.1 RE-USE OF EFFLUENT

The eThekwini Municipality investigated the feasibility of re-using effluent, which is detailed in the report entitled *Feasibility Study of Project Options for Reclamation and Re-use of Treated Sewage Effluents* by Golder Associates (2010).

The combined output of 42.4 million m³/a (116 Mℓ/day) from the KwaMashu and Northern WwTWs, both shown in **Figure 3.2**, can be treated to potable water standards, and discharged directly into the eThekwini water distribution system.

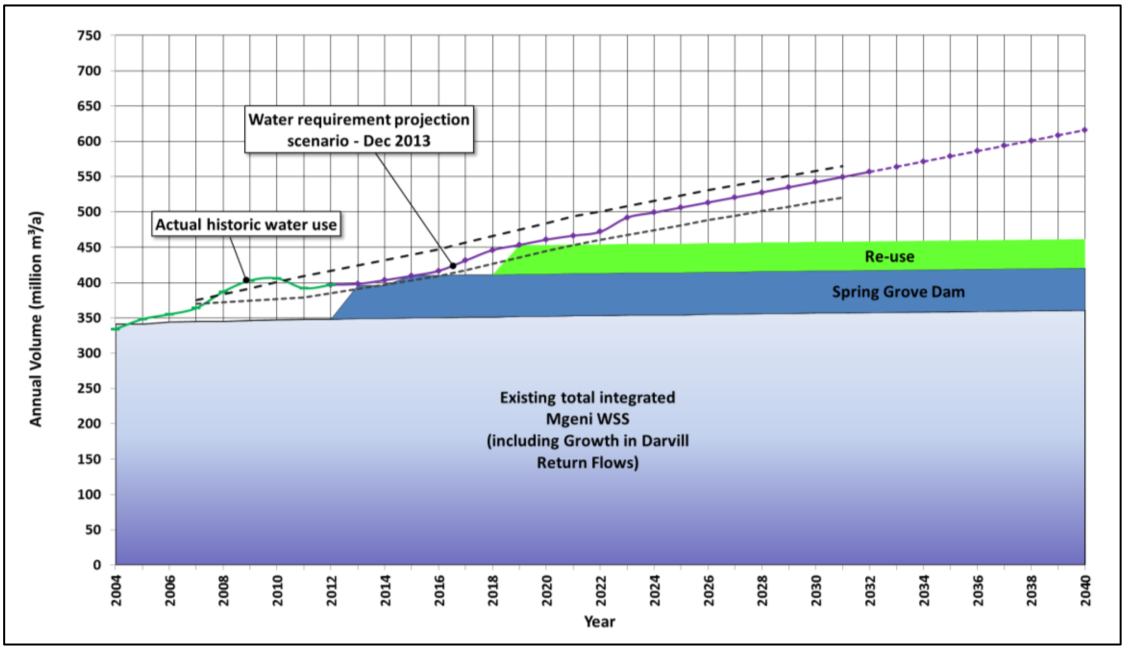


Figure 3.2: Integrated Mgeni WSS water balance with re-use

The water balance with re-use as the augmentation option, shown in **Figure 3.2**, indicates that the volumes from re-use are too low and that additional intervention will be needed when this is implemented.

The capital cost and annual operating expenditure (OPEX) of the 42.4 million m³/a (116 Mℓ/day) effluent re-use option were projected and are shown in **Table 3.1**. Refer to the *Institutional and Financial Aspects Report* (AECOM, et al., 2015) for detailed descriptions.

Table 3.1: Capital and annual operating cost of re-use option

Description	Cost, 2014 Rands (R'000)	
	KwaMashu WwTW	Northern WwTW
Capital cost (2014 Rands, R'000)		
Distribution Infrastructure	38 718	57 897
Reclamation Treatment Plants	621 171	487 380
Sub-Total	**659 889**	**545 278**
Total excl. VAT *(incl Ps&Gs, Professional fees, land acquisition, Environmental, contingencies, Implementing agent)*	**1 218 155**	**1 006 583**
Annual operating expenditure (R'000, unless specified otherwise)		
Distribution Infrastructure OPEX	11 354	16 979
Reclamation Treatment Plants OPEX	132 166	103 699
Total annual OPEX excl. VAT (R'000/year)	**143 520**	**120 678**
Total daily water production (Mℓ/d)	*65*	*51*
Total OPEX/m³ of water (R/m³)	*6.05*	*6.49*

Although the financial aspect of this option is attractive, since it can be implemented as soon as funds are made available and construction can be phased as the water requirements grow, public perception and social acceptance are problematic and need to be resolved. Re-use of treated waste water is being implemented around the world and public perceptions will need to be addressed as water resources become more scarce and expensive to develop. Re-use of treated waste water can be used for industrial purposes wherever possible as first priority.

An economic comparison of the option of re-use with the uMWP is discussed in **Section 9.3**.

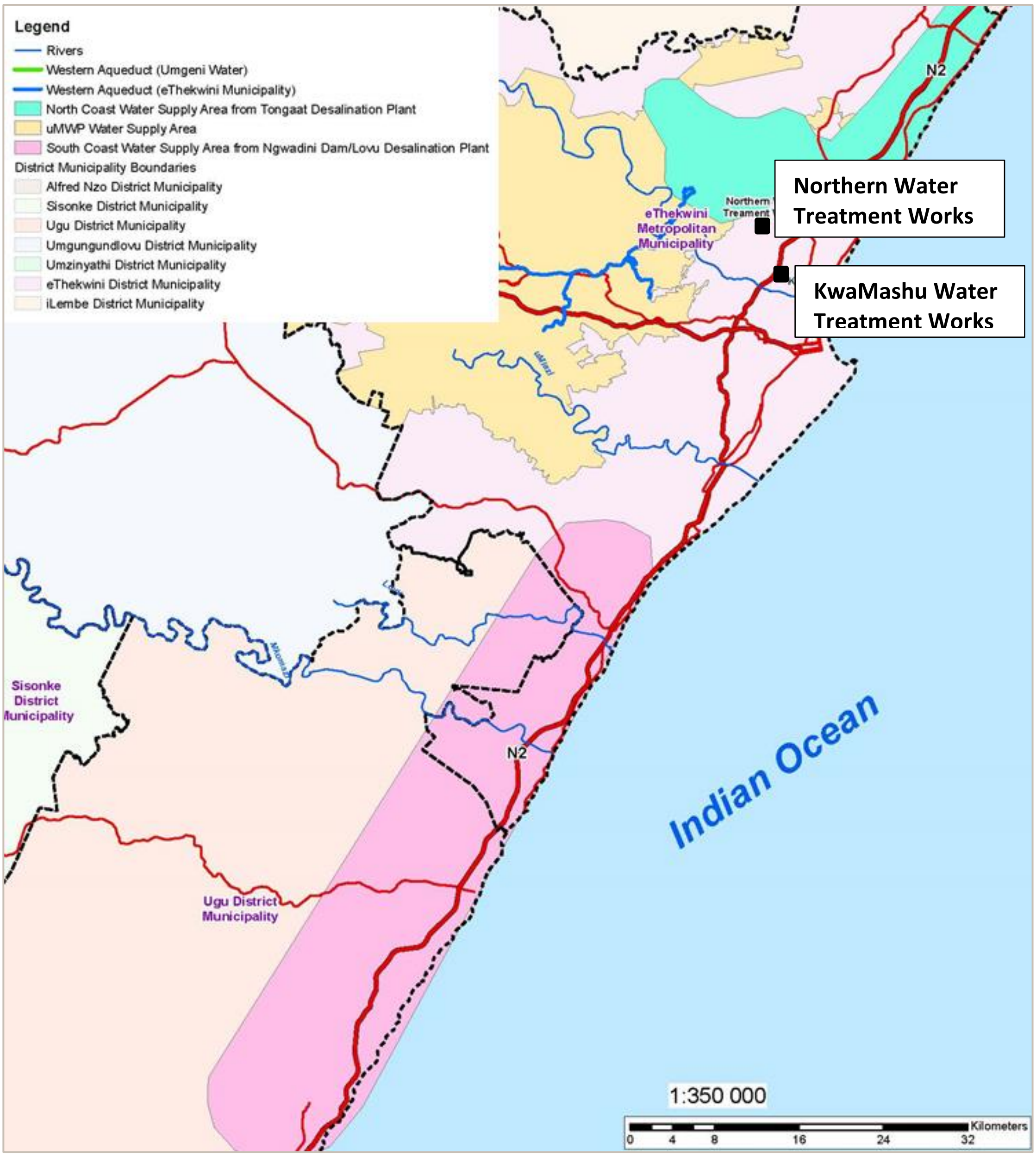


Figure 3.3: Map showing the relative positions (and supply areas) of the augmentation options such as uMWP, desalination and re-use

3.2 DESALINATION

UW is currently investigating the viability of two desalination plants; the first is at Lovu to supply the South Coast, and the other is at Tongaat to supply the North Coast. The possible supply areas of both plants are shown in **Figure 3.3**. Regardless of whether the uMWP is implemented or not, either the South Coast desalination plant or a dam at Ngwadini on the lower uMkhomazi River will be required to augment the South Coast as there are supply infrastructure constraints between the Mgeni WSS and the South Coast.

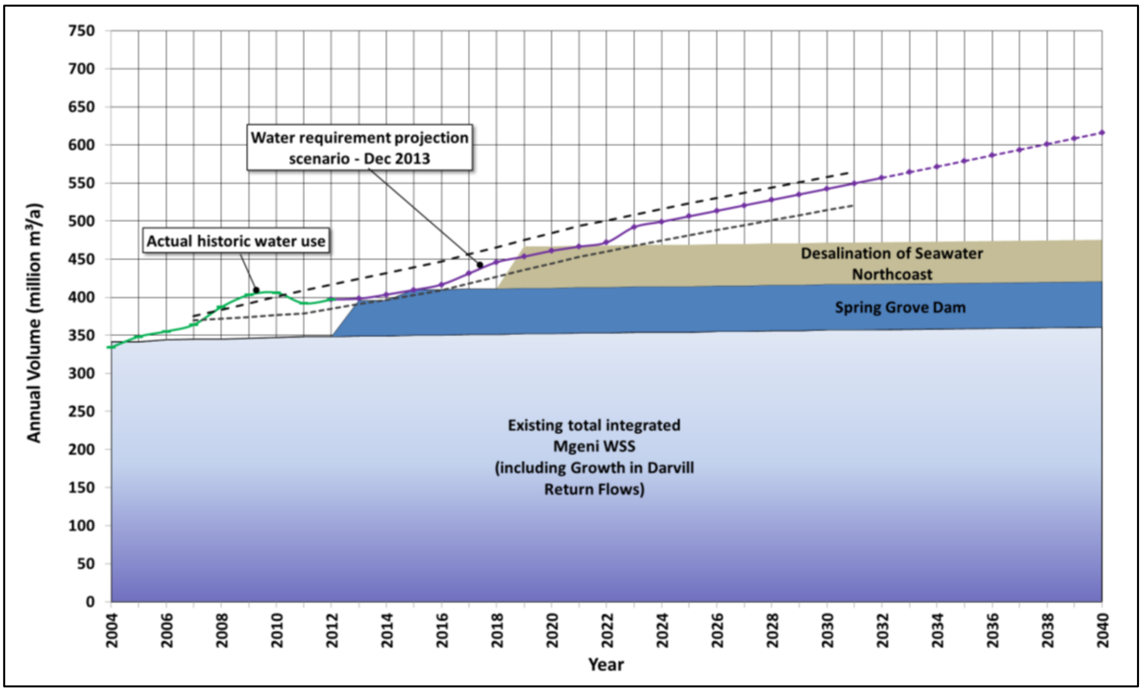


Figure 3.4: Integrated Mgeni WSS water balance with desalination

The water balance with desalination as the augmentation option, shown in **Figure 3.4**, indicates that the annual volumes from desalination are too small, and a further intervention will soon be needed due to the high projected growth in water requirements. However, due to the water shortages expected from 2016 and until a larger augmentation scheme can be implemented (expected only by 2023), this option needs to be considered and may form part of a medium-term intervention required in the area.

The first order capital cost and annual operating cost of the 54.7 million m^3/a (150 Mℓ/day) seawater desalination plant on the South Coast at Lovu are shown in **Table 3.2**.

Table 3.2: Capital and annual operating cost of Lovu Desalination Plant (Aurecon, 2013)

Item	Cost, 2014 Rands, R'000
Construction/Procurement/Installation Capital	2 056 400
Total (excl. VAT) *(incl professional services & fees, Ps&Gs, Environmental, land acquisition, contingencies and implementing agent)*	**4 350 346**
Operating and maintenance cost (R'000/year)	314 192
Operating and maintenance cost (R/m³) (excl. VAT)	5.73

The feasibility investigation into the desalination plant at Lovu is ongoing. The above costs are indicative only and will be revised. These costs are also for the supply of water to the plant at sea level and additional costs will be incurred to pump and convey the water up to the reservoir located close to the consumers.

An economic comparison of the desalination option with the uMWP is discussed in **Section 9.3**.

3.3 uMKHOMAZI WATER PROJECT

The DWA investigated the feasibility for the uMWP (this study), comprising a new dam at Smithfield on the uMkhomazi River to augment specifically the users downstream of Umlaas Road in eThekwini Municipality as part of the Mgeni WSS.

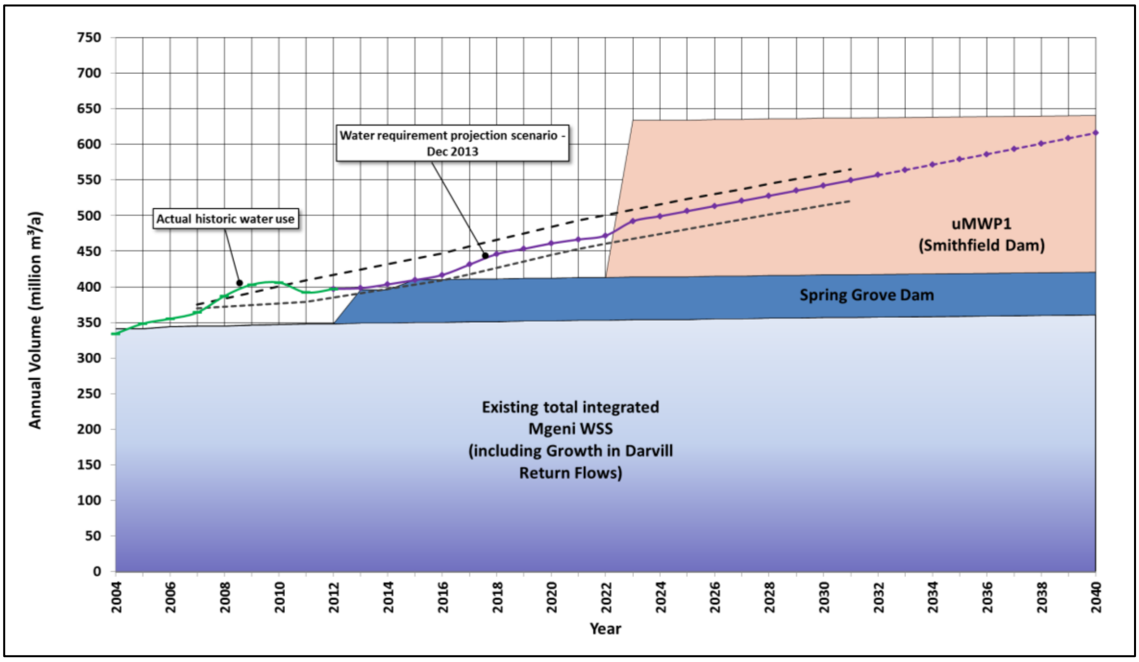


Figure 3.5: Integrated Mgeni WSS water balance with uMWP

The balance between the available yield and water requirements of the integrated Mgeni WSS with uMWP as the augmentation option, shown in **Figure** 3.5, indicates that the volumes from the uMkhomazi should suffice for at least 20 years, although short-term intervention may be needed due to the development period of such a large project.

Due to the high growth in water requirements, together with the volume available, neither desalination nor re-use will be sufficient to meet the long-term need of the Mgeni WSS. Thus, as confirmed during the *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy,* the uMWP is the preferred long-term augmentation option to meet the requirements, as shown in **Figure 3.5**.

3.4 RECONCILIATION OF WATER REQUIREMENTS AND AVAILABILITY

The anticipated growth in water demand in the Mgeni WSS was covered in **Section 2.2**. The phasing of water requirements onto the uMWP-1 (also known as shedding of water to the uMWP-1), was then estimated for the purposes of sizing and phasing the infrastructure of the uMWP-1, in particular the Baynesfield WTW which can accommodate phased development.

It was determined that the water requirement of the ***Outer West Area*** (supply area below Umlaas Rd) is best shed to the uMWP-1. This will decrease the Midmar supply area to provide for the future growth in water requirements of the Msunduzi area. Water requirements of the Western and Northern Aqueducts (Umlaas Road to the north coast) will then also be shed onto the uMWP-1 once Durban Heights WTW reaches its operating capacity, thereby reducing the load on the existing resources in the Mgeni WSS. Thus, the proposed uMWP supply area is shown in **Figure 3.6**.

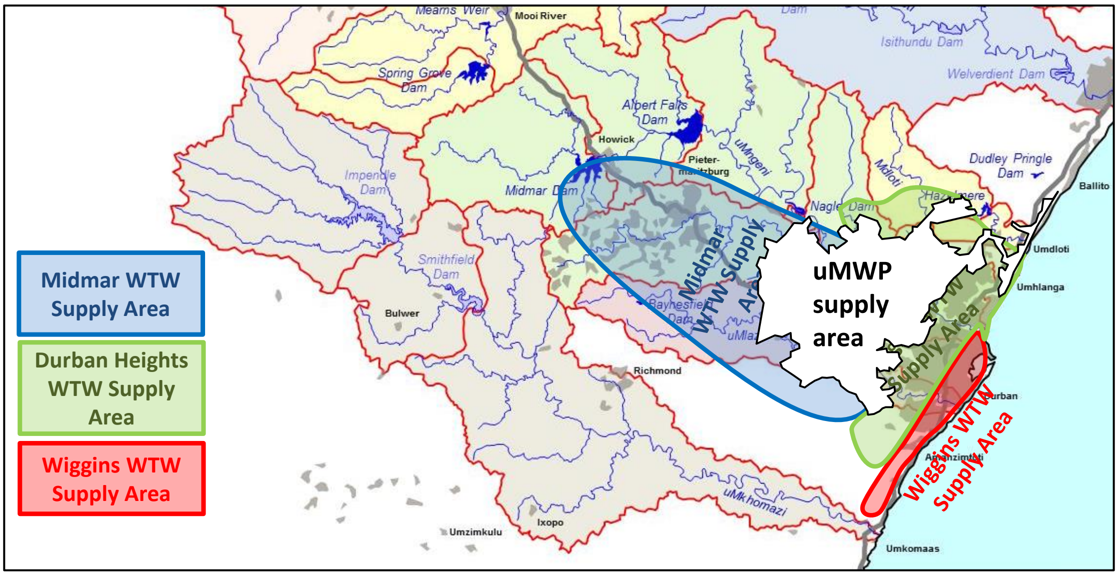


Figure 3.6: Proposed uMWP supply area

Figure 3.7 shows that by 2023[4] the projected water requirements on the uMWP-1 will be approximately 100 million m^3/a.

The supply from the uMWP-1 will then be increased as the water requirements increase and also as more supply areas from the existing Durban Heights system is shed onto the uMWP-1. Supply areas will only be shed when existing infrastructure reaches its capacity.

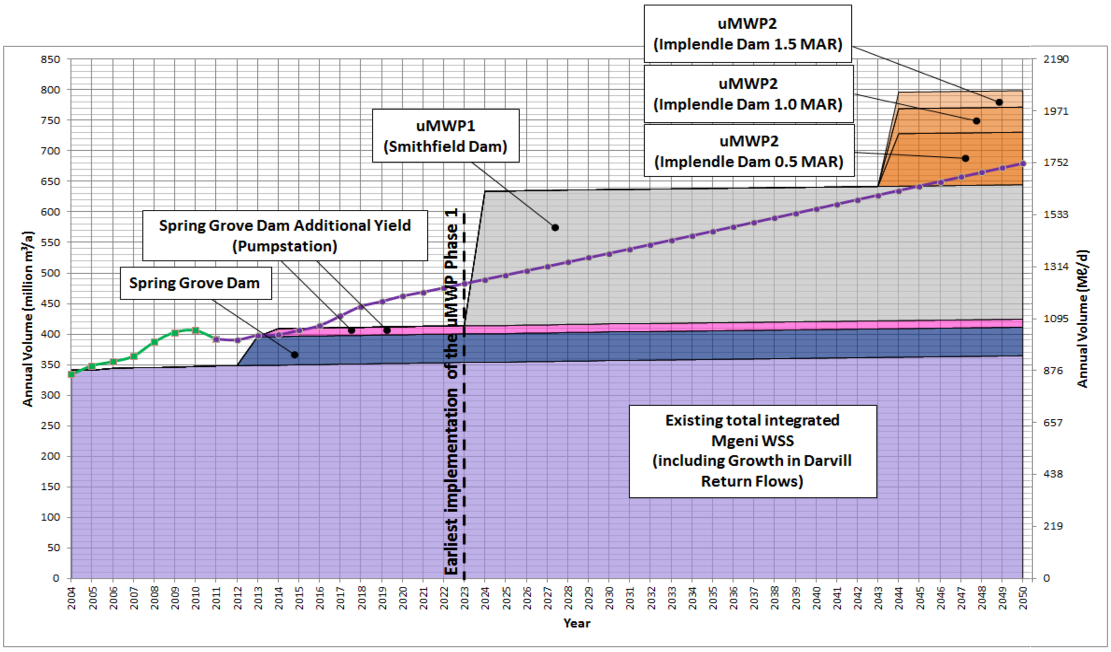


Figure 3.7: Projected future water balance of the Mgeni WSS

The projected future water balances for the Mgeni WSS, additionally augmented from various schemes, is shown in **Figure 3.7** and reflects a selected development scenario incorporating the following:

- Commissioning of the Smithfield Dam in 2023 with a yield of 220 million m^3/a.
- uMWP-1 designed as a gravity system that may be used in preference to Spring Grove Dam, as water from the latter is pumped to the uMngeni River catchment.
- Based on the UMWP-1 development, the water balance provides a preliminary estimate for the commissioning date for Impendle Dam of 2043.
- Dependent on the size of Impendle Dam (uMWP-2) with a live storage capacity of 50%, 100% or 150% of the natural mean annual runoff (MAR), the estimated water demand can be met to 2056 and beyond as shown in the orange shading.

[4] *As indicated in Section 11, 2023 is the earliest practical commissioning date for the uMWP-1*

3.5 uMKHOMAZI WATER PROJECT LAYOUT

As defined in the Technical Feasibility Study ToR the proposed layout for uMWP-1, as shown in **Figure 3.8**, would comprise the following components:

- A new dam at Smithfield on the uMkhomazi River (described in detail in **Section 5**);
- Conveyance infrastructure (tunnel and pipeline) to the WTW in the uMlaza River valley, including a balancing dam (described in detail in **Section 6**); and
- A WTW in the uMlaza River valley, followed by a gravity pipeline to the UW bulk distribution system, connecting in the area of the Umlaas Road reservoir (*Umgeni Water, 2013*). From Umlaas Road, water will be distributed under gravity through existing infrastructure to eThekwini. (The potable water infrastructure forms part of ***Module 3*** of the Feasibility Study and is not addressed further in this document.)

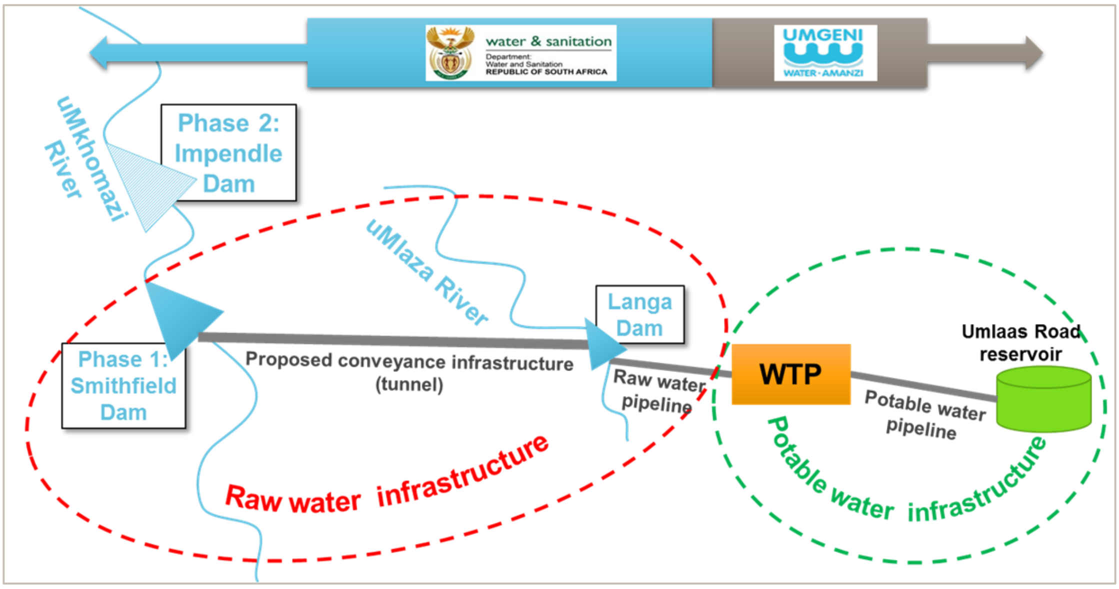


Figure 3.8: Schematic layout of the raw and potable water infrastructure of the uMWP

Phase two of the uMWP is scheduled for commissioning in 2043. It will comprise the construction of a second large dam at Impendle further upstream on the uMkhomazi River to release water to the downstream Smithfield Dam, and will also provide for an additional transfer tunnel from Smithfield Dam to the uMlaza River.

4 WATER RESOURCES OF THE UMKHOMAZI AND UMLAZA RIVER CATCHMENTS

As described in previous sections, the proposed uMWP is the most attractive next long-term option to meet the growing water requirements of the Mgeni WSS. As such the water resources of the uMkhomazi and upper uMlaza river catchments were further assessed and details are provided in the following subsections. This includes the hydrology, Ecological Water Requirements (EWRs), groundwater resources, current water use and future water requirements, as well as the yields of proposed uMWP dams on the uMkhomazi River.

A locality map of the uMkhomazi and uMlaza river catchments is shown in **Figure 4.1**.

Figure 4.1: Locality map of the uMkhomazi, uMlaza and uMngeni river catchments

4.1 HYDROLOGY

Hydro-meteorological characteristics of the uMkhomazi and upper uMlaza river catchments are summarised in **Table 4.1**. This shows that the uMkhomazi Catchment has a mean annual natural runoff (MAR) of 1 078 million m³/a. Of this volume 726 million m³/a (or 67%) is generated upstream of the proposed Smithfield Dam site.

Table 4.1: Hydro-meteorological characteristics of the uMkhomazi and upper uMlaza river catchments

Quaternary catchment	Incremental catchment area (km²)	MAP[(1)] (mm)	MAE[(2)] (mm)	Incremental natural MAR[(3)]		
				(million m³/a)	(mm)	(% MAP)
uMkhomazi River catchment						
U10A	418	1 287	1 300	209.5	501	39%
U10B	392	1 176	1 300	164.5	420	36%
U10C	267	1 091	1 300	96.7	362	33%
U10D	337	999	1 300	98.2	291	29%
U10E	327	1 034	1 300	100.9	309	30%
U10F	379	963	1 300	67.1	177	18%
U10G	353	981	1 250	70.1	199	20%
U10H	458	924	1 200	82.7	180	20%
U10J	505	878	1 200	78.0	154	18%
U10K	364	793	1 200	40.4	111	14%
U10L	307	758	1 200	29.6	96	13%
U10M	280	858	1 200	40.1	143	17%
Totals:	**4 387**	**981**[(4)]	**1 252**[(4)]	**1 077.7**	**246**	**25%**
Upper uMlaza River catchment						
U60A	105	981	1 200	22.65	216	22%
U60B	316	822	1 200	-[(5)]	-	-
Totals:	**421**	**862**[(4)]	**1 200**[(4)]	**-**	**-**	**-**

Notes (1) Mean annual precipitation (WRC, 1994).
(2) Mean annual Symons-pan evaporation (WRC, 1994).
(3) Mean annual runoff.
(4) Weighted average based on catchment area.
(5) Not included in this study.
(6) All statistics calculated over the period 1925 to 2008, hydrological years.

It should be noted that, as discussed in the study report *Hydrological Assessment of the uMkhomazi River Catchment* (AECOM, et al., 2014), the spatial distribution of rainfall gauging stations in the uMkhomazi River catchment is of great concern. The usable stations equates to a spatial density of only one gauge per 91 km², which is fairly sparse for an area characterised by high spatial variability in topography and rainfall. There are also no gauges located in the foothills or upper Drakensburg areas, where high rainfall is known to occur. Currently only 13 gauges in the study are still operational. These factors impacted upon the reliability of results obtained, especially that of catchment MAPs and representative catchment time-series rainfall data – particularly in the headwater catchment areas.

There are four important stream flow gauging stations in the study area, namely U1H005 at Camden, U1H006 at Delos Estate (now closed) and U1H009 at Shozi on the uMkhomazi River and U6H002 at Nooitgedacht on the uMlaza River. While the geographical location of the stream flow gauging stations, shown in **Figure 4.2**, covers most of the study area the quality of the data sets was found to be generally poor.

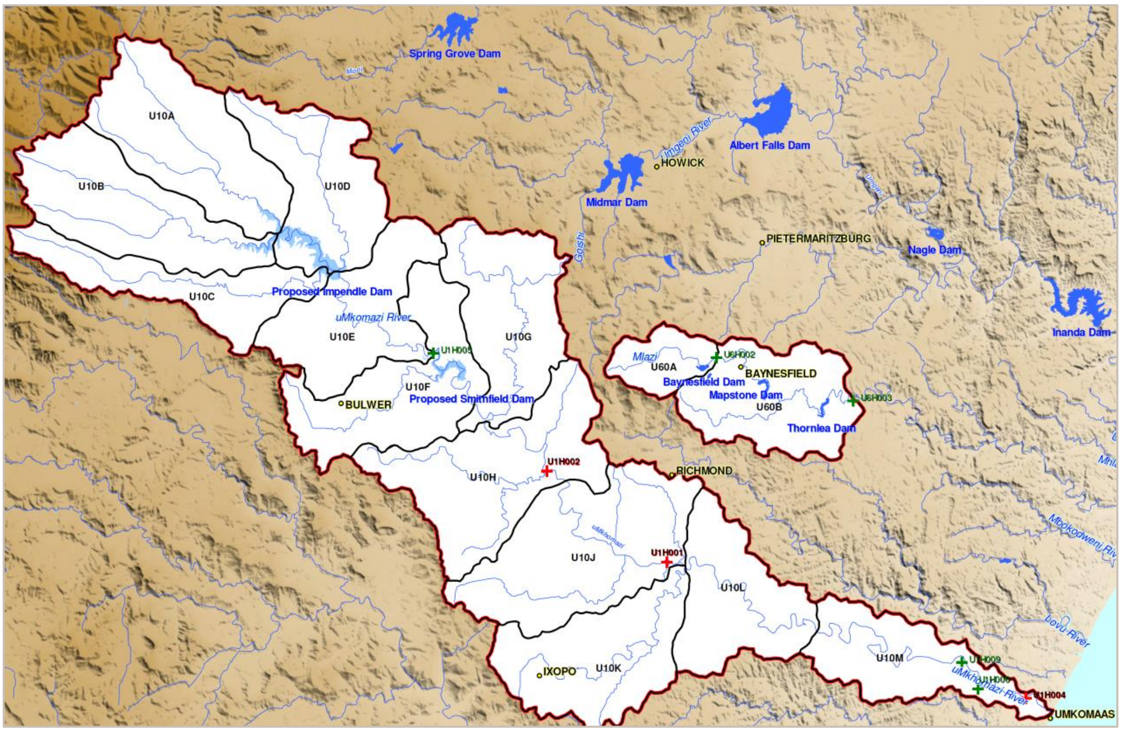


Figure 4.2: Steam flow gauging stations in the uMkhomazi and uMlaza River catchments

Despite the factors described above, good calibrations of the WRSM2000 rainfall-runoff model were achieved and modelled results were successfully used to infill, naturalise and extend observed stream flows. The reliability of the resulting hydro-meteorological data sets were therefore considered to be acceptable and appropriate for application in the water resource system analyses undertaken in this study.

4.2 ECOLOGICAL WATER REQUIREMENTS

As part of the earlier *Mkomazi IFR Study* (IWR Environmental, 1998) it was estimated that 350 million m³/a (32%) of the natural catchment runoff in the uMkhomazi River should be allocated for supplying Ecological Water Requirements (EWRs) and sustaining the system's riverine health at a desirable level. The location of the EWR sites is shown in **Figure 4.3**.

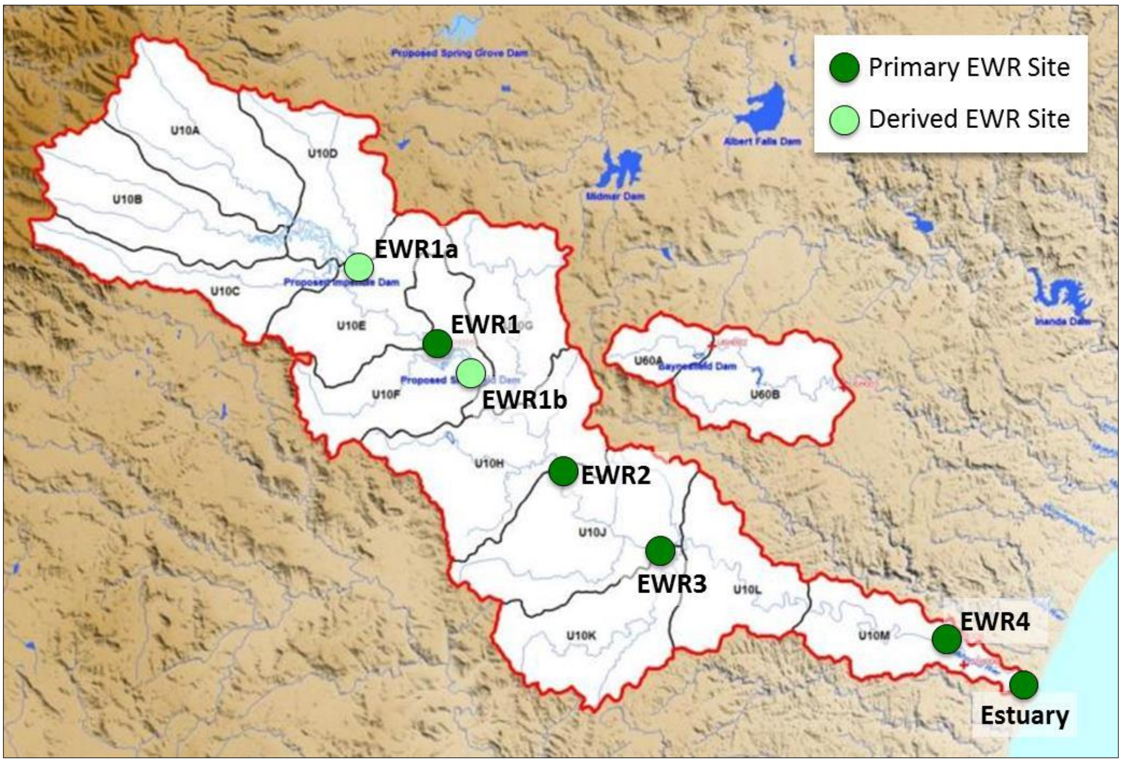


Figure 4.3: EWR sites in the uMkhomazi River catchment

However, one of these sites, EWR Site 1, will be inundated by the proposed Smithfield Dam. It was therefore decided that two additional EWR sites would be defined based on the desired flow regime at EWR Site 1, but scaled according to the respective catchment MARs to represent associated flows at the following sites:

- Site 1a: Located at the proposed Impendle Dam site, upstream of Site 1.
- Site 1b: Located at the proposed Smithfield Dam site, downstream of Site 1.

Furthermore, towards the end of this study results from a parallel study, *Classification of Water Resources and Determination of the Comprehensive Reserve and Resources Quality Objectives in the Mvoti to Umzimkulu Water Management Area* (DWA, 2013) ("*Classification Study*"), became available for the upper uMlaza River catchment. One of the sites adopted for that study is located at the outlet of quaternary catchment U60A, close to the Langa Dam site. This

EWR could be used to develop an EWR for Langa Dam by scaling according to the respective catchment MARs.

A summary of the resulting EWRs adopted in this study for the uMkhomazi and uMlaza river catchments is provided in **Table 4.2**.

Table 4.2: Summary of EWRs in the uMkhomazi and uMlaza river catchments

EWR site		Cate-gory	Location			Cumulative catchment		Modelled average EWR	
No.	Name		Description	Lat. (°S)	Long. (°E)	Area (km^2)	MAR (million m^3/a)	million m^3/a	% MAR
uMkhomazi River catchment									
1a(1)	Impendle	B	Impendle site	29°39'	29°46'	1 422	571	180	31%
1	Lundy's Hill	B	Outlet U10E	29°45'	29°55'	1 741	670	-	-
1b(1)	Smithfield	B	Smithfield site	29°46'	29°56'	2 058	726	228	31%
2	Hella Hella	B	Outlet U10H	29°55'	30°05'	2 931	890	226	25%
3	St Josephine's	B	u/s outlet U10J	30°01'	30°14'	3 339	953	330	35%
4	Mfume	B	u/s outlet U10M	30°08'	30°40'	4 330	1 070	350	33%
Upper uMlaza River catchment									
-	04533, Mlazi	C	Outlet U60A	29°45'	30°19'	105.0	22.6	-	-
-(2)	Langa	C	Langa site	29°47'	30°18'	5.3	1.2	0.3	25%

Notes: (1) Derived from EWR 1 by scaling according to respective catchment MARs.
(2) Derived from the U60A EWR by scaling according to respective catchment MARs.

In conclusion it should be noted that final results from the *Classification Study* were only published after the water resources modelling for this study had been completed. Importantly, updated EWRs for the uMkhomazi River could not be used in the analyses, while they were found to differ significantly from those shown earlier in **Table 4.2**. The most significant differences include the following:

- Since EWR Site 1 is situated upstream of the proposed Smithfield Dam it was not included in any of the operational scenarios undertaken for the *Classification Study*.
- In the case of EWR Site 2, which is located downstream of the Smithfield Dam site, the final average EWR from the *Classification Study* is given as 315 million m^3/a, or 35% of the natural MAR. This is 89 million m^3/a higher (almost 40%) compared to the EWR 2 of 226 million m^3/a used in this study.

The impact of these differences is briefly discussed in **Section 4.5.1**.

4.3 GROUNDWATER RESOURCES

The uMkhomazi River catchment is a relatively unique catchment in that it covers an outcrop of the whole Karoo Supergroup sequence of rocks for the given area of South Africa. It also presents some structurally complex geology with numerous folds, faults, thrusts and nappes in the Namaqua-Natal Province to the south-west, as shown in **Figure 4.4**.

The groundwater resources of the uMkhomazi Catchment were determined in order to model its interaction with surface water.

A groundwater flow balance model was used to assess at a desktop level the volumes of groundwater available in each catchment with the Groundwater Yield Model for the Reserve (GYMR) method. Water qualities for groundwater in the uMkhomazi catchment were obtained from the NGA and GRIP borehole databases, and evaluated using the DWA water quality guidelines, as shown in **Table 4.3** and **Figure 4.5**.

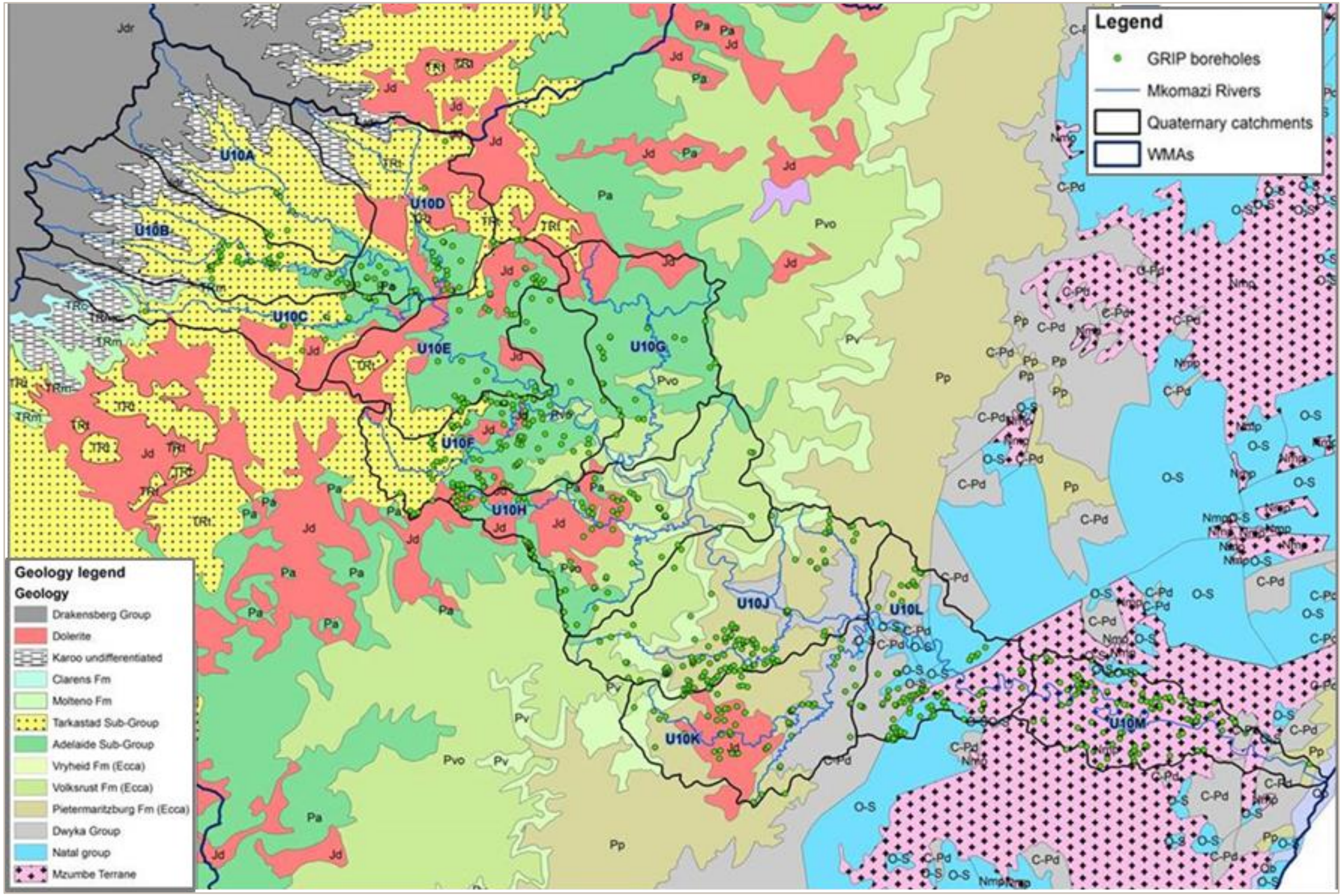


Figure 4.4: Basic geology map for the uMkhomazi River catchment

Table 4.3: Groundwater qualities of major constituents per quaternary catchment

Catchment	Overall Water Quality Class	pH	EC mS/m	TDS mg/l	Ca mg/l	Mg mg/l	Na mg/l	K mg/l	CO_3 mg/l	HCO_3 mg/l	Cl mg/l	SO_4 mg/l	F mg/l	N mg/l	Fe mg/l	Mn mg/l
U10A	Class 0	8.2	23.9	167.3	11.0	1.1	40.2	1.0	0.0	122.0	3.2	4.4	0.18	0.2	0.29	0.02
U10B	Class 1	7.8	27.0	178.1	16.4	6.9	35.3	1.7	0.0	118.2	8.1	11.4	0.49	0.6	0.76	0.06
U10C	Class 1	7.2	15.8	96.9	15.0	2.5	13.8	1.6	0.0	77.8	1.2	4.0	0.06	0.3	0.58	0.15
U10D	Class 1	7.3	64.8	416.0	55.4	23.8	60.4	1.7	0.0	210.0	10.0	124.0	0.31	0.4	0.09	0.14
U10E	Class 2	7.2	25.1	151.2	18.5	10.6	19.0	1.1	0.0	110.7	4.1	9.8	0.07	1.6	1.69	0.38
U10F	Class 2	7.4	23.2	228.8	19.4	6.4	28.5	1.2	0.0	103.4	10.2	19.2	0.36	1.7	1.39	0.09
U10G	Class 2	7.0	10.2	43.0	10.4	4.0	5.9	0.3	0.0	40.7	1.8	1.5	0.06	2.9	1.70	0.05
U10H	Class 0	7.4	25.2	178.8	11.6	6.8	26.0	1.9	0.0	83.2	22.0	1.6	0.11	2.0	0.36	0.04
U10J	Class 3	6.8	20.6	126.6	14.9	12.8	17.1	1.0	0.0	79.3	12.8	16.9	0.93	0.1	6.16	0.70
U10K*	Class 0	7.7	24.7	198.1	20.4	8.8	16.2	1.0	0.0	108.5	8.2	7.7	0.37	0.6		
U10L	Class 2	7.7	120.7	818.4	62.1	38.2	132.8	2.6	0.0	227.1	209.5	65.1	0.64	6.9	0.08	0.05
U10M	Class 3	7.3	108.0	802.0	90.5	36.2	155.7	3.1	0.0	231.8	205.2	101.2	1.90	2.2	4.51	0.21
DWA drinking WQ guidelines 1998																
Class 0: Ideal water quality		5.0<pH<9.5	70	450	80	70	100	25	N/A	N/A	100	200	0.7	6	0.5	0.1
Class 1: Good water quality		5.0>pH>9.5	150	1000	150	100	200	50			200	400	1	10	1	0.4
Class 2: Marginal water quality		4.5>pH>10.0	370	2400	300	200	400	100			600	600	1.5	20	5	4
Class 3: Poor water quality		4.0>pH>10.5	520	3400	300+	400	1000	500			1200	1000	3.5	40	10	10
Class 4: Unacceptable water quality		3.0>pH>11.0	520+	3400+		400+	1000+	500+			1200+	1000+	3.5+	40+	10+	10+

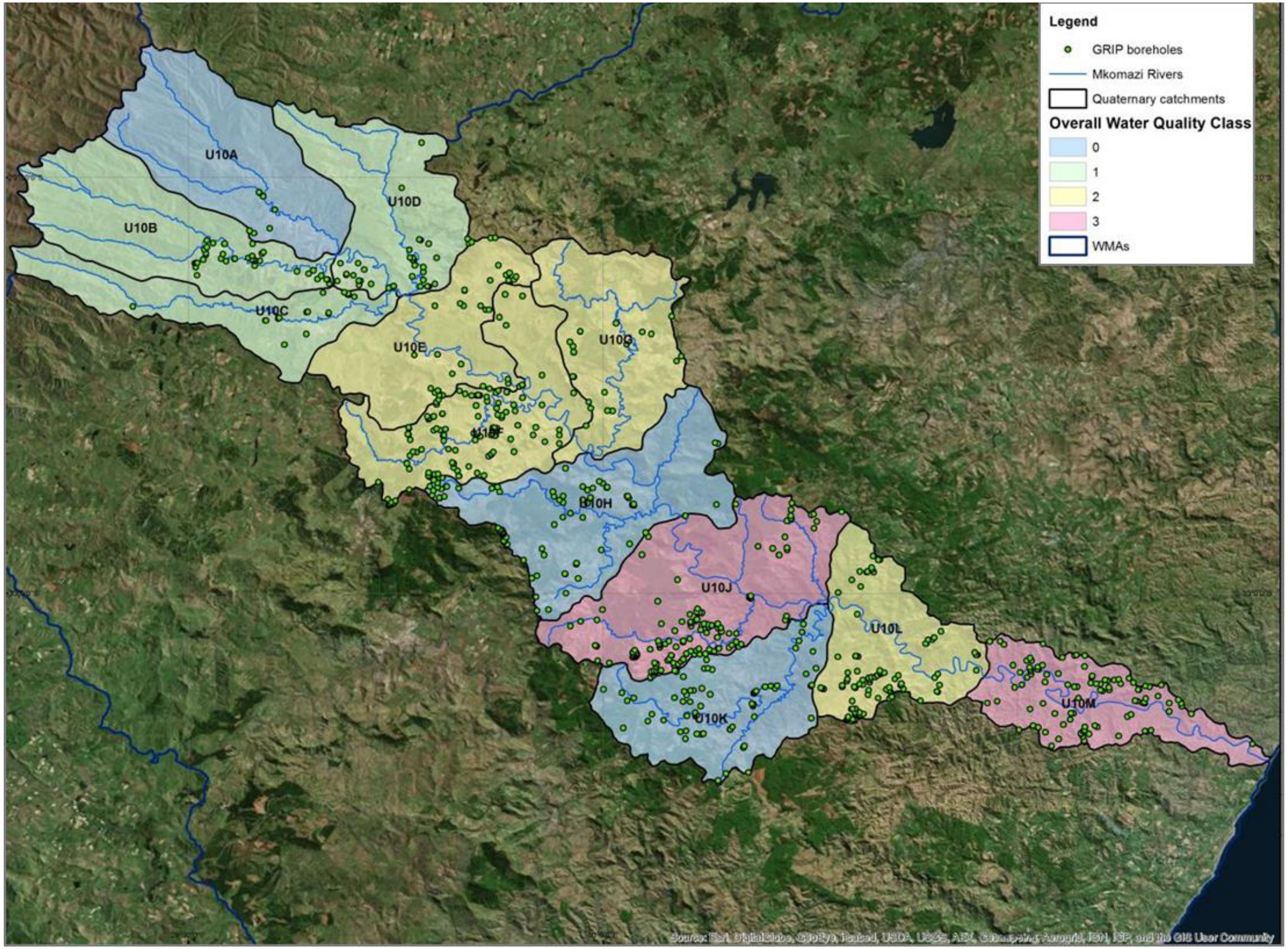


Figure 4.5: Overall water quality class per catchment

The highest potential for groundwater exploitation lies in fractured and faulted Natal Group sandstones, Karoo Supergroup sediment rocks that are faulted or fractured and intruded by dolerite dykes and sills, and alluvial porous aquifers if extensive enough and present in the study area. A large part of the study area is covered by the Karoo Supergroup and associated dolerite intrusions, and thus moderately yielding boreholes can be successful at the opportunely located dykes and sills if good geophysical surveys and structural analyses are conducted.

The quaternary catchments U10A – U10G are the most suited catchments for groundwater development based on volumes available in the GYMR with volumes of groundwater available after evapotranspiration ranging between 43.4 million m^3/a (U10A) and 14.0 million m^3/a (U10F) in steady-state scenarios.

Quaternary catchments U10H – U10M show lower potential for groundwater development based on GYMR groundwater volumes available.

Table 4.4: GYMR usable groundwater from base flow, AGEP and UGEP

Quaternary catchment	Surface Area (km²)	Usable GW component from Base Flow assured 95% (m^3/ km²/ a)	Average groundwater exploitation potential (AGEP) (m^3/km^2/a)	Utilisable Groundwater Exploitation Potential (UGEP) (m^3/ km²/ a)	Final Utilisable Groundwater per catchment (m^3/ km²/a)	Final Utilisable Groundwater per catchment (million m^3/a)
U10A	418.2	103 894	51 839	46 147	46 147	19.30
U10B	392.1	77 613	42 848	39 398	39 398	15.45
U10C	267.0	67 590	37 921	33 030	33 030	8.82
U10D	337.0	63 231	35 932	31 013	31 013	10.45
U10E	327.2	61 873	39 568	36 441	36 441	11.92
U10F	379.0	35 336	30 855	27 628	27 628	10.47
U10G	353.1	40 274	33 239	29 352	29 352	10.37
U10H	457.8	15 801	30 633	26 747	15 801	7.23
U10J	505.1	16 808	24 337	20 855	16 808	8.49
U10K	364.4	-2 094	14 035	11 836	-2 094	-0.76
U10L	307.2	20 292	12 528	9 847	9 847	3.03
U10M	280.0	42 858	18 203	19 101	19 101	5.35
Total	**4388.1**	**543 476**	**371 939**	**331 395**	**302 473**	**110.11**

The final, but conservative, groundwater volumes available per catchment are shown in **Table 4.4**. It compares the GYMR, the Average Groundwater Exploitation Potential (AGEP) and the Utilisable Groundwater Exploitation Potential (UGEP) from the GRA2 project.

Spring protection measures should be implemented in the upper quaternary catchments (U10A – U10D) of the uMkhomazi catchment due to the high number of spring occurrences there. These springs already supply water for domestic use and spring protection measures will ensure their sustainability and quality.

Based on the results from GYMR modelling, it is recommended that if large-scale groundwater development is considered for catchments U10H, U10J, U10K and U10L, a more thorough evaluation of the groundwater inflow and outflow components is performed there. These catchments show moderate to critical groundwater stress, based on the desktop-level groundwater flow balance using the GYMR method.

4.4 CURRENT WATER USE AND FUTURE WATER REQUIREMENTS

The uMkhomazi River catchment is currently fairly undeveloped, with the notable exception of large tracts of commercial forestry and irrigated areas in the central catchment areas around the towns of Richmond, Ixopo, Bulwer and Impendle, as well as water abstractions for the SAPPI SAICCOR mill located near the coastal town of Umkomaas. SAPPI-SAICCOR abstractions from the uMkhomazi River are limited to the total licensed volume of 53.0 million m^3/a from natural river runoff. However, in accordance with their current license conditions, water may only be abstracted when the flow into the downstream estuary exceeds 1 m^3/s.

Other water users include small towns and rural settlements, stock watering, dry-land sugarcane and invasive alien plants.

Table 4.5 and **Figure 4.6** provide a summary of the projected in-catchment water requirements and return flows in the uMkhomazi River catchment over a planning period of approximately 40 years, from 2012 to 2050 *(Water Resources Yield Report)* (AECOM, et al., 2014).

Table 4.5: Summary of projected water requirements and return flows in the uMkhomazi River catchment

Water user category	Water requirement (million m^3/a), at indicated development level				
	2012	2020	2030	2040	2050
Irrigation, supplied from all sources	37.90	41.90	46.85	51.69	56.54
Commercial forestry	59.71	62.96	67.03	71.10	75.17
Dry-land sugarcane	1.64	1.64	1.64	1.64	1.64
Invasive alien plants	6.37	6.37	6.37	6.37	6.37
Stock watering	2.66	2.77	2.90	3.04	3.17
Domestic water use, supplied from all sources	3.89	4.09	4.27	4.44	4.61
Industrial water use	53.00	53.00	53.00	53.00	53.00
Total water use	**165.17**	**172.74**	**182.06**	**191.28**	**200.50**
Return flows	6.66	7.06	7.55	8.03	8.51
Total net water use	**158.51**	**165.68**	**174.52**	**183.25**	**191.99**

The current net water use within the uMkhomazi River catchment totals 159 million m³/a, or 15% of the natural MAR of the catchment, and based on the selected water requirement projections it is estimated that this may grow to 192 million m³/a by 2050.

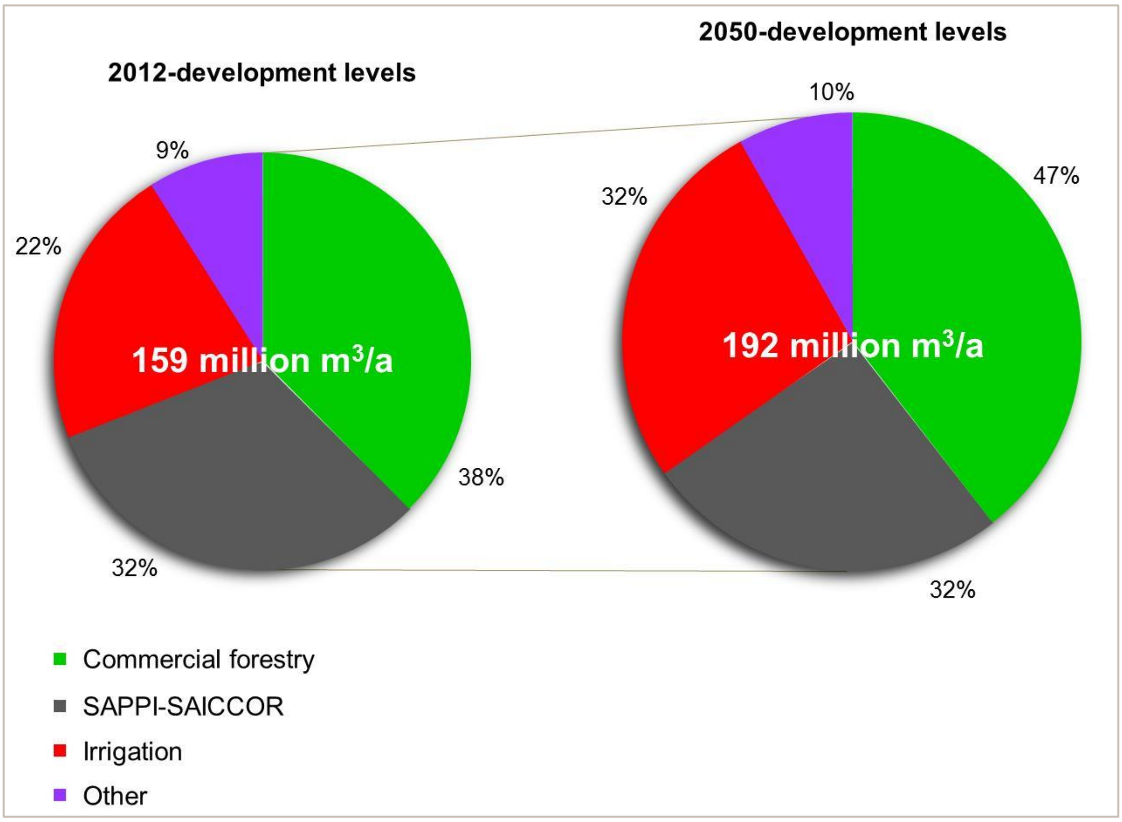


Figure 4.6: Summary of projected net water requirements in the uMkhomazi River catchment

Figure 4.7 provides a comparison of net water use, in 2012, and natural runoff in the uMkhomazi River catchment.

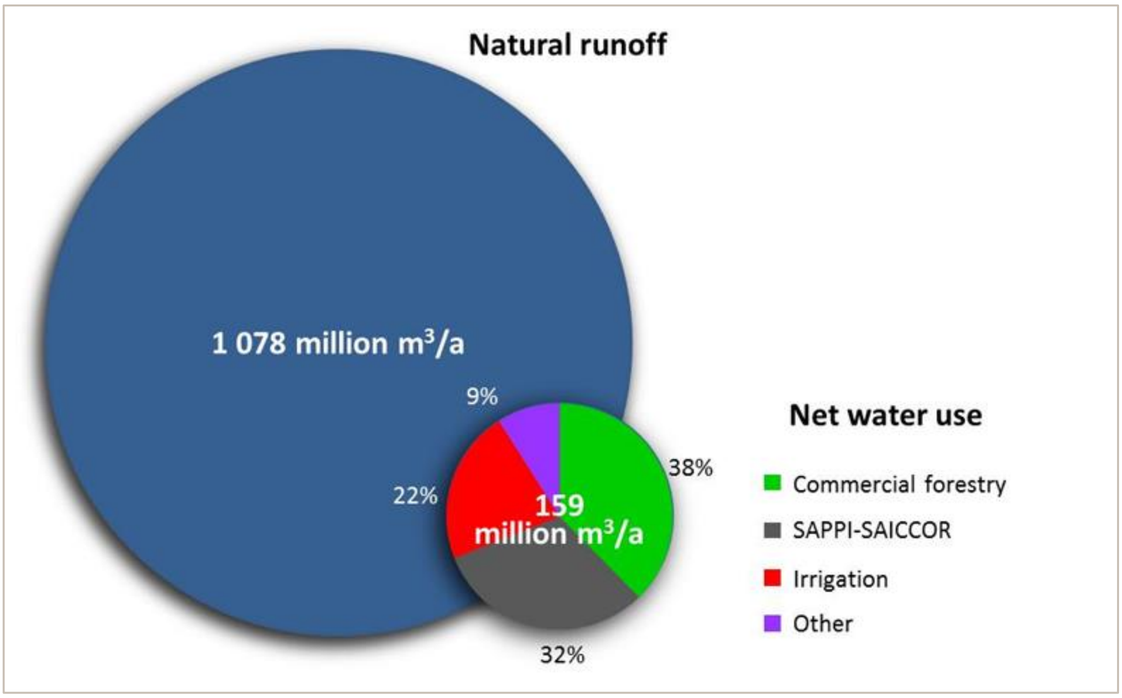


Figure 4.7: Net water use and natural runoff in the uMkhomazi River catchment

4.5 WATER AVAILABILITY AND YIELD OF THE PROPOSED DAMS

The availability of water from the uMkhomazi River Catchment was assessed with the Water Resources Yield Model (WRYM) and Water Resources Planning Model (WRPM), as described in the *Water Resources Yield Assessment (P WMA 11/U10/00/3312/2/3)* and *Water Resources Planning Model (P WMA 11/U10/00/3312/2/4)* reports. The objectives of the assessment were:

- To determine the water supply potential ("yield") of the proposed uMWP-1 (Smithfield Dam) and uMWP-2 (Smithfield Dam in combination with Impendle Dam);
- To provide an estimate of the implementation date of Impendle Dam; and
- To quantify the available resources in the lower uMkhomazi River catchment, particularly the development of either the proposed Ngwadini Dam, or the Lower uMkhomazi Abstraction Weir (which will be operated with support from Smithfield Dam).

4.5.1 Proposed Smithfield and Impendle dams

The proposed Smithfield Dam site is located on the uMkhomazi River, about 34 km north west from the town Richmond and about 14 km south west of the little village of Boston in the KZN midlands.

The proposed Impendle Dam is located 1 km downstream of the confluence of the uMkhomazi and the Mkhomazane Rivers. The site of the Impendle Dam is located within the Impendle Local Municipality (ILM), which is part of the greater uMgungundlovu DM, and is approximately 15 km west of the town of Impendle.

Figure 4.8 shows (in **green**) the 1:100 year stochastic yield for a range of dam sizes at Smithfield. From the optimization studies of this feasibility study (uMWP) (AECOM, et al., 2015), a full supply level (FSL) of 930 masl was selected for the feasibility design of Smithfield Dam. This dam size corresponds to a live storage capacity of 226 million m³ (a 31% MAR dam) and provides a 1:100-year yield (i.e. at an annual assurance of supply of 99%) of 220 million m³/a, at the 2050-development level.

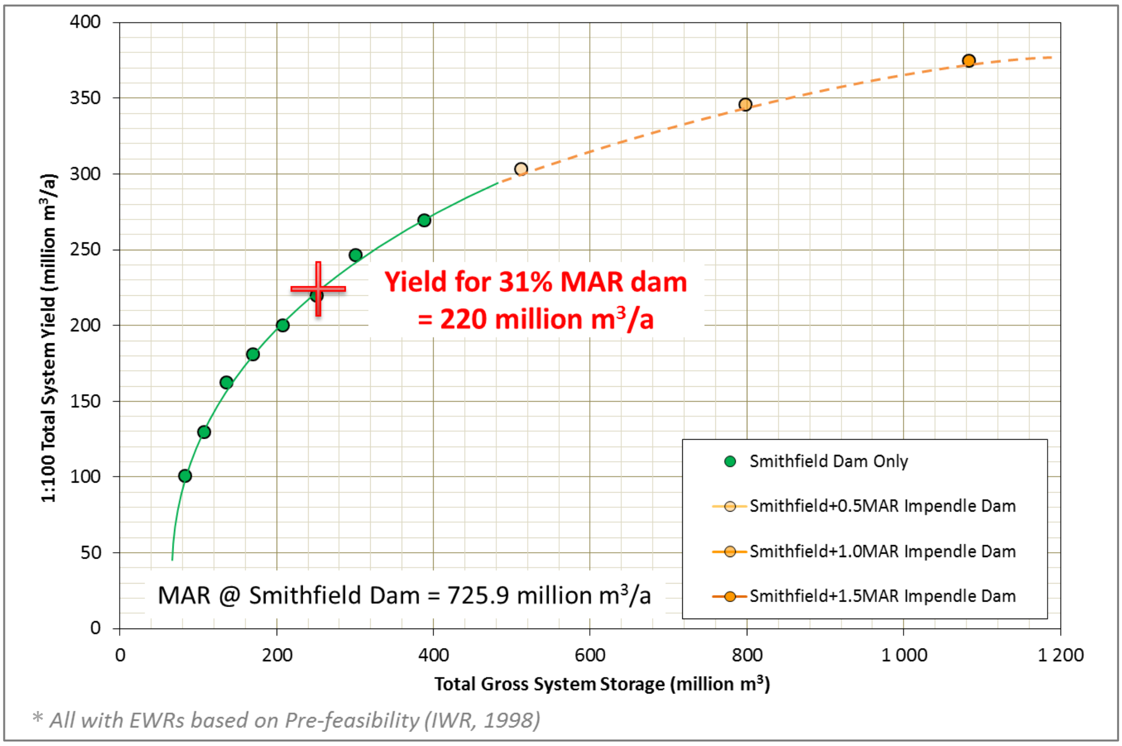


Figure 4.8: 1:100 year stochastic yield for Smithfield and Impendle Dams for the projected 2038 water use in the uMkhomazi River catchment

The yield for the uMWP was modelled for various catchment development levels, making releases for EWRs and the impact of sedimentation over time, as summarised in **Figure 4.9**.

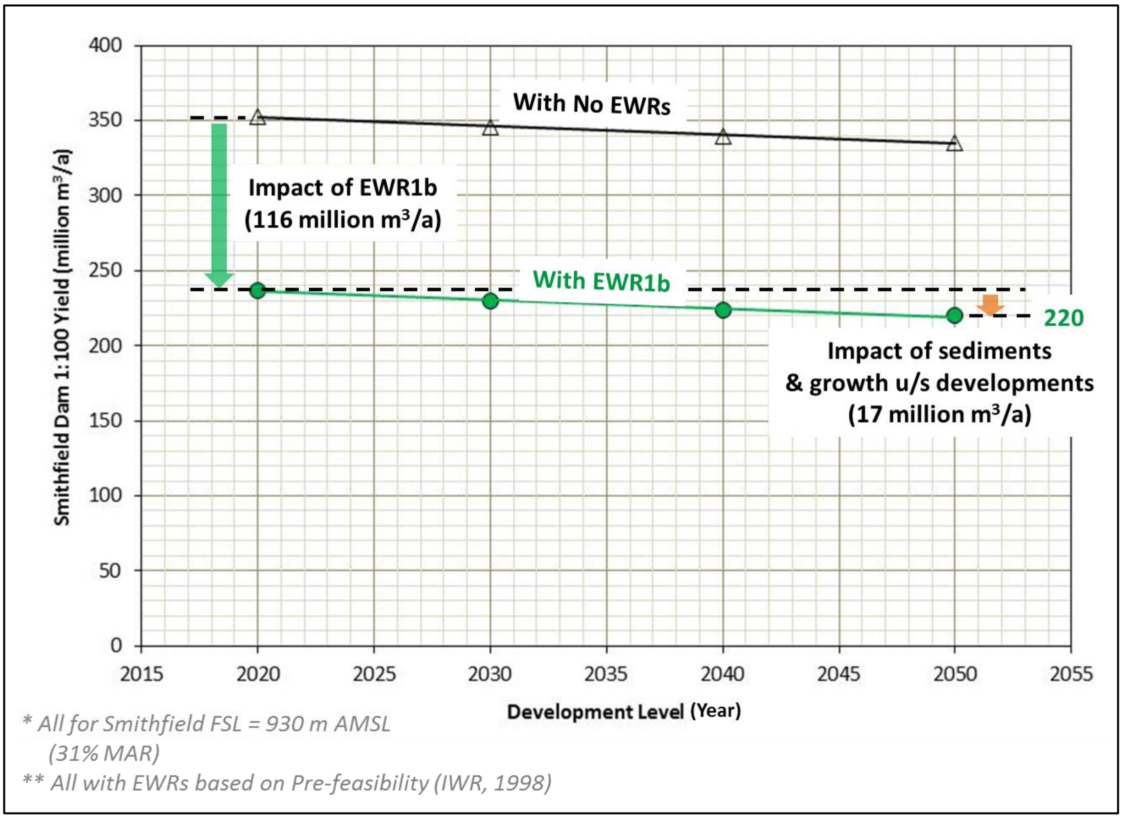


Figure 4.9: Yields for Smithfield Dam for various development levels

As shown the impact on the 1:100-year yield of Smithfield Dam of projected sediment deposition and growth in upstream catchment developments from 2020 to 2050 is 17 million m³/a, a decrease of 7%. Furthermore, support from the dam for EWR 1b results in a decrease in yield from 336 million m³/a to 220 million m³/a (a decrease of 34%).

It is important to note that, as discussed earlier in **Section 4.2** updated EWR results from the parallel *Classification Study* were not available in time to be used in the water resources analyses described above and were found to differ significantly from those adopted for this study. In order to assess the possible impact of these differences on the yield of Smithfield Dam a number of scenarios analyses were later undertaken. In summary the results show that if the *Classification Study* EWR2 is implemented instead of EWR1b the 1:100-year yield of the dam will decrease by approximately 5 million m³/a (a decrease of 2%).

An assessment of the total yield for both phases of the uMWP, including a future Impendle Dam of either 0.5, 1.0 or 1.5 times the MAR, is shown in **Figure 4.8**. The combined yield curve evens out with a larger storage at Impendle. This suggests that a combination of Smithfield Dam with a 1.0 MAR Impendle Dam will probably provide close to the optimum system size, and will increase the total yield of the scheme from 220 million m³/a to almost 350 million m³/a (an increase of almost 60%). However, the optimum size of the Impendle Dam needs to be confirmed in future studies.

Finally, based on the yield results shown above and updated water requirement projections for the proposed uMWP area of supply, a simple annual projected water balance was developed for the Mgeni WSS – resulting in a preliminary estimate for the implementation date of Impendle Dam (uMWP-2) of 2046. This result was confirmed with detailed planning analyses undertaken using an integrated WRPM configuration for the uMkhomazi, uMngeni and upper Mooi river catchments.

4.5.2 Lower uMkhomazi River (Ngwadini Dam and abstraction weir)

Assessments were also made of the available resources in the lower uMkhomazi River catchment for the proposed off-channel Ngwadini Dam. Although SAPPI-SAICCOR initially planned for this dam, UW is busy with the feasibility study for possible development of this dam to supply water to the South Coast, and occasionally to SAPPI-SAICCOR if needed and water is available.

Without the Smithfield Dam (at the 2012-development level), the 1:100-year yield available at Ngwadini Dam is 34 million m^3/a. With Smithfield Dam in the system, but with **no releases** being made in support of Ngwadini Dam, the yield of Ngwadini Dam decreases by 10 million m^3/a to only 24 million m^3/a (at the 2050-development level), resulting in a total system yield (i.e. from both Smithfield and Ngwadini Dams) of 244 million m^3/a.

If Smithfield Dam supports Ngwadini through releases, any of the selected target abstractions can be achieved at a recurrence interval of 1:100-years. However, while this results in a slight increase in the total yield of the system from 244 to 250 million m³/a (represented by the **solid blue line** in **Figure 4.10**), the remaining yield available from Smithfield Dam will decrease significantly to 195 million m³/a (represented by the **solid green line**) if a target abstraction of 150 Mℓ/d (55 million m^3/a) is selected for Ngwadini Dam.

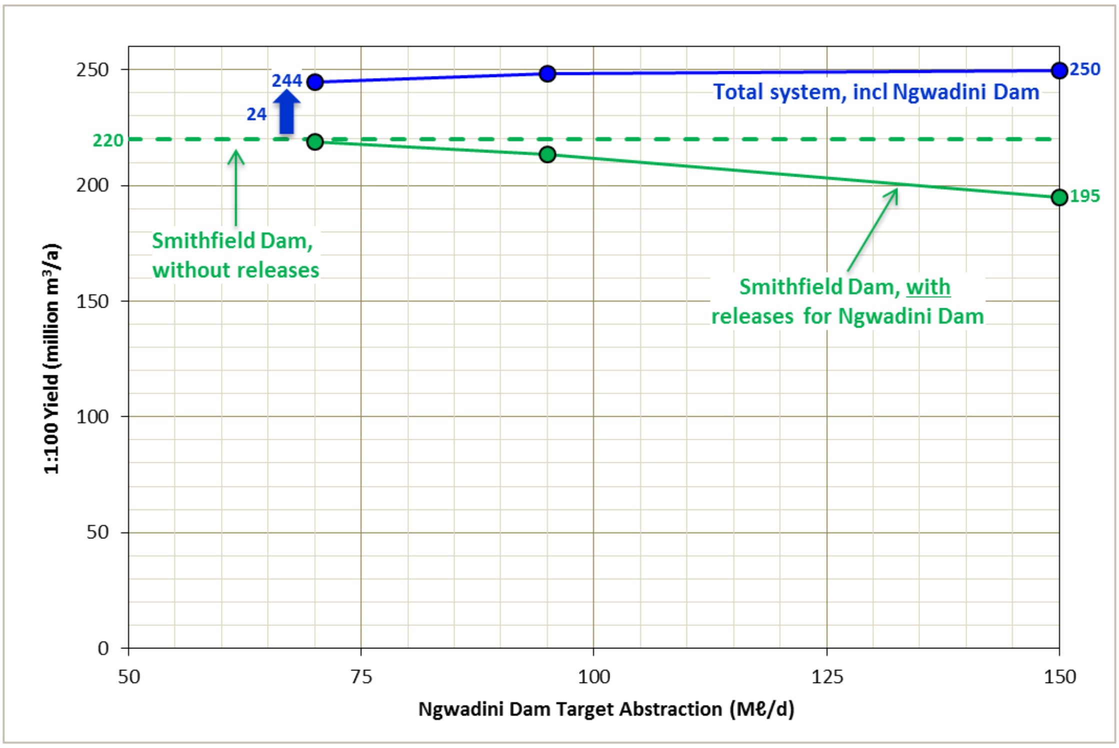


Figure 4.10: Comparison of uMkhomazi system yield including both the Lower uMkhomazi Abstraction Weir and Ngwadini Dam-options

It is stated in the *Reconciliation Strategy for the KwaZulu-Natal Coastal Metropolitan Areas* that Ngwadini Dam should be considered for further development of the lower uMkhomazi River resources to supply the South Coast, and since it does not require support from Smithfield Dam, it can be developed as soon as practically possible. It is **recommended** that the combined Ngwadini Dam and uMWP schemes' operation be optimised for the future water requirements with the development of the uMWP.

5 PROPOSED SMITHFIELD DAM

The proposed dam to be constructed on the uMkhomazi River at the farm Smithfield is situated about 35 km north-west of Richmond and about 6 km south-east of where the R617 Road crosses the uMkhomazi River. The dam layout is shown in **Figure 5.1**. The co-ordinates of the proposed dam are 29°46'30.31"S and 29°56'39.43"E. ***A name for the dam has not yet been decided upon, although it is referred to as Smithfield Dam***.

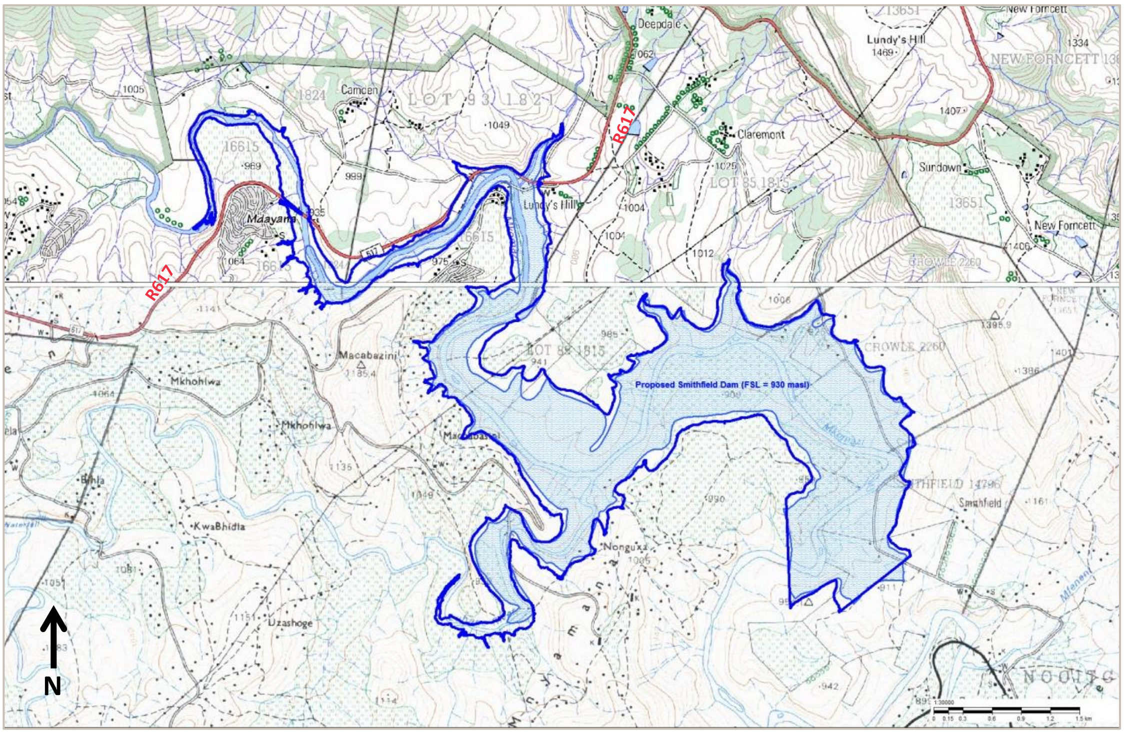


Figure 5.1: Location of Smithfield Dam

5.1 OPTIMISATION OF DAM SITE

In conjunction with the optimisation of the conveyance system, discussed in **Section 6.3**, various positions for the location of Smithfield Dam site were considered, as identified during the *Pre-feasibility Study* (Ninham Shand Consulting Engineers, May 1999a) and in this study. From the various dam types that were assessed for a dam at sites A, B and C, shown on **Figure 5.2**, it was concluded that the lowest cost option, Site B: Option 3 Dam, conforms to the requirement of the transfer of water through a pressure tunnel and pipeline. A summary of the optimisation process is described in **Appendix A**, **section A.1**.

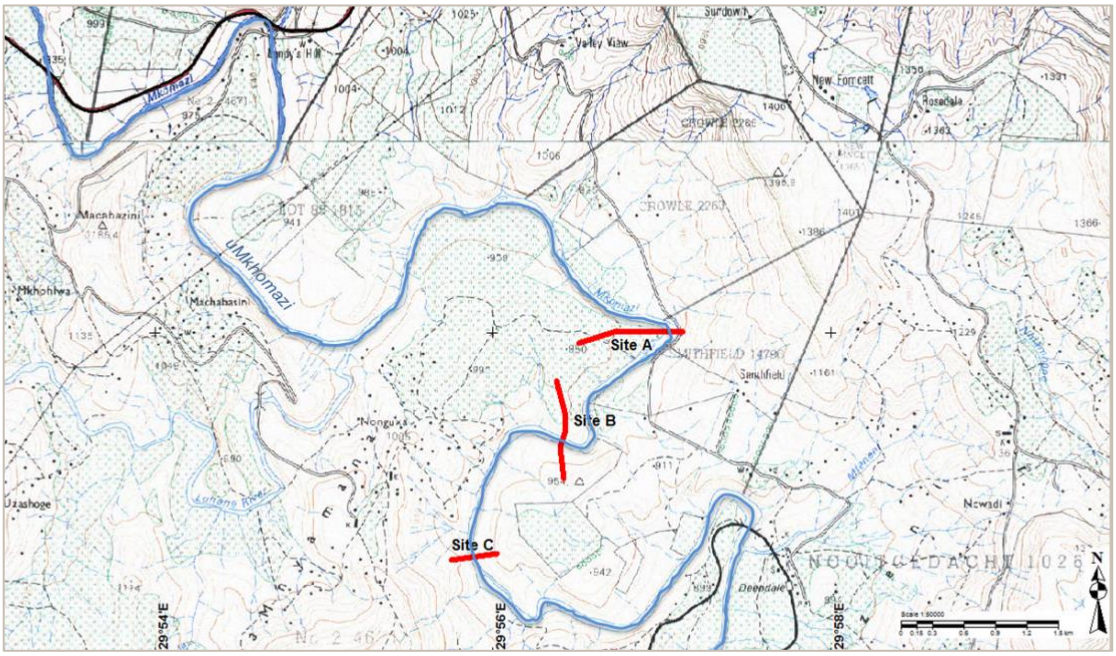


Figure 5.2: Smithfield Dam: Location of Site Alternatives

5.2 SIZING OF THE DAM

The optimum dam size of 31% MAR was selected by comparing the unit reference values (URVs) for both the capital and operational costs of various storage volumes, for the completed future scheme (including the conveyance system to Umlaas Road) for the given water requirements. Both development scenarios were considered, namely the uMWP-1 scheme only, and the complete uMWP (phase 1 and 2) scheme, as summarised in **Appendix A**, **section A.1.2**.

5.3 STORAGE VOLUME OF RESERVOIR

The stage-storage volume and surface area relationship determined from the available contour maps is shown in **Table 5.1** and **Figure 5.3**.

Table 5.1: Stage-storage volume and surface area for the proposed Smithfield Dam

Contour (masl)	Surface Area (km²)	Storage Volume (10^6 m³)
856	0.08	0.00
857	0.01	0.04
858	0.02	0.06
859	0.03	0.08
860	0.08	0.13
864	0.19	0.63
865	0.26	0.86
870	0.48	2.68
875	0.93	6.12
880	1.45	12.02
885	1.92	20.40
890	2.50	31.38
895	3.09	45.32
900	3.75	62.39
905	4.50	82.98
910	5.33	107.51
915	6.15	136.18
920	7.09	169.26
925	8.15	207.31
930	9.53	251.43
935	10.91	302.48
940	12.30	360.46

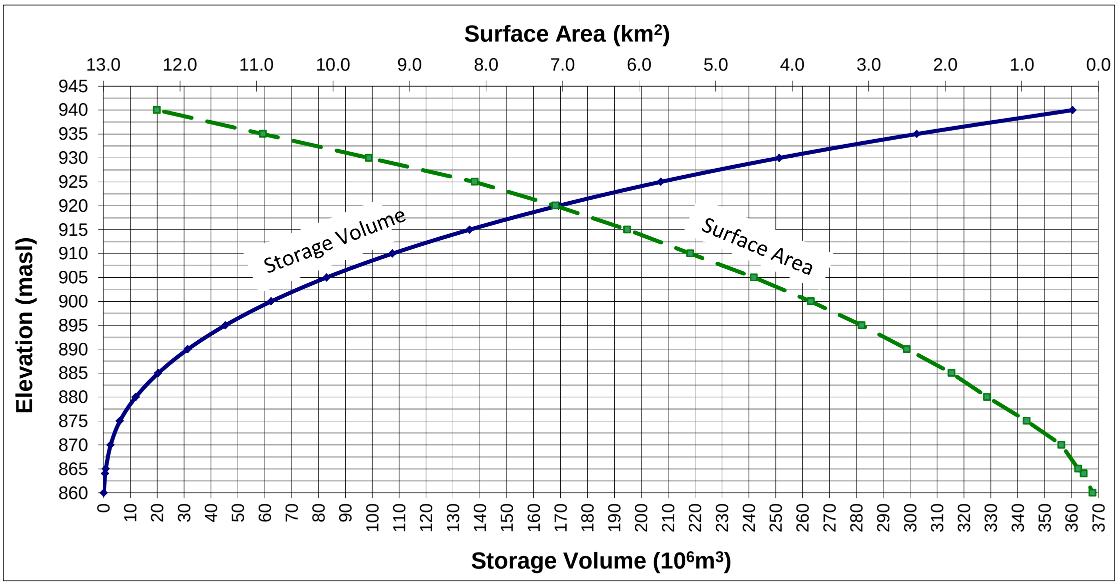


Figure 5.3: Stage-storage volume and surface area curves for the proposed Smithfield Dam

A sediment yield of 317 t/km²/a was estimated for the Smithfield Dam. The volume of sediment that will be accumulated in the dam basin after 50 years was estimated to be about 22.1 million m³. This volume of sediment is 16.2% of the dam's full supply capacity (FSC) of 137 million m³.

5.4 GEOTECHNICAL AND MATERIAL INVESTIGATION

5.4.1 Probabilistic seismic hazard analysis for Smithfield Dam

A Probabilistic Seismic Hazard Analysis (PSHA) has been performed for the Smithfield Dam Site. All earthquakes that occurred within a radius of 320 km from the dam site were used for the purposes of this assessment.

In accordance with the current seismic regulations provided in Bulletin #72 by the International Commission on Large Dams (ICOLD: Committee on Seismic Aspects of Dam Design, 2010), Eurocode 8 (2004) and ASCE (2005), the following three seismic designed levels were considered:

- Operating Basis Earthquake (OBE);
- Maximum Design Earthquake (MDE), and
- Maximum Credible Earthquake (MCE).

The results of the PSHA are given in terms of mean return periods and probabilities of being exceeded for the horizontal component of the peak ground acceleration (PGA). Based on the logic tree formalism, the expected values of horizontal component of OBE, MDE and MCE for the Smithfield Dam site are:

- OBE (Return Period 144 years) = 0.016 g
- MDE (Return Period 475 years) = 0.021 g
- MCE (Return Period 10 000 years) = 0.113 g

According to the applied guidelines, the site of the future dam is rated as low risk. The uniform acceleration response spectra (horizontal component) are also provided.

5.4.2 Seismic refraction investigation at the proposed uMWP-1

A Seismic Refraction Investigation was conducted as part of the geotechnical investigation for the uMWP-1.

The geology of the area is generally comprised of the Beaufort and Ecca groups typically consisting of shales, sandstones, mudstones, coal and dolerite intrusions in the form of dykes and/or sills.

A total linear distance of 7 025 metres was acquired using the Seismic Refraction technique at the Smithfield Dam, Transfer Tunnels and New Mbangweni Dam sites. The data quality is on average of a high quality and the seismic tomographical velocity models derived are considered accurate velocity models of the subsurface conditions.

5.4.3 Smithfield Dam: Geotechnical and materials investigation

In accordance with the detailed investigations carried out on site, the founding levels for the sites of the main rockfill embankment are summarised as follows:

- At the upper left and right flanks a 6 to 10 m layer of colluvium and residual soil/completely weathered shale has to be removed;
- In the central river section 1.5 to 5 m of residual soil/completely weathered shale/dolerite and medium dense river alluvium has to be removed; and
- A large part of the right flank has 11.2 to 14.4 m of transported sandy clay with boulders, which have to be removed.

The excavation for the founding level will yield a large volume of material, which might be suitable as impervious and semi-pervious earthfill for the saddle embankment. Laboratory testing of this material will have to be conducted to confirm the suitability.

The geotechnical investigation recommended that it would be necessary to make provision for a **grout curtain** to a depth of about 66% of the water head along the centre line. Although grout penetration might be small except in local zones, the drilling, water tests and grout records from a grouting operation are very important and can be considered the final stage of a geotechnical investigation when sub-surface information is obtained at close intervals below the footprint of the dam.

The **clay core** of an earthfill dam of this nature is normally founded on material that is either sufficiently impervious or can be rendered impervious by means of grouting. The clay core of the saddle dam can be founded on moderately weathered shale that occurs at depths of between 2 and 4 m. This excavation depth will also be adequate for the concrete structure of the fuse plug spillway.

If Quarry I is developed just upstream of the saddle embankment, the flow path underneath the embankment will be considerably shortened and it is recommended that provision be made for a grout curtain to a level at least 20 m below the quarry floor, at approximately 845 masl. Excavation depths at borehole positions were based on the results of the geotechnical investigation carried out along the saddle dam's centre line.

The position of the main spillway structure was not drilled for foundation levels and needs to be investigated during the tender and detail design stages.

The control structure for a side spillway on the upper left flank can be founded on slightly weathered shale at depths ranging between 15 and 20 m below ground surface and the concrete lined channel can be founded on moderately weathered shale at depths of between 10 and 12 m.

The geotechnical investigation for Smithfield Dam *(Supporting document 3: Smithfield Dam: Materials and geotechnical investigation)* (AECOM, et al., 2014) identified three borrow and four quarry areas. The type of materials, quality of the materials and their uses are described in **Table 5.2**.

Table 5.2: Type, quality and uses of soil and rock materials

Type of material / location	Quality	Use / application
Overburden	Soil mixed with topsoil	Rehabilitation of disturbed areas
Impervious earthfill material – in Borrow Areas A and B	Classify as CI and few CH in Casagrande Classification. Two samples have a plasticity index (PI) of 30 to 40 and a liquid limit (LL) of 60 to 70. These materials must be mixed with materials with lower values for quicker construction.	Core zones of Smithfield Main and Saddle Dam Embankments
Semi-pervious earthfill materials – all over the site except for Borrow Areas A and B	Classify as CL or CI in Casagrande Classification	To be used in zones of embankment
Soft shale rockfill	Moderately weathered shales	To be used in zones of embankment
Coarse shale rockfill (material below dolerites in Quarry I)	Good coarse rockfill	To be used in zones of embankment dam if dolerite quantity is not sufficient
Weathered dolerites	Soil to be used as earthfill	May be usable in outer zones of embankment dams
Rockfill, aggregates, filters, transition zones, rip-rap	Moderately weathered dolerite	Rockfill in main dam embankment. Rip-rap and transition zones in saddle dam embankment. Transition zones in main dam embankment.

The layout of Quarry I was based on a rockfill saddle dam with steeper slopes and hence its toe further away from the quarry. The *Dam Type Selection Report* (AECOM, et al., 2014) has shown that an earthfill saddle embankment dam is, however, the most economical dam type. The toe of an earthfill embankment dam is closer to the quarry. Furthermore, the good quality rockfill is confined by a fault/displacement on the western side of it. Further material allocation of Quarry I was executed by means of 3D modelling, and the available dolerite as well shale quantities were determined for the following two scenarios:

- The confined area investigated, with the unweathered dolerite between the saddle dam (but 40 m away) and the displaced area on the east.
- The full area investigated. Note: to the eastern side of the displaced area the dolerites are of varying quality and may not be unweathered (uncertain distribution of quality).

From a material balancing exercise, it was clear that sufficient materials are available for Smithfield Dam. If the dolerites are insufficient, the unweathered shale below the dolerites can be used in inner zones of the rockfill embankment, thereby saving on dolerite. Material to the eastern side of the displacement could be utilised if at all required.

From an available material perspective, it was therefore proposed that final design of the layout is based on the Earth Core Rockfill Dam (ECRD), with an ECRD or zoned embankment saddle dam, during the tender design phase, unless substantial information to contradict this is obtained. If necessary, further drilling investigations should also be done during this phase.

In terms of the saddle embankment, the shells of an earth embankment of this nature are typically founded on material with low organic content, low compressibility and with shear strength similar to the dam wall material. This means that a 0.1 m to 0.5 m thick layer of organic topsoil will have to be removed along the centre line of the saddle dam, and that founding will take place on highly weathered shale.

5.5 CLIMATOLOGY

As the uMWP-1 needs to be fast tracked, the climatology is vital to provide reasonable predictions of the expected climate at a specific site prior to construction, as inclement weather conditions might have a significant impact on the execution of work on site and need to be planned for by the contractor.

Daily and monthly rainfall data in the vicinity of the proposed construction sites were obtained from the selected rainfall station ***0238682A*** (Inglenook, Donny Brook). The climate station No. 02388066 at Emerald Dale (Lat. 29° 56' S; Long. 29° 57' E) was selected with data for a period of 1961 to 1990. At the Emerald Dale station the highest maximum temperature of 38.5°C was recorded during January 1974 and the lowest minimum of -5°C in July 1974. Furthermore, mild to warm temperatures are experienced during summer, while winters are characterised as being cold with frost occurring regularly. The proposed Smithfield Dam site can reasonably be summarised as shown in **Table 5.3**.

Table 5.3: Summary of climatology for the proposed Smithfield Dam site

MAP(1) (mm)	Number of days with rainfall > 10 mm	MAE(2) (mm)	Number of days with minimum air temp. less than 0°C(3)
809	28	1 300	12

(1) Annual adopted rainfall from station 0238682A (Inglenook, Donny Brook)

(2) Annual adopted evaporation for Smithfield Dam

(3) Climate statistics for stations No. 02388066 at Emerald Dale

5.6 DAM TYPE SELECTION

A detail dam type selection analysis, considering cost, spoil of construction materials, time to construct and other aspects, indicated that the preferred layout for Smithfield Dam is an 81 m high zoned ECRD, with a 26 m high earthfill embankment saddle dam.

Based on the available construction materials, the topography at the site and the specific foundation conditions, several possible dam type options were considered.

Although all possible dam type options were considered, six of the possible dam type options were eliminated from the start as they have traditionally proven to be extremely expensive and time-consuming or the topography at the chosen dam sites was not favourable for the specific option. Depending on the availability of materials on site, some of the dam type options had to be eliminated, or adjusted to include zones of alternative obtainable material. The details of this in-depth dam type selection are discussed in the *Dam Type Selection Report (P WMA 11/U10/00/3312/3/1/5)* (AECOM, et al., 2014).

The eight options defined below were compared in **Table 5.4**, indicating the order of preference:

- Option 1: Main dam - Roller compacted concrete (RCC) gravity; Saddle dam - Zoned earthfill embankment dam
- Option 2: Main dam - ECRD; Saddle dam - Zoned earthfill embankment dam
- Option 3: Main dam - Concrete faced rockfill dam (CFRD); Saddle dam - Zoned earthfill embankment dam
- Option 4: Main dam - Zoned ECRD; Saddle dam - Zoned earthfill embankment dam
- Option 5: Main dam - Zoned ECRD; Saddle dam – Zoned ECRD
- Option 6: Main dam - Composite dam (RCC and zoned ECRD); Saddle dam - Zoned earthfill embankment dam
- Option 7: Main dam - Zoned CFRD (option 1); Saddle dam - Zoned earthfill embankment dam
- Option 8: Main dam - Zoned CFRD (option 2); Saddle dam - Zoned earthfill embankment dam

Table 5.4: Comparative summary of the lowest cost dam type options for Smithfield Dam

Aspect	Order of option preference					
	1	2	3	4	5	6
Lowest construction cost (R Million excluding VAT)	**Option 4** (2.029)	**Option 5** (2.227)	**Option 7** (2.230)	**Option 2** (2.339)	**Option 8** (2.412)	**Option 3** (2.695)
Shortest construction period	All Options*					
Aggregates to be imported from Midmar & Pietermaritzburg (Less EMP & public roads related problems)	**Options 4 & 7** (0 m^3)	**Option 6** (20 000 m^3)	**Option 5** (444 000 m^3)	**Option 2** (470 000 m^3)	**Option 8** (550 439 m^3)	**Option 3** (584 180 m^3)
Sand to be imported from Umkomaas (Less EMP & public roads related problems)	**Options 3, 7 & 8** (87 000 m^3)	**Option 6** (137 000 m^3)	**Options 4 & 2** (180 000 m^3)	**Option 5** (200 000 m^3)	-	-
Less volume of material to be spoiled	**Option 6** (710 000 m^3)	**Option 4** (2.5 million m^3)	**Options 2 & 8** (3.06 million m^3)	**Option 5** (3.25 million m^3)	**Option 3** (3.5 million m^3)	-

Aspect	Order of option preference					
	1	2	3	4	5	6
Visual impact	All equal					
Delay/damages risk involved with river diversion	All equal					

** Option 1's construction period is longer than all those presented in this table*

From **Table 5.4** the following is clear:

- Option 1, the RCC gravity dam, is too expensive and was not included in the preference order of options;
- The composite RCC gravity/embankment dam (option 6) is R840 million more expensive than the lowest cost embankment type dam. This represents about 40% of the cost of the lowest cost embankment dam type;
- The embankment types of dams vary in cost within 13% from the lowest cost option. Any of these types can therefore be considered. However, option 4, 7 and 8 are within the same margin below 10%;
- Rockfill for embankment types can be constructed more quickly than the RCC gravity types. This may have an influence on the completion date. However, it is foreseen that the composite RCC gravity/ECRD type can be constructed in the same time as the embankment type dams; and
- Option 4, the lowest cost option, is the best option selected, although an amount of sand should be imported. There may be a socio-environmental impact for the import of materials from Umkomaas. In addition, more materials will be spoiled, but this can be a positive factor as these materials may be used for other purposes e.g. rehabilitation of borrow and camp areas, or for gravelling roads.

The best-recommended dam type that was considered for Smithfield Dam's feasibility design is ***Option 4***, which is:

- A zoned ECRD for the main dam, and
- A zoned earthfill embankment dam for the saddle dam.

5.7 WATER QUALITY AND LIMNOLOGICAL REVIEW

Good long-term data records indicated that water quality measured to date in the Smithfield Dam catchment is generally satisfactory, with the exception of elevated turbidity, total organic carbon and phosphorus concentrations recorded during high intensity rainfall events, particularly during the first flush of the summer rainfall period. Low conductivity results reflect that this water is likely to be aggressive and will require lime stabilization during treatment. There are no indications of elevated heavy metals such as copper, cobalt, lead or mercury and there are no known mining activities, except for sand and/or stone mining.

During impoundment, processes such as sedimentation of suspended material, biological processing of nutrients, predation and natural mortality of potential pathogens, and ultra-violet light disinfection are anticipated to improve surface water quality between the uMkhomazi Smithfield inflow and the proposed Smithfield Dam wall. Significant improvements will thus occur in recorded concentrations of suspended materials and the bacteriological quality of the river water, despite relatively short impoundment residence times.

The anticipated trophic status of the proposed Smithfield Dam is mesotrophic – moderately enriched with nutrients, with occasional blooms of nuisance algal species. Smithfield Dam is likely to stratify thermally during summer from October, with dam turnover (de-stratification) occurring around April, dependent on air temperatures and impoundment drawdown. Water abstracted from below the oxycline is likely to cause treatment problems. At the onset of the annual impoundment turnover, anoxic water will be mixed into the water column, reducing dissolved oxygen concentrations throughout the water column. Elevated concentrations of metals which will be liberated from the sediments under anoxic conditions will thus be mixed through the water column at turnover. These metals may require additional treatment for removal, and to avoid post-precipitation in final drinking waters. From information at impoundments in adjacent or nearby catchments, elevated concentrations of both iron and manganese may present a risk at these times.

Smithfield Dam's impoundment volume is relatively small compared to the MAR, and significant rain events are likely in the catchment at times. Under very severe storm conditions, inflows of highly turbid water may be sufficient to reach the abstraction zone or temporarily mix the dam (particularly if the impoundment is drawn-down). Under these conditions, significantly elevated turbidity is possible in the raw water abstracted from the impoundment.

In order to allow abstraction from the aerobic zone, as well as abstraction when the proposed Smithfield Dam's impoundment is significantly drawn-down, it was recommended that a number of abstraction levels be constructed at 6 to 8 m intervals from FSL. Selection of the most favourable abstraction level will optimise raw water quality at the water works, reduce water treatment costs and facilitate compliance with potable water quality standards.

A dam scour/river release should be constructed to be able to release dam bottom water during high summer inflows. Sleeve valves with dispersers should be used to oxygenate the water used for environmental releases. Spilling is the recommended release mechanism when algal numbers are high and when water levels permit. As far as possible, water for environmental flows should be distributed according to the natural flow patterns. The bottom scour/river release valves should be large enough to emulate natural flood events downstream.

Water quality and biological monitoring, using the South African Scoring System (SASS), was recommended during the pre-construction, construction and operational phase of the proposed Smithfield Dam in order to assess impacts on the environment, and to optimise dam management. For more detail, refer to the *Water Quality and Limnological Review (P WMA 11/U10/00/3312/3/1)* (Umgeni Water, 2014).

5.8 FLOOD HYDROLOGY

The main purpose of a hydrological and associated flood peak analysis is to determine a representative flood for various return periods. The historical record of flow gauging weir U1H005, located approximately 11.4 km upstream of the proposed Smithfield Dam site, was used in conjunction with other approaches, such as the TR137 (Kovacs, 1988) and the HRU (Midgley, 1972) methods.

a) Spillway design floods

The Smithfield Dam will be a large dam (>30 m high) with a high hazard potential (due to extensive downstream developments), and will be classified as a **Category III** dam in terms of the standing Dam Safety Regulations.

Flood hydrographs with the following flood peaks were selected to size the spillway in terms of the Recommended Design Flood (RDF), Safety Evaluation Flood (SEF), Regional Maximum Flood (RMF) and Probable Maximum Flood (PMF):

- RDF - 1:200 year recurrence interval 2 620 m^3/s
- SEF - RMF+Δ 5 650 m^3/s
- PMF 6 185 m^3/s

b) River diversion design floods

The following design flood peaks were used for the design of river diversion arrangements at Smithfield Dam:

- 1:10 year for earthfil cofferdams 1 and 2: 937 m³/s
- 1:10 year winter flood event for earthfill cofferdam 3: 74.5 m^3/s
- 1:20 year winter flood event for concrete gravity cofferdam 5: 145.1 m³/s
- 1:50 year for cofferdam 4 and rockfill cofferdam 6: 1 708 m³/s

5.9 FEASIBILITY DESIGN OF SMITHFIELD DAM

The following major components of the proposed Smithfield Dam, as shown in **Figure 5.4**, were considered:

- An 81 m high ECRD (Main Dam), constructed with a residual dolerite earthfill core and dolerite rockfill on the outer zones with a small inner shale rockfill zone;
- A primary side channel spillway with a gravity weir structure, chute and ski jump structure;
- A permanent double pipe system bottom outlet laid out from an intake structure to one of the two 8 m diameter tunnels (used initially for river diversion) with an access bridge from the Main Dam crest;
- A zoned earthfill embankment saddle wall of 26 m high;
- A secondary fuse plug spillway;
- Material to be obtained from the excavations, as well as specific quarries;
- Access roads for construction and operations;
- The flooding of the dam basin required the deviation of the R617, and new access roads to communities that will be cut off by the reservoir;
- Making provision to support the Eskom high voltage power line across the new reservoir; and
- An Intake Tower (designed for both uMWP phases) and access bridge in the Smithfield Dam Reservoir to the Transfer Tunnel.

River diversion was designed using two 8 m diameter tunnels and an array of six cofferdams to accommodate construction during varying flooding conditions of the mighty uMkhomazi River. This river diversion arrangement is explained in the Engineering Feasibility Design Report (*P WMA 11/U10/00/3312/3/1 – Engineering Feasibility Design Report)*.

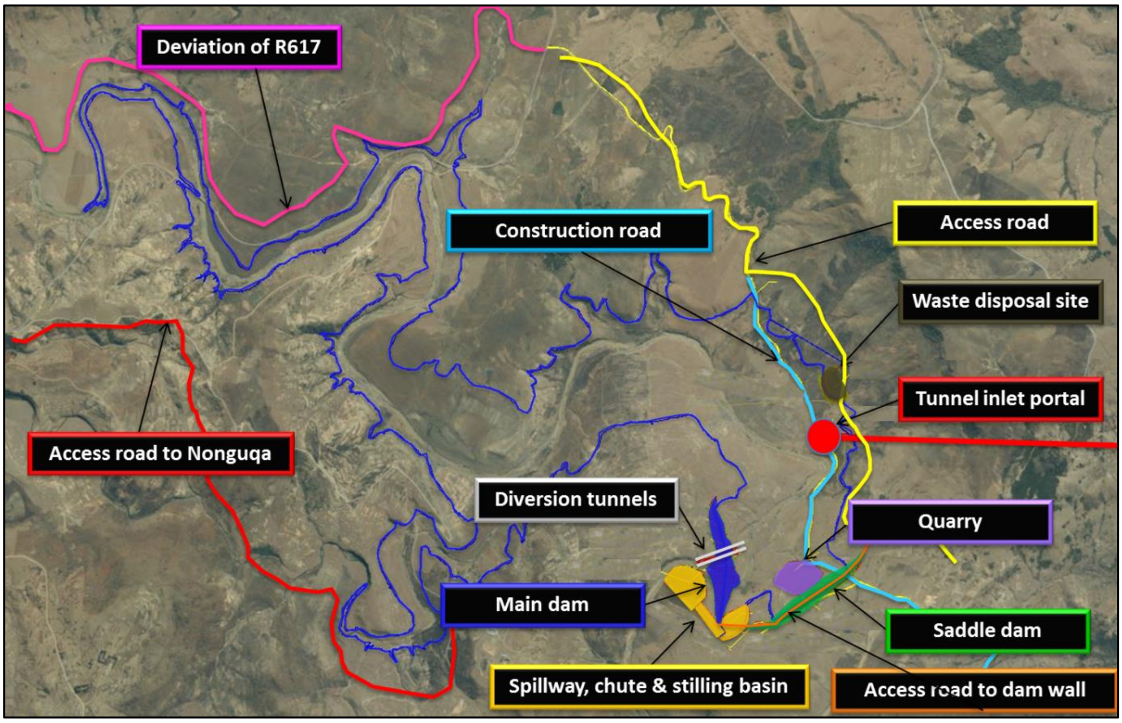


Figure 5.4: Proposed Smithfield Dam and Appurtenant Structures

The principal data for Smithfield Dam is summarised in **Table 5.5**. The area/storage volume characteristics for the dam are discussed in **Section 5.3** of this Main Report.

Table 5.5: Smithfield Dam Principal Data

Parameter	Description	
General		
Name	Smithfield Dam	
Purpose	Bulk water supply for domestic and industrial use	
Estimated date of completion	2023	
River	uMkhomazi River	
Nearest town	Richmond	
District	KwaZulu-Natal	
Location	29°46'33.36" S; 29°56'26.62" E	
Classification: Category	III	
Hazard potential	High	
Non-overspill crest level	RL 936 masl	
Full supply level (FSL)	RL 930 m	
Gross storage capacity at FSL	251 million m^3	
Water surface area at FSL	9.53 km^2	
	Main wall	**Saddle wall**
Wall height above river level (Maximum height)	81 m (855 masl to 936 masl)	26 m (910 masl to 936 masl)
Type of dam wall	Earth core rockfill	Zoned earth fill
Crest length	1 200 m	1 090 m

Parameter	Description	
General		
Spillway type	Side channel with ogee weir, chute and ski jump	Fuse plug with gravel and sand, controlled by a concrete sill which acts as a broad crested weir when breached
Spillway length	150 m	100 m
Freeboard	6 m	2 m
Hydrology and floods		
Catchment area	2 058 km²	
Safety evaluation flood (RMF+Δ)	5 650 m³/s	
Regional maximum flood	4 540 m³/s	
$Q_{1:100}$	2 389 m³/s	
$Q_{1:200}$	2 620 m³/s	
Outlet works		
Dam Outlet	Dual pipe system of ND 1.8 m, six intakes, Butterfly and gate valves	
Tunnel Inlet	Tri pipe system of ND 2 m, six intakes, Butterfly and gate valves	
Foundations		
Description of dam wall foundations	The site comprises shales with sub-ordinate sandstones and intrusions of dolerite. Three near-horizontal dolerite sills have intruded mainly concordantly into the sedimentary strata and are responsible for the narrow river valley at the dam site and the presence of good quality dolerite rock for concrete aggregate and rockfill at depth.	

Figures 5.5 to 5.7 below show an artist's impression of the proposed Smithfield Dam.

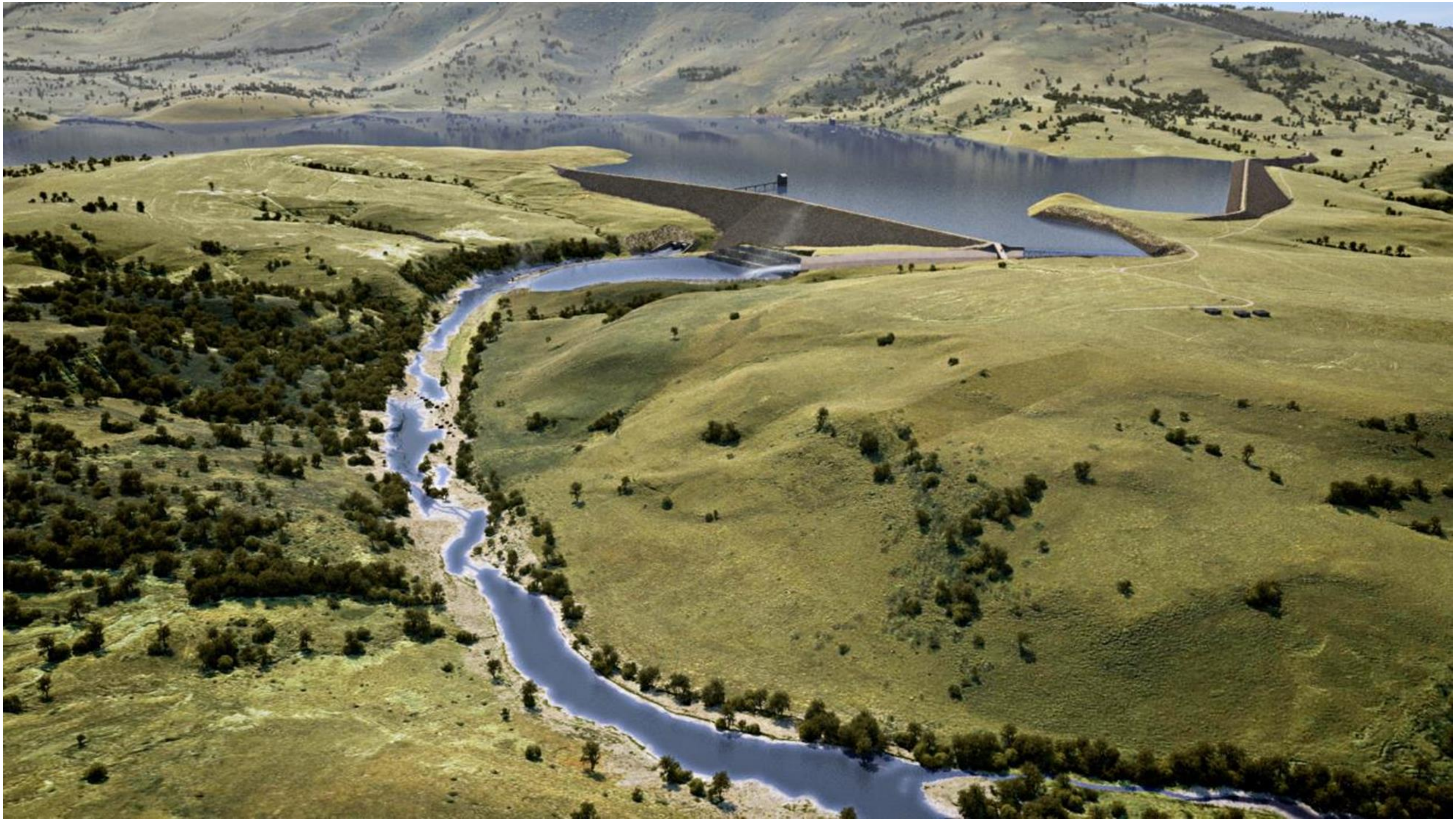


Figure 5.5: Artist's impression of the completed Smithfield Dam (1)

Figure 5.6: Artist's impression of the completed Smithfield Dam (2)

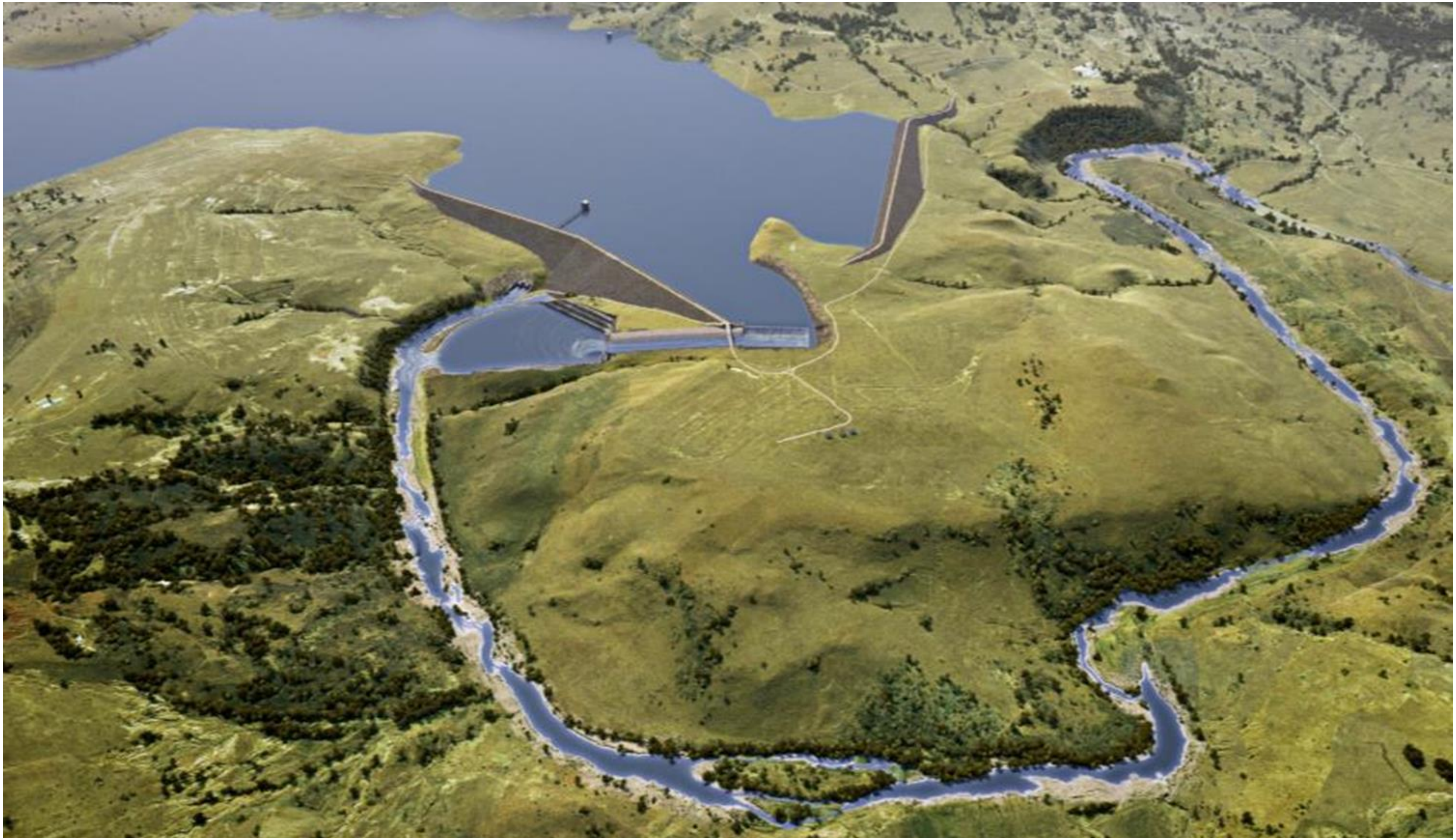


Figure 5.7: Artist's impression of the completed Smithfield Dam (3)

5.10 Possible water supply from Smithfield Dam to surrounding communities

The Smithfield Dam site is located within the Ingwe Local Municipality, which is within the Water Services Authority (WSA) Harry Gwala District Municipality's (DM) area of jurisdiction. This area is supplied by the Bulwer Donnybrook Water Supply Scheme (WSS), including the towns of Bulwer, Donnybrook, Creighton and Ixopo and surrounding communities. Currently there are no communities that will be inundated by the proposed dam, only a few scattered households. However, several communities shown in **Figure 5.8**, many of which are located on top of hills, surround the Smithfield Dam. As part of this study, a pre-feasibility-level study was carried out to ascertain the following:

- the current water sources being used by the communities surrounding the dam,
- the possibility of feasibly supplying these communities with water, either from existing Harry Gwala DMs resources or from Smithfield Dam in the future.

The current (2015) estimated combined water requirement of communities within the Bulwer Donnybrook WSS was in the order of **3.45 million m^3/a,** which will grow to an ultimate future water requirement of **4.13 million m^3/a** in 2045.

The current and planned resources (including the proposed Bulwer Dam) of the Bulwer Donnybrook WSS will not be able to supply the water requirements in the long-term, and Smithfield Dam was recognised as a future intervention. Also, the Harry Gwala DM has an agreement in place with Sappi-Saicor to use water for a period of 10 year from the Comrie Dam. It was assumed that the bulk Bulwer Donnybrook WSS, as currently planned and constructed by Harry Gwala DM, will be fully implemented, including the Bulwer Dam (also known as the Steven Dlamini Dam), and all future augmentation from the either the Smithfield and/or Comrie dams will supply into the Bulwer-Donnybrook WSS.

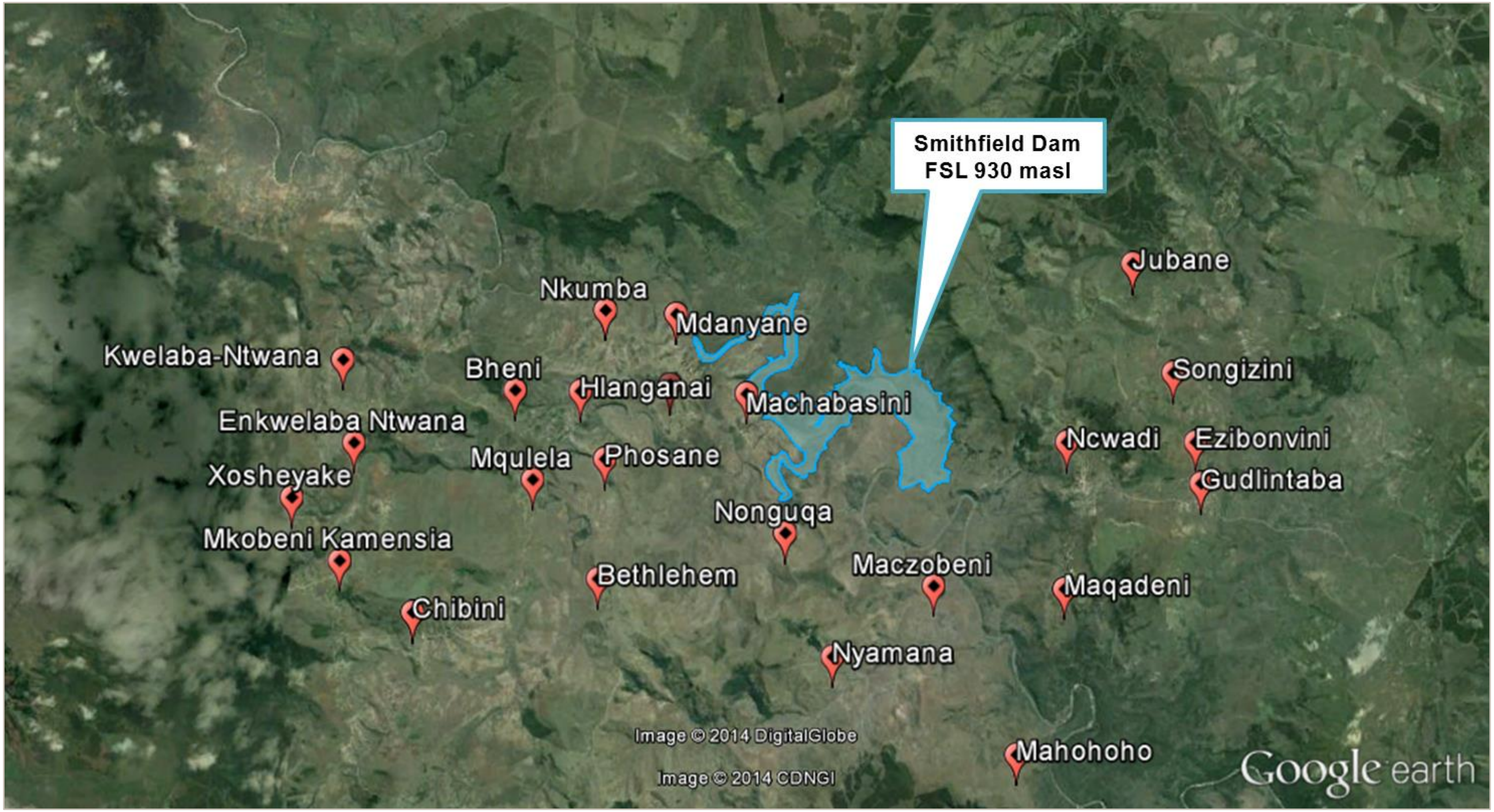


Figure 5.8: Google image of the communities surrounding Smithfield Dam Site

Several options were investigated to supply water to the Bulwer Donnybrook WSS from either/or Smithfield and Comrie dams, as listed below and shown in **Figure 5.9**:

- Option 1: Smithfield Dam via Comrie Dam;
- Option 2: Smithfield Dam to the villages Sizanenjane and Kwalaba-Ntwana;
- Option 3: Smithfield Dam to the villages Bethlehem and Ncwadi;
- Option 4: Smithfield Dam enhancing (supplementing) Comrie Dam; and
- Option 5: Rising of Comrie Dam.

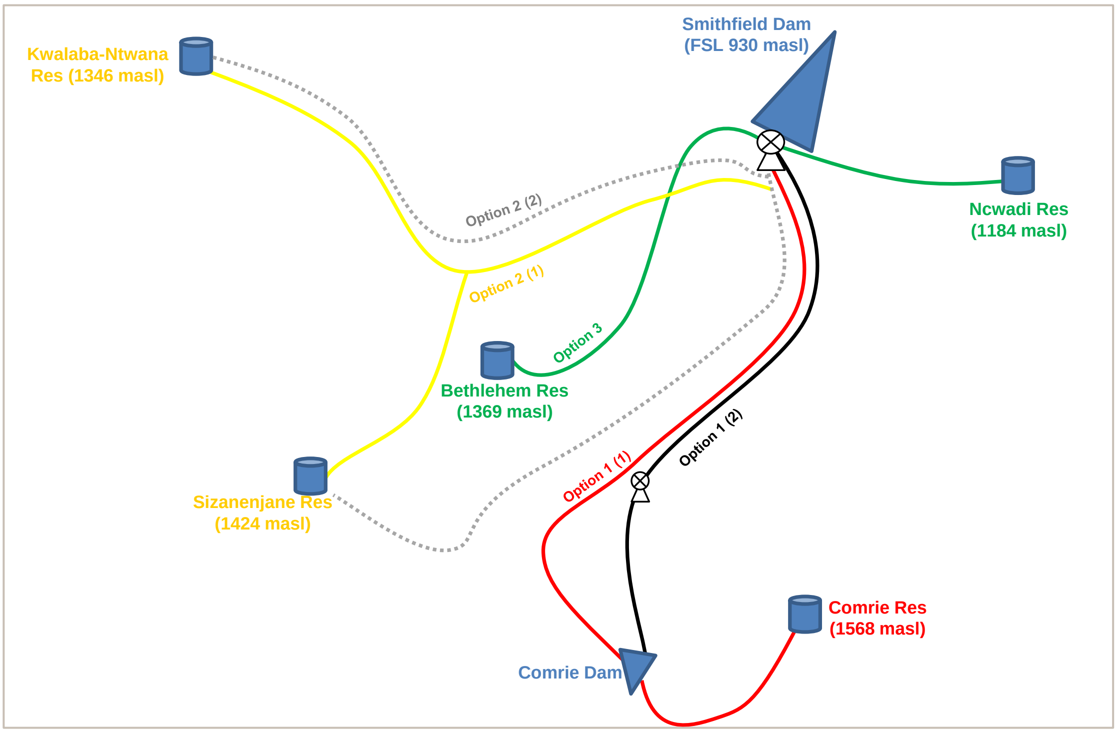


Figure 5.9: Schematic image of possible supply options to communities

The capital, operation and maintenance cost were considered for all options in URV calculations, as shown in **Table 5.6**.

Table 5.6: URV values obtained for the various options

Description	URV (R/m³) Alternative 1	URV (R/m³) Alternative 2
Option 1. Smithfield Dam via Comrie Dam	**18.80**	**18.04**
Option 2. Smithfield Dam to the villages Sizanenjane and Kwelaba-Ntwana	22.50	23.78
Option 3. Smithfield Dam to the villages Bethlehem and Ncwadi	67.88	-
Option 4. Smithfield Dam enhancing (supplementing) Comrie Dam	57.29	53.71
Option 5. Raising of Comrie Dam	**17.76**	-

Raising Comrie Dam and augmenting the Bulwer Donnybrook WSS seems to be the most feasible options, with the provider that Harry Gwala DM need to secure the water from Comrie Dam for the long-term and raise the dam. It is recommended that this option is pursued.

However, if the Harry Gwala DM does not get permanent access to the water of Comrie Dam, Option 1, pumping water from Smithfield Dam to the Bulwer Donnybrook WSS via Comrie Dam is the most feasible alternative. It is recommended that an estimated water requirement of approximately **1 million m³/a** is provided from Smithfield Dam to supply Bulwer Donnybrook WSS. This supply from Smithfield Dam will not have any significant impact on the yield of Smithfield Dam as it is relatively small when compared to the transfer of water to the integrated Mgeni WSS.

The total estimated capital cost of the bulk infrastructure necessary to supply the Bulwer Donnybrook WSS from Smithfield Dam for option 1 was estimated at about **R155.5 million,** including engineering fees as well as environmental and social costs. In addition the operational and maintenance costs, including water treatment and pumping cost of **R 3.8 million/annum**. This large elevation difference (about 638 m) between the Smithfield Dam, FSL of 930 masl, and Comrie Dam's end reservoir results in high operation costs in terms of pumping.

Before large capital schemes are considered, local resources (i.e. springs, groundwater and surface water supplies from a weir on the Luhane River) should be considered to supply communities in the Bulwer Donnybrook WSS' area. Further, 2023 is the milestone for first delivery of water from the proposed Smithfield Dam, thus management interventions such as Water Conservation/Water Demand Management (WC/WDM) should be implemented.

5.11 COST ESTIMATE FOR SMITHFIELD DAM

Table 5.7 provides a summary of the cost estimates for Smithfield Dam, with a base date of March 2014, excluding VAT.

Table 5.7: Summary of cost estimate for Smithfield Dam (2014 Rands)*

Description	Cost (R million, excluding VAT)
River diversion works	178.5
Development of quarries and borrow areas	9.9
Smithfield Dam main embankment (zoned ECRD)	813.5
Smithfield Dam saddle embankment (zoned earthfill dam)	252.1
Main embankment side channel spillway	189.7
Saddle embankment fuse plug spillway	66.0
Outlet works, intake structure	146.4
Tunnel intake structure	288.4
Transmission lines	5
Miscellaneous	68.5
TOTAL	**2 018**

* *The cost for the Smithfield Dam Local WSS is not included.*

6 PROPOSED CONVEYANCE INFRASTRUCTURE

In transferring water from the proposed Smithfield Dam to the uMngeni River catchment, the scheme crosses the uMlaza River valley. The conveyance infrastructure was laid out on the shortest possible straight route based on a comparative analysis between pumping schemes and the selected gravity conveyance system.

6.1 OPTIMISATION OF CONVEYANCE SYSTEM

Several conveyance options were investigated with the aim to minimise life cycle and energy cost as summarised in **Appendix A**, **Section A.2**. Option 2B (i.e. twin 3.5 m diameter pressure tunnels) was determined to be the preferred option as it had the lowest NPVs, and will provide the following benefits:

- Minimal O&M requirements with no pumping requirements;
- Potential for generation of hydropower at the tunnel outlet; and
- Residual head advantages for gravity supply pipelines to Umlaas Road.

The gravity scheme was accepted by both the DWA and UW.

6.2 OPTIMISATION OF TUNNEL ALIGNMENT TO BAYNESFIELD ESTATE

Several ***horizontal alignment*** options were identified for comparative purposes as described in **Appendix A**, section **A.3.1** and shown in **Figure 6.1**.

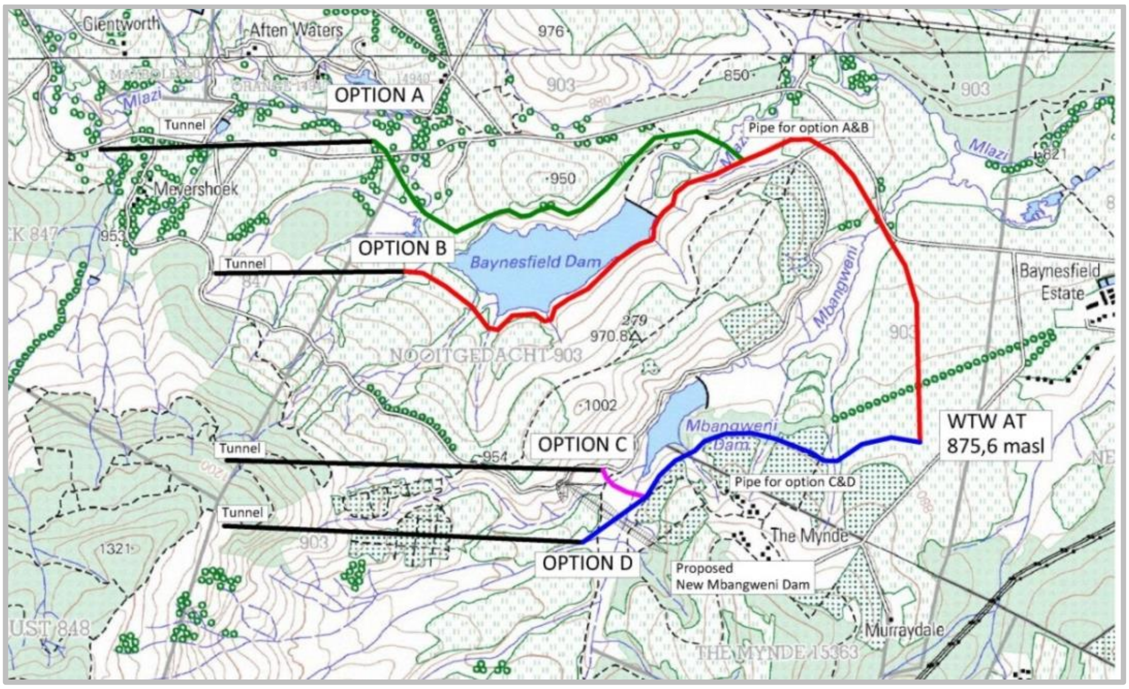


Figure 6.1: Plan layout of options

The slightly cheaper Option C was selected for the feasibility design, where the areas for the inlet and the outlet portals were selected on flatter mountain slopes, having easier access and areas for assembling the tunnel bore machine (TBM) available. The pipeline lengths are also shorter than for the initial Baynesfield route.

In the optimisation of the ***vertical alignment***, parameters such as geological conditions, potential high groundwater inflow conditions, construction methods, practical conditions and drainage aspects were considered, as described in **Appendix A**, **Section A.3.2**. Research indicated that 15 km is the maximum economical length of drive achievable by a TBM.

Based on the lower cost of Option 2 and limitations of the critical construction path of the project, the tunnel has been designed for two TBMs as shown in **Figure 6.2**. The tunnel was laid out with a downward slope towards the east, meaning the TBMs have to bore in the upstream direction (west) accommodating encountered ground water in gravity flow requirements. The tunnel is designed for drainage during construction as seepage from groundwater inflow is expected. Some parts of the tunnel, e.g. a central access adit with a 5 m diameter, are to be excavated using drill and blast techniques (DBT).

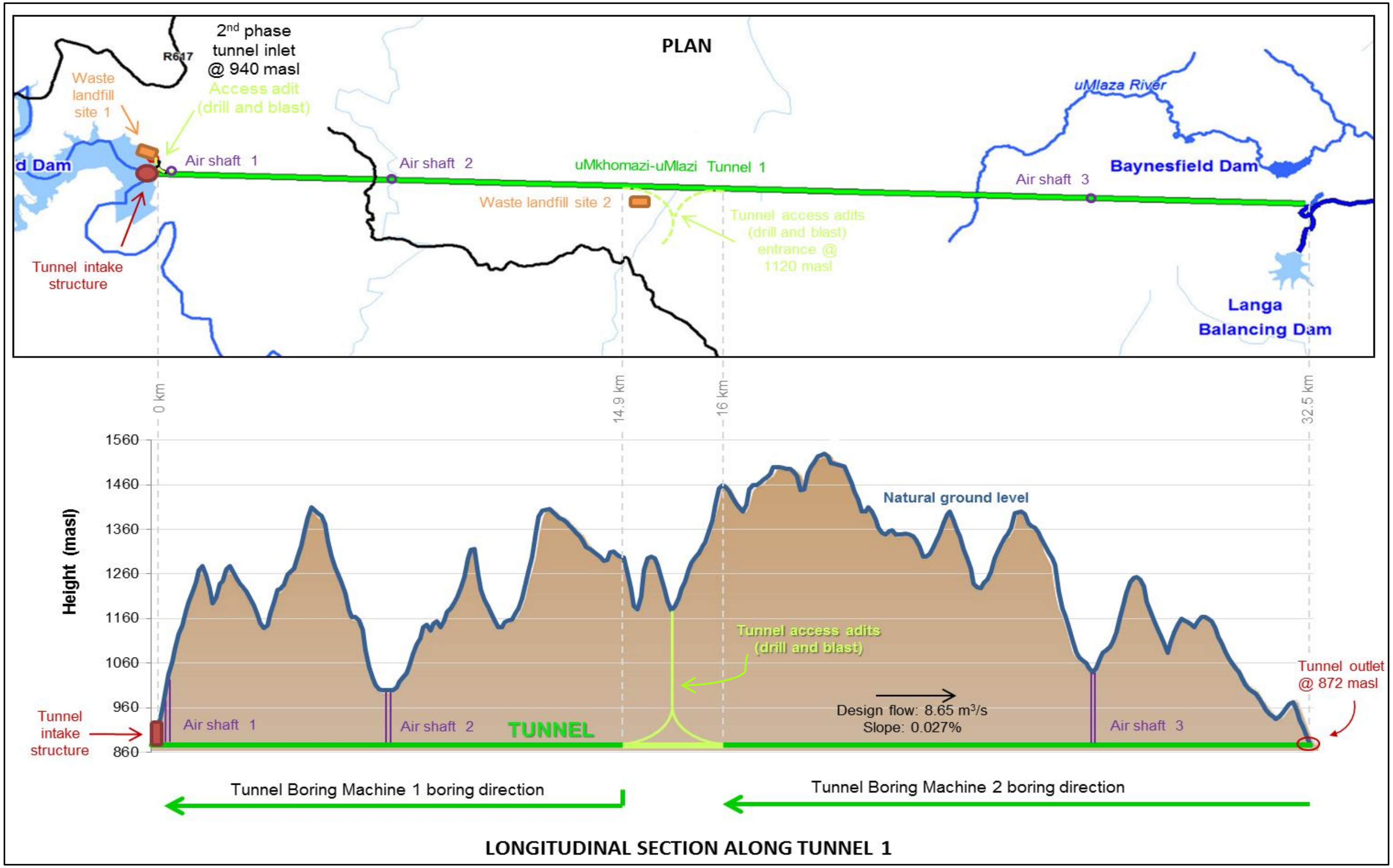


Figure 6.2: uMkhomazi-uMlaza tunnel plan and longitudinal alignment

6.3 UMKHOMAZI-UMLAZA TUNNEL

The tunnel is 32.5 km long and the selected optimum inside diameter for a discharge at peak demand of 8.65 m^3/s is 3.5 m diameter. This pressure tunnel has to be driven through hard quality shales and dolerites and is connected with a pressure pipeline from the tunnel end to the site of the Baynesfield WTW. This system is sized to accommodate design flows with Smithfield Dam at the minimum operating level. The aligned and longitudinal section is shown in **Figure 6.2**.

6.3.1 Hydraulic design

The hydraulic design of the water conveyance tunnel and pipeline is based on the available pressure head from Smithfield Dam, as well as the maximum design flow requirement of 8.65 m^3/s.

A longitudinal layout of the structures with the associated energy line is shown in **Figure 6.3**.

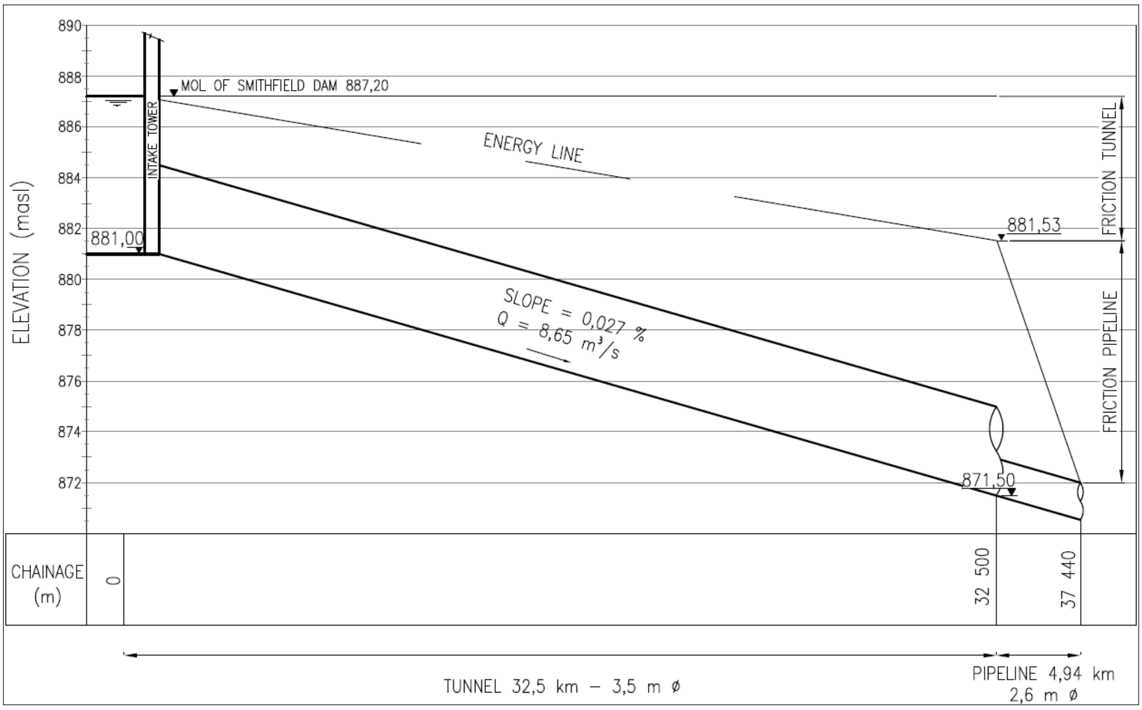


Figure 6.3: Schematic layout of conveyance system showing the energy line

The selected horizontal and vertical layout of the tunnel is shown in **Figure 6.2** and is based on the following:

- The minimum operating level (MOL) of Smithfield Dam (887.2 masl) is the minimum water level at the upstream side of the intake tower to the tunnel.

- The intake centre level of the lowest pipe in the tunnel intake structure is at 881.5 masl.
- Excavations at both portals of the tunnel.
- A constant slope of 0.027% for the vertical alignment of the tunnel.
- A lined tunnel with an inside diameter of 3.5 m, cross sectional area of 9.616 m^2 and length of 32.5 km as indicated in **Figure 6.3** and **Figure 6.4**.
- Ventilation shafts have been provided for in the design to accommodate air flow in the tunnel. One 5 m diameter ventilation shaft with concrete lining is provided at the entrance of the tunnel for phase 1 (tunnel 1), and two other 5 m diameter shafts with shotcrete lining have been included on either side of the central access adits (which are approximately in the middle of the tunnel).
- Two 5 m diameter DBT access adits in the central part of the tunnel. The portion of tunnel between the two entrances of the access adit to the tunnel will also be excavated using DBT, from chainage 14 750 m to 16 250 m.
- Two TBM drives, both up-slope in a westerly direction.

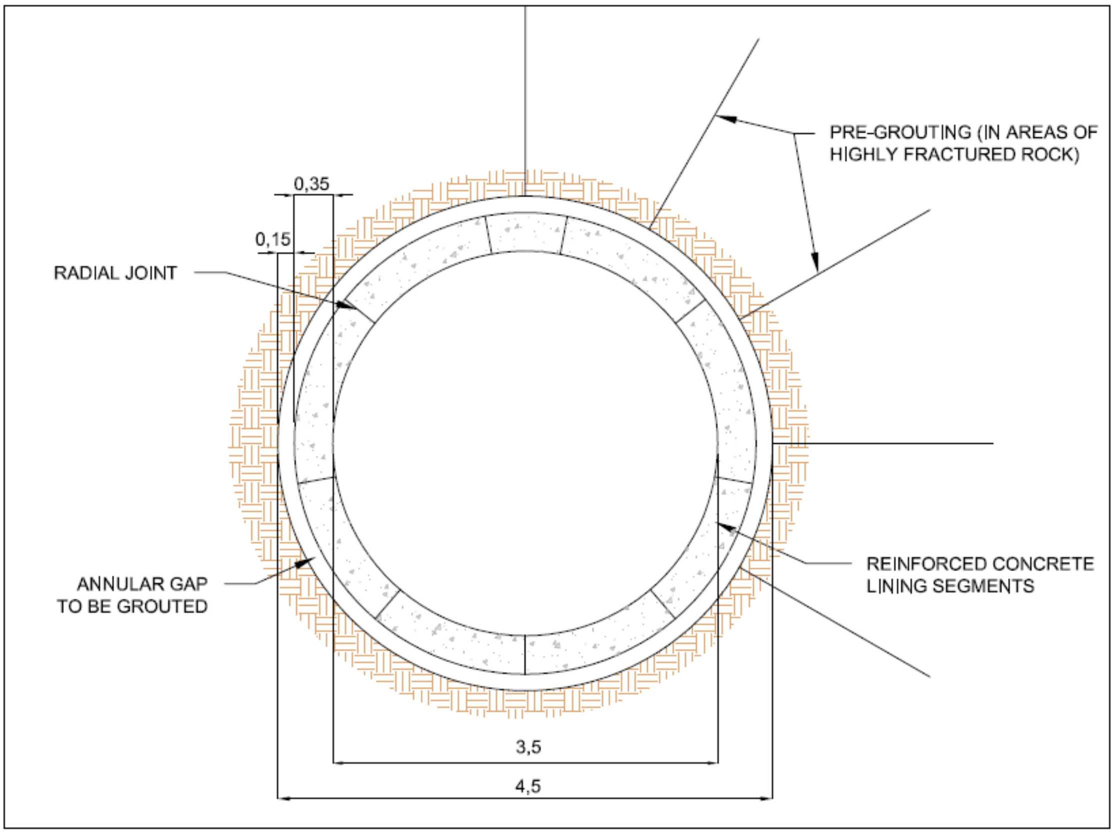


Figure 6.4: Cross section of tunnel

- The Raw Water Pipeline (Tunnel to Langa Dam to Baynesfield WTW) is a 2.6 m inside diameter pipe from the tunnel end to Baynesfield WTW and has a length of 5.2 km.

- A stilling basin at the end of the pipeline at the Baynesfield WTW with a tailrace water level of 872 masl. This is required to provide water under gravitation to the Umlaas Road Pipeline.
- Three tunnel waste disposal landfill sites (including one at Langa Dam) – the waste disposal landfill sites are discussed in **Section 8.3**.

The second phase of the project, to be implemented at a later date, involves the construction of a similar tunnel which is to be built alongside the tunnel discussed above. The first 100 m of the second tunnel will be excavated during the construction of the first tunnel. Thus, an additional excavation will take place at the inlet and this excavation will be done using DBT. The inlet of the second tunnel will be at an elevation of 940 masl.

A hydraulic model study is recommended for the tunnel intake arrangement.

6.3.2 Geological conditions for the tunnel

Limited boreholes were drilled at proposed ventilation shaft positions, to determine the depth to bedrock, the rock mass quality and stratigraphy. All boreholes indicated the presence of hard to extremely hard rock shale and very hard to extremely hard rock dolerite at tunnel level. Hard bedrock was generally encountered at depths between 10 and 20 m below ground surface (*P WMA 11/U10/00/3312/3/1/1 – Geotechnical Report: Supporting document 5: Conveyance system: Materials and geotechnical investigation*) (AECOM, et al., 2014).

In general, the rock at the above locations tended to be highly fractured and jointed within the first 40 to 50 m. The carbonaceous shale rock tended to be more jointed, with the joints being partly open to very tight. Joints in the shale rock were mostly smooth while joints in the dolerite rock were mostly rough. Dykes are expected and water-bearing fracture zones trending northwest and north may be encountered below the water table. Without any pre-grouting, significant water inflow may be expected in the event that a water-bearing fracture is struck.

Access adits at the mid-point, driven from the valley bottom at a gradient of 1V:10H, would need to be between 1 500 m and 2 000 m long.

The borehole log and test pit profiles indicate that the area around the outlet portal is overlain by colluvium (up to 2.6 m thick) and residual shale rock down to a depth of approximately 9.0 m. The residual shale rock generally consists of either gravelly sandy silt or clayey silt. The residual shale rock is in turn underlain by a 2.3 m thick zone of highly fractured moderately to completely weathered laminated soft grey shale rock, which in turn is underlain by highly weathered fractured laminated soft dark-grey shale rock.

6.3.3 Cost estimates

A summary of the tunnel, shafts and access adits costs, with a base date of March 2014 and excluding VAT, have been included in **Table 6.1**. The detailed cost estimates for each component are in the annexure to the *Engineering Feasibility Design Report* (*P WMA 11/U10/00/3312/3/1)* (AECOM, et al., 2015).

Table 6.1: Summary of cost estimate for the uMkhomazi–uMlaza Tunnel

Description	Cost (R million, excluding VAT)
Tunnel	
Transfer tunnel	3 362.2
Miscellaneous	538.8
Total	**3 901**

During the design of the tunnel outlet in the Baynesfield valley, the visual impact of the tunnel outlet was minimised. A preliminary design of the tunnel outlet arrangement for the following components was undertaken:

- An open area with a concrete slab for assembling the TBM during construction;
- The transition section between the tunnel and pipeline;
- The mass concrete unit used for the submergence of the pipeline underground; and
- Access into the tunnel for future maintenance.

Figure 6.5 shows an artistic impression of the tunnel outlet in the Baynesfield valley and how the visual impact was mitigated. Refer to the *Engineering Feasibility Design Report* (AECOM, et al., 2015) for a detailed description of the access arrangements.

Figure 6.5: Artistic impression of the tunnel outlet in the Baynesfield valley

6.4 RAW WATER PIPELINE FROM TUNNEL OUTLET TO WATER TREATMENT WORKS

The pressure raw water pipeline from the tunnel outlet to the WTW also connects the tunnel to the Langa Dam, as shown in **Figure 6.6**.

Figure 6.6: Pipeline route

6.4.1 Conceptual design

The maximum flow velocity in the 2.6 m diameter raw water pipeline, from the tunnel to the WTW, is 1.63 m/s with a thickness of roughly 22.5 mm to accommodate water hammer as well as the potential hydropower. A total of 20 high points for air valves and 27 low points for scours were identified along the proposed route. The total length of the raw water pipeline to the WTW is about 5.2 km. A stilling basin (or possible hydropower plant) was provided at the end of the pipeline for dissipating the energy of the water before it is routed through the WTW.

A 1.6 m diameter pipeline will supply raw water to the balancing dam and the take-off is about 1.3 km downstream of Langa Dam. During maintenance periods of the tunnel, the stored water in Langa Dam will be supplied via this pipeline under gravity to the WTW, at a flow rate of 8.65 m³/s, for the duration of the maintenance period or until the dam is empty.

6.4.2 Geological conditions

The areas to be traversed by the proposed water pipeline are mainly underlain by firm to stiff silty clay or clayey silt containing sand, gravel, cobbles or boulders. In-situ material excavated during trenching will be suitable for use both as selected layers in pavement and as backfill, and marginally suitable as bedding material in water pipeline construction. The western section of the water pipeline traverses a stream and recognisable wetland, therefore unstable sidewall conditions are envisaged during trenching.

To ensure acceptably stable sidewalls in areas having a potential for unstable sidewalls during pipeline construction, trench excavations should not advance too far ahead of water pipeline placement i.e. water pipeline placement and subsequent backfilling should proceed immediately after excavation. The risk of unstable sidewalls may be mitigated by benching or battering of trenches so as to maintain adequate levels of safety.

In-situ material excavated during trenching will be suitable for use both as selected layers in pavement and as backfill, and marginally suitable as bedding material in water pipeline construction.

6.4.3 Cost estimates

A detailed cost estimate of all construction activities for the raw water pipeline, comprising quantities and rates, has been completed, and is summarised in **Table 6.2**.

Table 6.2: Summary of length and cost estimate of the raw water pipeline between Langa Dam, the tunnel outlet and Baynesfield WTW

Description	Length (m)	Cost (R million, excl. VAT)
Pipeline – 2.6 m diameter section	5 120	277.3
Pipeline – 1.6 m diameter section	1 250	27.0
Miscellaneous (establishment of a sub-consultant)	-	60.9
TOTAL	**6 370**	**365.2**

7 PROPOSED LANGA DAM

The Langa Dam site is located in the uMlaza Catchment on the Mbangweni River at the downstream end of the tunnel outlet portal on the farm Nooitgedacht 903. This dam is required for storing water and for supply to Mgeni WSS during emergency closure and maintenance periods of the tunnel. It is connected to the Baynesfield WTW through the raw water pipeline, discussed in **Section 6.3.3**. ***A name for the dam has not yet been decided upon, although it is referred to as Langa Dam***[5].

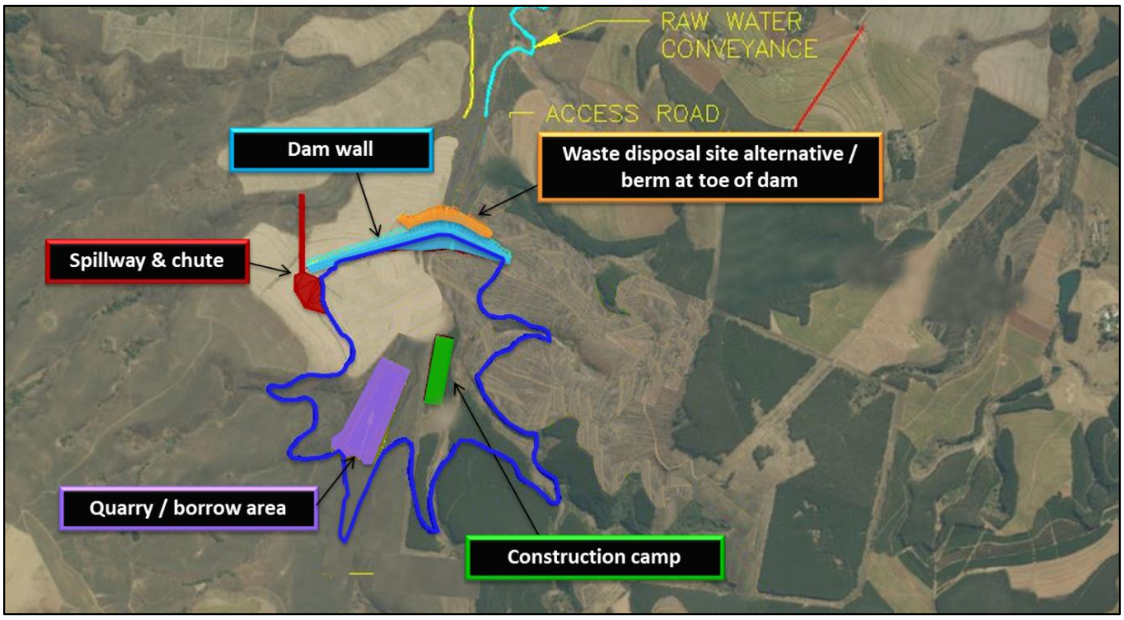


Figure 7.1: Layout of the proposed Langa Dam in the Mbangweni River

7.1 SELECTION OF THE BALANCING DAM SITE

Although the pre-feasibility study recommended that the existing Baynesfield Dam be utilized as a balancing dam, from a detailed analysis described in **Appendix A** (**Section A.4.1**) the Baynesfield Dam was discarded and alternative dam sites were investigated.

With the selection of the tunnel C route as described in the previous sections, a dam site upstream of the Mbangweni Dam on the Mbangweni River (which is a tributary of the uMlaza River) was selected, as shown in **Figure 7.2**. This site is referred to as Langa.

[5] *Standing policy dictates that a new dam be identified by the farm name on the right flank of the dam wall, in this case Nooitgedacht. However, since the name Nooitgedacht is already allocated to an existing dam, the balancing dam is uniquely referred to as Langa Dam, the name of a nearby hill, as was concluded during the 5th PMC.*

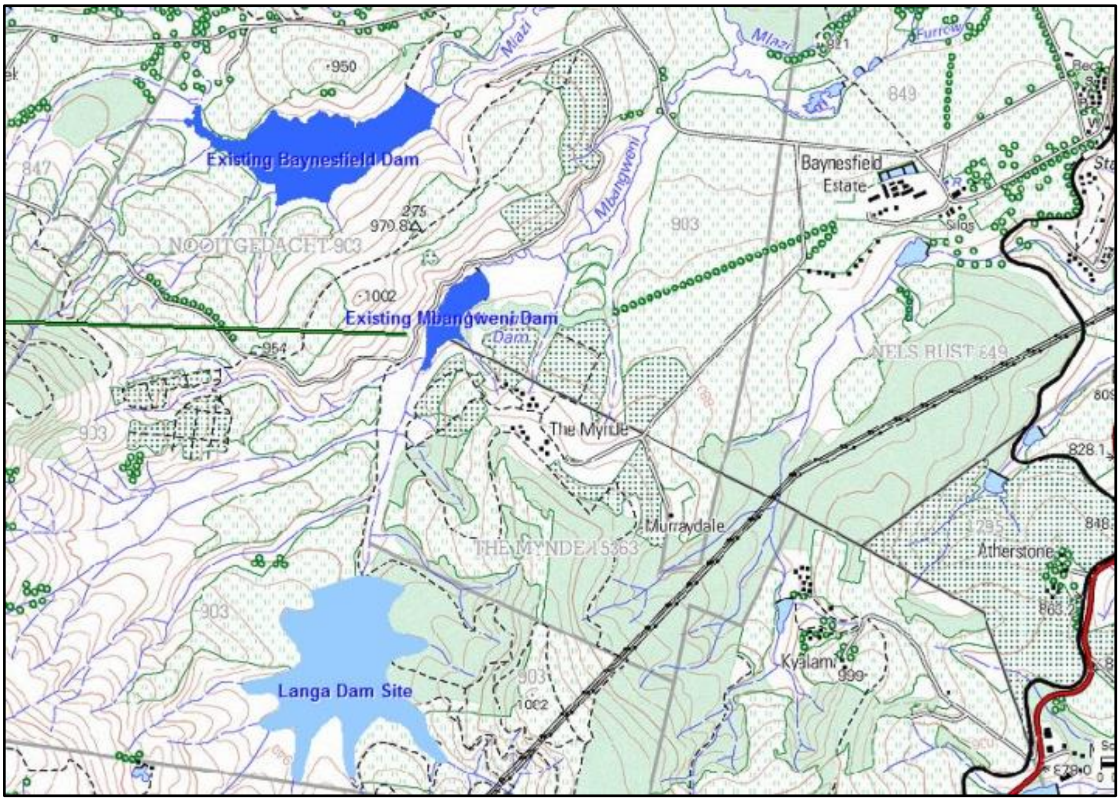


Figure 7.2: Langa Dam site

7.2 uMLAZA RIVER CATCHMENT

Since the Langa Dam is located in the upper reaches of the uMlaza River catchment, various aspects pertaining to the catchment were investigated to assess the impacts or consequences of the uMWP infrastructure, including a balancing dam in the uMlaza River catchment, and to determine what issues needed to be addressed as part of the study, such as:

- Hydrology;
- Water use and water requirements; and
- Environmental Water Requirements.

7.2.1 Hydrology

This study investigated the upper uMlaza River Catchments, comprising of the quaternary catchments of U60A and U60B, with three large dams, namely Baynesfield Dam in quaternary catchment U60A and Thornlea and Mapstone dams in U60B.

Table 7.1: Hydro-meteorological characteristics of the upper uMlaza River Catchment

Quaternary catchment	Incremental catchment area (km^2)	MAP (mm)	MAE (mm)	Incremental natural MAR		
				(million m^3/a)	(mm/a)	(% MAP)
U60A	105	981	1 200	22.65	216	22%
U60B	316	822	1 200	-(1)	-	-
Totals:	**421**	**862**	**1 200**	-	-	-

Note: (1) Catchment not included in this analysis.

In the upper uMlaza River catchment, the available flow gauges are U6H002 at Nooitgedacht and U6H003 at Umlaas, although the quality of the data sets was found to be generally poor. The capacity of the U6H002 gauging station was often exceeded for high flows during the observed period.

7.2.2 Current water use and future water requirements

A summary of the water requirements and return flows in the uMlaza River Catchment at 2012-development levels is provided in **Table 7.2**.

Table 7.2: Summary of water requirements and return flows in the uMlaza River Catchment at 2012-development levels

Quaternary catchment	Water use (million m^3/a)							
	Irrigation*	Commercial forestry	Dry-land sugarcane	Invasive alien plants	Stock watering	Domestic water use*	Return flows	Totals
U60A	0.69	4.75	0.25	0.07	0.01	0.11	0.07	**5.82**
U60B	22.37	3.77	4.87	0.23	0.03	0.94	2.24	**29.97**
Totals:	**23.06**	**8.52**	**5.13**	**0.30**	**0.04**	**1.05**	**2.31**	**35.79**

** Supplied from all sources*

The upper uMlaza River catchment is highly developed, predominantly for the cultivation and irrigation of sugarcane and vegetables, with a total current net water requirement of 36 million m^3/a, which is over 60% of the natural MAR.

Since the proposed balancing dam will be located on the upper reaches of a small tributary of the uMlaza River, it is unlikely that further development will be allowed within the small upstream catchment area and therefore no water requirement projections were developed for the upper uMlaza River catchment

7.2.3 Ecological water requirements

The closest EWR site – defined by the recently commissioned *RDM Reserve Study* for the upper uMlaza River catchment (Louw, 6 October 2014) – is at the outlet of quaternary catchment U60A, while the selected balancing dam site is on the Mbangweni River, a tributary of the uMlaza River directly downstream of U60A, as shown in **Figure 7.3**.

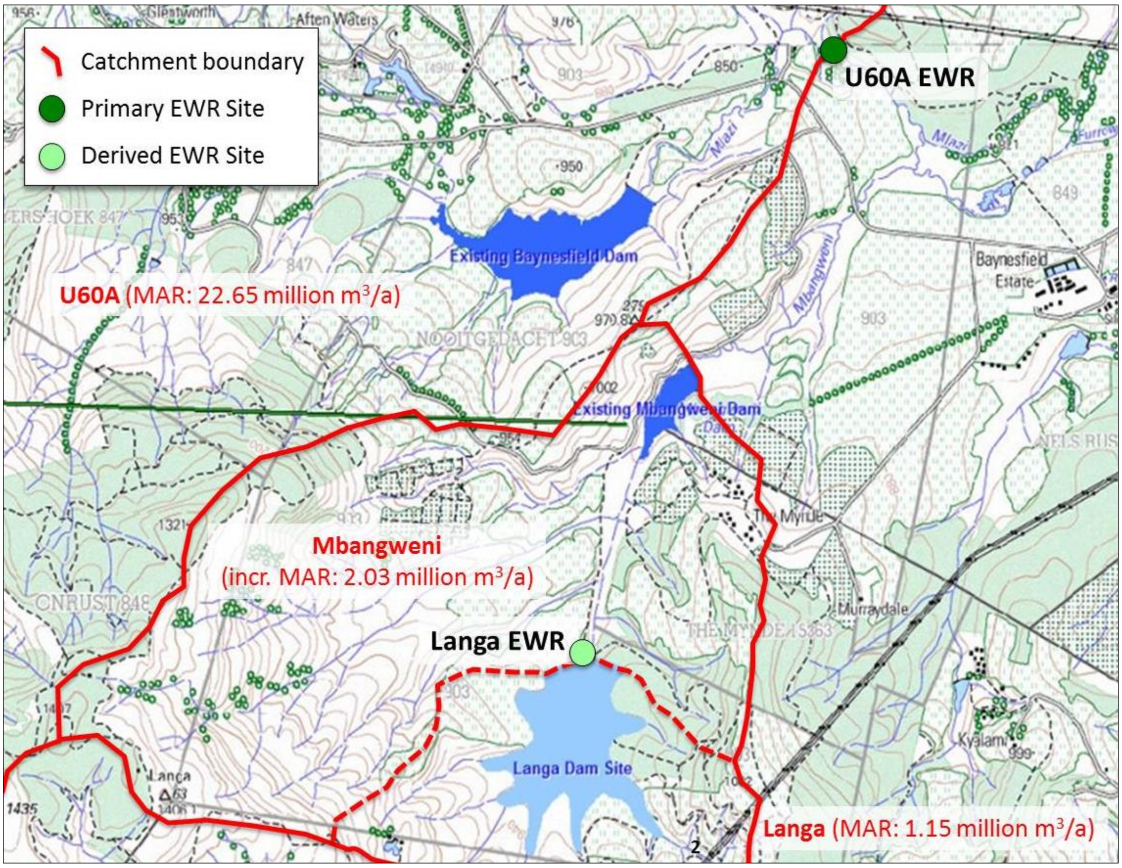


Figure 7.3: EWR sites in the upper uMlaza River catchment

An EWR was consequently derived for the dam site by scaling the U60A EWR according to the respective catchment MARs, with the results shown in **Table 7.3**.

Table 7.3: Summary of EWRs in the upper uMlaza River Catchment

EWR site		Cate-gory	Location			Cumulative catchment		Modelled average EWR	
No.	Name		Description	Lat. (°S)	Long. (°E)	Area (km^2)	MAR (million m^3/a)	million m^3/a	% MAR
-(1)	04533, Mlazi	C	Outlet U60A	29°45'	30°19'	105.0	22.6	-	-
-(2)	Langa	C	Langa site	29°47'	30°18'	5.3	1.2	0.3	25%

Notes: (1) Not part of the WRYM system model.
(2) Derived from the U60A EWR by scaling according to respective catchment MARs.

Since final results from the Reserve Study were not available, and although conservative assumptions were used in this analysis, it is recommended that, when the Reserve Study is completed, the impact of the Reserve on the balancing dam be re-evaluated.

7.3 SIZING OF LANGA DAM

The criteria applied for the sizing of the balancing dam were the following:

- Two months' supply of water must be available for supply to the Mgeni WSS from the balancing dam and the current Mgeni WSS resources, during tunnel maintenance when water from Smithfield Dam is not available[6].
- The FSL of Langa Dam is limited by the FSL of Smithfield Dam (930 masl), since Langa Dam has to be filled under gravity from Smithfield Dam.
- The hydraulic requirements of supplying water via the tunnel and the Langa Dam to the Baynesfield WTW must be met.

A yield analysis of the Langa Dam, including EWR releases, indicated that the inflows from the local catchment are insufficient to fill and maintain the dam at acceptable storage volumes; therefore, the balancing dam must be both filled and supported from Smithfield Dam.

The live storage of Langa Dam is about 14.82 million m^3. This volume represents about 24 days of supply, at an average flow rate of 7.1 m^3/s, to the Baynesfield WTW, with no water supply from the tunnel. The remainder of the required two months of supply will be provided from the existing Mgeni WSS's resources, as modelled with the WRPM.

7.4 CLIMATOLOGY

Climatology is discussed in more detail under **Section 5.1**. The Rainfall Station 0239585W (Baynesfield Estate) was selected to be most representative of the long-term rainfall characteristics of the proposed Langa Dam site, summarised in **Table 7.4**, with the mean annual Symons-pan (S-pan) evaporation.

Table 7.4: Summary of climatology for the proposed Langa Dam site

MAP (mm)	Number of days with rainfall > 10 mm	MAE (mm)	Number of days with minimum air temp. less than 0°C
812	23	1 200	12(1)

Note: (1) From observed data for climate station No. 02388066 at Emerald Dale (SAWS, n.d.).

[6] Requested by the DWA Directorate: Strategic Asset Management

7.5 STORAGE VOLUME

The stage-storage volume and surface area characteristics for Langa Dam are given in **Table 7.5** below. The proposed MOL for Langa Dam is 898.24 masl and the FSL is 923 masl.

Table 7.5: Stage-storage volume and surface area characteristics for Langa Dam

Contour (masl)	Surface Area (ha)	Gross Storage (million m³)
880	0.54	0.00
885	3.08	0.09
890	7.40	0.35
895	13.28	0.87
898	19.95	1.43
900	24.39	1.81
905	36.25	3.33
910	49.84	5.48
915	66.51	8.39
920	83.95	12.15
923	**95.41**	**14.95**
925	103.05	16.82
930	120.42	22.41

The first order estimated sediment yield from Langa Dam's catchment of 5.34 km^2 is 1 165 t/km^2/a with 90% confidence. Based upon this sediment yield, the estimated volume of sediment to accumulate in Langa Dam over 50 years is about 0.21 million m^3.

7.6 FOUNDATION AND CONSTRUCTION MATERIALS

The area around the proposed site is underlain by rocks of the Pietermaritzburg Formation of the Ecca Group, comprising shales and siltstones with subordinate sandstones.

There is sufficient hard shale rockfill available for the construction of a CFRD or ECRD. For any of these dam types, durable dolerite may have to be imported from a commercial quarry (Pietermaritzburg) to serve as a protective layer above the shale or dolerite/shale mixture from the tunnel excavation and the quarry. However, it is possible that some or all of this dolerite might be obtained from the quarry, but this will require further investigation.

As much of the spoil from the tunnel excavation as possible will be used for dam material. This spoil from the tunnel excavation is expected to have the properties of G5 gravel and must be compacted to form part of a rockfill embankment.

For the shells of the proposed rockfill embankment, between 1.6 and 5.3 m of colluvium and residual soil/completely weathered shale will have to be removed along most parts of the centreline. However, in an area on the right flank, weak completely weathered shale and dolerite extend to a depth of over 17 m and will have to be removed.

It will be necessary to make provision for a grout curtain to a depth of about 66% of the water head along the centreline.

The risk for slope failures around the rim of the reservoir that might endanger the dam wall is considered negligible.

Due to environmental restrictions, the geotechnical investigation was limited. Thus, additional test pitting, core drilling, sampling and laboratory tests are recommended during the design stage in order to confirm the properties and volumes of construction materials actually required, and to confirm founding conditions for the selected type of dam and spillway structure.

7.7 DAM TYPE SELECTION

Based on the valley and the geotechnical investigations (available materials and optimum use thereof), the following dam types were considered:

- CFRD;
- RCC gravity; and
- Composite dam: central RCC gravity type with CFRD on left and right flank.

A summary of the initial cost estimation for these options is shown in **Table 7.6**.

Table 7.6: Initial cost estimates for dam types

Option	Dam type	Cost (R, excl. VAT)
1	CFRD	549 087 699
2	RCC gravity	1 591 187 651
3	Composite comprising an RCC central spillway section and CFRD left and right flank	1 148 067 443

Due to the lack of sufficient earthfill materials and relatively deep foundations encountered, the best dam type identified was a CFRD. This dam type also provided the least amount of material that would need to be spoiled.

7.8 FLOOD HYDROLOGY

The recommended peak floods are summarised in **Table 7.7**. Langa Dam is located in Kovacs Region K7 for the purposes of the RMF calculation. The recommended SEF for Langa Dam is $RMF_{+\Delta}$.

Table 7.7: Recommended peak floods for Langa Dam

Recurrence interval (years)								
2	5	10	20	50	100	200	RMF	SEF
Recommended peak discharges (m³/s)								
20	39	56	76	128	163	204	283	313

7.9 WATER QUALITY AND LIMNOLOGICAL REVIEW

The dominant land cover in the Langa Dam catchment is natural thicket and bushland, with some improved grasslands. Some acacia and eucalyptus plantations also occur in the catchment. This catchment appears to be in reasonable condition, with limited potential for significant pollution issues in Langa Dam. Some areas of sugar cane are also present in this catchment and there is not any significant erosion in this small catchment.

With a maximum water depth of 38 m and long retention times, Langa Dam will display thermal and chemical stratification during the summer period. This is particularly likely due to its sheltered location, low inflows and likely low wind mixing. However, a variable abstraction/environmental release mechanism in Langa Dam is not recommended because Langa Dam is only planned to be used once in about 10 years for a period of about three weeks. Water quality and biological (SASS) monitoring is recommended during the pre-construction, construction and operational phase of Langa Dam.

7.10 FEASIBILITY DESIGN OF LANGA DAM

The principal data for Langa Dam is summarised in **Table 7.8**. Artistic impressions of the proposed dam are shown in **Figure 7.4**.

Table 7.8: Principal data for Langa Dam

Parameter	Description
Type of dam	Concrete Faced Rockfill Dam (CFRD)
Catchment area	5.34 km^2
Recommended design flood (RDF)	1:200 year
Peak inflow of the 1:200 year flood	204 m^3/s
Regional maximum flood (RMF)	283 m^3/s
Safety evaluation flood (SEF)	313 m^3/s
Full supply level (FSL)	923.0 masl
Total length of the dam wall	573 m
Minimum operating level (MOL)	898.2 masl
Non overspill crest level (NOC)	926.6 masl
Embankment crest width	7 m
Proposed upstream and downstream slopes of the rockfill embankment	1V:2H and 1V:2.2H.
Gross storage volume at FSL, including additional storage created by the quarry	15.67 million m^3
Live storage volume at FSL, including additional storage created by the quarry	14.82 million m^3
Area at full supply level	95.48 ha
Estimated sediment volume after 50 years	0.21 million m^3
Mean annual runoff (MAR)	2.03 million m^3/a
Maximum wall height of the embankment	46.60 m
Maximum wall width of the embankment	202.72 m
Time of supply at 7.10 m^3/s	24 days

Tunnel muck and excavated material from the downstream outlet portal will be used for the construction of the downstream zone of Langa Dam and thus a waste disposal site will not be required.

Figure 7.4: Artistic impressions of the proposed Langa Dam

7.10.1 River diversion

The following two river diversion phases are proposed for Langa Dam during construction:

- **Phase 1:** A 250 m long cofferdam that is designed for the recommended peak discharge of 76 m^3/s for the 1:20 year recurrence interval. This cofferdam is required to ensure that river flow remains within the river channel during construction of the two proposed 1.6 m diameter outlet pipes for Langa Dam.
- **Phase 2:** A short and low cofferdam that is designed for the recommended winter peak discharge of 8.20 m^3/s, for the 1:20 year recurrence interval. This cofferdam is required to ensure that river flow is diverted through the two proposed 1.6 m diameter outlet pipes during the construction of the last section of the rockfill embankment for Langa Dam during the winter season.

7.10.2 Spillway design

Although Langa Dam has a very small catchment area, and the dam's capacity at the FSL will be about 11 times the MAR, Langa Dam will require a spillway to accommodate at least the 8.65 m^3/s that is being supplied from Smithfield Dam to Langa Dam. The outlet pipeline can accommodate 4.64 m^3/s when Langa Dam is at its FSL of 923 masl.

The recommended option for detail design is an ogee spillway with a spillway length of 10 m and a 177 m long chute on the left flank for the routed 1:200 year peak discharge plus 8.65 m^3/s base flow.

7.10.3 Outlet and inlet tower for Langa Dam

A multi-draw-off system is not required for Langa Dam, as mentioned in **Section 7.9**. A dual outlet pipe system will however be required for maintenance purposes. A tower outlet/inlet structure is proposed, to serve the following purposes:

- An inlet structure, comprising two 1.6 m diameter pipes at the bottom, for water that will be supplied to Langa Dam from Smithfield Dam
- An outlet structure, with one 1.6 m diameter outlet pipe, for water that will be supplied to Baynesfield WTW from Langa Dam; and
- An outlet structure for environmental releases from Langa Dam, through one of the 1.6 m diameter pipes.

Through the two proposed 1.6 m diameter outlet pipes, the outlet system will be able to draw down Langa Dam from its FSL to 50% within 9.6 days, and draw down to the lowest level will be achieved in less than 60 days.

7.10.4 Downstream protection of rockfill embankment

From an environmental point of view, the proposed dolerite downstream protection layer for the embankment may not be acceptable, and provision was made for vegetation on the downstream slope of the embankment. The capital cost for this option, as shown in **Table 7.9**, will be about R 11.23 million more than the initial proposed dolerite downstream slope protection.

This option for downstream slope protection will, however, need to be re-assessed during the final design of Langa Dam.

Figure 7.5: Artistic impressions of the alternative vegetation downstream slope for the proposed Langa Dam

7.11 Operating Rule for Langa Dam

In accordance with the water yield analysis, the following operating rule was developed for the operation of Langa Dam:

- Langa Dam shall be filled and topped up from Smithfield Dam, preferably when Smithfield Dam is spilling;
- Langa Dam shall release water for EWR between the dam and the new Mbangweni Dam; and
- Langa Dam shall provide water to the Baynesfield WTW through the raw water pipeline during maintenance and repair periods of the tunnel.

7.12 Cost Estimate for Langa Dam

The estimated cost for all the construction activities of Langa Dam is summarised in **Table 7.9** below.

Table 7.9: Summary of cost estimate for Langa Dam

Description	Cost (R million, excl. VAT)
River diversion works	1.4
Development of quarry	0.5
Langa Dam main embankment (CFRD)	315.8
Spillway	3.6
Outlet pipes	12.8
Outlet works, intake structure	47.1
Miscellaneous	57.7
TOTAL	**438.8**

8 OTHER INFRASTRUCTURE

For a mega project such as the uMWP, several other related infrastructure components will need to be developed, either as an integral part of the infrastructure required or due to the impact of the project on existing infrastructure. This includes but is not limited to gauging weirs, roads and the possibility of hydropower generation.

8.1 GAUGING WEIRS

Three gauging weirs are required to measure river flows at the following positions, as shown on **Figure 8.1**:

- Location 1: Just downstream of Impendle Dam to measure inflow to Smithfield dam;
- Location 2: Just downstream of Smithfield Dam to determine the discharges from Smithfield Dam required for the dam balance and EWR; and
- Location 3: Near EWR/IFR2, further downstream of Smithfield Dam to determine the run-off from the incremental catchment downstream of Smithfield Dam to assist with the operation of the EWR.

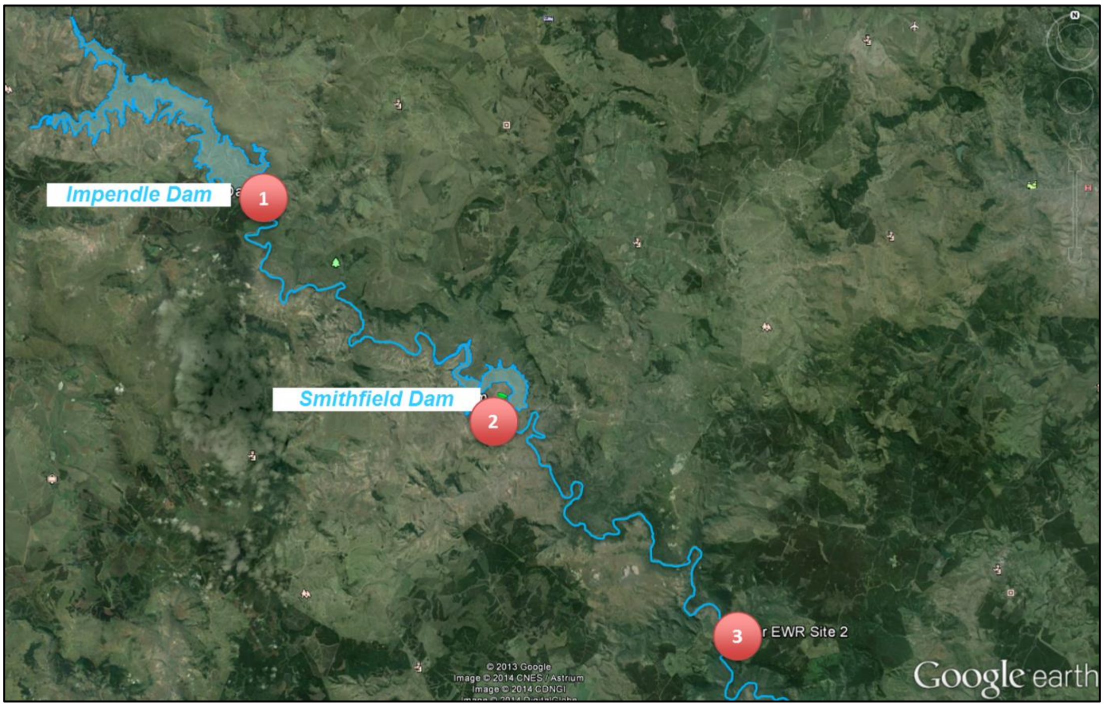


Figure 8.1: Positions of the proposed uMWP gauging weirs

The three gauging weirs will be designed as Crump Weirs to accommodate monitoring associated with 80% of the flows.

A cost estimate for the construction of each of the flow gauging weirs, comprising quantities and rates, has been completed, as shown in **Table 8.1**.

Table 8.1: Summary of cost estimate of activities for flow gauging weirs

Description	Cost (R million, excl. VAT)
Weir 1: Upstream of Smithfield Dam	9.2
Weir 2: Downstream of Smithfield Dam	8.3
Weir 3: Near EWR/IFR2, further downstream of Smithfield Dam	11.3
Miscellaneous	1.4
TOTAL	**30.2**

8.2 ROADS INFRASTRUCTURE

The R617, a public road between Pietermaritzburg/Howick and Underberg, will be inundated by the new proposed Smithfield Dam and will have to be deviated.

Furthermore, several new access roads to the various project components will be needed during and after construction, and to provide access for communities that will be cut-off due to the inundation of the dam. The required deviations and access roads are as follows:

- Roads around Smithfield Dam (refer to **Figure 8.2**):
  - Deviation of the R617;
  - Access road to Nonguqa;
  - Access road to the tunnel inlet portal;
  - Access road to the dam wall[7];
  - Construction road; and
  - Main access road.
- Tunnel (refer to **Figure 8.3**):
  - Access road to Ventilation Shaft 1;
  - Access road to Ventilation Shaft 3; and
  - Access road to the centre adit entry.
- Langa Dam (refer to **Figure 8.4**):
  - Access road to tunnel outlet portal and Langa Dam (Option 1); and
  - Access road to tunnel outlet portal and Langa Dam (Option 2).
- Access roads to the three gauging weirs.

[7] *The impact of the Saddle Dam fuse plug on the access road should be considered during final design.*

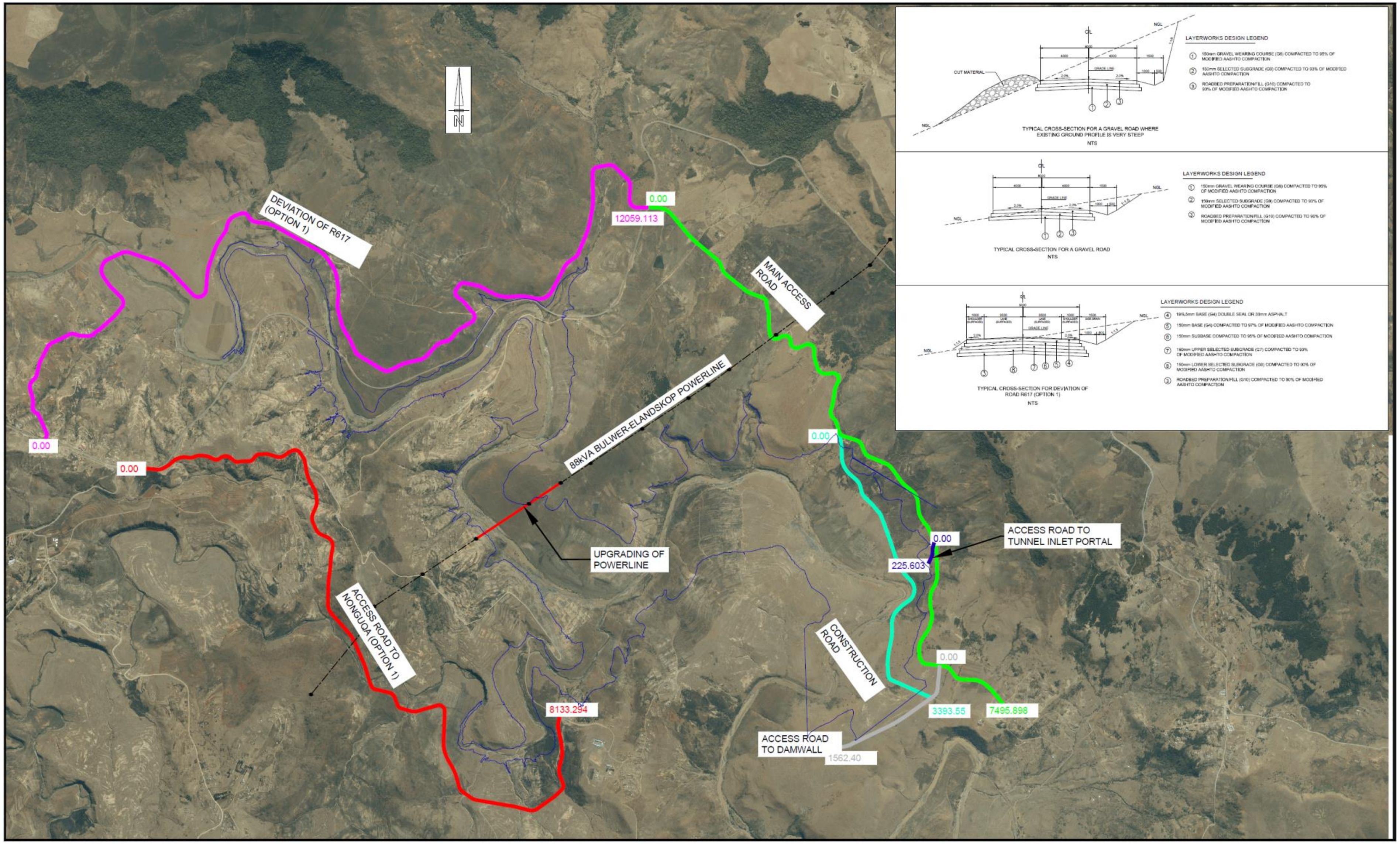


Figure 8.2: Deviation of roads surrounding Smithfield Dam

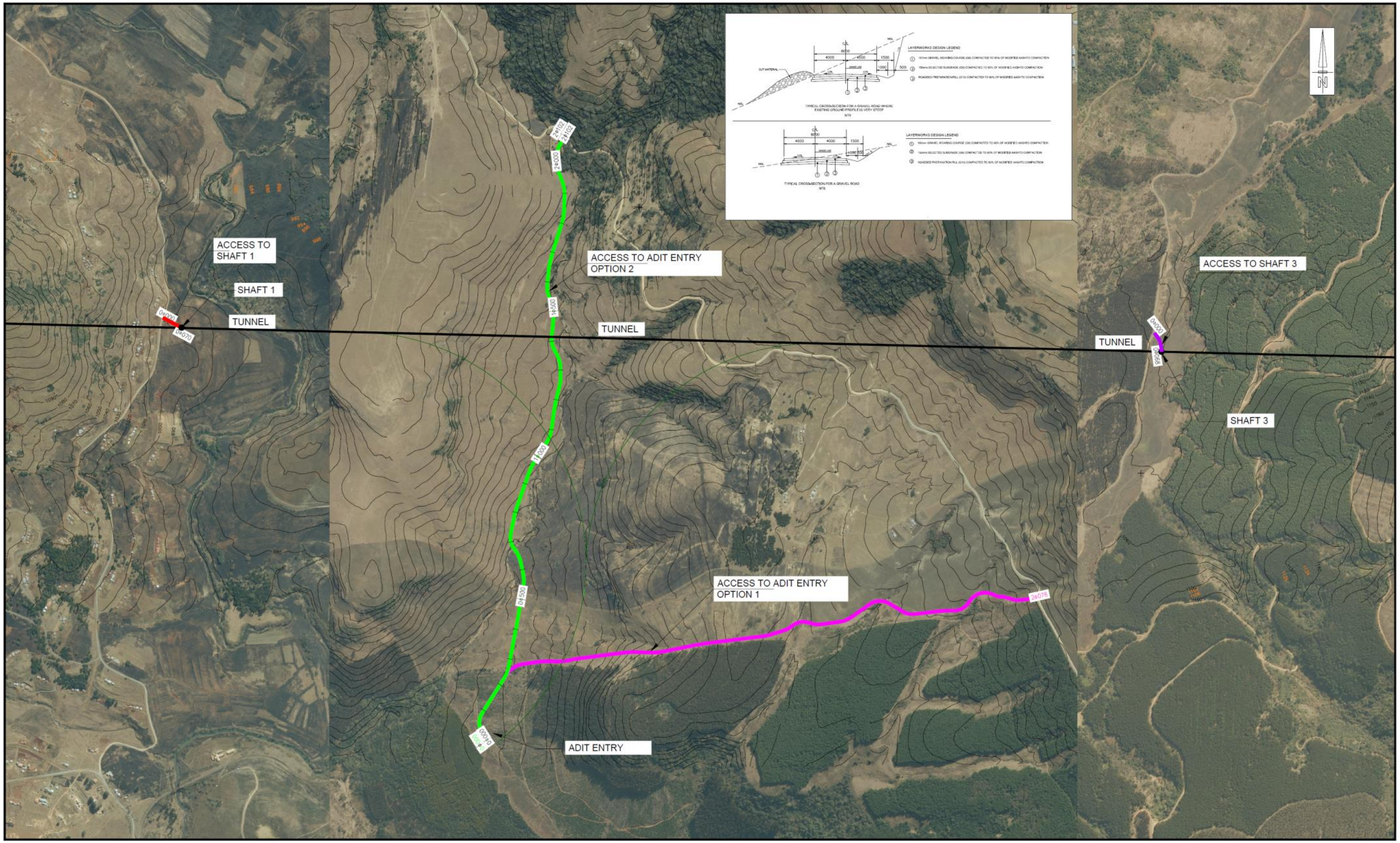


Figure 8.3: Deviation of roads surrounding the Transfer Tunnel

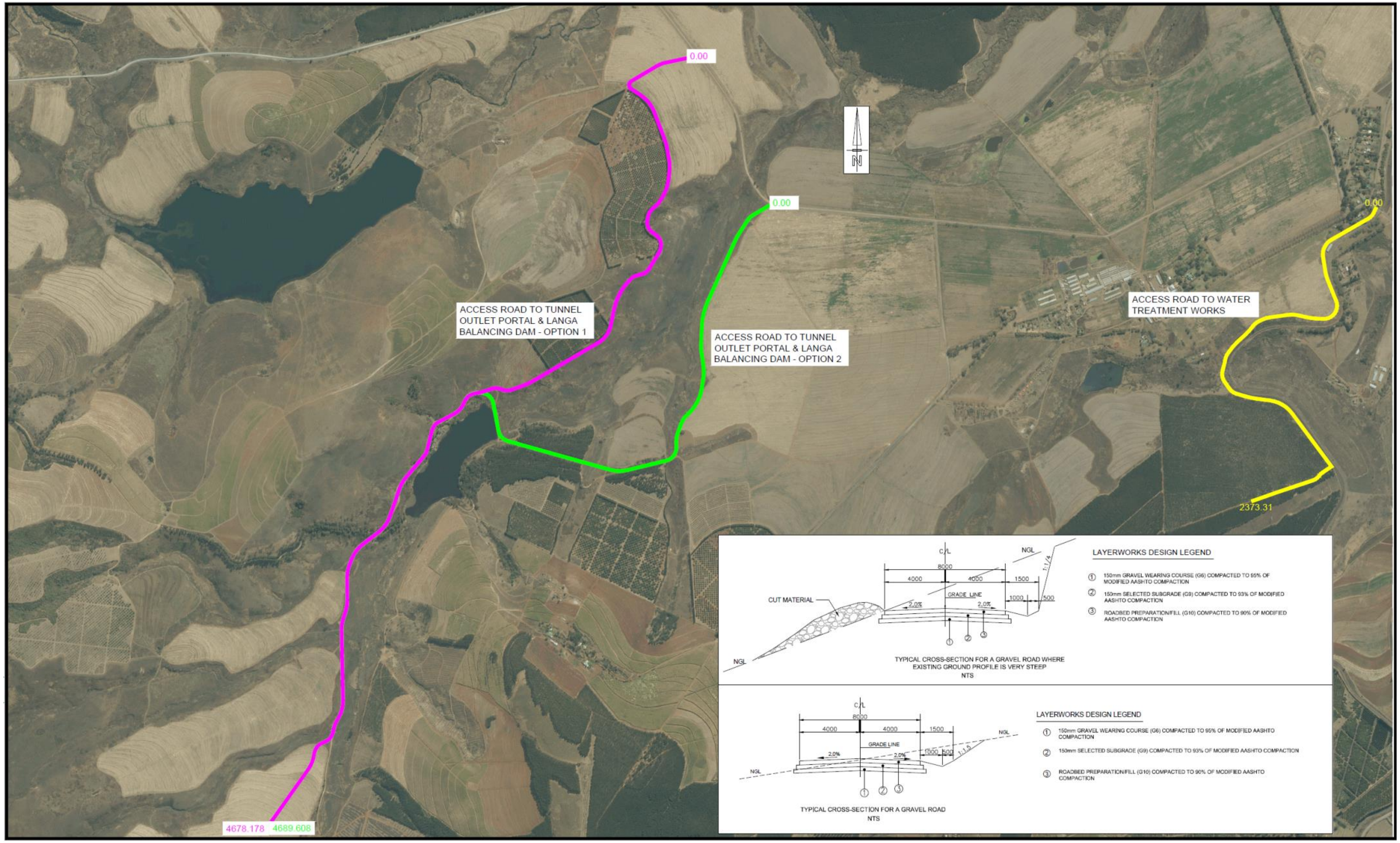


Figure 8.4: Deviation of roads surrounding Langa Dam

A geotechnical investigation was not carried out for the road; however, it is likely that all road fills and the selected layers can be constructed from material obtained from cut during road construction. However, materials for the sub-base layer and wearing course will probably have to be obtained from borrow areas.

A detailed cost estimate of all construction activities for access and deviation of roads, comprising quantities and rates, has been completed. **Table 8.2** shows a summary of this cost estimate.

Table 8.2: Summary of cost estimate for new access roads and deviation of existing roads

Description	Cost (R million, excl. VAT)
Smithfield Dam	
Deviation of the R617 and a major bridge	100.4
Access road to Nonguqa	16.3
Access road to tunnel inlet portal	0.5
Access road to dam wall	3.4
Construction road	13.4
Main access road	37.5
Tunnel	
Access road to Ventilation Shaft 1	3.3
Access road to Ventilation Shaft 3	0.1
Access road to centre adit entry	8.5
Langa Dam	
Access road to tunnel outlet and Langa Dam (Option 2)	28.9
Gauging Weirs	
Access road to gauging weir upstream of Smithfield Dam	0.3
Access road to gauging weir downstream of Smithfield Dam	2.9
Access road to gauging weir at EWR/IFR2 site	5.1
Miscellaneous	11.0
Total	**231.6**

8.3 WASTE DISPOSAL SITES

Although three waste disposal sites have been identified for disposal of construction materials during the construction of the uMWP-1, only two waste disposal sites – one near the tunnel inlet portal and one midway along the tunnel near the central access adits – will be used.

Excavated material from the uMkhomazi–uMlaza Tunnel and the portals will be mainly disposed of at these sites. Tunnel muck and excavated material from the downstream outlet portal will be used for the construction of Langa Dam and thus the development of the third waste disposal site is not necessary.

The waste disposal sites will only be operational for the construction period of uMWP-1 and will be rehabilitated afterwards.

The new *National Norms and Standards for the Disposal of Waste to Landfill* (DEA, 2013) classifies these sites as Class D landfills with Type 4 waste (building and demolition waste and excavated earth material not containing hazardous waste of hazardous chemicals).

The locations of the waste disposal sites are shown on **Figure 6.2**. The spoil volumes to be disposed of at the waste disposal sites during construction and the sources thereof are summarised in **Table 8.3**. Layouts of the two waste disposal sites are shown in **Figure 8.5**.

Table 8.3: Spoil volumes, sources and disposal sites

Source	Excavated material, in-situ volume (m^3)	Excavated material (LCM*)	Available volume at waste disposal site (LCM)
Site 1			
Tunnel 1 inlet portal	365 000	584 000	
Tunnel 2 (first portion of tunnel)	1 590	2 544	
Tunnel 2 access adit	12 959	20 734	
Ventilation Shaft 1	216	346	
Total excavated material to spoil		**607 624**	**615 000**
Site 2			
Tunnel 1 (portion from central adit to inlet portal)	233 014	372 822	
Tunnel 1 (central tunnel section between adits)	32 558	52 093	
Tunnel 1 central access adit	79 334	126 934	
Ventilation Shaft 2	2 598	4 157	
Total excavated material to spoil		**556 006**	**560 000**
Langa Dam			
Ventilation Shaft 3	3 593	5 749	
Tunnel 1 outlet portal	401 000	641 600	
Tunnel 1 (portion from outlet portal to central adit)	285 117	456 187	
Total excavated material to spoil		**1 103 536**	Part of dam design
Roads	Approx. 37 791	-	Closest fill position

* *Loose cubic metre based on a 1.6 swell factor*

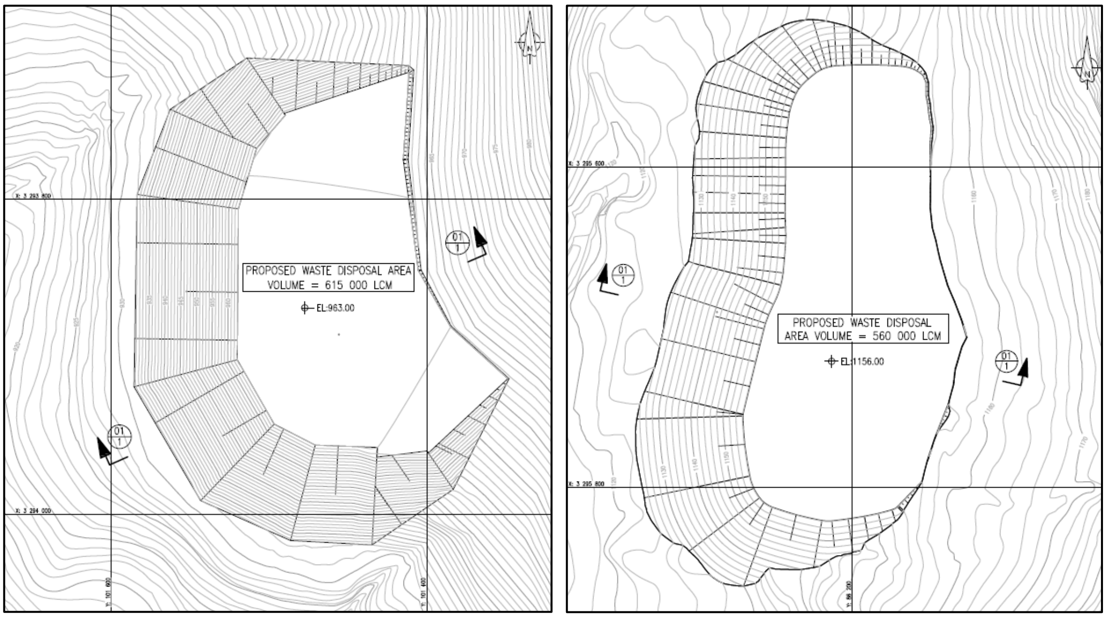


Figure 8.5: Waste disposal site 1 (left) and 2 (right)

A cost estimate for the development of each of the waste disposal sites, comprising quantities and rates, has been completed, as shown in **Table 8.4**.

Table 8.4: Summary of cost estimate for development of waste disposal sites

Description	Cost (R million, excl. VAT)
Waste Disposal Site 1	7.1
Waste Disposal Site 2	7.1
Miscellaneous	0.7
TOTAL	**14.9**

8.4 HYDROPOWER ASSESSMENT

In light of government's policy of promoting renewable energy, and where the seasonality and volume of river flows in sub-Saharan Africa are normally a limitation for the generation of hydropower, the development of a new dam with constant flow provides an opportunity for hydropower generation. Therefore, the hydropower potential of the uMWP has been assessed for both phases.

A pre-feasibility assessment (or viability assessment) of hydropower generation as a secondary, but potentially major, benefit to the uMWP-1 was undertaken at the following two sites:

- Baynesfield WTW – at the outlet of the conveyance structure from Smithfield Dam, referred to as the Baynesfield Hydropower Plant (HPP); and
- On the outlet works of Smithfield Dam, referred to as the Smithfield Dam HPP.

To accurately capture the future flow scenarios as best as possible, the Water Resource Planning Model (WRPM) was used to simulate the future dam levels and flow volumes over the project period, including the yield transferred to the Mgeni WSS, which were used to determine the hydropower potential at each site for key probabilities.

The Baynesfield HPP was conceptually designed for a rated point of 8.65 m^3/s flow and 41.7 m net head, which has the potential of 3 MW power.

The Smithfield Dam HPP was conceptually designed for a potential of 2.6 MW for a rated point of 5.0 m^3/s flow and 64.0 m net head. However, the modifications required to the dam's outlet works to accommodate the potential powerhouse were not included and should be included in the detail design.

A construction cost estimate was determined and a summary is included in **Table 8.5**.

Table 8.5: Summary of cost estimate for both hydropower plants

Description	Cost (R million, excl. VAT)
Baynesfield HPP (alternative 1)	42.8
Smithfield Dam HPP (alternative 2)	36.6
Miscellaneous	4.0
TOTAL	**83.3**

An economic feasibility assessment for both Baynesfield and Smithfield Dam HPPs indicated that both plants will be feasible to wheel power into the grid.

Although the hydropower options are feasible, the development of HPPs is not within the mandate of the DWA, as the NWA of 1998 and subsequent amendments are silent on the topic. Therefore, the DWA should confirm their involvement in the development of hydropower, or identify other entities, such as UW, a municipality or private company, that would be interested in developing the hydropower scheme in a renewable energy program for small hydropower schemes.

9 INSTITUTIONAL AND FINANCIAL ARRANGEMENTS

The purpose of this section is to highlight the institutional arrangements surrounding the proposed uMWP and to consider the options available for addressing financial arrangements related to the mega bulk water supply scheme. The capital expenditure and operational costs that were determined and included in the financial modelling are provided as summary background to the water tariff determination. This is described in more detail in the *Institutional and Financial Aspects Report* (AECOM, et al., 2015).

9.1 INSTITUTIONAL ARRANGEMENTS

The uMWP's raw water components will form part of the national water resource infrastructure and therefore ownership and control will be vested in the Government of the Republic of South Africa, and thus administered by the Department of Water Affairs. UW is responsible for bulk water supply and will be the owner and developer of the uMWP potable bulk water components of the scheme, with the upstream battery limit being at the inlet to the Baynesfield WTW (refer to *Umgeni Water Master Plan*).

Various institutional arrangements and options for funding and operating the project are considered bearing in mind the roles and responsibilities of DWA, National Treasury, TCTA, UW and Municipalities. While the establishment of the National Water Resources Infrastructure Agency (NWRIA) is introduced in the report, it is not currently considered as an option for the implementation of the uMWP-1 as progress on its establishment is inadequate for it to make timely contribution.

The uMWP will supplement the Mgeni WSS and as such will form an integral component of this strategically important system. This system provides water to the greater economically important eThekwini Metropolitan area, where the DWA owns the major dams in the uMngeni Catchment as well as some dams in neighbouring catchments, such as the newly constructed Spring Grove Dam. The Mgeni WSS is currently operated by UW.

The institutional arrangement as shown in **Figure 9.1** below is recommended.

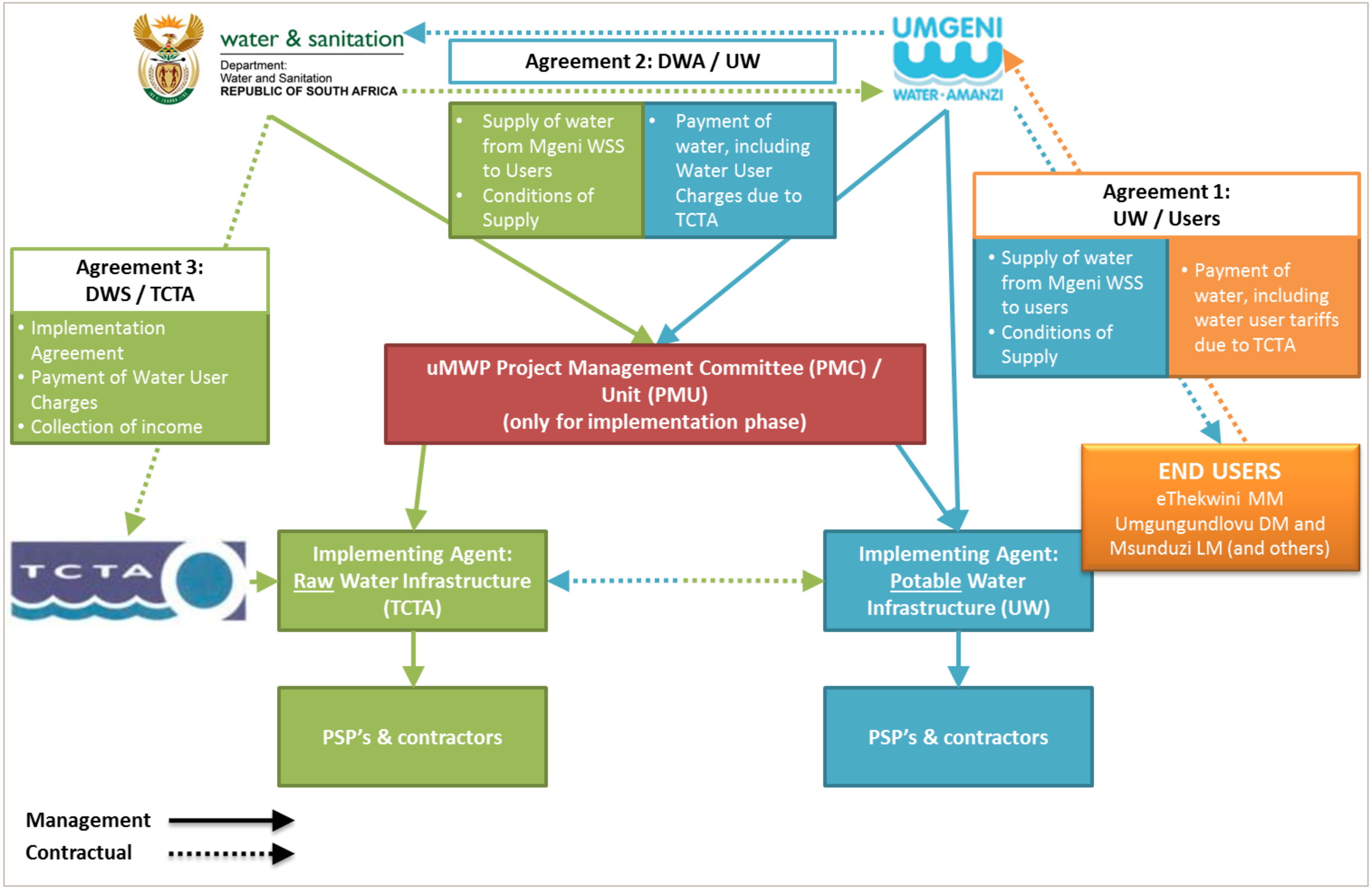


Figure 9.1: Proposed institutional arrangements during the implementation phase

It is recommended that the TCTA proceed with implementation of the project as soon as off-take agreements have been signed with the relevant Water Service Authorities (WSAs) for at least 85% of the current water volume as this has proven to be acceptable to DWA and bankers on previous projects.

It is further recommended that UW fund and implement the potable bulk water component of the project and that Umgeni Water operate the complete project (raw and potable water supply) once it has been commissioned.

The institutional arrangements relating to the possible development of the hydropower project(s) has not been included, as the full feasibility of the hydropower potential needs to be further investigated and is therefore not regarded as part of the uMWP infrastructure. Should the hydropower be implemented, it will most probably be developed by UW or an Independent Power Producer (IPP).

9.2 FINANCIAL ASPECTS – RAW WATER COMPONENT

The costs for the development of uMWP-1 are presented and scenarios for the determination of water tariffs are considered in light of sources of funding including off-budget loan financing and possible partial subsidisation through grant funding.

There are two major policy considerations when deciding on the appropriate funding model for the uMWP:

- The first policy consideration is the *2007 Pricing Strategy for Raw Water Use Charges* (DWAF, 2007) gazetted by the Minister on 16 March 2007. **Section 7.1** of the Pricing Strategy provides that "*State funding will in the future be confined mostly to social water resource development or betterment projects, which conform to the purpose, set out in section 2 of the NWA, 1998 and where the demand is not driven by specific commercial water users or sectors*." **This strategy thus explicitly supports the concept of allocating State Funding to the social component of the water supply.**
- Precedent was established with the implementation of schemes such as MMTS2 and the Berg Water Project where decisions were made regarding the status and intention of the project and the levels of social and commercial / economic benefits to be derived from the project. DWA adopted the stance that large municipalities have the economic and financial capacity to cover the costs of large bulk water supply schemes and can also cross-subsidise water

tariffs internally without requiring additional project specific grant funding from National Treasury.

However, the Pricing Strategy also recognises that the debts on projects where loan repayments overlap should not cause "**.....financial strain to end users or unhealthy financial balance in the water sector.**"

9.2.1 Capital expenditure and operational costs

Based on the individual cost estimates detailed in previous sections, the estimated feasibility capital cost of the uMWP-1 is ***R16.4 billion (excl. VAT, 2014)***, and is summarised in **Table 9.1**. This comprises two large dams at Smithfield and Langa, raw water conveyance infrastructure, treatment at Baynesfield and potable water conveyance infrastructure (shown in **Figure 9.2**).

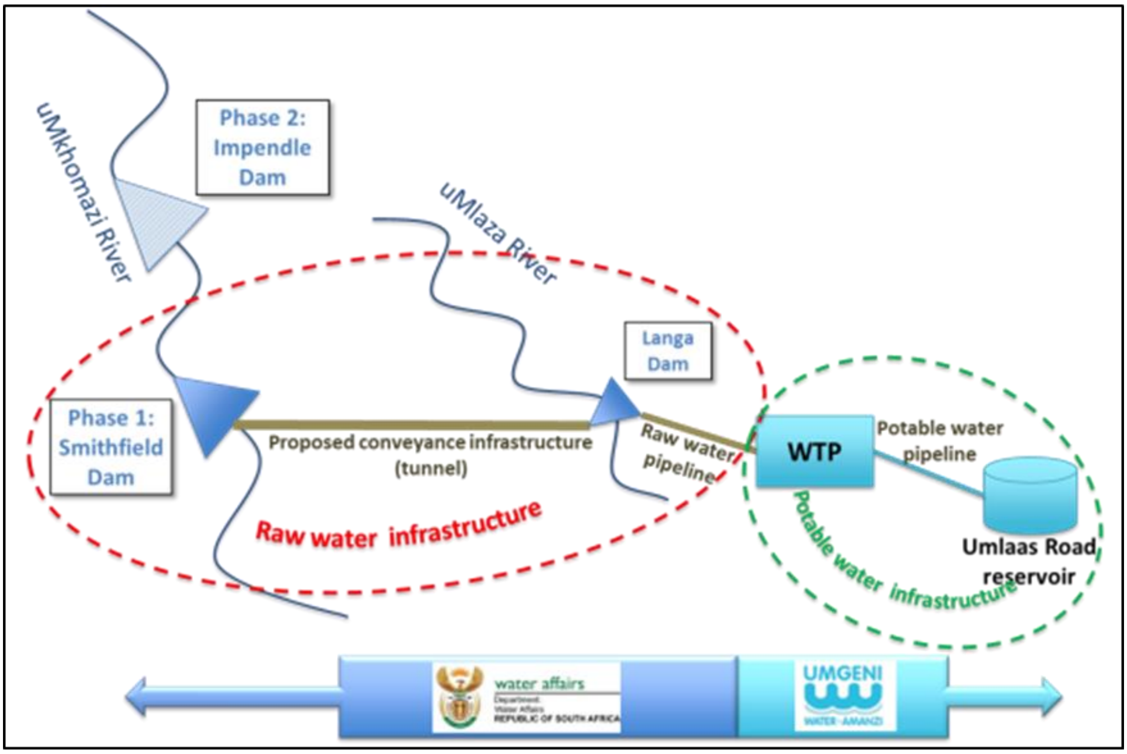


Figure 9.2: Raw and potable water components of the uMWP

Table 9.1: Capital cost of uMWP-1 *(2014 prices)*

Component	Capital cost (R million)
1. Raw water system activities (incl. miscellaneous)	
Smithfield Dam	2 018
uMkhomazi-uMlaza tunnel	3 901
Langa Dam	439
Raw Water Pipeline	365
Transmission lines	5

Component	Capital cost (R million)
Smithfield Dam and Baynesfield hydropower plants	Nil[1]
Waste disposal sites	15
Flow gauging stations	30
Roads and bridges	232
Sub-total of activities	**7 005**
Ps&Gs (25% of activity cost)	1 752
Professional fees (12% of activity cost)[2]	841
Environmental, landscaping and social costs	450
Land acquisition (lump sum)	37
Sub-total of activities and value-related costs	**10 084**
Contingencies (25% of above sub-total)	2 521
Implementing agent - TCTA[3]	200
Total: Raw water system	**12 805**
2. Potable water system activities (incl. miscellaneous)[4]	
Baynesfield WTW-Umlaas Road Pipeline	1 143
Baynesfield WTW and potable water reservoirs	795
Sub-total of activities	**1 938**
Ps&Gs (25% of activity cost)	485
Professional fees (12% of activity cost)[2]	233
Environmental, landscaping and social costs (5% of activity cost)	97
Land acquisition (lump sum)	10
Sub-total of activities and value-related costs	**2 762**
Contingencies (25% of above sub-total)	691
Implementing agent - Umgeni Water (5% of sub-total)[3]	138
Total: Potable water system[4]	**3 591**
3. Grand total	
uMkhomazi Water Project Phase 1 (excl VAT)	**16 396**
uMkhomazi Water Project Phase 1 (incl VAT)	**18 691**

*(1) Hydropower is not included, as it does not form part of the raw water system. However, the cost of the Smithfield-Baynesfield hydropower is shown as R 83.3 million in **Table 8.5**.*

(2) Project management, design and construction monitoring costs are included as professional fees.

(3) Administration costs include raising funds, procurement, project management and administration of the project as implementing agent.

(4) Refer to Module 3 reports for cost of potable water components.

Funding costs and ***interest*** were excluded from the total capital expenditure shown in **Table 9.1** above, but were incorporated into the financial modelling.

Operating costs required for the raw and bulk potable water infrastructure, including the WTW, are summarised in **Table 9.2**.

Table 9.2: Annual operating costs for the uMWP-1 *(2014 prices excl. VAT)*

Component	Annual operating cost (R million)
1. Raw water system activities (incl. miscellaneous)	
Smithfield Dam	12.7
uMkhomazi-uMlaza tunnel	12.4
Langa Dam	2.8
Raw Water Pipeline	2.3
Transmission lines	0.1
Waste disposal sites	0.0
Flow gauging stations	0.3
Roads and bridges	1.5
Total: Raw water system	**32.0**
2. Potable water system activities (incl. miscellaneous)	
Baynesfield WTW-Umlaas Road Pipeline	10.1
Baynesfield WTW and potable water reservoirs (costs in R/m^3)	
- WTW chemicals	R 0.15/m^3
- WTW energy	R 0.25/m^3
- WTW maintenance	R 0.33/m^3
- WTW staff costs	R 0.30/m^3
- Total operation cost	**R 1.03**/m^3

As noted in the *Umgeni Water Policy Statement and Five-Year Business Plan (Volume 2: Business Plan 2012/13 to 2016/17)* and *Umgeni Water Infrastructure Master Plan 2015 (2015/2016 – 2045/2046)*, UW will be the owner and implementing agent for the uMWP-1 bulk potable water component. This will include raising the funds, possibly through a mix of grant funding from National Treasury and through private sector loans secured through its balance sheet.

9.2.2 Water tariffs

Should the uMWP immediately be fast tracked, then the project could deliver water in 2023 at the earliest. The water tariff was calculated with the following assumptions:

- The uMWP-1 (raw and potable water) is to be fully funded off-budget by private sector loan (debt) funding;
- The capital debt is to be redeemed over a 20-year period (current standard practice) at a real interest rate of 3.83% from first water delivery in 2023 to 2042;

- The debt and operating cost of both the raw and potable water component are to be recovered over all of UW's bulk potable sales; and
- The benefits of power generation are to be ignored.

With these assumptions, the UW's bulk potable tariff would need to be increased by a constant real surcharge of ***R 2.70/kℓ in terms of 2014 prices*** (or R 4.57/kℓ in 2023 prices), of which R 1.88/kℓ in 2014 would be for the raw water component.

This uMWP future tariff of R 2.70/kℓ constitutes a ***59% increase*** which will financially strain end users (UW bulk water tariff increase from ***R 4.55/kℓ*** to ***R 7.25/kℓ***). To lessen the impact of this increase, various subsidy and/or phasing arrangements were considered as shown in **Table 9.3**.

Table 9.3: Bulk Potable Water tariff implications for the various subsidy and phasing scenarios

Funding arrangements	Increase in Umgeni Tariff	
	2014 Rands (R/kℓ)	2023 Rands (R/kℓ)
1. uMWP-1 redeemed over 20 years from 2023; No subsidy *[uMWP-1, <u>raw water component only</u>, redeemed over 20 years from 2023; No subsidy]*	R 2.70 *[R 1.88]*	R 4.57 *[R 3.18]*
2. uMWP-1 redeemed over 20 years from 2023; 25% Capital grant subsidy	R 2.12	R 3.58
3. uMWP-1 redeemed over 25 years from 2023; 25% Capital grant subsidy	R 1.86	R 3.15
4. uMWP-1 redeemed over 25 years from 2023; but phased in over the prior 5 years from 2018; 25% Capital grant subsidy	R 1.60	R 2.71

The substantial increase of the tariff raises affordability concerns, which, together with the number of households affected (refer to **Section 2.4**), makes it ***recommended that National Treasury considers grant funding*** of the capital cost of the project to facilitate continued access to water for these poorer households, which use about 25% of the water. If 25% funding assistance by National Treasury were therefore to be made available, the tariff of R 2.71/kℓ will reduce to an estimated R 1.86/kℓ depending on scenarios for phased implementation of tariff increases and loan repayment periods.

It is recommended that TCTA, as preferred implementing agent for the raw water components, fund the remaining approximately 75% of the raw water component of the project with private sector funding. As previously noted, it is recommended that the TCTA proceed with implementation of the project as soon as off-take agreements have been signed with the relevant WSAs for at least 85% of the current volume. The TCTA income stream for the redemption of their loans will then be through the sale of water to UW at an approved tariff. This is the same approach that was adopted on the MMTS-2 scheme.

The TCTA loans should be recovered through the UW tariff. This is the same approach as that adopted for the funding of the MMTS2 project.

Further, the phasing in of a tariff increase prior to the raising of any funding or implementation of the scheme may soften the impact of a substantial tariff increase. However, a suitable strategy should be composed to ensure that the surplus funds gained are earmarked for the loan repayment, otherwise there is a risk that the surplus funds will be used for other purposes, thereby necessitating further tariff increases later.

9.2.3 Recommendations from institutional and financial aspects

As DWA has confirmed that the uMWP-1 needs to be implemented as a priority project, the crucial next steps towards implementation of the uMWP-1 are as follows:

- Appointment of TCTA as the Implementing Agent by the Minister for DWA for the uMWP-1 Raw water component;
- Determination of the availability of funds for National Treasury for subsidisation of the costs of the project through grant funding;
- Development of the financial models for the raw water and potable water components by TCTA and UW respectively;
- Finalise off-take agreements with water service authorities that constitute 85% of the current water users, by September 2017;
- Formulation of a procurement strategy and programme for the implementation of the uMWP-1 by TCTA and UW to ensure an integrated approach towards timeous completion of the project in 2023; and
- Appointment of UW as operator for the whole uMWP-1 (raw and potable water components).

9.3 Economic comparison of the uMWP-1 with desalination and re-use options

As the uMWP-1 is estimated to be commissioned in 2023 at best, the Mgeni WSS will be stressed until then and alternative augmentation schemes were investigated including desalination of sea water desalination and/or re-use of waste water. Three implementation scenarios had been investigated that comprise various possible combinations of the uMWP-1 with the desalination and re-use options (discussed in **Section 3**), as described below:

- ***Scenario 1***: uMWP-1 only, with delivering of water from 2023 and revenue to be generated to repay the project and O&M costs over a 20-year period from 2023 to 2042.
- ***Scenario 2***: 150 Mℓ/day sea water desalination plant implemented at Lovu to deliver water from 2019, followed by uMWP-1 to deliver water from 2023. Revenue will then be generated to repay the combined project and O&M costs commencing in 2019 and extending to 2042 (loan repayment period of 20 years).
- ***Scenario 3***: re-use plants at KwaMashu and Northern WwTW with a combined capacity of 120 Mℓ/day to deliver water from 2019, followed by 150 Mℓ/day sea water desalination plant at Lovu to deliver water from 2023, followed by uMWP-1 to deliver water from 2027.

The scenarios were compared with their URVs, which is the cost per cubic metre of water over the total life cycle of the scheme. This comparison is summarised in **Table 9.4**.

Table 9.4: URV comparison of augmentation scenario options

Discount rate	Scenario 1	Scenario 2	Scenario 3
	uMWP-1 raw water and WTW delivering in 2023	Desalination* delivering in 2019 + uMWP-1 raw water and WTW delivering in 2023	Re-use delivering in 2019 + Desalination delivering in 2023 + uMWP-1 raw water and WTW delivering in 2023
Present value costs (R'000)			
6%	13 113 723	20 413 894	21 065 423
8%	10 897 457	16 774 351	16 198 665
10%	9 250 739	14 185 392	12 863 637
Present value water demand (kl'000)			
6%	1 412 307	1 624 440	1 664 243
8%	864 213	1 008 591	1 024 538
10%	557 618	666 224	672 777
URV (R/kl)			
6%	9.29	12.57	12.66
8%	12.61	16.63	15.81
10%	16.59	21.29	19.12

* *The desalination option does not include the cost (capital and energy) of distributing the water by pumping from sea level to inland users. This option will therefore be much higher in URV.*

The above results show that the implementation of the uMWP-1 is the most economically feasible option. However, due to the looming water deficit in the system together with the risk of late delivery of the uMWP-1, other options may need to be considered in the short term.

The implementation of either or both of these alternatives will have a further substantial impact on the water tariff and also on the financial burden or borrowing capacity of eThekwini Municipality and UW depending on who is to actually implement the projects. Implementation of one of these alternatives is regarded as important for addressing the possible risk of short term water supply shortages and avoiding major water restrictions. This will further add to the strain on end users and once again the social component of the project will need to be factored in.

10 LEGISLATIVE REQUIREMENTS

10.1 ENVIRONMENTAL IMPACT ASSESSMENT

It is a statutory requirement that new infrastructure developments conform to the Environmental Conservation Act (ECA) as well as to the principles of the NEMA.

10.1.1 Environmental Screening

An environmental screening was done to investigate and analyse the different options proposed, with a view to identifying environmental “red flags” and “fatal flaws” that would render an option unsuitable and not worthy of further investigation. This would assist in determining an optimal solution and configuration for the uMWP-1, informing the EIA. Subsequently, a detailed EIA of the selected options and configuration were done in Module 2, to obtain formal environmental authorisation for the project (refer to **Section 10.1.2**).

A ***critical consideration*** in the development of the uMWP will be the damming of one of the few “undammed” rivers remaining within South Africa. Therefore, the objectives of the feasibility study and EIA were to determine whether the benefits that may be accrued from the development of the scheme as a whole significantly exceed the advantages of leaving the uMkhomazi River undammed. The EIA will assess the risk through specialist studies, such as:

- Biodiversity: Confirmation of the presence of terrestrial fauna and flora species of conservation importance, and the ecosystems that they form part of.
- Biodiversity: Consideration of impacts on the riverine and aquatic ecosystems.
- Changes to water quality and hydrology combined.
- Socio-economic issues – to both the immediate communities and the wider population of KwaZulu Natal.
- The possible occurrence of unknown heritage resources and graves.
- The exact quantification of the number of people to be displaced.
- The environmental impacts of general construction activities (e.g. increased traffic, noise and dust generation).
- Inclusion of the consideration of ancillary items such as hydropower generation at the outlet of the tunnel and linked to each of the proposed dams.

- Consideration of alternatives to optimise the size of the dams. This is a factor that will be considered in detail in the EIA process based on the outcome of the specialist / technical studies undertaken.
- And finally, the process specific consideration that the Environmental Authorisation may be appealed by the interested and affected parties even after the EIA process is carried out.

10.1.2 Environmental Impact Assessment

After the Environmental Screening, the EIA process was followed. During this process, an extensive public participation process was conducted as required by the EIA process. The EIA process milestones are shown below:

- Plan of Study for Scoping;
- Scoping Report (completed 12 November 2014);
- Plan of Study for Environmental Impact Assessment (completed 12 November 2014);
- Environmental Impact Assessment (current, to be completed by 12 July 2016);
- Environmental Authorisation (expected by 15 November 2016); and
- Environmental Management Programme (current, to be completed by 12 July 2016).

The outcomes of the EIA are completely described in the Environmental Impact Reports for both raw and potable water components (refer to **Module 2**).

10.1.3 Public Participation

A public participation programme was launched during the feasibility study as part of the EIA, Module 2 study. This programme was complemented by the workings of the Project Steering Committee (part of the Technical Study) through its stakeholders and the ongoing consultation processes on water related issues, conducted by the DWA in the KZN region and especially in parts of the project area.

The purpose of meeting with key stakeholders was to:

- Inform stakeholders about the intent to develop the uMWP and to provide them with information on the project as well as on the investigations and processes envisaged; and

- Gain the perspectives (perceptions, impressions, concerns, needs, ideas and suggestions) of stakeholders on issues that are relevant to the project.

The outcomes served to inform decisions with respect to selection of the best options and configuration for the project as well as to formulate the need for further investigations.

A concise summary of the main stakeholder issues are presented below:

- **Overall need for and desirability of the uMWP.** Although different stakeholders may have different views on what the best options would be for augmenting water supply to the Mgeni WSS, there is general consensus regarding the need for the uMWP. In fact, it is regarded as already overdue by most WSAs.
- **Construction of new dams.** There is general support by stakeholders in the project area for the construction of a new dam on the uMkhomazi River. However, there is strong argument that negative impacts should be mitigated or compensated for, and that priority must be given to the employment of local people on the project.
- **Interim measures required to relieve water shortages.** The availability of sufficient water while the uMWP is being implemented is an issue and of extreme concern to stakeholders, especially those in the drought-stricken north and south coast areas.
- **The Ecological Reserve.** The current Classification Study will soon be completed, and Smithfield Dam's EWR releases need to be confirmed and incorporated in an operating rule so that stakeholder concerns about conserving the ecology of the uMkhomazi River are addressed.
- **Community water supply.** Although this study addressed the supply of water to communities surrounding Smithfield Dam in the Harry Gwala DM at pre-feasibility level, the WSAs remain the responsible authority for community (urban and rural) water supply. The area around the dam will be included in the Bulwer-Donnybrook bulk water supply system, which may be later augmented by the Smithfield Dam.

10.2 Economics Impact Assessment

The Economics Impact Assessment aimed at providing input into the Environmental Authorisation and an economic motivation for the project.

The econometric model for the study was developed using the KZN Social Accounting Matrix (SAM) updated to 2014 figures. The SAM is a comprehensive, economy-wide database that contains information about the flow of resources between economic agents in the provincial economy. The socio-economic assessment developed considers three different types of economic impact, namely:

- **Direct impact.** This occurs when the project creates jobs and procures goods and services resulting in increased employment, production, business sales, and household income. Many of these impacts occur directly in relation to the construction.
- **Indirect impact.** This occurs when the suppliers of goods and services to the proposed project experience a larger market and the potential to expand, typically accrued to the first round of spend experienced by suppliers into the direct impact zone.
- **Induced impact.** This represents further shifts in spending on food, clothing, shelter and other consumer goods and services due to increased income in the directly and indirectly affected businesses, mainly due to impact of additional wages entering the economy.

This study (refer to the *Economic Impact Assessment report, P WMA 11/U10/00/3312/6*) concluded that the proposed uMWP-1 will have an impact on the regional and local economies during the construction (short-term) and operational and refurbishment (long-term) phases. The impact during construction is considerable, especially on the uMkhomazi Catchment, yet it is not sustainable in the long-term as the construction will only last for approximately 60 months. The operational phase (modelled for a 50-year period) has a more sustainable contribution to the domestic economy. The refurbishment phases will contribute to the overall impact during the operational phase; these are identified as discrete expenditure undertaken in single year increments over the lifespan of the assets.

The total scheme impact for the various impact assessments associated with the proposed development, modelled for a duration of 55 years and including employment opportunities[8], are summarised in **Table 10.1**.

[8] *Employment opportunities are reflected as annualised job opportunities, thus the total impact of the operational annual figures shown are multiplied out over the period measured and added to the construction and refurbishment employment opportunities.*

Table 10.1: uMWP-1 impact assessment summary

Total Impact (Capex and Opex modelled for Lifespan)				
Indicator	**Direct**	**Indirect**	**Induced**	**Total**
Production	R 33 333	R 35 644	R 17 685	R 86 661
GDP	R 7 807	R 14 355	R 8 143	R 30 305
Employment opportunities[8]	9 670	69 311	44 866	123 846
Worker Income	R 5 271	R 5 935	R 3 260	R 14 466

The analysis has shown that the development of the uMWP-1 has the potential to generate high levels of production, employment creation as well as household income. This will stimulate business and human capital development and assist in raising living standards.

Total additional production (new business sales)[9] anticipated to be generated by the project equates to R 86 661 million. Gross domestic product (GDP) is anticipated to increase by R 30 305 million.

The graph below illustrates the total employment creation of the uMWP-1 between 2018 and 2072. The start year of 2018 is illustrative, and assumes that all approvals and finance requirements are in place for the project.

[9] *Production is defined as the process in which labour and assets are used to transform inputs of goods and services into outputs of other goods and services. The impact assessment will measure the change in production expected to result from the project.*

Figure 10.1: Total job* creation during the construction, operational and refurbishment phases of uMWP-1 only

**One person employed for one year*

Employment opportunities present in the form of 4 280 direct employment opportunities related to construction and site operation. Of these, 110 annual opportunities are created in a permanent manner for the operation of the scheme, which equates to 5 500 employment opportunities generated in the operational phase of 50 years. This means that total direct employment opportunities equate to 9 670 over both construction and operation. In total 123 846 employment opportunities are generated through ***direct, indirect and induced*** activities over the ***same period***.

During each of the identified phases, on average, 87% of the direct employment will be sourced in South Africa. Only 13% of all employment will be towards core skilled personnel from outside the study area. During the infrastructure construction phase, cranes, pipes and special equipment will be manufactured within South Africa, but not necessarily in the study area. Imported tunnel boring machinery will be required. All the other construction materials will be obtained from the local region, provided that the area can supply the required materials, otherwise some materials will have to be sourced from elsewhere in the country. Local procurement will increase the positive impact associated with the proposed uMWP-1 and the following is recommended to maximise the positive economic impacts of the project:

- Use local labour and inputs as far as possible; and
- Require that appointed consulting and construction companies have a skills development plan in order, which will result in impacts that will have a long-lasting nature.

Worker income is set to increase by R 14 billion over the modelled period.

10.2.1 Economic Cost-Benefit Analysis

An Economic Cost-Benefit Analysis (ECBA) provides decision-makers with the quantitative comparison of options, through calculating the net effect. When the net effect is positive (cost of implementation is less than the benefits), it can be seen as a profitable project; i.e. by implementing the project there will be greater benefits than costs.

Table 10.2 gives the net effect in NPV and the ECBA results for the costs of the scheme's development and current price analysis based on the provided water sales figures.

Table 10.2: ECBA Current Water Values (2014 Rands) at NPV 8%

Item	Total (R million)	
Sub-total Construction Cost	R	27 014
Sub-total Operation Cost	R	29 448
Total Construction and Operation	**R**	**56 462**
Sub-total Water Sales Revenue Benefit	R	68 693
Sub-total Construction GDP Benefit	R	22 757
Sub-total Operation GDP Benefit	R	23 380
Total Construction and Operation GDP Benefit & Water Sales Revenue Benefit	**R**	**114 833**
Net Benefit (Benefit – Cost)	**R**	**58 370***

** The net effect is positive (cost of implementation is less than the benefits), therefore it can be seen as a profitable project*

10.2.2 Economic opportunity cost of water constraints due to no augmentation

A 19-year review of economic production in KZN and the supply area in specific indicates that the average economic growth rate achieved over the period equates to an approximate 3% annual increase in gross value added year on year. Obviously, the economic cycle over this period includes troughs as well as years of higher production, but the compounded annual growth rate reflects a rate of 3.31% for KZN in its totality, shown in **Table 10.3**.

Table 10.3: Economic Production Levels in Supply Area (R million, 2005 Rands)

Measurement area	Average Annual Growth Rate	Level of Economic Production				Potential foregone production
Year	**1995-2013**	**2014**	**2024**	**2034**	**2044**	**2022 - 2044**
KZN	**3.31%**	**302 451**	**419 013**	**580 497**	**804 216**	**13 227 458**
Ugu	3.48%	13 349	15 842	18 800	22 312	431 346
uMgungundlovu	2.73%	34 826	39 841	45 579	52 143	1 048 865
iLembe	2.85%	11 582	13 331	15 343	17 660	352 890
eThekwini	3.10%	159 332	185 636	216 283	251 989	4 969 341

These growth rates have been projected forward, to provide a proxy for what economic production levels could be generated on an annual basis, should all other variables (including the access to water resources) remain constant.

If 2022 is used as the critical tipping point for water scarcity in the system, then the forgone economic production, i.e. the opportunity cost to the economy from 2022 until 2044, equates to R 13.3 billion in constant 2005 year Rands.

In terms of economic impacts, this translates into forgone economic benefits to the regional economy related to the inability of the economy to produce at the average level of economic growth. These are estimated to be the following scale as shown in **Table 10.4**.

Table 10.4: Forgone Economic Benefits Calculated for the Period 2022 – 2044

	Production	Gross Geographic Product	Employment Opportunities	Income/Wages
KZN	13 227 458	1 222 866	376 055	1 717 103
Ugu	431 346	39 878	12 263	55 995
uMgungundlovu	1 048 865	96 967	29 819	136 157
iLembe	352 890	32 624	10 033	45 810
eThekwini	4 969 341	459 411	141 278	645 088

As a developing nation with substantial levels of existing unemployment evident in the catchment areas, forgoing future economic growth is not a preferred outcome for the province or the country.

This would have the consequence of forgone business sales for KZN province of R13 227 458 in 2005 Rand terms; a loss of R 1 222 866 in 2005 Rands of gross geographic production; an absolute loss of 376 055 employment opportunities over the 19-year period; and a loss of income and wages of R1 717 103 in 2005 Rands.

10.3 World Commission on Dams

Based on the findings of the World Commission on Dams' (WCD) Global Review, seven strategic priorities and related policy principles for future decision-making regarding large dams were developed. These are complemented by a set of guidelines for good practice, under the same headings as the strategic priorities.

The strategic priorities are:

- Gaining public acceptance;
- Comprehensive options assessment;
- Addressing existing dams (operating rules);
- Sustaining rivers and livelihoods;
- Recognising entitlements and sharing benefits;
- Ensuring compliance; and
- Sharing rivers for peace, development, and security.

The guidelines developed by the WCD are generally accepted by water resources practitioners worldwide and have also been reflected in South African practice for some time already.

All the strategic priorities of the WCD are well addressed with respect to the uMWP. An extensive public participation programme has been embarked upon to gain public acceptance. Comprehensive assessment of options is being performed through various studies (some of which are reflected in this report), such as the *Pre-feasibility Study*, the ongoing *KwaZulu-Natal Coastal Metropolitan Areas Reconciliation Strategy*, UW's masterplans, UW Desalination Feasibility Study, eThekwini's Re-use Feasibility Study, etc. This includes the addressing of existing dams and operating rules of the Mgeni WSS. The sustaining of rivers and livelihoods is provided for through the Reserve. All existing entitlements are fully recognised whilst socio-economic and other investigations were conducted to ensure the most beneficial use of water and sharing of benefits. Compliance after implementation will be ensured through comprehensive existing legislation. The sharing of the resource with co-basin countries, although not relevant to the uMkhomazi or uMngeni rivers, is well covered by the existing protocols and agreements to which South Africa fully complies.

10.4 OTHER RELEVANT POLICIES

10.4.1 National and provincial policy

a) New Growth Path

The New Growth Path is a statement of government's commitment to forging a developmental consensus, by identifying areas where employment creation is possible on a large scale as a result of substantial changes in South African and global conditions.

b) National Development Plan

The National Development Plan (NDP) is the 2030 vision for South Africa, through focus on the following three priorities: raising employment through faster economic growth; improving the quality of education, skills development and innovation; and building the capability of the state to play a developmental and transformative role.

c) KwaZulu-Natal Provincial Growth and Development Strategy and Plan

The KwaZulu-Natal Provincial Growth and Development Strategy and Plan (PGDS&P) provides a strategic framework for accelerated and shared economic growth through catalytic and developmental interventions. This is done within a coherent, equitable spatial development architecture, putting people first – particularly the poor and vulnerable – and building sustainable communities, livelihoods and living environments.

d) Provincial Spatial Economic Development Strategy

The Provincial Spatial Economic Development Strategy (PSEDS) provides a strategic framework, sectoral strategies and programmes aimed at a rapid improvement in the quality of life for the poorest people of the Province. It sets out to address the developmental challenges posed by these socio-economic contexts through a ten-year development plan. The PSEDS specific programmatic interventions are built around the particular nature of inequality and poverty in KZN.

e) Comprehensive Rural Development Programme

The Comprehensive Rural Development Programme (CRDP) is strategic priority number three within government's current Medium Term Strategic Framework, and was established with the aim to eliminate rural poverty and food insecurity. This would be done by maximising the use and management of natural resources to create vibrant, equitable and sustainable rural communities.

The implication of the above national and provincial informants is to be found in their prioritisation of projects such as the proposed uMWP. Provincial planning documents identify projects such as the proposed scheme as forming part of a set of critical infrastructure interventions, aimed at unlocking the province's development potential by assisting to secure water resources.

10.4.2 Municipal policy

An Integrated Development Plan (IDP) is the primary means of service delivery used by municipalities in identifying principle developmental needs and implementing actions to face these needs. eThekwini Municipality, uMgungundlovu, Ugu and Harry Gwala district municipalities' IDPs speaks to the development goals of the uMWP.

Both eThekwini and the uMgungundlovu municipalities will be directly impacted if the uMWP is not developed to augment the Mgeni WSS, and the lack of sustainable water supply will limit economic growth.

11 IMPLEMENTATION ARRANGEMENTS

11.1 IMPLEMENTATION PROGRAMME

A comprehensive project implementation programme has been developed for the uMWP-1. The purpose of the programme was to identify all the critical activities and milestones that will influence the expected date of water delivery, estimated at 2023. The programme has been divided into the different main phases of the implementation process, including:

- Departmental approvals (DWA);
- Institutional and funding;
- Environmental;
- Permits and licenses;
- Design;
- Acquiring and clearing land; and
- Construction.

The various activities and milestones within a specific implementation phase are presented in a work flow diagram. The links between the different activities and milestones from the end of the feasibility study to the end of the implementation process are shown in **Figure 11.1**. As seen in the figure, the implementation process is interconnected with various activities providing input to one another. The work flow diagram provides a visual representation of the implementation programme with various assumptions made to produce a realistic structure and timeline for the implementation process.

At the time of reporting, it was assumed that the Record of Implementation Decisions (RID) would be finalised by early 2016 and would form the basis upon which the implementation process of the project could proceed. Once the RID is finalised, the subsequent DWA approval process should be prioritised to ensure that the rest of the implementation phases are not delayed. Developing a funding strategy can only commence after Ministerial approval has been granted and the implementing agent and operator of the uMWP-1 have been appointed. A proposed framework for the institutional arrangements and funding strategy is contained in the Institutional and Financial Aspects Report (*P WMA 11/U10/00/3312/5 – Institutional and Financial Aspects Report*).

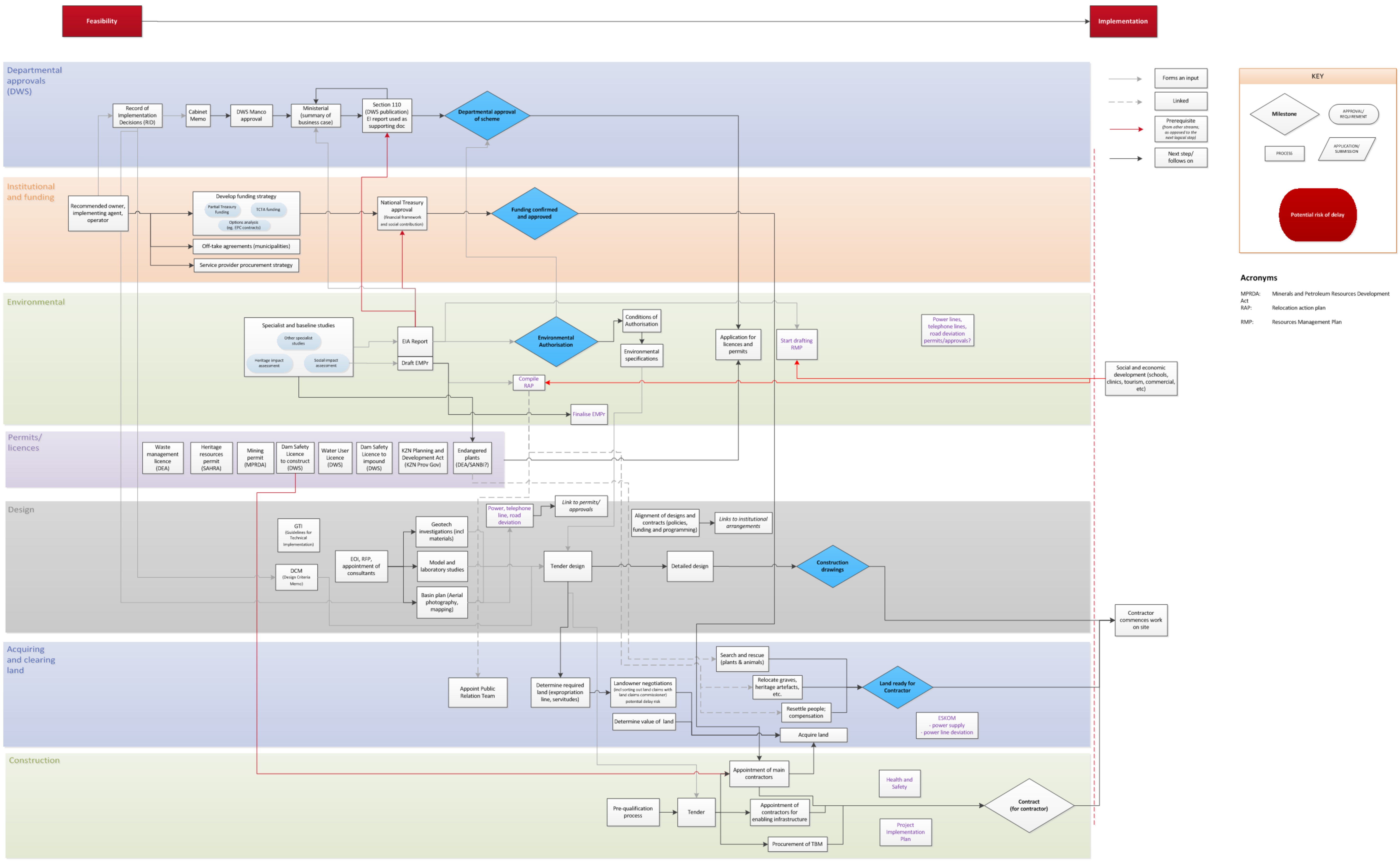


Figure 11.1: Flow chart with different implementation phases

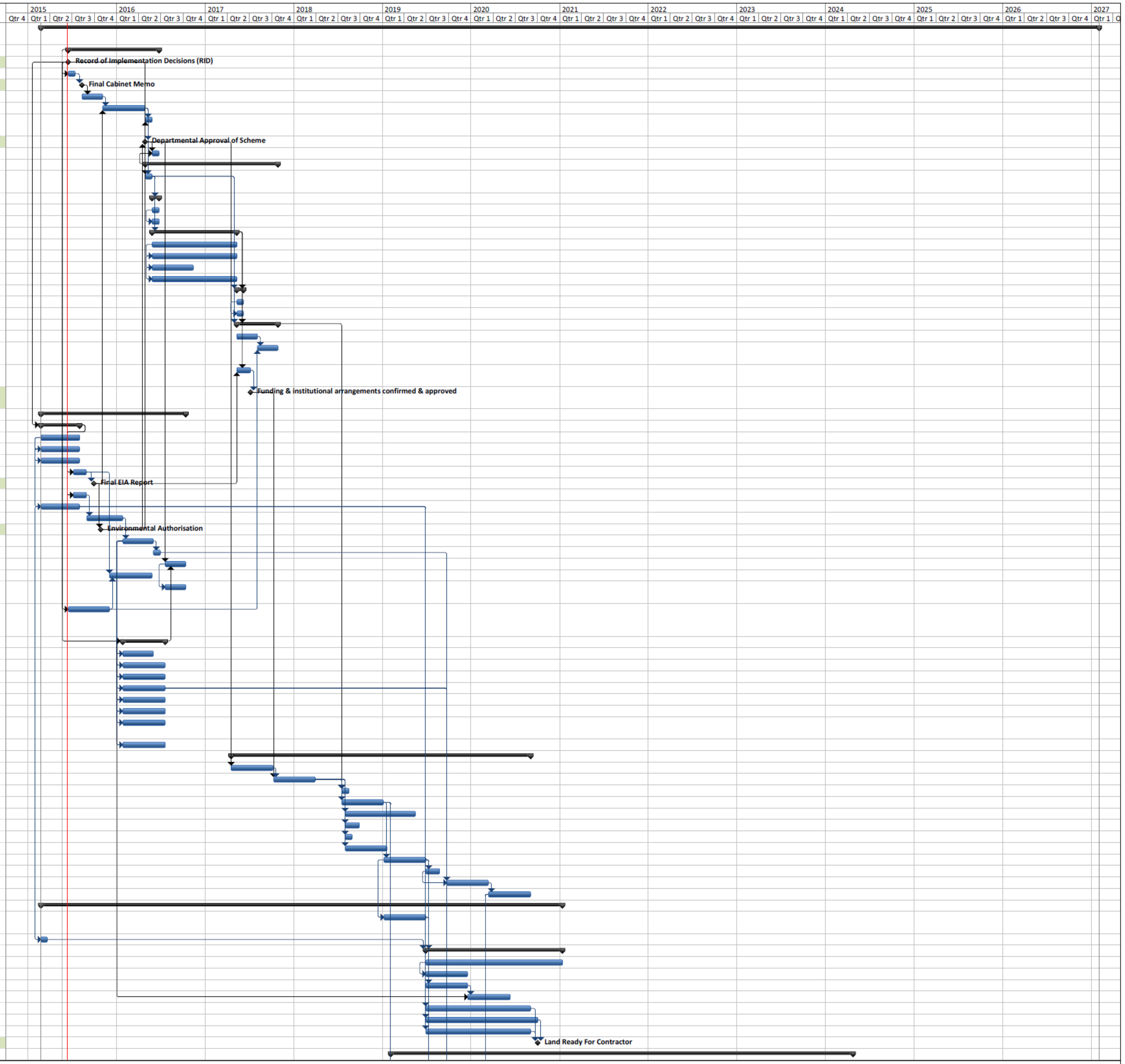
The programme shown in **Figure 11.2** is based on the departmental approval of the scheme by April 2016 and confirmation of institutional and funding arrangements by July 2017. Both these key milestone dates are dependent on the outcome of the environmental authorisation milestone in September 2015. The environmental phase comprises the detailed Environmental Impact Assessment (EIA) and EMPr (Environmental Management Programme). Any appeal or delay experienced in the process of environmental authorisation can extend the date of approval and the overall key date of water delivery. After updating the implementation programme and considering the current status of the environmental phase, water delivery is only expected in March 2024.

The proposed construction programme contained in the *Engineering Feasibility Design Report* (AECOM, et al., 2015) shows that the construction of Smithfield Dam would take approximately 4 years to complete from mobilization to impoundment. The uMkhomazi to uMlaza tunnel would also take approximately 4 years to complete, while Langa Dam would take approximately 3 years to complete from mobilization to impoundment. The construction of the tunnel is part of the critical path of the project since water delivery can only commence after the completion of the infrastructure. Therefore the procurement of the necessary infrastructure should be done in advance to ensure the expected water delivery date is achieved.

Therefore the development of the procurement strategy for the uMWP-1 needs to be prioritised so that:

- Implementation of the various components can be integrated;
- Critical tasks that have significant time implications for tasks that follow (e.g. geotechnical investigations and land acquisition processes) need to be planned, programmed and procured; and
- Appointments of PSPs may be secured.

ID	Task Mode	WBS	Task Name	Duration	Start	Finish	Predecessors
1		0	**uMkhomazi Flowchart Programme: Feasibility to Water Delivery**	**3030 days**	**Mon 15/02/23**	**Tue 27/02/02**	
2		1	**Departmental Approvals (DWS)**	**260 days**	**Mon 15/06/1**	**Thu 16/06/23**	
3		*1.1*	*Record of Implementation Decisions (RID)*	*0 days*	*Mon 15/06/1*	*Mon 15/06/1*	
4		1.2	Draft Cabinet Memo	1 mon	Mon 15/06/15	Mon 15/07/1	3SS
5		*1.3*	*Final Cabinet Memo*	*0 mons*	*Mon 15/08/1*	*Mon 15/08/1*	*4FS+1 mon*
6		1.4	DWS Manco Approval	3 mons	Tue 15/08/11	Tue 15/11/03	5
7		1.5	Ministerial (Summary of Business Case)	6 mons	Wed 15/11/04	Tue 16/04/26	6,35
8		1.6	Section 110 (DWS Publication) - EI Report used as Supporting Document	1 mon	Thu 16/04/28	Wed 16/05/25	39,7
9		*1.7*	*Departmental Approval of Scheme*	*0 days*	*Tue 16/04/26*	*Tue 16/04/26*	*7,39*
10		1.8	Expression of Interest	1 mon	Thu 16/05/26	Thu 16/06/23	9,11SS+1 mon
11		2	**Institutional & Funding**	**380 days**	**Thu 16/04/28**	**Thu 17/10/26**	
12		2.1	Implement recommendations on Owner, Implementing Agent, Operator	1 mon	Thu 16/04/28	Wed 16/05/25	3FS+15 days,7
13		2.2	**Institutional appointments**	**20 days**	**Thu 16/05/26**	**Thu 16/06/23**	**12**
14		2.2.1	Minister to direct Implementation Agent	1 mon	Thu 16/05/26	Thu 16/06/23	
15		2.2.2	Minister to appoint Operator	1 mon	Thu 16/05/26	Thu 16/06/23	14SS
16		2.3	**Develop Funding Stratgey**	**240 days**	**Thu 16/05/26**	**Tue 17/05/09**	**12**
17		2.3.1	Partial Treasury Funding	12 mons	Thu 16/05/26	Tue 17/05/09	
18		2.3.2	TCTA Funding	12 mons	Thu 16/05/26	Tue 17/05/09	17SS
19		2.3.3	Options Analysis (i.e. EPC Contracts)	6 mons	Thu 16/05/26	Fri 16/11/11	18SS
20		2.3.4	Develop bridging finance strategy	12 mons	Thu 16/05/26	Tue 17/05/09	19SS
21		2.4	**Off-take Agreements (Municipalities)**	**20 days**	**Wed 17/05/1**	**Tue 17/06/06**	**12,16**
22		2.4.1	Umgeni Water	1 mon	Wed 17/05/1	Tue 17/06/06	
23		2.4.2	Municipalities	1 mon	Wed 17/05/1	Tue 17/06/06	22SS
24		2.5	**Service Provider Procurement Strategy**	**120 days**	**Wed 17/05/1**	**Thu 17/10/26**	**12,16**
25		2.5.1	Service Providers	3 mons	Wed 17/05/1	Wed 17/08/0	
26		2.5.2	Socio-economic/ Enterprise development strategy	3 mons	Thu 17/08/03	Thu 17/10/26	25,45
27		2.6	National Treasury Approval (Financial Framework and Social Contribution)	2 mons	Wed 17/05/10	Wed 17/07/05	16,35
28		*2.7*	*Funding & institutional arrangements confirmed & approved*	*0 days*	*Wed 17/07/05*	*Wed 17/07/05*	*27*
29		3	**Environmental**	**417 days**	**Mon 15/02/2**	**Tue 16/10/11**	
30		3.1	**Specialist & Baseline Studies**	**114 days**	**Mon 15/02/2**	**Fri 15/07/31**	**3SS-4 mons**
31		3.1.1	Other Specialist Studies	114 days	Mon 15/02/2	Fri 15/07/31	
32		3.1.2	Heritage Impact Assessment	114 days	Mon 15/02/2	Fri 15/07/31	31SS
33		3.1.3	Social Impact Assessment	114 days	Mon 15/02/2	Fri 15/07/31	32SS
34		3.2	Draft EIA Report	2 mons	Mon 15/07/0	Fri 15/08/28	30FS-1 mon
35		*3.3*	*Final EIA Report*	*0 days*	*Mon 15/09/2*	*Mon 15/09/2*	*34FS+1 mon*
36		3.4	Draft EMPr	2 mons	Mon 15/07/0	Fri 15/08/28	30FS-1 mon
37		3.5	Compile Framework RAP	114 days	Mon 15/02/2	Fri 15/07/31	31SS
38		3.6	Public Review & Finalise EIA Report & EMPr	103 days	Mon 15/08/31	Mon 16/01/2	36
39		*3.7*	*Environmental Authorisation*	*0 days*	*Mon 15/10/2*	*Mon 15/10/2*	*35FS+1 mon*
40		3.8	Conditions of Authorisation	86 days	Tue 16/01/26	Mon 16/05/3	38
41		3.9	Environmental Specifications	1 mon	Tue 16/05/31	Tue 16/06/28	40
42		3.10	Application for Licences & Permits	3 mons	Tue 16/07/19	Tue 16/10/11	9,46
43		3.11	Draft RMP	6 mons	Wed 15/12/02	Wed 16/05/2	34,45
44		3.12	Power Lines, Telephone Lines, Road Deviation Permits/Approvals	3 mons	Tue 16/07/19	Tue 16/10/11	42SS
45		3.13	Social & Economical Development (Schools, Clinics, Tourism, Commercial, etc.), Spatial Development Framework	6 mons	Mon 15/06/15	Tue 15/12/01	3SS
46		4	**Permits & Licences**	**120 days**	**Tue 16/01/26**	**Mon 16/07/1**	**3SS**
47		4.1	Waste Management Licence (DEA)	86 days	Tue 16/01/26	Mon 16/05/3	40SS
48		4.2	Heritage Resources Permit (SAHRA)	6 mons	Tue 16/01/26	Mon 16/07/1	40SS
49		4.3	Mining Permit (MPRDA)	6 mons	Tue 16/01/26	Mon 16/07/1	40SS
50		4.4	Dam Safety Licence To Construct (DWS)	6 mons	Tue 16/01/26	Mon 16/07/1	49SS
51		4.5	Water User Licence (DWS)	6 mons	Tue 16/01/26	Mon 16/07/1	40SS
52		4.6	Dam Safety Licence To Impound (DWS)	6 mons	Tue 16/01/26	Mon 16/07/1	51SS
53		4.7	KZN Planning & Development Act (KZN Prov Gov)	6 mons	Tue 16/01/26	Mon 16/07/18	52SS
54		4.8	Endangered Plants (DEA/SANBI)	6 mons	Tue 16/01/26	Mon 16/07/1	40SS
55		5	**Design**	**855 days**	**Mon 17/04/1**	**Wed 20/09/0**	
56		5.1	Guidelines for Technical Implementation (GTI)	6 mons	Mon 17/04/17	Thu 17/10/05	9
57		5.4	RFP, Appointment of Consultants	6 mons	*Mon 17/10/0*	Thu 18/03/29	28,56
58		5.3	Alignment of Designs & Contracts	1 mon	Tue 18/07/17	Tue 18/08/14	24,57
59		5.2	Design Criteria Memorandum	6 mons	Tue 18/07/17	Fri 19/01/04	57
60		5.5	Geotechnical & Materials Investigations	10 mons	Tue 18/07/31	Thu 19/05/16	57FS+2 wks
61		5.6	Model & Laboratory Studies	2 mons	Tue 18/07/31	Wed 18/09/2	57FS+2 wks
62		5.7	Basin Plan (Arial Photography & Mapping)	1 mon	Tue 18/07/31	Tue 18/08/28	57FS+2 wks
63		5.8	Road, Power & Telephone Lines Deviation	6 mons	Tue 18/07/31	Fri 19/01/18	57FS+2 wks
64		5.9	Tender Design	6 mons	Mon 19/01/07	Thu 19/06/27	59
65		5.10	Tender documentation	2 mons	Fri 19/06/28	Fri 19/08/23	64
66		5.11	Detailed Design	6 mons	Mon 19/09/2	Thu 20/03/12	41,65SS+3 mons
67		5.12	Construction Drawings	6 mons	Fri 20/03/13	Wed 20/09/0	66
68		6	**Acquiring & Clearing of Land**	**1490 days**	**Mon 15/02/2**	**Mon 21/01/1**	
69		6.1	Determine Required Land (Expropriation, Line, Servitudes)	6 mons	Mon 19/01/07	Thu 19/06/27	64SS
70		6.2	Appoint Public Relation Team	1 mon	Mon 15/02/2	Fri 15/03/20	37SS
71		6.3	**Land Owner Negotiations**	**390 days**	**Fri 19/06/28**	**Mon 21/01/1**	**69,70**
72		6.3.1	Interaction With Land Claims Commissioner	390 days	Fri 19/06/28	Mon 21/01/11	
73		6.3.2	Determine Value of Land	6 mons	Fri 19/06/28	Tue 19/12/17	72SS
74		6.3.3	Acquisition of Land	6 mons	Fri 19/06/28	Tue 19/12/17	69
75		6.3.4	Search & Rescue (Fauna & Flora)	6 mons	Wed 19/12/1	Tue 20/06/09	46SS+1 mon,74
76		6.3.5	Relocation of Graves & Heritage Artefacts	300 days	Fri 19/06/28	Wed 20/09/0	37
77		6.3.6	Resettlement of People & Compensation	320 days	Fri 19/06/28	Thu 20/10/01	37
78		6.3.7	Eskom (Power Supply & Line Deviation)	300 days	Fri 19/06/28	Wed 20/09/0	37
79		*6.4*	*Land Ready For Contractor*	*0 days*	*Thu 20/10/01*	*Thu 20/10/01*	*77,76,78*
80		7	**uMWP Construction Phase**	**1319 days**	**Mon 19/02/0**	**Tue 24/04/23**	



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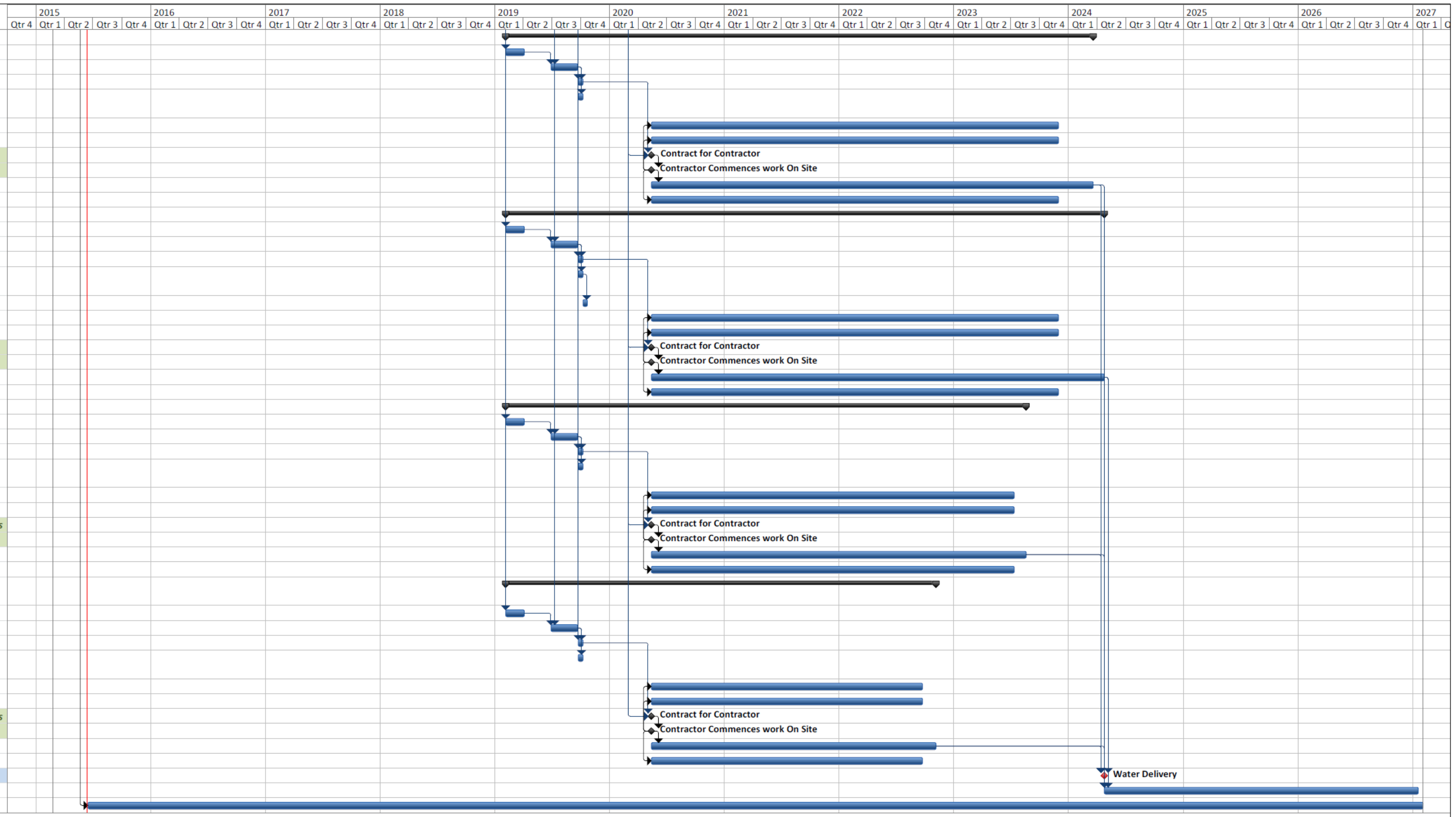
Task | Split | Milestone | Summary | Project Summary | External Tasks | External Milestone | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | Deadline | Progress

Figure 11.2: Implementation programme for uMWP-1

ID	Task Mode	WBS	Task Name	Duration	Start	Finish	Predecessors
81		**7.1**	**Construction of Smithfield Dam**	**1297 days**	**Mon 19/02/04**	**Tue 24/03/19**	
82		7.1.1	Pre-qualification Process	2 mons	Mon 19/02/04	Wed 19/04/03	59FS+1 mon
83		7.1.2	Tender	3 mons	Fri 19/06/28	Fri 19/09/20	64,82
84		7.1.3	Appointment of Main Contractor	10 days	Mon 19/09/23	Mon 19/10/07	50,83
85		7.1.4	Appointment of Contractors for Enabling Infrastructure	10 days	Mon 19/09/23	Mon 19/10/07	83
86		7.1.5	Health & Safety	900 days	Wed 20/05/13	Wed 23/11/29	89SS
87		7.1.6	Project Implementation Plan (PIP)	900 days	Wed 20/05/13	Wed 23/11/29	89SS
88		*7.1.7*	*Contract for Contractor*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*84,67SS+2 mons*
89		*7.1.8*	*Contractor Commences work On Site*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*88*
90		7.1.9	Construction period	977 days	Wed 20/05/13	Tue 24/03/19	89
91		7.1.10	Performance Certificate	900 days	Wed 20/05/13	Wed 23/11/29	89SS
92		**7.2**	**Construction of Conveyance System**	**1319 days**	**Mon 19/02/04**	**Tue 24/04/23**	
93		7.2.1	Pre-qualification Process	2 mons	Mon 19/02/04	Wed 19/04/03	59FS+1 mon
94		7.2.2	Tender	3 mons	Fri 19/06/28	Fri 19/09/20	93,64
95		7.2.3	Appointment of Main Contractor	10 days	Mon 19/09/23	Mon 19/10/07	94,50
96		7.2.4	Appointment of Contractors for Enabling Infrastructure	10 days	Mon 19/09/23	Mon 19/10/07	94
97		7.2.5	Procurement of TBM	10 days	Tue 19/10/08	Mon 19/10/21	96
98		7.2.6	Health & Safety	900 days	Wed 20/05/13	Wed 23/11/29	101SS
99		7.2.7	Project Implementation Plan (PIP)	900 days	Wed 20/05/13	Wed 23/11/29	101SS
100		*7.2.8*	*Contract for Contractor*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*95,67SS+2 mons*
101		*7.2.9*	*Contractor Commences work On Site*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*100*
102		7.2.10	Construction period	999 days	Wed 20/05/13	Tue 24/04/23	101
103		7.2.11	Performance Certificate	900 days	Wed 20/05/13	Wed 23/11/29	101SS
104		**7.3**	**Construction of Langa Dam**	**1147 days**	**Mon 19/02/04**	**Fri 23/08/18**	
105		7.3.1	Pre-qualification Process	2 mons	Mon 19/02/04	Wed 19/04/03	59FS+1 mon
106		7.3.2	Tender	3 mons	Fri 19/06/28	Fri 19/09/20	105,64
107		7.3.3	Appointment of Main Contractor	10 days	Mon 19/09/23	Mon 19/10/07	106,50
108		7.3.4	Appointment of Contractors for Enabling Infrastructure	10 days	Mon 19/09/23	Mon 19/10/07	106
109		7.3.5	Health & Safety	800 days	Wed 20/05/13	Tue 23/07/11	112SS
110		7.3.6	Project Implementation Plan (PIP)	800 days	Wed 20/05/13	Tue 23/07/11	112SS
111		*7.3.7*	*Contract for Contractor*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*107,67SS+2 mons*
112		*7.3.8*	*Contractor Commences work On Site*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*111*
113		7.3.9	Construction period	827 days	Wed 20/05/13	Fri 23/08/18	112
114		7.3.10	Performance Certificate	800 days	Wed 20/05/13	Tue 23/07/11	112SS
115		**7.4**	**Construction of uMlazi Water Treatmentplant Pipeline**	**951 days**	**Mon 19/02/04**	**Fri 22/11/04**	
116		7.4.1	Pre-qualification Process	2 mons	Mon 19/02/04	Wed 19/04/03	59FS+1 mon
117		7.4.2	Tender	3 mons	Fri 19/06/28	Fri 19/09/20	64,116
118		7.4.3	Appointment of Main Contractor	10 days	Mon 19/09/23	Mon 19/10/07	50,117
119		7.4.4	Appointment of Contractors for Enabling Infrastructure	10 days	Mon 19/09/23	Mon 19/10/07	117
120		7.4.5	Health & Safety	600 days	Wed 20/05/13	Thu 22/09/22	123SS
121		7.4.6	Project Implementation Plan (PIP)	600 days	Wed 20/05/13	Thu 22/09/22	123SS
122		*7.4.7*	*Contract for Contractor*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*118,67SS+2 mons*
123		*7.4.8*	*Contractor Commences work On Site*	*0 days*	*Tue 20/05/12*	*Tue 20/05/12*	*122*
124		7.4.9	Construction period	631 days	Wed 20/05/13	Fri 22/11/04	123
125		7.4.10	Performance Certificate	600 days	Wed 20/05/13	Thu 22/09/22	123SS
126		***8***	***Water Delivery***	***0 days***	***Tue 24/04/23***	***Tue 24/04/23***	***90,102,113,124***
127		9	Operation & Maintenance	700 days	Wed 24/04/24	Mon 27/01/18	90,102,113,124
128		10	River Monitoring System	2950 days	Mon 15/06/15	Tue 27/02/02	2SS



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Task		Milestone	◆	Project Summary		External Milestone	◆	Inactive Milestone	◇	Manual Task	
Split		Summary		External Tasks		Inactive Task		Inactive Summary		Duration-only	

Manual Summary Rollup		Start-only	[	Deadline	
Manual Summary		Finish-only	]	Progress	

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Figure 11.3: Implementation programme for uMWP-1 (continued)

The time-intensive activities – including DWA decision-making and approvals, environmental authorisations and funding arrangements – must be prioritised in the roll out of the implementation programme.

According to the implementation programme, taking all the decision-making and implementation activities into consideration, the expected date of water delivery is only in 2024. In the *Water Resources Yield Assessment Report* (AECOM, et al., 2014), the results show a deficit from 2016 up to the earliest expected date of water delivery from uMWP-1, if it is implemented. A further deficit of approximately 10 million m³/a will be the resultant of water delivery only starting in 2024. If the projected date of water delivery is to be achieved, the implementation process of the uMWP-1 should be seen as of critical importance to the assurance of water supply to the Mgeni WSS.

11.2 RISK REGISTER

A Risk Register was developed for both the study level and the implementation level of the uMWP-1 to reflect the rating of potential risks and mitigation measures for various activities. The Risk Register includes the potential risk involved with each activity, the cause of the potential risk, the impact on the project's implementation process and the possible mitigation measures. The activities for the feasibility level and implementation level included activities related to project management (PM), financial (Fin), environmental (Env), water resources (WR), technical (Tech) and implementation (Imp). A risk rating was derived from the extent of the impact and the likelihood of the risk occurring. The Risk Register is shown in **Figure 11.4**.

uMkhomazi Water Project Phase 1 Module 1: Technical Feasibility Study: Raw Water - RISK ASSESSMENT AND MANAGEMENT MEASURES

Ref	Issue	Cause	Impact	Inherent Risk: Impact	Inherent Risk: Likelihood	Inherent Risk: Rating	Mitigation measures	Status	Action Plan / Comments
	Study level assessment								
Env002	EMP for the geotechnical investigation delayed	The EMP delays the geotechnical investigation	The geotechnical investigation is on the critical path so the impact on the completion of the project is major	5	0	0	Timely submission of the EMP to DWS for approval	AECOM is busy with the compilation of the EMP for submission to DWS The geotechnical investigation is due to start April '12	
Env001	Delay in the completion of the EIA	Late appointment of the EAP Unforeseen specialist studies	The EAP is appointed late, the EIA is completed after the Feasibility study and impacts cannot be incorporated into the report and the FS PSP cannot support the EAP	4	0	0	DWS to expedite the appointment of the EAP. VO to be approved at a later stage for the FS PSP to further support the EAP and to incorporate key EIA findings into the Study reports	EAP has been appointed Scoping to start soon	Programme set up. Started with discussions with DEA
Env003	EIA appointment and programme	Delay in the EIA has impact on study and implementation programmes	Delay in the EIA has impact on implementation programme and AECOM may not be still under contract for management of the EIA	4	4	16	DWS to manage the programme for the service provider	AECOM's contract has been extended to assist EIA	
Env004	DEA processes and requirements	DEA may decide that an EIA and authorisation is required for the geotechnical investigation	The EIA to secure an authorisation will significantly delay the programme	4	0	0	AECOM has studied NEMA an believes that an EMPr is adequate. DWS has been requested to liaise with DEA on the matter to confirm	DWS to liaise to DEA to confirm that the EMPr is adequate	
Env005	ECO monitor geotechnical investigation	Listed activities triggered during geotechnical investigation	If listed activity is triggered, apply for it through Basic Assessment. Also, probable Section 24G fine	5	0	0	Discuss with DEA. Put Rehabilitation programme in place. Weekly ECO visits. Instruct contractor to avoid listed activities	Discussion with DEA on 20 Feb 2013. Contractor is busy with Rehabilitation under guidance of ECO	All actions completed and signed off
Fin001	Inadequate budget for the geotechnical investigation	The provisions in the budget for the geotechnical investigation are inadequate	A lower level geotechnical investigation is completed for the dam and tunnel raising doubts about the findings (especially costs) in the feasibility study	4	0	0	DWS to provide for additional budget through a VO	DWS to provide for additional budget through a VO	Motivation has been by AECOM to DWS DBAC or approval
Env006	EIA programme - specialist studies & submission of EIR	Delay in the EIA has impact on environmental authorisation and project approval	Delay in environmental authorisation may delay the project implementation and subsequently delivery of water	5	4	20	DWS to actively manage the programme together with the service provider	Specialist studies on hold after community hindered the socio-impact survey.	Meeting with community leaders. To be followed up with 2nd round of meetings & formal support by community leaders and Harry Gwala DM
Env007	DEA processes and requirements	DEA delay authorisation	The EIA to secure an authorisation will significantly delay the programme	4	4	16	AECOM has studied NEMA and believes that an EMPr is adequate. DWS has been requested to liaise with DEA on the matter to confirm	DWS to liaise to DEA to confirm that the EMPr is adequate	
Fin002	Feasibility study task budgets inadequate	Scope of work (breadth or intensity) grows and the budget is inadequate for completion of the task to the quality standards required or expected	Budget is inadequate for completion of the task to the quality standards required or expected	4	0	0	Monitor progress and inform the Client and stakeholders regarding any variations on the scope of work	1 year into project, some tasks overspend for various reasons.	Monitor progress against programme and keep all stakeholders well informed. A record of scope changes are kept. VO motivated for more funds and extension of time Re-allocation of budget between tasks and disbursements
PM001	Delay in the potable water feasibility study	Umgeni Water is late in appointing service providers for the potable water feasibility study	The bulk water supply scheme is completed ahead of the potable water scheme and additional resources cannot be distributed	5	0	0	Close liaison between DWS and UW to ensure that the potable water feasibility study is started on time	ToR to be approved internally by Umgeni Water	Umgeni Water to provide update
PM002	Project completion delay	Delays in the completion of tasks on the critical path delays the completion of the project	Delay in the completion of the feasibility study directly delays the implementation of the bulk water scheme which has a major impact on water supply in the region	5	1	5	Very tight management of the programme and progress on tasks under the feasibility study. Tasks outside of the study must be monitored and responsible parties prompted to expedite progress.	Project is 95% complete, and most deliverables submitted.	Monitor progress against programme and keep all stakeholders well informed

Figure 11.4: Risk register for study level and implementation level of the uMWP-1

Ref	Issue	Cause	Impact	Inherent Risk			Mitigation measures	Status	Action Plan / Comments
				Impact	Likelihood	Rating			
PM003	Sub-consultants delays	Sub-consultants do not perform as expected and cannot delivery quality deliverables on time	Delay in the completion of the feasibility study directly delays the implementation of the bulk water scheme which has a major impact on water supply in the region	5	0	0	Very tight management of the programme and progress on tasks of sub-consultants, although they are not on the critical path and the work flow is more relevant to AECOM own staff.	Project is still at an early stage and no critical issues at the moment	Monitor progress against programme and keep all stakeholders well informed
PM004	Quality of deliverables	Quality of deliverables is substandard and the Client cannot approve/ sign off of deliverables which delays the project	Delay in the completion of the feasibility study directly delays the implementation of the bulk water scheme which has a major impact on water supply in the region	2	1	2	Very tight management of the quality of deliverables to meet the expectations of the Client on time and within budget	Most deliverables submitted - quality at high standard	Monitor progress against programme and keep all stakeholders well informed
PM005	Loss of key staff on the project	Key staff on the project resign or are moved to other commitments	Delays in completing tasks and quality impacted upon	1	1	1	AECOM to monitor staff commitments and future plans and to provide for contingency measures should there be key staff changes	Key staff completed relevant tasks	No critical areas evident at present. The loss of Andriette had an impact on the deliverables
PM006	DWS study decision making	Delays in decision making on administrative matters and deliverables	There is little lag time / slack or provision for long decision and approval periods in the programme following the shortening of the programme period from 5 to 3 years and therefore most activities are critical. Any delays will delay the completion of the study project and therefore implementation.	2	2	4	AECOM to regularly remind DWS of outstanding items and decisions but DWS to also address internal procedures to avoid delays.	Most decisions done. Finalisation of final deliverables.	Several reports still to be finalise, mostly due to long comment periods with client, and change in signatures
PM007	HR Capacity	Work overload for key resources on the project.	Targets / deadlines are not met with knock on effect on the programme and end dates and also possible impacts on quality of work	1	2	2	Careful management of resources of AECOM and proactive inclusion of additional resources as needed	Finalisation	As noted above
PP001	Non-involvement of key stakeholders	Key stakeholders are invited to participate in the project through the PSC etc. but do not participate	Lack of transparency in decision making and direction to the project and broader stakeholders are not informed. Stakeholders resistance can delay the project	5	4	20	The public relations person on the project is to initiate and maintain good contact with the stakeholders to ensure their participation	Regular PSC meetings were held. All key stakeholders were invited, and all attended at least one of the meetings	Bongi Shinga to participate in the PMC meetings. Making contact with key persons. Municipalities lately attended PSC and other meetings. Keep inviting the relevant stakeholders
Tech001	Assessment of alternatives	Information for alternatives e.g. Water re-use and desalinisation to be available for the study	If information on alternatives is not available on time, a comparison of alternatives is not possible under the raw water study. Information will therefore not be available for decision makes and appeals against implementation proposals may be lodged later delaying the project.	1	0	0	Liaison between DWS and UW and EThekwini us crucial	Issues to be raised in the PMC and PSC	From recon strat, desal and re-use not alternatives to uMWP. Conclude in DWS memo
Tech002	Non-agreement on water requirement projection to be supplied from Smithfield Dam in future	No/delayed decision on which water requirement projection curve to use	Delay on the engineering investigation task	1	0	0	AECOM to continue with Umgeni Water requirement curve for a first optimisation, to be concluded and finalised during the second optimisation stage. Sensitivity analyses to be carried out for higher requirements (1m3/s higher)	Currently hasn't resulted in any delays but are critical on the way forward	Umgeni Water/DWS to provide required water demand curve as soon as possible. Water requirements sorted
Tech003	Inadequate results from materials investigation	Quality and quantity of materials on site inadequate	Import materials Increase cost of dam	4	0	0	Find commercial sources Re-assess dam type	Material investigation in process	Completed
Tech004	Foundations of balancing dam	Foundations of selected balancing dam not suitable	Can't build balancing dam on selected site, high cost of balancing dam Impact on scheme layout	4	0	0	Find alternative site for balancing dam Re-assess scheme layout Optimise scheme	Drilling to start soon	Task completed
Tech005	Labour unrest at site during geotechnical investigation	Different land claimants of dam site	Delay in investigations, Additional cost of investigations	5	0	0	PR, Bongi Shinga to discuss issues with stakeholders	Currently calm	Sorted

Figure 11.4: Risk register for study level and implementation level of the uMWP-1 (continued)

Ref	Issue	Cause	Impact	Inherent Risk Impact	Inherent Risk Likelihood	Inherent Risk Rating	Mitigation measures	Status	Action Plan / Comments
WR001	Reserve determination	Delay in the provision of final reserve determination could delay optimization	Work is delayed or the preliminary reserve determination must be adopted for optimization. Final reserve to be included in final design capacities	4	3	12	DWS to manage the programme for the service provider. Conservative Reserve figures used in feasibility design. To be included in final design.		Use current Reserve values to finalise yields. New Reserve values to be taken into account during final design. Meet with RDM regarding Langa dam EWR
WR002	Operating rules and implementation of Reserve	Design of operating rules and development of Reserve	Outlet structure to be designed for final Reserve figures, together with operating rules	3	4	12	DWS to manage the programme for the service provider. Early design of operating rules based on Reserve implementation scenarios	Reserve study commenced	

Critical/ high risk — Significant / moderate risk — Low risk

Ref	Issue	Cause	Impact	Inherent Risk Impact	Inherent Risk Likelihood	Inherent Risk Rating	Mitigation measures	Status	Action Plan / Comments
	Implementation level assessment								
Imp001	Sign off of RID	Delay in agreements between NWRP & NWRI	Delay in implementation actions	5	4	20	Timely submission of RID for DWS approval	Draft RID has been submitted for review	
Imp002	DWS Manco approval	Delay in project approval by DWS Manco	Delay in implementation actions	5	4	20	Draft memorandum with project information and need to MANCO before completion of studies	In Process	
Imp003	Ministerial Approval of Business Case	The submission or the Ministerial approval of the business case is delayed	Delay in the project and supply of water to the region	5	4	20	Submit a Summary of Business Case to Minister for approval	In Process	DWS PM (Kobus Bester) to submit document to Minister
Imp004	NWA Section 110 approval	Await DWS approval, and supporting EIA information	Delay in the project and supply of water to the region	3	3	9	Prepare NWA S110 submission timeously to be submitted soon after approval	Not started, although EIA process 70% completed	
Imp005	Cabinet approval of the project for implementation	The implementation of the project is delayed due to a slow approval process	Delay in the project and supply of water to the region	5	5	25	DWS to approve and submit in time relevant documentation to promote Cabinet approval	Not started	Submit evidence to fast-track project
Imp006	Appointment of Implementing Agent/ Owner/Operator	The appointment of the Implementing Agent, Owner and Operator is delayed	Delay in the project and supply of water to the region	5	4	20	Appoint PSP (either Project Management or Design Consultant) ASAP. Structure project management through to implementation stage. Consider RID as guidance to appoint implementing agent.	Not started	
Imp007	Develop funding strategy for the project	Funding for the project is not secured in time for soonest implementation of the project	Delay in the project and supply of water to the region	5	4	20	Appoint Implementing ASAP. DWS to manage the process together with the Implementing Agent	Preliminary funding options have been identified in RID	
Imp008	Off-take agreements with Municipalities	The Implementing Agent/Client has slow process for reaching final off-take agreements with Local Municipalities	Delay in obtaining funding, and delay in the project and supply of water to the region	5	5	25	DWS to inform WSAs and discuss off-take agreements with WSA's after project approval	Started with informative discussions with municipalities	Meetings have been held to discuss tariffs with relevant municipalities
Imp009	Procurement of service providers	The Implementing Agent/Client has slow process for the procurement of service providers which delays implementation	Delay in the project and supply of water to the region	5	4	20	Structure project management through to implementation stage. IA to draft TOR for design PSP	Not started	
Imp010	Environmental aspects	The environmental processes delay implementation	Delay in the project and supply of water to the region	5	5	25	DWS to manage the programme. Structure project management through to implementation stage.	AECOM is in the process of providing support to the EIA PSP	
Env008	Draft EMPr	Delay in the EIA has impact on environmental authorisation and project approval	Delay in environmental authorisation may delay the project implementation and subsequently delivery of water	4	4	16	DWS to manage EIA PSP for soonest authorisation.	Not started	

Figure 11.4: Risk register for study level and implementation level of the uMWP-1 (continued)

Ref	Issue	Cause	Impact	Inherent Risk			Mitigation measures	Status	Action Plan / Comments
				Impact	Likelihood	Rating			
Env009	Finalise EMPr	Delay in the EIA has impact on environmental authorisation and project approval	Delay in environmental authorisation may delay the project implementation and subsequently delivery of water	3	4	12	EIA PSP to prepare draft EMPr as part of EIA	In Process	
Env010	Compile Relocation Action Plan (RAP)	The environmental processes delay implementation	Delay in the project and supply of water to the region	3	4	12	DWS with support from EIA PSP to identify I&AP and liaise with I&AP on RAP. Relocation to start ASAP with construction activities	Initial discussions started	Meeting with municipalities on Resettlement Plan
Env011	Environmental Authorization: appeals	I&AP appeals	Appeals of the environmental authorisation will significantly delay the programme	5	5	25	The DWS with support of the EIA PSP to anticipate possible appeals, and possible appellants	Detail public participation, also several discussions with key stakeholders	
Env012	Application for Waste Management Licence	Delay in the processing of the application has impact on environmental authorisation	May delay the project construction and subsequently delivery of water	4	4	16	Timely submission of Waste Management Licence to prevent a delay in the construction activities	Preparative work started as part of EIA	
Env013	Application for Heritage Resource Permit	Delay in the processing of the application has impact on environmental authorisation	May delay the project construction and subsequently delivery of water	4	4	16	Timely submission to prevent a delay in the construction activities	Preparative work started as part of EIA	
Env014	Application for Mining Permit	Delay in the processing of the application has impact on environmental authorisation	May delay the project construction and subsequently delivery of water	4	4	16	Timely submission to prevent a delay in the construction activities	Preparative work started as part of EIA	
Env015	Application for Dam Safety Licence to Construct and Impound	Delay in the processing of the application has impact on construction and impoundment	May delay the project construction and subsequently delivery of water	4	4	16	Timely submission to prevent a delay in the construction activities	Not started	
Env016	Application for Water User Licence	Delay in the processing of the application has impact on construction and impoundment	May delay the project construction and subsequently delivery of water	4	4	16	Timely submission to prevent a delay in the construction activities	Preparative work started as part of EIA	
Env017	KZN Planning and Development Act approval	Delay in the processing of the application has impact on environmental authorisation	Delay in environmental authorisation may delay the project implementation and subsequently delivery of water	4	4	16	Timely submission to prevent a delay in the implementation	Not started	
Imp011	Request for Proposal (RfP) for appointment of Consultant for Implementation Phase	The appointment of consultant for the implementation phase is delayed	Delay in detail design, and subsequently construction and delivery of water	5	5	25	IA to actively manage appointment of design PSP for the implementation phase. Prepare draft RfP	Not started	
Imp012	Integration of the Raw Water and Potable Water contracts (policies, funding and programming)	Implementation of the different components of the bulk water supply project are not coordinated / integrated with the resultant possible lag between water availability and delivery.	Additional costs and delay in delivery of water to the end user	5	4	20	Careful planning and management between the various stakeholders, DWS, UW and implementing agents, through Project Management Committee	Not started	
Imp013	Design Criteria Memorandum	Design standards are not produced in time for implementation phase	Detail design phase is delayed, subsequently construction and water delivery	5	5	25	Appointed PSP to start immediately after appointment with DCM	Not started	
Imp014	Geotechnical and material investigations	Delay in the appointment of geotechnical PSP	Detail design phase is delayed, subsequently construction and water delivery	5	3	15	Timely appointment of Geotechnical PSP by DWS or IA. May consider separate appointment of Geotechnical Team prior to appointment of design PSP. Extend project management through to implementation stage.	Not started	
Imp015	Basin Plan (aerial survey)	Delay in the appointment of surveying PSP	Detail design phase is delayed, subsequently construction and water delivery	4	3	12	DWS or IA to obtain basin survey as soon as project is approved.	Not started	
Imp016	ESKOM HV as well as MV voltage lines running through the impoundment area of Smithfield Dam	Eskom processes too slow to address	Delay in construction, and subsequently impoundment and delivery of water	5	4	20	DWS to liaise with ESKOM ASAP, then to formalise application after project approval	Initial discussions started	
Imp017	Deviation of roads surrounding dam sites	Department of Transport delays the approval of the deviation of roads	Delay in construction, and subsequently impoundment and delivery of water	5	3	15	DWS to liaise with Department of Transport on deviation options	Initial discussions started	

Figure 11.4: Risk register for study level and implementation level of the uMWP-1 (continued)

Ref	Issue	Cause	Impact	Inherent Risk Impact	Inherent Risk Likelihood	Inherent Risk Rating	Mitigation measures	Status	Action Plan / Comments
Imp018	Tender Design	The PSP appointed for tender design phase is slow to produce designs	Delay in construction, and subsequently impoundment and delivery of water	5	3	15	IA to actively manage PSP programme	Not started	
Imp019	Determine land required (expropriation line, servitudes)	The land required for construction is not identified in time	Delay in construction, and subsequently impoundment and delivery of water	4	3	12	Define land requirements soon after project approval. Appoint Land Surveyor to manage process	Initial expropriation line and servitudes identified during Feasibility Study	
Imp020	Land Owner negotiations (sorting out land claims)	Land claims of selected sites not yet addressed	Delay in construction, and subsequently impoundment and delivery of water	5	5	25	Careful planning and management between Department Land Affairs, Land Claim Commissioner and stakeholders. PR team to be closely involved	Current landowners identified, and involved in EIA public participation	
Imp021	Procurement of contractors	The procurement of contractors is delayed	Delay in construction, and subsequently impoundment and delivery of water	5	3	15	Effective project management, together with severe incentives / penalties	Not started	
Imp022	Acquiring of land	Land owners resist and delay the resettlement process	Delay in construction, and subsequently impoundment and delivery of water	5	5	25	Careful planning and management between Department Land Affairs, Land Claim Commissioner and stakeholders. PR team to be closely involved	Not started	
Imp023	Availability of electricity and other services to the Smithfield Dam site	Eskom processes too slow to address	Delay in impoundment and delivery of water	5	3	15	Contractor to provide standby generator	Initial discussions started	
Imp024	Labour unrest on site	Land claims of selected sites not yet addressed Job opportunities created during construction	Delay in the project. Additional cost	5	4	20	Careful planning and management between IA, RE, Contractor, Department of Labour and stakeholders. PR team to be closely involved.	Not started	
Imp025	Implement RAP	Stakeholders resist the implementation process	Delay in construction, and subsequently impoundment and delivery of water	4	4	16		Not started	
Imp026	Procurement of TBM	Transporting of the TBM is delayed	Critical path item	5	3	15	DWS with support from Implementing Agent to ensure that resources and funding are available for the procurement of TBM	Not started	
Imp027	Start of Construction	Construction phase is slow to start	Delay in construction, and subsequently impoundment and delivery of water	4	3	12	Structure project management through to implementation stage	Not started	
Imp028	Public Relations Team	A fast track dam development maybe contentious, and any protest/disputes/discontent may delay the project.	Delay in project implementation and delivery of water	5	5	25	Appointment of solid PR team (with specific reference to Ms Bongi Shinga), with regular liaison and meetings with key stakeholders, including the Traditional Leaders around Smithfield Dam.	Not started	
Imp029	DWS Human Resource Capacity to manage and initiate project	inadequate DWS human resources will cause delay in implementation	Delay in project implementation and delivery of water	5	5	25	Appoint Project Management PSP or early appointment of Design PSP to also support DWS	Not started	
Imp030	Project Scope	Clearly define Scope for IA as discussed in RID	Cost overrun	4	3	12	Effective project management by DWS & IA	Not started	
Imp031	Cost overruns	Clearly define Scope for IA, and track cost	Expensive project that may not be affordable by users.	5	3	15	Effective project management by DWS & IA	Not started	
Imp032	Technical Quality Management	poor workmanship	Sub standard workmanship, that may delay delivery of water or even cause dam safety issues	4	2	8	use international best practices, also define in DWS design guidelines	Not started	
Imp033	Public acceptance of the overall project	Public opposing the implementation of the project due to conflicting issues	Delay in project implementation and delivery of water	5	2	10	DWS with support from PR team (with specific reference to Ms Bongi Shinga) to ensure key stakeholders and public are notified and informed about the uMWP to ensure public acceptance	A number of public meetings have been held with various municipalities in the Study Area to discuss details regarding the uMWP	

Figure 11.4: Risk register for study level and implementation level of the uMWP-1 (continued)

12 SUMMARY AND CONCLUSIONS

Based on the results of the uMWP Technical Feasibility Study the following consolidated **high level conclusions** are made for the uMWP, comprising both the DWA raw water and UW bulk potable water infrastructures.

12.1 WATER AVAILABILITY AND RESOURCES

- The current resources of the Mgeni WSS, comprising Nagle, Midmar, Albert Falls and Inanda dams, augmented by Spring Grove Dam, are insufficient to supply water to the integrated Mgeni WSS's area beyond 2016.
- Future water requirements supplied by the integrated Mgeni WSS are estimated to grow at 1.5%/a to about 600 million m^3/a in 2040.
- Due to the expected high growth in water requirements, interventions such as desalination or re-use would not provide sufficient water, and therefore augmentation from the uMkhomazi River is the only feasible long-term alternative.
- The integrated Mgeni WSS supplies water to eThekwini and Msunduzi municipalities, and part of iLembe, Ugu and uMgungundlovu municipalities, equalling about 5 million users.
- About 62% of the population earns below the poverty line, and this has implications for recovery on infrastructure cost.
- The uMkhomazi River has a natural runoff of 1 078 million m^3/a. This is sufficient water to augment the Mgeni WSS, as well as to provide long-term local water requirements of 192 million m^3/a by 2050, while releasing the EWR of about 350 million m^3/a.
- The uMkhomazi River catchment has sufficient (more than 10 million m^3/a) in the upper catchments, U10A to U10J, to provide for local use.
- The 1:100 year stochastic yield for the proposed Smithfield Dam is 220 million m^3/a for a 31% MAR dam size.
- The proposed off-channel Ngwadini Dam in the lower uMkhomazi River catchment does not require support from Smithfield Dam, although it is recommended that the operation of both dams be optimised for future water requirements.

12.2 Engineering Design

The feasibility study concluded the following infrastructure to be developed:

- The development of the uMWP-1 raw water infrastructure (the Smithfield Dam, a tunnel, balancing dam and pipelines) and potable water infrastructure (water treatment plant and conveyance infrastructure), that will be doubled up in future with uMWP-2 (the Impendle Dam, a second tunnel, extension of the water treatment plant and double up of conveyance infrastructure),
- A dam on the farm Smithfield:
  - The development of a large dam on the uMkhomazi River at site B on the farm Smithfield for a dam size of 31% MAR, with a gross storage of 251 million m^3.
  - Sediment yield of 22.1 million m^3 will be accumulated after 50 years.
  - Flood hydrology indicated an SEF of 5 650 m^3/s for the spillway and 1 708 m^3/s for the 1:50 year flood event for the river diversion.
  - Three borrow areas and four quarry areas have been identified during the geotechnical investigation.
  - The optimised dam type is an ECRD for the 81 m high main dam, and a zoned earthfill embankment dam for the saddle dam of 26 m high.
  - The Main Dam will be constructed with a residual dolerite earthfill core and dolerite rockfill on the outer zones with a small inner shale rockfill zone.
  - A primary side channel spillway with a gravity weir structure, chute and ski jump structure.
  - A permanent double pipe system bottom outlet laid out from an intake structure to one of the two 8 m diameter tunnels (used initially for river diversion) with an access bridge from the Main Dam crest.
  - A secondary fuse plug spillway.
  - Material to be obtained from the excavations, as well as specific quarries.
  - Access roads for construction and operations.
  - The flooding of the dam basin required the deviation of the R617, and new access roads to communities that will be cut-off by the reservoir.
  - Making provision to support the Eskom high voltage power line across the new reservoir.
  - An intake tower and access bridge in the Smithfield Dam reservoir to the transfer tunnel.
- Proposed conveyance infrastructure:

    - A 32.5 km pressure tunnel between the uMkhomazi and uMlaza valleys, with option C being selected.
    - The 3.5 m inside diameter tunnel will be lined (to be confirmed during final design). It has a cross-sectional area of 9.616 m^2 for a design flow of 8.65 m^3/s.
    - Ventilation shafts have been provided for in the design to accommodate air flow in the tunnel.
    - Two TBM drives, both being up-slope and in a southerly direction.
    - The raw water pipeline (Tunnel to Langa Dam to Baynesfield WTW) is a 2.6 m inside diameter pipe from the tunnel end to Baynesfield WTW and has a length of 5.2 km. This pipeline connects to the Langa Dam with a 1.6 m diameter, 1.3 km long pipeline.
    - A stilling basin at the end of the pipeline at the Baynesfield WTW with a tailrace water level of 872 masl.

- Langa Dam:

    - A balancing dam on the Mbangweni River, a tributary of the uMlaza River, on Baynesfield Estate (the farm Nooitgedacht 90);
    - The FSL of 923 masl for a gross capacity of 15.7 million m^3 that can supply the uMWP supply area for 24 days at the maximum supply rate of the conveyance system.
    - Dam type selection study recommended a Concrete Face Rockfill Dam (CFRD).
    - The rockfill will consist of shales from the reservoir (dam basin) of the dam.
    - Finer bored rockfill from the tunnel will be used on its downstream toe section and the rest of the excavations from the outlet portal will be accommodated in a berm on the downstream side of the dam.
    - A side spillway on the left flank would ensure that the dam cannot be overtopped during flood events.
    - A single level draw-off with double pipe intake system in an intake tower and bottom outlet would facilitate water to fill the dam from Smithfield Dam under gravitation, to release the required reserve water to accommodate wetlands and to release water for supply when required.

- Possible hydropower plants at the entrance of the Baynesfield WTW and the outlet of the proposed Smithfield Dam.
- Potable water infrastructure (WTW and potable water pipelines) connected to the UW bulk water system, as proposed in **Module 3**.

- Possible water supply from Smithfield Dam to Harry Gwala District Municipality.

12.3 Environmental

- The environmental screening concluded that a detailed EIA with selected specialist studies was required, to understand the impact and risks of the proposed uMWP.
- A comprehensive EIA is undertaken in the Module 2 study, done by Nemai Consulting.

12.4 Institutional and Finance

- Different implementation and funding options were identified for the proposed uMWP, proposing that the TCTA should implement the raw water infrastructure and UW should implement the potable water infrastructure and operate the uMWP-1 as part of the Mgeni WSS. Therefor
- The Minister for DWA to appoint the TCTA as the Implementing Agent for the uMWP-1 Raw water component, and to appoint the UW as operator for the whole uMWP-1 (raw and potable water components),
- The substantial increase of the tariff raises affordability concerns, which, together with the number of households affected, makes it ***recommended that National Treasury considers grant funding*** of the capital cost of the project to facilitate continued access to water for these poorer households, which use about 25% of the water.
- Urgent determination of the availability of funds from National Treasury for subsidisation of the costs of the project through grant funding. Funding options to be further discussed between DWS, UW, NT and the WSAs. Then the financial models for the raw water and potable water components by TCTA and UW respectively, can be developed. The significant increase in tariffs should also be mitigated, probably through phasing in of the tariffs.
- It is recommended that TCTA, as preferred implementing agent for the raw water components, fund the remaining approximately 75% of the raw water component of the project with private sector funding.
- It is further recommended that the TCTA proceed with implementation of the project as soon as off-take agreements have been signed with water service authorities that constitute 85% of the current water users as this has proven to be acceptable to DWA and bankers on previous projects.

12.5 Socio-Economic Assessment

- The analysis has shown that the development of the uMWP-1 has the potential to generate high levels of production, employment creation as well as household income.
- Total additional production (new business sales) anticipated to be generated by the project equates to R 86 661 million. Gross domestic product is anticipated to increase by R 30 305 million.
- Employment opportunities in the form of 4 280 direct employment opportunities related to construction and site operation. Of these, 110 annual opportunities would be created in a permanent manner for the operation of the scheme, which equates to 5 500 employment opportunities generated in the operational phase of 50 years, and total direct employment opportunities equate to 9 670 over both construction and operation. In total, 123 846 employment opportunities are generated through ***direct, indirect and induced*** activities over the ***same period***.

12.6 Project Hand Over

- An RID will be finalised once the EIA study is completed and financial and institutional arrangements are made.
- The implementation programme shows that, even with decision making being taken timeously, the construction of the dam would begin in 2019, with the delivery date of water probably only in 2024. The program is very tight, however, and any delays will increase the risk of water supply of this system that will be in deficit from 2016.

13 RECOMMENDATIONS

The following **high level[10] recommendations** are made for the development of the uMWP:

- Develop the uMWP-1 for water delivery in 2023, with the following components:
  - a dam at Smithfield on the uMkhomazi River with storage volume equal to 31% of the MAR, FSL 930 masl;
  - a Balancing Dam with storage volume 12.5 million m^3 on the Mbangweni River; and
  - A single 3.5 m internal diameter uMkhomazi to uMlaza Tunnel and associated 2.6 m diameter pipeline to the Baynesfield WTW with a design (seasonal) transfer capacity of 8.65 m^3/s. A single 1.6 m diameter pipeline will carry water from this pipeline to the balancing dam.
- Finalise the financial and institutional arrangements for the project and secure funding, taking the following steps:
  - Appointment of TCTA as the Implementing Agent by the Minister for DWA for the uMWP-1 Raw water component,
  - Determination of the availability of funds for National Treasury for subsidisation of the costs of the project through grant funding,
  - Development of the financial models for the raw water and potable water components by TCTA and UW respectively,
  - Finalise off-take agreements with water service authorities that constitute 85% of the current water users, by September 2017,
  - Formulation of a procurement strategy and programme for the implementation of the uMWP-1 by TCTA and UW to ensure an integrated approach towards timeous completion of the project in 2023, and
  - Appointment of UW as operator for the whole uMWP-1 (raw and potable water components).
- Conduct additional geotechnical investigations during the design stage of the tunnel, Smithfield Dam and Langa Dam and roads, as per geotechnical report.
- Conduct a hydraulic model study of Smithfield Dam's spillway and tunnel intake arrangement.

[10] *Detail recommendations for each component of the study are included in the relevant reports.*

- Confirm the preferred feasible scheme to augment the Donnybrook-Bulwer WSS (either Comrie or Smithfield dams), for development. Also, consider the optimal use of groundwater for communities in the uMkhomazi River catchment.
- Finalise the RID once the environmental authorisation approval is received in early 2016.
- DWA to confirm their involvement in the development of hydropower, or identify other entities, such as UW, a municipality or private company, that would be interested in developing the hydropower scheme in a renewable energy program for small hydropower schemes.
- Consider short term interventions, such as water demand management, desalination, re-use, etc., to supply the Mgeni WSS until the first delivery from the uMWP-1.
- Since final results from the Reserve Study were not available, and although conservative assumptions were used in this analysis, re-evaluate the impact of the Reserve on the Smithfield and balancing dams and also consider the final EWRs in the uMkhomazi and uMlaza rivers to determine detailed operating rules.
- Optimise the operating rules for the proposed lower and upper uMkhomazi dams (Ngwadini and Smithfield dams).

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Appendix A

Optimisation of uMWP-1 Smithfield Dam and uMkhomazi-uMlaza Tunnel

A.1 OPTIMISATION OF SMITHFIELD DAM

A.1.1 Optimisation of dam site

In conjunction with the optimisation of the conveyance system, discussed in **Section 6.3**, various positions for the location of Smithfield Dam site were considered.

The *Pre-feasibility Study* recommended that the dam be located at Site B, shown in **Figure A.1**, in the uMkhomazi River. In addition, pumping from the Smithfield Dam should be at the position of Site A, with an intake to a free-flow tunnel being the preferred transfer option.

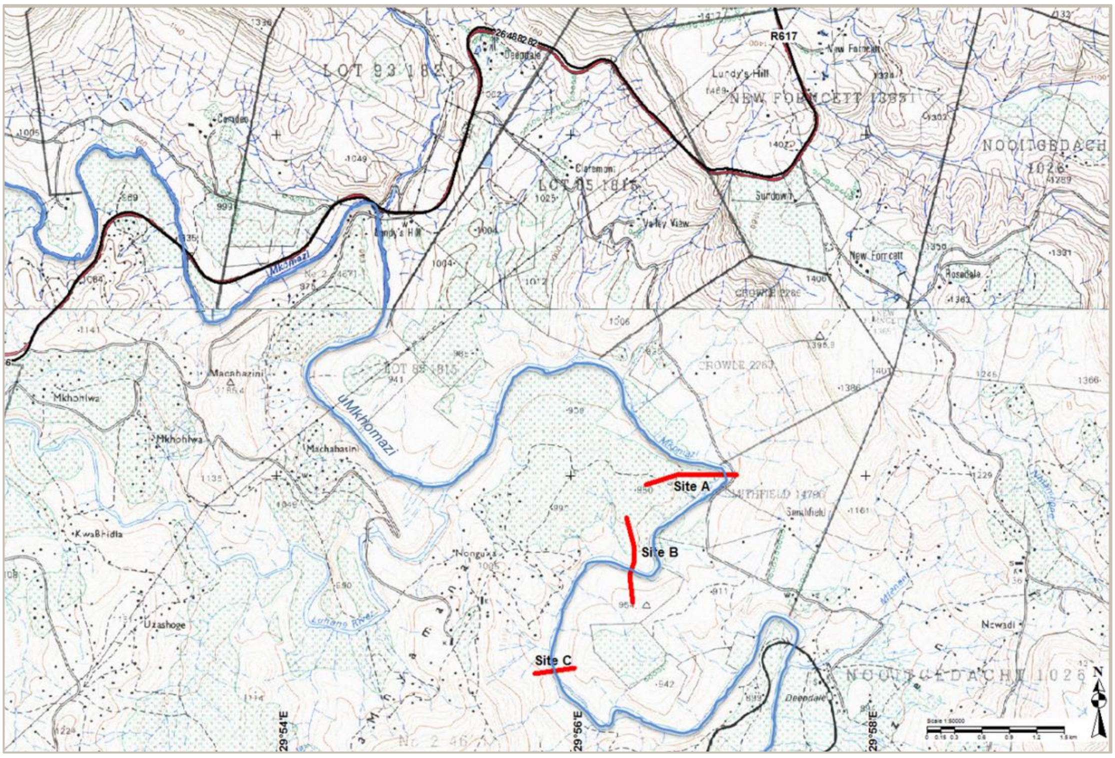


Figure A.1: Smithfield Dam: Location of Alternative Sites

In this Feasibility Study (uMWP), the location of Smithfield Dam at sites A, B and C, shown on **Figure A.1**, was considered for various dam types and combinations of dam types, including Earth Core Rockfill Dam (ECRD), Roller Compacted Concrete (RCC) gravity dam and Earthfill Embankment Dam (EED). A summary of the capital costs for the different dam types are shown in **Table A.**, based on tender rates from recent developments, e.g. Spring Grove Dam.

Table A.1: Summary of comparable cost estimates for the dams

Dam option	Capital cost (R million excluding VAT)
Site A: Option 1: ECRD with side channel spillway on right bank and tunnel/cofferdam diversion structure.	1 328
Site A: Option 2: Combined RCC gravity spillway with EED right bank.	1 844
Site B: Option 1: ECRD with side channel spillway and tunnel/cofferdam diversion structure on right bank and saddle embankment.	**935**
Site B: Option 2: Central RCC spillway structure with EED flanks and saddle embankment.	1 384
Site B: Option 3: ECRD with tunnel/cofferdam diversion structure, saddle embankment and chute spillway at left side of saddle embankment.	**817**
Site C: Option 1: ECRD with side channel spillway on left bank and tunnel/cofferdam diversion structure.	1 229
Site C: Option 2: RCC gravity dam with central spillway.	1 469

From **Table A.1**, the lowest cost option – Site B: Option 3 Dam – was selected, which also conforms to the requirement of the transfer of water through a pressure tunnel and pipeline. The site was influenced by the operating levels required for a gravity scheme all the way to Umlaas Road. The outcome of the combined dam and conveyance system (**Section 6.3**) confirmed the Site B: Option 3 Dam with a pressure tunnel as the preferred option.

A.1.2 Sizing of the dam

The *Pre-feasibility Study* recommended a full supply level (FSL) of 920 masl for Smithfield Dam. During this Feasibility Study, the proposed Smithfield Dam size was optimised, together with the future Impendle Dam.

The optimum dam size was selected by comparing the unit reference values (URVs) for both the capital and operational costs of the completed future scheme (including the conveyance system to Umlaas Road) for the given water requirements.

During this analysis, capital costs for the following dam sizes were determined:

- Impendle Dam for storage volumes of 50%, 100% and 150% of the MAR volume; and
- Smithfield Dam for storage volumes 15%, 20%, 25%, 31% and 38% of the MAR volume at the site. Provision was made for road deviations around the reservoirs (especially the R617 road) as well as for power line deviations.

Two development scenarios were considered, namely:

- **Option 1**: Development of Smithfield Dam and one tunnel only (taking into account a future scenario where Impendle Dam is not developed). A plot of unit reference values at 8% discount rate against FSLs of Smithfield Dam is shown in **Figure A.2**.
- **Option 2**: Development of combinations of Smithfield (15%, 20%, 25%, 31% and 38% MAR) and Impendle Dam (50%, 100% and 150% MAR) sizes and two conveyance systems. A plot of unit reference values at 8% discount rate against FSLs of Smithfield Dam is shown in **Figure A.3** to **A.5**.

These graphs also show the years of supply from Smithfield Dam until water is required from another water resource.

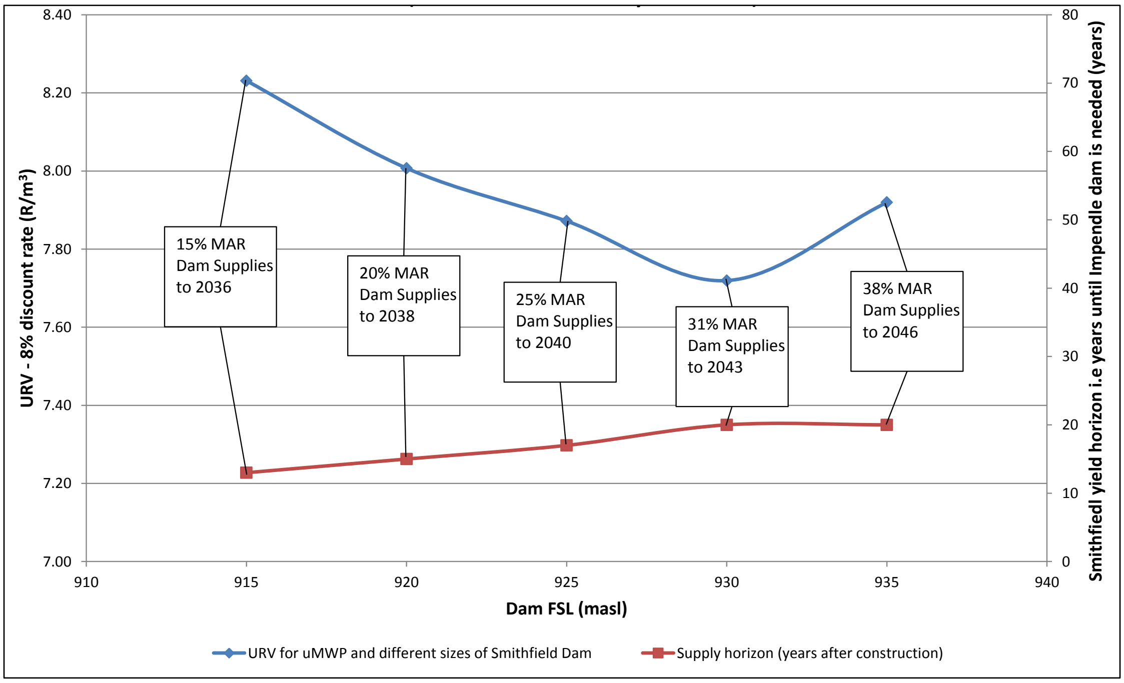


Figure A.2: URV results for Option 1: Smithfield Dam and one tunnel

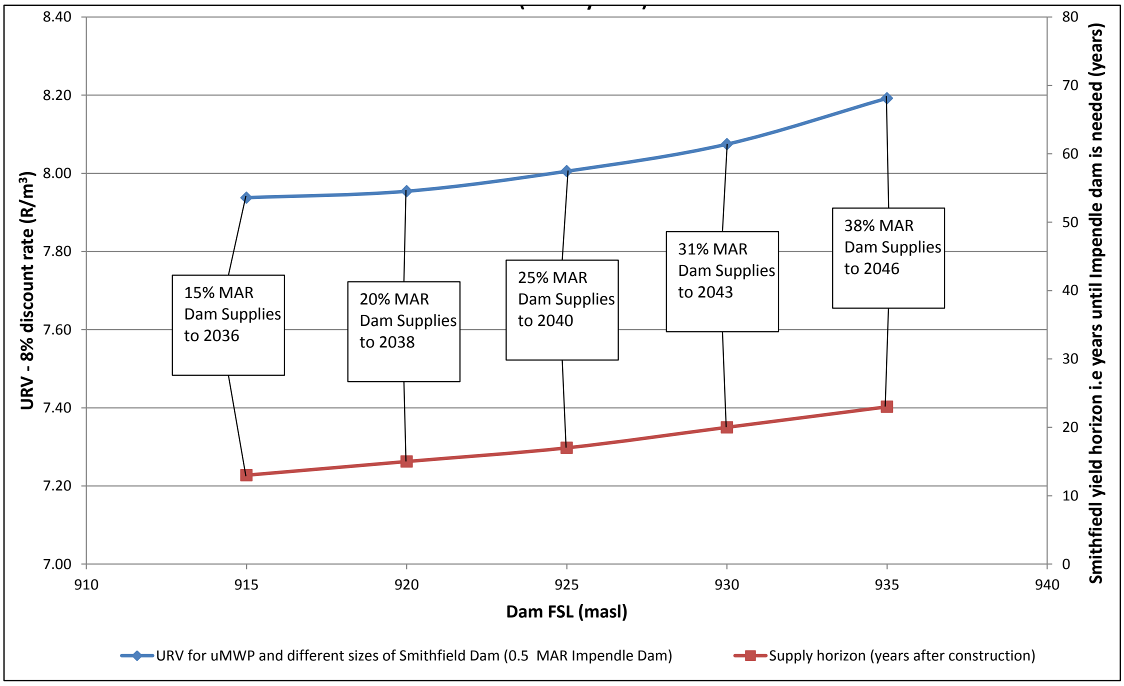


Figure A.3: URV results for Option 2: Smithfield Dam, 0.5 MAR Impendle Dam and two tunnels

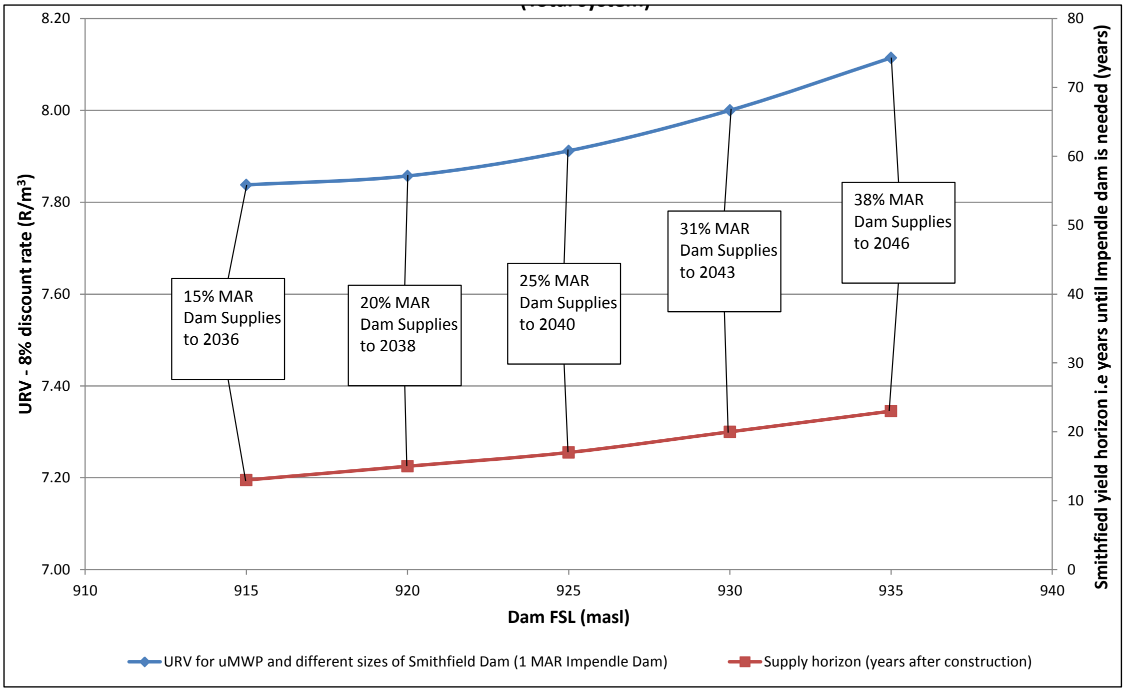


Figure A.4: URV results for Option 2: Smithfield Dam, 1.0 MAR Impendle Dam and two tunnels

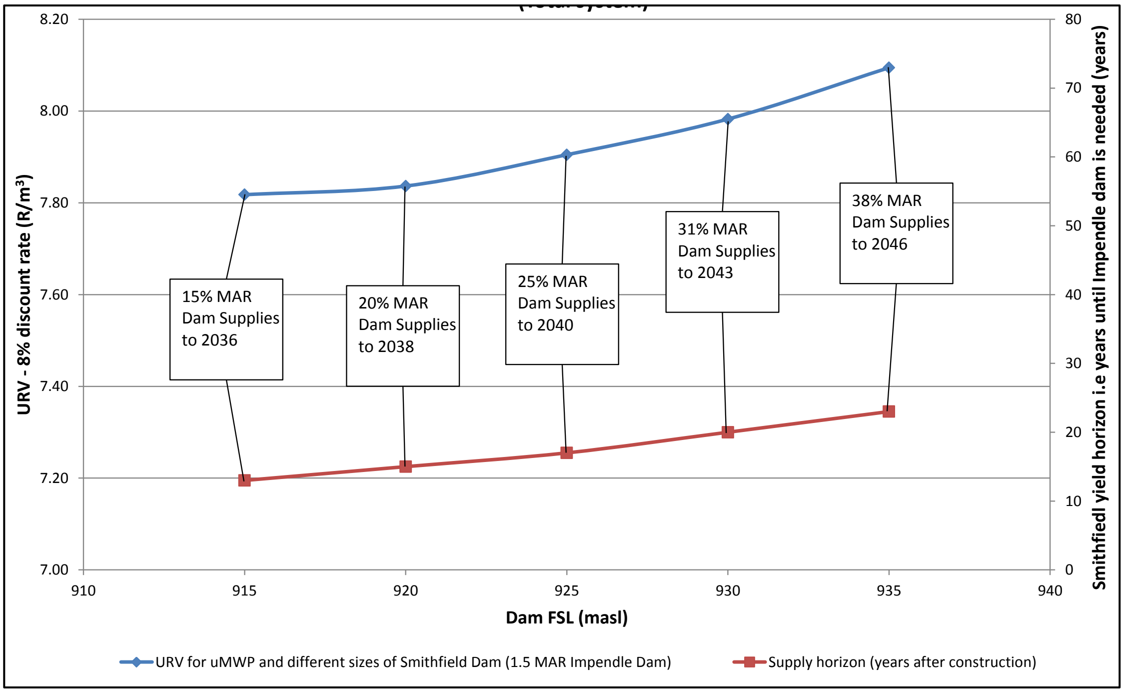


Figure A.5: URV results for Option 2: Smithfield Dam, 1.5 MAR Impendle Dam and two tunnels

From the figures above, the following was concluded:

- The optimum URV for Phase 1 only – the case where the Impendle Dam and the second conveyance system are not developed – is at the 31% MAR Smithfield Dam, as shown in **Figure A.2**.
- Although results from **Figure A.3**, **Figure A.4** and **Figure A.5** show that the smallest Smithfield Dam has the lowest URV for both phases, the next phase, Impendle Dam should then be constructed within 12 years by 2036.
- From the above figures, it is clear that the 31% Smithfield Dam, which provides a 21-year window of water supply (based on current water requirement projections) before the Impendle Dam will be required, is the optimal option. The difference in URV for a 31% Smithfield Dam with smaller Smithfield dam sizes (about R 0.15 or 2%) is insignificant, and within the margin of accuracy for feasibility level.

It was recommended to size the Smithfield Dam to a 31% MAR capacity during the feasibility design study

Planning of implementation of a 1 MAR Impendle Dam should be considered for optimisation in future.

A.2 OPTIMISATION OF CONVEYANCE SYSTEM

As was recommended in the *Pre-feasibility Study*, different conveyance options between the uMkhomazi River and uMlaza valley were to be identified and compared to obtain a sustainable system for both phases 1 and 2 of the uMWP. While several options were investigated, the request from both DWS and UW was to minimise life cycle and energy cost, and thus the study focused on a gravity system.

The following three transfer options were evaluated and compared:

- Option 1A and 1B: Pumping via a free flow tunnel (similar to the preferred option from the pre-feasibility study) for both the single and twin tunnel options;
- Option 2A and 2B: Pressure tunnel for both the single and twin tunnel options; and
- Option 3: Pumping via a combination of longer rising mains and a shorter free flow tunnel.

Preliminary analyses showed that the cost of the tunnel dominates the net present value (NPV) analyses. The shortest route was thus selected for all three options, as shown in the longitudinal section in **Figure A.6**. The NPVs of the conveyance options are shown in **Table A.2**.

Table A.2: Net present value (R million) of conveyance options

Option	Discount rate		
	6%	8%	10%
1A	2 777	2 278	1 905
1B	2 531	2 123	1 801
2A	2 647	2 246	1 919
2B	**2 514**	**2 057**	**1 717**
3	3 488	2 656	2 104

From **Table A.** it is clear that Option 2B (i.e. twin 3.5 m diameter pressure tunnels) is the preferred option, as it has the lowest NPVs and will provide the following benefits:

- Minimal O & M requirements with no pumping requirements;
- Potential for generation of hydropower at the tunnel outlet; and
- Residual head advantages for gravity supply pipelines to Umlaas Road.

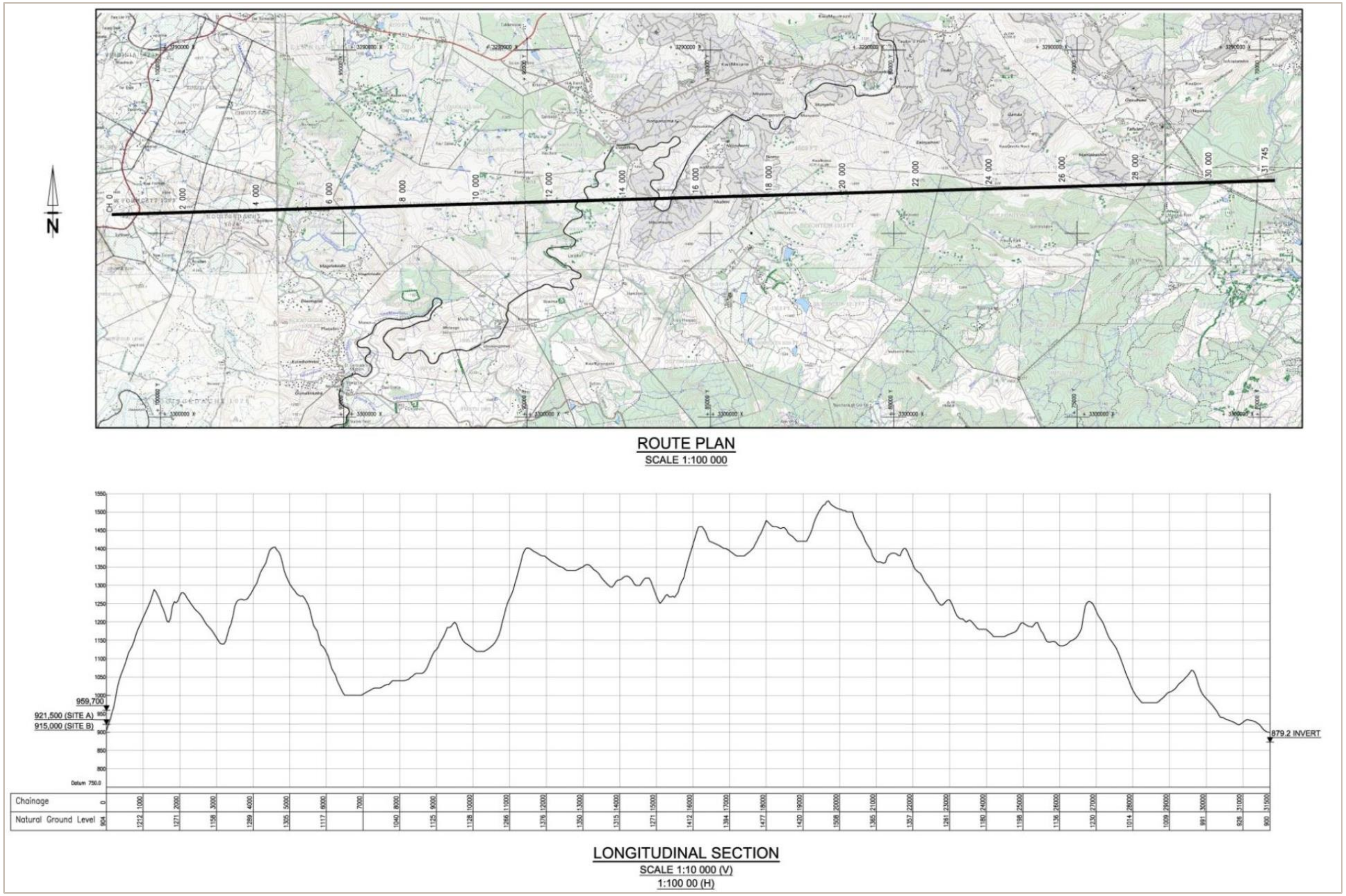


Figure A.6: Route and longitudinal section for the transfer system

A.3 OPTIMISATION OF TUNNEL ALIGNMENT TO BAYNESFIELD ESTATE

A.3.1 Horizontal alignment of tunnel

Several horizontal alignment options identified for comparison purposes, as shown in **Figure A.7**, are:

- Option A: Tunnel end at western side of Baynesfield Dam and pipeline connection on downstream side of dam;
- Option B: Tunnel end in upper reaches of the Baynesfield Dam. Pipeline bypass is provided around Baynesfield Dam;
- Option C: Tunnel end at western side of the Mbangweni Dam, with short pipeline connection around Mbangweni Dam; and
- Option D: Same as Option C but the tunnel ends on the upper reaches of Mbangweni Dam.

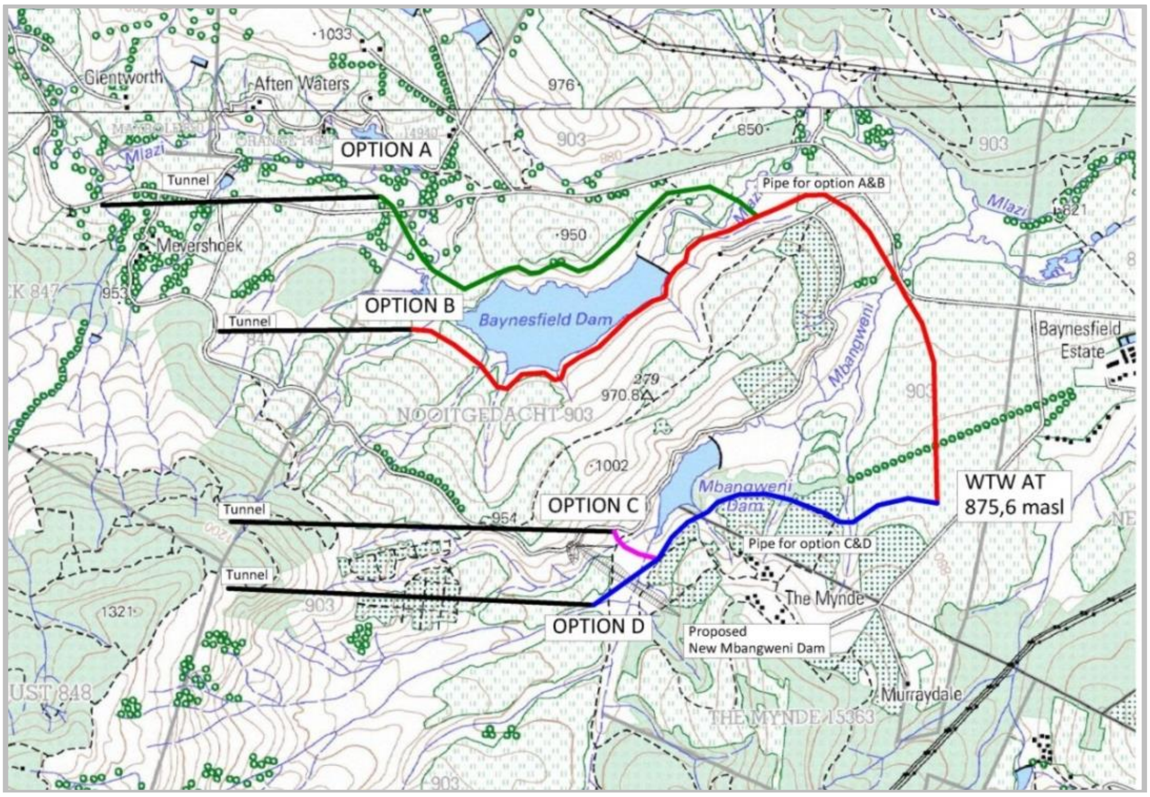


Figure A.7: Plan layout of conveyance horizontal alignment options

In this comparison, the balancing dam was not added as it is common to all options. A connection pipe to the dam was, however, included. The options were compared regarding dimensions, cost and other aspects, and are shown in **Table A.3**.

Table A.3: Comparison of tunnel and pipeline options

Component	Option			
	A	B	C	D
Tunnel length (km)	32.5	32.4	34.1	33.8
Unit cost for tunnel (R/m)	71 000	71 000	71 000	71 000
Total tunnel cost (R million)	2 308	2 305	2 421	2 399
Pipeline length (km)	5.82	5.70	3.05	2.6
Unit cost for pipeline (R/m)	23 320	23 320	20 900 (ND 1 900)	19 800
Total pipeline cost (R million)	136	132	63	52
Additional Excavation required (m^3)	85 127	85 127	0	0
Cost of excavation (Average Soft and hard rock) (R/m^3)	100	100	0	0
Total additional excavation cost (R million)	8.5	8.5	0	0
Additional pipe length from Balancing Dam (m)	2106	2106	100	NA
Unit cost for pipeline from balancing dam (R/m)	23 100 (ND 2 100)	23 100 (ND 2 100)	20 900 (ND 1 900)	NA
Total pipeline cost from Balancing Dam (R million)	49	49	2,1	NA
Total conveyance cost (R million)	2 502	2 494	**2 486**	NA
Other aspects	Actual tunnel length to end point: 34.3 km. Due to lack of rock cover the tunnel was ended at 32.5 km and a pipeline connected from there. However, roof cover still less than 10 m for last km.		Based on a TBM drilling rate of 130 m/week the construction programme for constructing relative to Option B's additional 1.6 km will be 3.1 months longer	The tunnel end daylights below FSL of the proposed Balancing Dam reservoir.

From **Table A.3** it was concluded that Option C, although only slightly cheaper, is preferred. For this route, areas for the inlet and the outlet portals were selected on flatter mountain slopes where access would be possible and areas for assembling the TBM could be made. However, large areas at the portals would have to be excavated in soft materials. The cost for excavating and stockpiling material and adding pipes of these areas are, however, less than to bore and line rock in these areas with TBMs. The pipeline lengths are also shorter than the initial Baynesfield route.

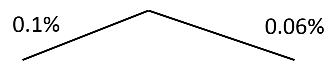
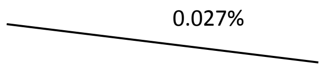
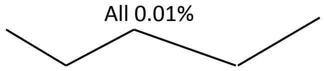
Tunnel alignment Option C was therefore selected for the feasibility design.

A.3.2 Vertical alignment of tunnel

The vertical alignment of the tunnel was optimised by considering parameters such as geology and potentially high groundwater inflow conditions, construction methods, practical conditions and drainage aspects.

Research from other completed tunnel projects indicated that 15 km is the maximum economical length of drive achievable by a tunnel boring machine (TBM). As the tunnel excavation is on the critical path, it is envisaged that at least two TBMs would be utilized on this project, working from both ends. The alternative vertical tunnel alignments and drainage options are shown in **Table A.4**.

Table A.4: Description of tunnel vertical alignment options

Option	Configuration	Direction of excavation and drainage requirements during construction	Drainage requirements during operation
1	Slopes from centre towards downstream ends  Intake foundation level: 862 masl Outlet level: 875 masl	TBM accesses from both ends. No drainage requirements for free draining conditions	Pumping or drainage for inspection required for upstream half. Air shaft provided in centre.
2	One downstream slope  Intake foundation level: 883.87 masl Outlet level: 871.5 masl	Upstream half to be driven from centre in an upstream direction. Pumping of drainage water from centre.	Free draining: Air Shaft required at entrance
3	Slopes to meet the 0.1% criteria  Intake foundation level: 883.87 masl Outlet level: 871.5 masl	Drainage towards low points and pumping from these points	Pumping from lower points.

Cost comparisons of these options are shown in **Table A.5**.

Table A.5: Cost estimates for options

Activities	Quantity	Unit Cost	Amount (R million excluding VAT)		
			Option 1	Option 2	Option 3
Intake Tower	Sum		88.7	76.5	76.5
Upstream part of tunnel	15 000 m	71 000(1)	1065.0		
Upstream part of tunnel	15 000 m	74 100(2)		1 111.5	1 111.5
Downstream part of tunnel	19 100 m	71 000(1)	1 356.1	1 356.1	
Downstream part of tunnel	19 100	74 100(2)			1 415.3
Additional excavation cost at intake tower (m^3)	308 000	100	30.8		
Tunnel drainage pipe to dam outlet	3 500	20 000	70.0		
Additional ventilation shaft	Sum			2.0	
Total			2 611.6	**2 546.1**	2 603.3

(1) Boring uphill
(2) Boring downhill

From **Table A.5**, the following has relevance:

- The unit cost for the tunnel was adjusted in accordance with the complexity of tunnelling/drilling below water conditions;
- Vertical alignments of the tunnels are required to meet both the hydraulic and construction drainage requirements;
- The additional cost for the intake tower relates to a deeper foundation for Option 1 as compared to the others;
- The tunnel drainage pipe is necessary to drain the upstream part of the Option 1 tunnel through the reservoir of the dam and through the outlet of the dam. This is, however, not favoured from a maintenance point of view. Draining of the tunnel can also be done by pumps from the bottom of the intake tower. This option is also not favoured due to pumps which may not be available for pumping when needed; and
- Option 2 is the option with lowest cost.

Option 2 therefore best suits the construction and operational requirements.

A.4 OPTIMISATION OF LANGA DAM

A.4.1 Selection of the balancing dam site

From the *Pre-feasibility Study*, it was recommended that the existing Baynesfield Dam be enlarged to accommodate the extra volume required for a balancing dam. During the Feasibility Study, a detailed analysis of Baynesfield Dam revealed that this option could not be considered for the following reasons:

- Integrity of the existing Baynesfield Dam wall.
- The levels of the dam. The balancing dam will need to be constructed to provide for the correct levels to gravitate, which will result in a dead storage of about 50% of the volume.
- Current users will need to be accommodated, resulting in detailed management of the dam. This may result in conflicting operating rules.
- The raw water pipeline around the proposed Baynesfield Dam would have encountered problems when laying the pipeline in high ground on the right side of the dam, and in saturated conditions.

The Baynesfield Dam was therefore discarded and alternative dam sites were investigated.

With the selection of the tunnel C route as described in the previous sections, a second dam site, referred to as the New Mbangweni Dam site, was considered. It is upstream of the Mbangweni Dam on the Mbangweni River, a tributary of the uMlaza River, as shown in **Figure A.8**.

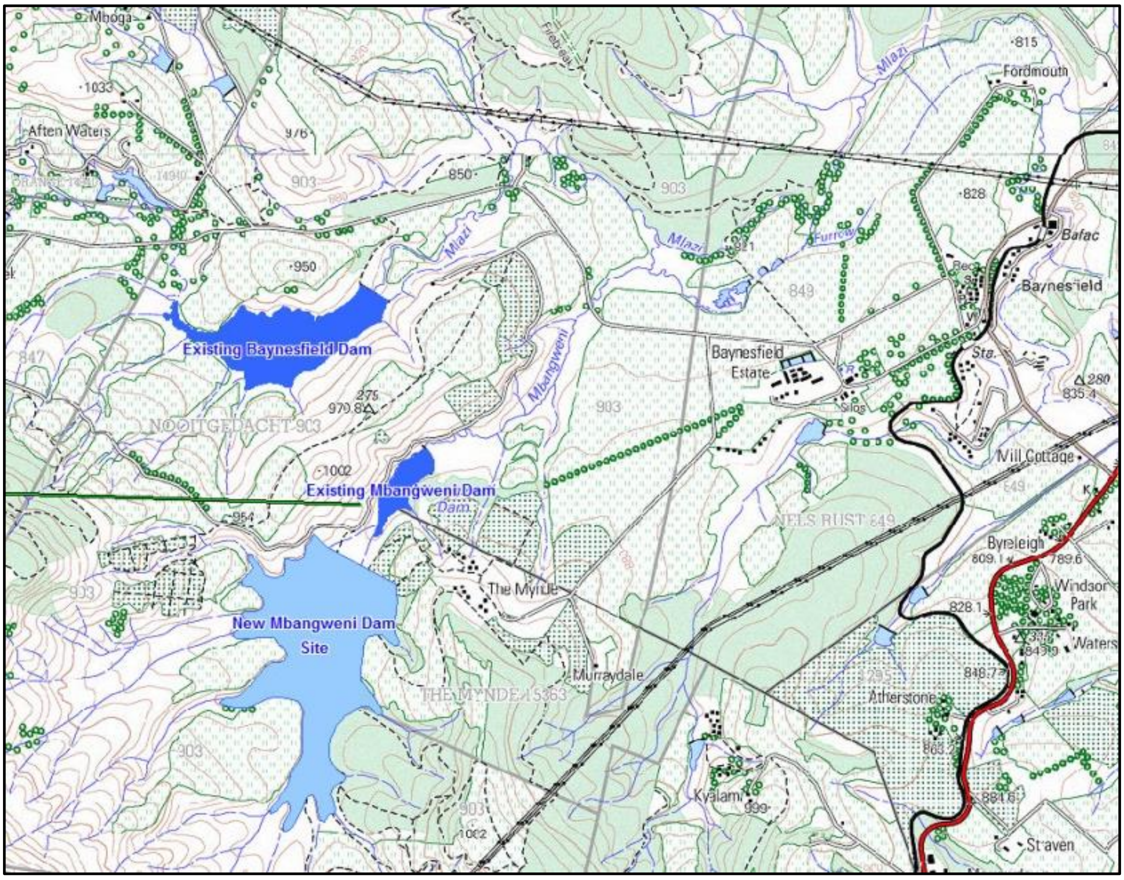


Figure A.8: New Mbangweni Balancing Dam site

A site visit revealed that the proposed New Mbangweni Dam has a wider marshy area (Vleiland) than an upstream dam site (referred to as Langa Dam site), shown on **Figure A.9**. Thus, the lower site was not considered further due to:

- A wider valley within the river section;
- The deep foundation that will need to be excavated for any dam type due to the marshy area; and
- The higher costs associated with excavation and construction costs.

The Langa Dam site was therefore selected and further analysed in this study.

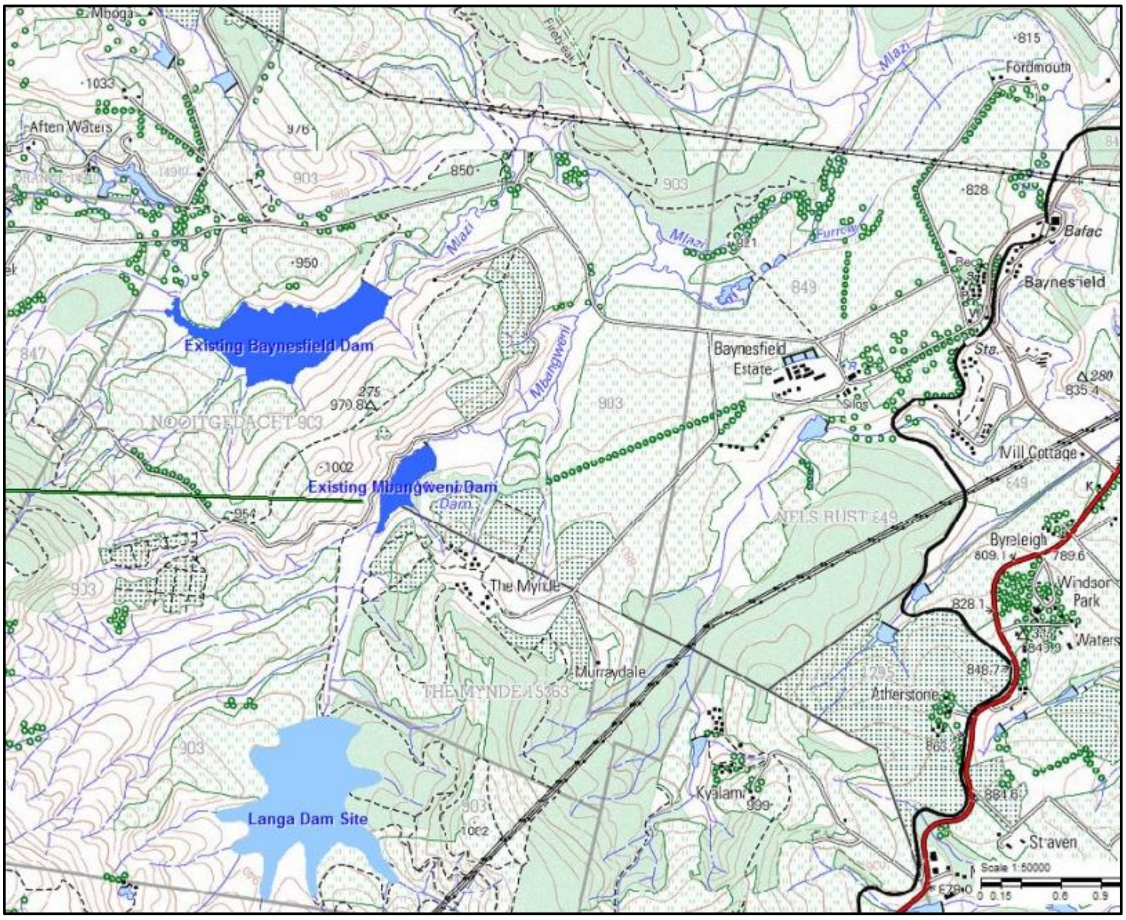


Figure A.9: Langa Dam site

Appendix B

List of municipal meetings

Municipality / meeting	Date	Resolution
eThekwini Metropolitan Municipality		
• Briefing Meeting with Mr Ednick Msweli, Head: Water & Sanitation	Monday, 08 June 2015	*
• Infrastructure Committee Meeting (Human Settlement Infrastructure Meeting)	Tuesday, 21 July 2015	*
• Site Visit to uMkhomazi Water Project Study Area	Wednesday, 12 August 2015	*
• Executive Committee Meeting	Pending: Sept / Oct 2015	*
		*
Ilembe District Municipality		
• Presentation to Management Committee	Monday, 08 June 2015	*
• Presentation to Technical/Portfolio Committee	Wednesday, 24 June 2015	*
• Executive Committee Meeting	Pending: Sept / Oct 2015	*
•		
Harry Gwala District Municipality/WSA		
• Meeting with Technical Team	Tuesday, 21 April 2015	*
• Executive Committee Meeting	Tuesday, 25 August 2015	*
• Site Visit to uMkhomazi Water Project Study Area	Wednesday, 28 October 2015	*
•		
Msunduzi Local Municipality/WSA		
• Presentation to Management Committee	Tuesday, 21 October 2014	Received
• Infrastructure Portfolio Committee	Tuesday, 17 March 2015	*
• Executive Committee Meeting	Thursday, 02 April 2015	*
•		
Ugu District Municipality/WSA		
• Presentation to Management Committee	Monday, 15 September 2014	Received
• Water & Sanitation Portfolio Committee	Tuesday, 14 October 2014	*
• Executive Committee Meeting	Wednesday, 29 April 2015	*
Umgungundlovu District Municipality /WSA		
• Presentation to Management Committee	Pending: September 2015	*
• Water & Sanitation Portfolio Committee	Pending: October 2015	
• Executive Committee Meeting	Pending: October 2015	
Ingwe Local Municipality		
• Executive Committee Meeting	Thursday, 02 Oct 2014	*
• Site Visit to uMkhomazi Water Project Study Area	Wednesday, 28 October 2015	*

**Await resolutions / documents from relevant committee / authorities*