Coega Development Corporation

Upper Ncise Bulk Infrastructure Scoping Report

H-351254

May 2016

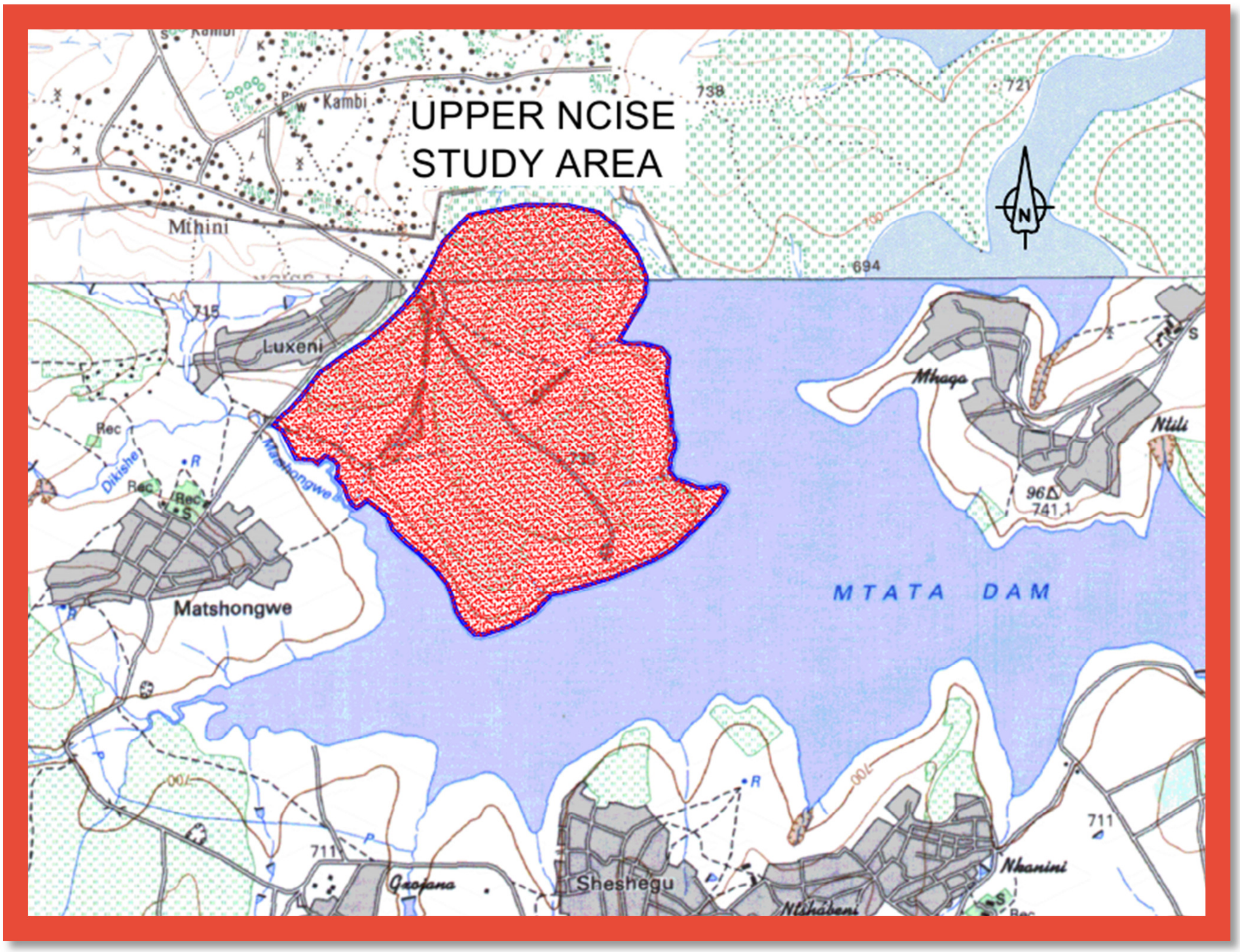

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Table of Contents

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Abbreviations

CDC	Coega Development Corporation
DWA	Department of Water Affairs
WTW	Water Treatment Works
SEZ	Special Economic Zone
EIA	Environmental Impact Assessment
WUL	Water Use License
NWA	National Water Act
ECBCP	Eastern Cape Biodiversity Conservation Plan
CBP	Critical Biodiversity Plan
KSD	King Sabata Dalindybo
ha	Hectares
km^2	Square kilometers
l/c/day	Litres per capita per day
l/s	Liters per second
mm	millimeters
Ml	Megalitres
m^3/a	Cubic metres per annum
m^3/s	Cubic meters per second

Executive Summary

Hatch was appointed by Coega Development Corporation to conduct a scoping of bulk and link infrastructure for the Upper Ncise area.

Included in the scoping study is a land suitability study. The purpose of this study is to understand the land suitability, availability and ownership of a portion of Upper Ncise.

In order to determine infrastructure requirements for the proposed Aquaponics systems to be constructed on site a study was commissioned upon which bulk infrastructure demands were calculated.

Due to the volume of water required for this development it is not feasible to connect to the existing municipal infrastructure as the nearest bulk main, of 300mm diameter, runs along the R61 to the airport (approximately 8.5km from the site).

Water would be extracted from the dam at the dam wall, treated and then pumped approximately 15km to site.

Currently there is no surplus capacity of water in the Mthatha Dam. However if Eskom's guaranteed level of supply for the First and Second Falls hydro power stations was decreased capacity would be made available.

The Mthatha Wastewater Treatment Works (located on the eastern side of Mthatha) cannot accommodate wastewater flows from the site and therefor a wastewater treatment works will be required on site.

The site is accessed from the R61 via a gravel road (DR08217) approximately 10.2km long. It is proposed that this road be upgraded to a surfaced road.

Eskom is the licensed Electricity Supply Authority for this region, and has installed electricity overhead reticulation to service the existing villages positioned adjacent to this area. A new substation would be required to cater for the electrical demand from the development.

The development facility would trigger several listed activities in terms of the EIA regulations. Most notably, a full Scoping and EIA process would need to be conducted due to the large footprint of the area to be developed. In addition a Water Use License and Waste License would also be required.

The study area comprises various portions. Included in these portions are RE 75, portion 3 of 75 as well as various unregistered surveyed portions.

According to a document received from the Department of Rural Development, the land is endorsed to KSD local municipality.

A Risk Assessment has been undertaken and risks have been identified and classified as Insignificant, Minor, Moderate, Significant, Major or Catastrophic to enable the Client to manage and mitigate risks.

The high order estimated cost of bulk infrastructure is R350 million

1. Introduction

The Coega Development Corporation (CDC) has been tasked with the development of the Wild Coast Special Economic Zone (SEZ). Upper Ncise has been identified as one of the alternative land parcels for this development and thus a scoping of the bulk and link infrastructure has been commissioned. CDC has appointed Hatch to conduct the scoping of the bulk infrastructure, including water, wastewater, roads, stormwater, solid waste.

Included in the scoping study is a land suitability study. The purpose of this study is to understand the land suitability, availability and ownership of a portion of upper Ncise.

In order to determine infrastructure requirements for the proposed Aquaponics systems to be constructed on site a study was commissioned. This report (by ATS Consulting) was used as a basis for all assumptions made regarding the infrastructure services required and can be found in Appendix A.

Relevant legislation has been reviewed and recommendations made regarding compliance with environmental, waste and water use licences.

A Risk Assessment has been undertaken and risks have been identified and classified as Insignificant, Minor, Moderate, Significant, Major or Catastrophic.

2. Bulk Infrastructure Assessment

2.1 Basis of Infrastructure Assessment

The estimated water demand for the proposed aquaponic systems (based on ATS Consulting Report) is 110m³ per tunnel. On the 430ha of land approximately 3600 units are possible allowing for some areas to be used as offices/workshops etc.

2.2 Water Resources

The 430ha study area falls within the T20B catchment of the Mthatha River Basin. The Mthatha Dam has a volume of 249million m³. The Department of Water and Sanitation, in 2011, issued a Water Use Licence (12/T20E/A/931) to OR Tambo District Municipality to abstract 55.1million m³ per annum. An additional 1.16million m³ per annum is utilised by the Rosedale Water Treatment Works (WTW).

Due to the volume of water required for this development it is not feasible to connect to the existing municipal infrastructure as the nearest bulk main, of 300mm diameter, runs along the R61 to the airport (approximately 8.5km from site) and this bulk main would have to be upgraded. In addition the existing water treatment works (Thornhill) would need to be upgraded in order to supply the proposed development.

In villages adjacent to the site there are standpipes however this supply is limited to reticulation only and would be insufficient to supply the proposed development.

The Department of Water Affairs (DWA) was contacted regarding the possibility of extracting water for the project from the Mthatha Dam. Currently there is no surplus capacity in the Mthatha Dam to make additional allocation of water for this development. However if Eskom's guaranteed level of supply for the First and Second Falls hydro power station was decreased, capacity would be made available. This would require negotiations between Eskom and DWA.

2.2.1 Dam Abstraction

Ideally water would be extracted from the dam on site however due to the inconsistent water level and gently sloping topography it is not deemed to be possible. Therefore water would need to be extracted from the dam at the dam wall some 15km away. The water would then be treated (placed in settling tanks and filtered) before being pumped to site.

It is essential that land near the dam wall be acquired in order to situate the water treatment works on. In addition servitudes will need to be obtained for the pipeline route from the treatment works to the site.

2.2.2 Water Demand for Aquaponic System

In total 410 000m³ will be required to fill the aquaponics systems. Approximately 15% of the water will require replenishing per month due to evaporation. Therefore approximately

6100m^3 of water will be required per week. This equates to approximately 0.5million m^3 per annum.

Allowance has been made to refill the aquaponics systems once every six months, which equates to approximately 0.8 million m^3 per annum. Therefore a total water demand of 1.3million m^3 per annum will be required for the aquaponics system.

In order to ensure a constant supply of water to the aquaponics systems it is recommended that 2 days storage allowed for, this will require a 7.1Ml reservoir on site.

This development has been classified as a moderate risk for fire and as such requires 1500l/min flow of water for a minimum duration of 4 hours.

An inline pressure pump system will be required to boost the pressure in the system should firefighting be necessary. It is suggested that this water not be treated to potable standard but be water that would be used to the aquaponics system.

2.2.3 Water Quality Requirements for Aquaponics System

Water extracted from the Dam for the aquaponics systems will require treatment, namely sedimentation and filtration.

Water for the Aquaponics system needs to be regularly tested. The most critical water quality parameters to monitor are dissolved oxygen concentrations, temperature, pH and nitrogen from ammonia, nitrate and nitrite.

2.2.4 Potable Water

The amount of water required for human consumption will be similar to that for the aquaponics and has been calculated based of Department of Human Settlements Guidelines for Human Settlement Planning and Design (Red Book) guidelines.

Assumptions have been made regarding the number of employees required. As aquaponics requires low levels of labour, allowance has been made for 15 labourers per hectare. In total 6500 people could be employed. The required potable water demand (based on 90l/person/day) will be 870m^3 per day or 36 000l/hr. For the full development a water treatment works of 4.2Ml/day will be required.

Water to be used for human consumption will require further treatment (disinfection) to attain a potable standard as per SANS 241-1 once it arrives on site. Thereafter it will be gravitated to various points on site.

2.3 Wastewater

The existing wastewater treatment works is located on the eastern side of Mthatha. The Northern Outfall Sewer is proposed to be extended to the airport which currently is not connected to the municipal sewer network. However this extension has not taken into account the flows generated from the site.

A wastewater treatment works of 2.9Ml/day will be required on site. In order to release effluent into the Dam a Waste Licence would be required (discussed further under Legal Requirements).

Figure 1, over the page, shows a schematic representation of a general layout of the proposed extraction point and bulk services.

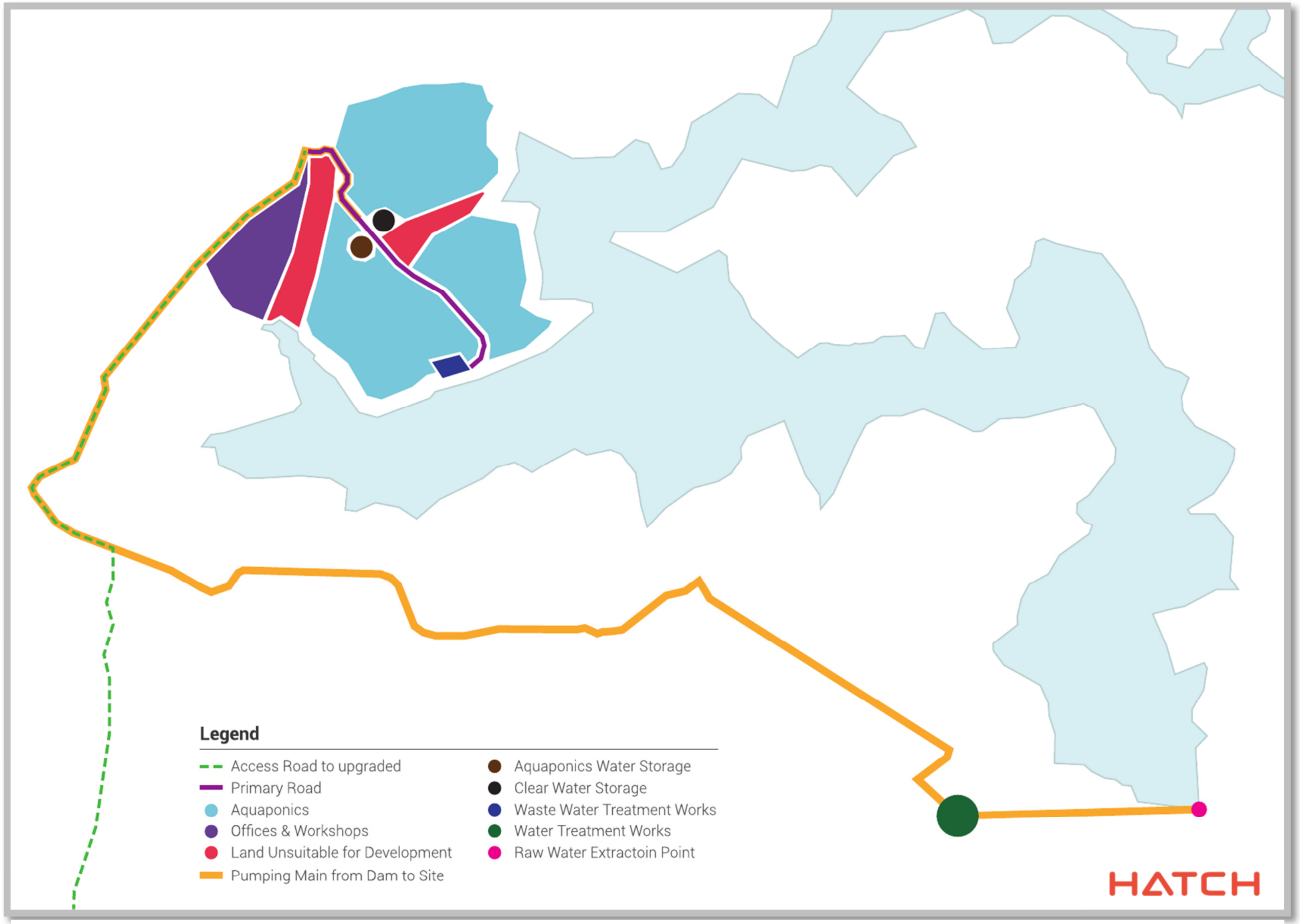


Figure 1 - Schematic Layout of Water & Wastewater Infrastructure

2.4 Roads

The site is accessed from the R61 via a gravel road (DR08217) approximately 10.2km long.

It is proposed that the access road from the R61 to the site be upgraded to a surfaced road. The main road within the site is also to be surfaced, the smaller roads within the site are to be gravel.

2.5 Stormwater

Stormwater on site is to be accommodated in a piped stormwater system as well as side channel drains.

2.6 Solid Waste

The KSD Municipal refuse collection area does not extend to the site. Any refuse generated on site would have to be transported to the Municipal Solid Waste Site. Alternatively it may be possible to establish a private landfill on site, however it will be necessary to engage with the Department of Environmental Affairs as having a solid waste site so close to a water source will require an in-depth investigation. Various permits are required which are discussed under Legal Requirements. In addition the disposal of fish offal and /or high volumes of vegetable matter must be taken into consideration.

2.7 Electricity

Eskom is the licensed Electricity Supply Authority for this region, and has installed electricity overhead reticulation to service the existing villages positioned adjacent to this area.

2.7.1 Capacity Existing Electricity Infrastructure To Supply Future Demand

Electricity is supplied to this region via Eskom's 132 000/22 000/400/230 volt overhead reticulation network supported by a combination of lattice steel and wooden pole structures, which is considered reliable based on outage data.

Eskom has confirmed electricity supply constraints on their 22 000 volt network to accommodate any new development in this immediate area. This statement however is subject to review on receipt of official application and currently Eskom has plans in place to reconfigure these 22 000 volt networks, thus creating additional capacity, but it is anticipated that this will only come into effective in the year 2020 . Special mention needs to be made that time lines for Eskom to deliver electricity supplies of this nature, range from three (3) to five (5) **Years** from date of payment to Eskom and application to initiate this process is encouraged timeously to meet project roll out program.

The anticipated demand for this development project is estimated at a minimum of a 25 MVA firm capacity, which would necessitate the building of a new 132/11KV Eskom substation and extending Eskom's 132 000 volt over reticulation network within close proximity to the site.

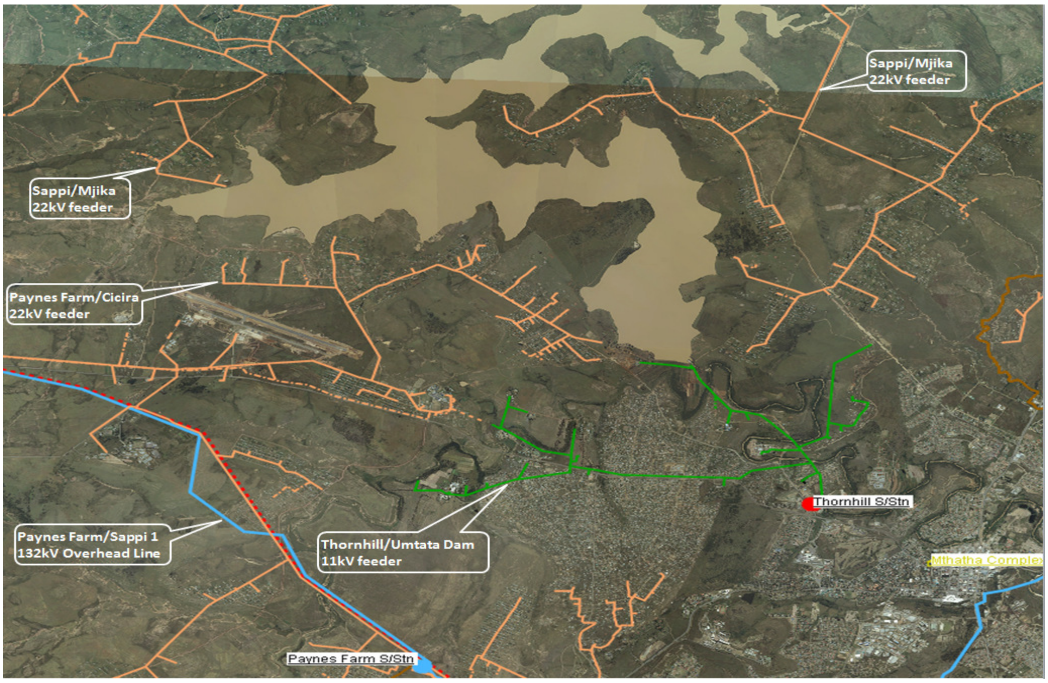


Figure 2 - Schematic Layout of Existing Electrical Infrastructure

2.7.2 Internal Electricity Services

The existing electricity network adjacent to the site comprises of overhead power lines supported on wooden poles and the internal proposed design philosophy for this development would comprise of a main intake 11 000 volt Switch House, 11 000 volt underground reticulation circuits to supply miniature substations, 400/230 volt underground reticulation to supply local distribution, Area Lighting, Perimeter Protection and Security. Bulk metering will be supplied by Eskom, however internal metering will be supplied to reconcile cost centres.

The study has estimated the installation of 3670 modular plants @ 300m²/plant, which provides an effective 25% development coverage and comprises the following key diversified load elements:

3670 Modular Plant	: 20 000 KVA
2 Pumping	: 450 KVA
1 Offices	:100 KVA
3 Workshop	:150 KVA
1 Area Lighting	:100 KVA
3 External Heating	:1500 KVA
Total Sum	22 300 KVA

3. Legal Requirements

This section constitutes the review of the environmental authorisation and permitting requirements associated with an aquaponics installation. This opinion is limited to a new development and does not take into account expansion of existing facilities. Since no specific site layout has been completed, the review of the potential activities that may trigger environmental authorisation and permitting is exhaustive (based on the available project description) but would require a site specific assessment of geographical, social and environmental features that may apply to the development footprint.

The objective of this permitting review is to provide a list of potential activities that will require an Environmental Authorisation.

The following legislation has been reviewed as part of this permitting opinion:

- National Environmental Management Act: EIA regulations, GN 982 December 2014
    - Listing Notice 1 GN 983
    - Listing Notice 2 GN 984
    - Listing Notice 3 GN 985
- National Water Act, Act 36 of 1998
- National Environmental Management: Waste Act, Act 59 of 2008
- National Environmental Management: Air Quality Act, Act 39 of 2004– not considered to have any application on the project scope described
- National Environmental Management: Biodiversity Act, Act 10 of 2004 (NEM:BA)

This review has been done on a conservative interpretation of the scope to ensure that all potential activities triggered against the EIA regulations were taken into account. If the development progressed into further phases these activities can reviewed and possibly eliminated. However, in the event that a listed activity is triggered in any listing notice, it is advisable to include all possible activities to ensure that authorisation is obtained prior to commencement of construction.

A short review of the project scope against the NEMWA and NWA is also included.

3.1 Environmental Authorisation

The project scope was evaluated against the listed activities of the EIA regulations(Table 3.1). The project requires a full Scoping and Environmental Impact Assessment based on the fact that at least 1 activity is triggered under Listing Notice 2 of GN 984 (activity 15). However, the activities proposed as part of the project scope trigger several listed activities under GN 983 and GN 985 that would need to be evaluated in an EIA Process.

If an Environmental Impact Assessment process is initiated it would be advisable to include all the potential listed activities that could potentially be triggered. A summary of these listed activities are as follow (described in more detail in Table 3.1 below):

- GN 983 Listing Notice 1: Basic Assessment:
  - Activity 3: Fish processing facilities in excess of 20 000kg
  - Activity 6: Aquaculture facilities with a production output in excess of 20 000kg of fish
  - Activity 9: Bulk water and storm water infrastructure
  - Activity 10: Bulk sewer infrastructure
  - Activity 12: Aquaculture channels and tunnels/runways and bulk storm water outlets within 32 meters of a water course
  - Activity 27: Clearance of vegetation in excess of 1 hectares
  - Activity 28: Development on agricultural land
  - Activity 30: Activities in terms of the NEM:BA
- GN 984 Listing Notice 2: Scoping and EIA
  - Activity 6: activities requiring a permit for the release of effluent
  - Activity 15: Development in excess of 20 hectares
- GN 984 Listing Notice 3: Basic Assessment (regional)
  - Activity 12: Clearance of vegetation
  - Activity 13: Aquaculture developments in the Eastern Cape
  - Activity 14: developing canals and channels in or within 32 meters of a water course.

Table 3.1: Listed activiites in terms of the EIA regulations

Project Activity	Potential activity triggered - Activity Number	Environmental Requirements	Process triggered
Listing Notice 1 of GN 983 of 2014			
Processing or slaughter of fish at the aquaponics facility.	3. The development and related operation of facilities or infrastructure for the **slaughter** of animals with a product throughput of- (iii) finfish with a wet weight product throughput of 20 000 kg per annum.	Only applicable if a slaughtering/processing facility will be included in the development proposal. The throughput of the facility will exceed the threshold of 20 000kg.	**Basic Assessment**
Growth of finfish in aquaculture	6.The development and related operation of facilities, infrastructure or structures for aquaculture of-; (i) finfish, where such facility, infrastructure or; structures will have a production output exceeding 20 000 kg per annum (wet weight);	For the scaled up facility this activity will be triggered due to the wet weight of the fish under culture exceeding 20 000kg	**Basic Assessment**
Bulk water and storm water infrastructure	9.The development of infrastructure exceeding 1000 metres in length for the bulk transportation of water or storm water- (i) with an internal diameter of 0,36 metres or more; or (ii) with a peak throughput of 120 litres per second or more; excluding where- (a) such infrastructure is for bulk transportation of water or storm water or storm water drainage inside a road reserve; or (b) where such development will occur within an urban area.	This is likely considering the infrastructure required within the dam catchment area.	**Basic Assessment**

Project Activity	Potential activity triggered - Activity Number	Environmental Requirements	Process triggered
Bulk Sewer infrastructure	10. The development and related operation of infrastructure exceeding 1000 metres in length for the bulk transportation of sewage, effluent, process water, waste water, return water, industrial discharge or slimes) with an internal diameter of 0,36 metres or more; or (ii) with a peak throughput of 120 litres per second or more; excluding where- (a) such infrastructure is for bulk transportation of sewage, effluent, process water, waste water, return water, industrial discharge or slimes inside a road reserve; or (b) where such development will occur within an urban area.	Bulk sewer infrastructure could potentially trigger this activity	**Basic Assessment**
Construction of cascading canals for growth of fish or crops.	12. The development of- (i) canals exceeding 100 square metres in size; (ii) channels exceeding 100 square metres in size; (v) weirs, where the weir, including infrastructure and water surface area, exceeds 100 square metres in size; (vi) bulk storm water outlet structures exceeding 100 square metres in size; (x) buildings exceeding 100 square metres in size; (xi) boardwalks exceeding 100 square metres in size; or (xii) infrastructure or structures with a physical footprint of 100 square metres or more; where such development occurs- (a) within a watercourse; (b) in front of a development setback; or (c) if no development setback exists, within 32 metres	This activity is likely to be triggered if channels are used in the design if the activity will be within 32 meters of the water course. The water course for the dam may be dependent on dam fluctuations.	**Basic Assessment**

	of a watercourse, measured from the edge of a watercourse; -		
Project Activity	**Potential activity triggered - Activity Number**	**Environmental Requirements**	**Process triggered**
Clearance of land for placement of infrastructure	27 The clearance of an area of 1 hectares or more, but less than 20 hectares of indigenous vegetation, except where such clearance of indigenous vegetation is required for- (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.	Triggered but superseded by activity 15 of GN 984 of December 2014	**Basic Assessment to EIA**
Development area on rural land use.	28 Residential, mixed, retail, commercial, industrial or institutional developments where such land was used for agriculture or afforestation on or after 01 April 1998 and where such development: (ii) will occur outside an urban area, where the total land to be developed is bigger than 1 hectare; excluding where such land has already been developed for residential, mixed, retail, commercial, industrial or institutional purposes.	Potentially triggered depending on past land use	**Basic Assessment**
Cultivation of exotic or extralimitel species	30. Any process or activity identified in terms of section 53(1) of the National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004).	Assessment in terms of the biological release risk to the dam and associated water courses.	**Basic Assessment**

Project Activity	Potential activity triggered - Activity Number	Environmental Requirements	Process triggered
Listing Notice 2 GN 984			
	6. The development of facilities or infrastructure for any process or activity which requires a permit or license in terms of national or provincial legislation governing the generation or release of emissions, pollution or effluent, excluding (i) activities which are identified and included in Listing Notice 1 of 2014; (ii) activities which are included in the list of waste management activities published in terms of section 19 of the National Environmental Management: Waste Act, 2008 (Act responsible for mineralNo. 59 of 2008) in which case the National Environmental Management: Waste Act, 2008 applies; or resources. (iii) the development of facilities or infrastructure for the treatment of effluent, wastewater or sewage where such facilities have a daily throughput capacity of 2000 cubic metres or less	Release of effluent from sewage treatment plants or potentially other treatment facilities. Since this is not clear at this stage of the development it is initially accepted as triggered.	**Scoping and EIA**
	15. The clearance of an area of 20 hectares or more of indigenous vegetation, excluding where such clearance of indigenous vegetation is required for- (i) the undertaking of a linear activity; or (ii) maintenance purposes undertaken in accordance with a maintenance management plan.	Triggered due to the 430 hectares to be developed	**Scoping and EIA**

Project Activity	Potential activity triggered - Activity Number	Environmental Requirements	Process triggered
Listing Notice 3 GN 985			
Clearance of the development area	12. The clearance of an area of 300 square metres or more of indigenous vegetation except where such clearance of indigenous vegetation is required for maintenance purposes undertaken in accordance with a maintenance management plan. (a) In Eastern Cape, Free State, Gauteng, Limpopo, North West and Western Cape provinces: i. Within any critically endangered or endangered ecosystem listed in terms of section 52 of the NEMBA or prior to the publication of such a list, within an area that has been identified as critically endangered in the National Spatial Biodiversity Assessment 2004; ii. Within critical biodiversity areas identified in bioregional plans; iii. Within the littoral active zone or 100 metres inland from high water mark of the sea or an estuarine functional zone, whichever distance is the greater, excluding where such removal will occur behind the development setback line on erven in urban areas; or iv. On land, where, at the time of the coming into effect of this Notice or thereafter such land was zoned open space, conservation or had an equivalent zoning.	Potentially triggered but superseded by Listing notice 1 and 2 activities	**Basic Assessment**

Project Activity	Potential activity triggered - Activity Number	Environmental Requirements	Process triggered
Development of aquaponics facility	13. The development and related operation of facilities of any size for any form of aquaculture. (b) In Eastern Cape: i. In an estuarine functional zone; ii. In a Protected Area identified in the NEMPAA; or iii. Areas on the watercourse side of the development setback line or within 100 metres from the edge of a watercourse where no such setback line has been determined.	Triggered	**Basic Assessment**
Aquaponics infrastructure within a watercourse. A water course may be present due to drainage features around the dam and also proximity to the dam.	14. The development of- (i) canals exceeding 10 square metres in size ; (ii) channels exceeding 10 square metres in size; CO bridges exceeding 10 square metres in size; (iv) dams, where the dam, including infrastructure and water surface area exceeds 10 square metres in size; (v) weirs, where the weir, including infrastructure and water surface area exceeds 10 square metres in size; (vi) bulk storm water outlet structures exceeding 10 square metres in size; (vii) marinas exceeding 10 square metres in size; (viii) jetties exceeding 10 square metres in size; (ix) slipways exceeding 10 square metres in size; (x) buildings exceeding 10 square metres in size; (xi) boardwalks exceeding 10 square metres in size; or (xii) infrastructure or structures with a physical footprint of 10 square metres or more; where such development occurs (a) within a watercourse; (b) in front of a development setback	This activity is likely to be triggered due to the proximity of the dam and the drainage features in close proximity to the catchment around the dam.	**Basic Assessment**

	(c) if no development setback has been adopted, within 32 metres of a watercourse, measured from the edge of a watercourse; excluding the development of infrastructure or structures within existing ports or harbours that will not increase the development footprint of the port or harbour.		

3.2 Water Use Licence

The development area is close to the Mthatha dam which would infer that drainage channels are located across the site. The proximity to the dam would also potentially require a water use license for developments within close proximity to the dam's upper level. Roads, storm water and water infrastructure is likely to require culverts and stream/watercourse crossings. Water for the operation of the facility is expected to be from surface water abstraction.

Based on these activities, the following items may require a license in terms of the water act based on the following listed activities:

Table 3.2: Potential NWA Activities triggered

No	Activity	Applicability to project
21a	Taking water from a water resource	Water abstraction from the Mthatha dam
21b	Storing water	Due to the large volumes of water to be used in the aquaculture activities and the potential for emergency release into the dam.
21c	Taking water from a water resource: Water abstraction from the Mthatha dam or boreholes	Installation of culverts and development in drainage channels
21f	Discharging waste or water containing waste into a water resource through a pipe, canal, sewer, sea outfall or other conduit;	Discharges to the Mthatha dam from stormwater, sewer or treatment plants
21g	Disposing of waste in a manner which may detrimentally impact on a water resource;	Potentially included for storm water dams
21i	Altering the bed, banks, course or characteristics of a watercourse;	Installation of culverts and development in drainage channels

A detailed impact assessment would be required to evaluate the impact on the surrounding water courses. The EIA to be conducted must address these impacts though a dedicated specialist study.

3.3 Waste License

Due to the shortage of a waste disposal facility in the area, it is proposed to develop a disposal site on the property. This could potentially trigger a waste license under the following listed activities in terms of GN 718 of July 2009:

	Category A (Basic Assessment)	
2	The storage including the temporary storage of general waste in lagoons.	In the event that fish waste/excrement is stored in ponds for disposal.
11	The treatment of effluent, wastewater or sewage with an annual throughput capacity of more than 2 000 cubic metres but less than 15 000 cubic metres.	If water and sewage treatment facilities exceed 2 000 cubic meters per annum
17	The storage, treatment or processing of animal manure at a facility with a capacity to process in excess of one ton per day.	This activity will be triggered if waste was to be cleaned out of tanks or facilities and stored. The throughput of 1 ton per day would be unlikely considering the use of the waste as fertiliser.
18	The construction of facilities for activities listed in Category A of this Schedule	If the above facilities were being constructed as part of the development a waste license would be required for construction.
	Category B (EIA)	
7	The treatment of effluent, wastewater or sewage with an annual throughput capacity of 15 000 cubic metres or more.	This activity will be triggered should the treatment plant exceed 15 000 cubic metres per annum.
10	The disposal of general waste to land covering an area in excess of 200m^2	This activity would be triggered if a disposal site will be developed on site.
11	The construction of facilities for activities listed in Category B of this Schedule	Construction of the facilities listed under Category B above.

The above activities would be included in the EIA process. A detailed specialist study would be required to evaluate the impact on the surroundings. Because the site is in close proximity to the Mthatha dam, any waste disposal activities would need to investigate the waste classification to determine the nature and content of the waste produced as well as the groundwater to ensure that development of a waste site does not pose a substantial risk to a strategic natural resource (groundwater for domestic use).

The development of the aquaponics facility would trigger several listed activities in terms of the EIA regulations. Most notably, a full Scoping and EIA process would need to be conducted due to the large footprint of the area to be developed. The nature of the aquaponics facility, and the sheer size would require a very detailed EIA process with several specialist studies required. Fish waste (faecal matter) also has the potential to be high in hazardous substances in areas where they could be exposed to chemicals, although this would be unlikely considering the nature of aquaculture and requirements for clean water as well as the fact that this material will be re-used as fertiliser.

However the facility would need to be managed in strict accordance to environmental management plans to be produced as part of the EIA process.

If slaughtering or processing of the fish will take place as part of the development, waste management facilities would need to be suitable to handle organic and biological wastes produced.

3.4 Occupational Health and Safety

The Occupational Health and Safety Act (85 of 1993) is applicable and must be complied with. This is to ensure a safe working environment.

3.5 Construction Regulations

Construction Regulations 2014 are applicable and as such an Occupational Health and Safety Agent must be appointed during the design phase. As per Construction Regulations 2014 a Construction Work Permit is required to be obtained prior to the commencement of construction.

4. Town Planning Assessment

The study area comprises various portions. Included in these portions are RE 75, portion 3 of 75 as well as various unregistered surveyed portions. Complications were discovered regarding the ownership of RE75. Initial studies uncovered that farm 75 belongs to an unknown owner. After conferring with the Deeds Office, it was discovered that the previous name of the farm was LOT C Umtata and was held by the Department of Transkei under T7193/1949.

According to a document received from the Department of Rural Development, the land is endorsed to KSD local municipality (see Appendix B).

Previous Farm Name	Previous Owner	Extent	Title Deed no.
Lot C Umtata	Department of Transkei	1048.6ha	T7193/1949

Current Farm Name	Current Owner	Extent	Title Deed no.
RE75	Unknown	3314.78ha	Unknown

Portion 3 of 75	Current Owner	Extent	Title Deed no.
Portion 3 of 75	Unknown	292m^2	Unknown

There are various registered portions of the land with only one of these registered portions being located within the study area. This is portion number three (3). There is no information regarding the owner of portion 3 of 75 (as seen in the table above).

There are also various portions of land within the study area which have been subdivided. See plan below. It can be assumed that these portions are surveyed, unregistered state owned land, however after conferring with the Surveyor General, it has become evident that these portions have not been captured on their system and thus no surveyor general diagrams are available for these portions.

Figure 3 - Unregistered, Surveyed Portions of Farm75

4.1 Land Audit

The surveyed portion of farm RE75 located within the study area is portion 3. The size of this portion is 292m². No information can be found for the unregistered portions of land within the study area. The total site area is 430ha and the perimeter is 8.9km.

4.2 Zoning

The study area falls outside of the Mthatha urban edge, thus according to the Mthatha Town Planning Scheme, no municipal zoning has been allocated for the area.

4.3 Access

Access into the study area can be gained through DR08217.

4.4 Land use

The majority of the land is utilised as agricultural farming. There are also a few properties located at the north eastern portion of the study area where this can be termed "residential". There are also social facilities which include two schools and a clinic located within RE75. The road network has been developed within the residential areas of the farm.

4.5 Land Claims

There have been no discovered claims on the land. To date, no claims on the land have been made as per the city's records.

4.6 Suitability

4.6.1 Slope Analysis

It can be seen through the slope analysis below that the study area is at a fairly flat level. There are not many slopes to cause restrictions for development

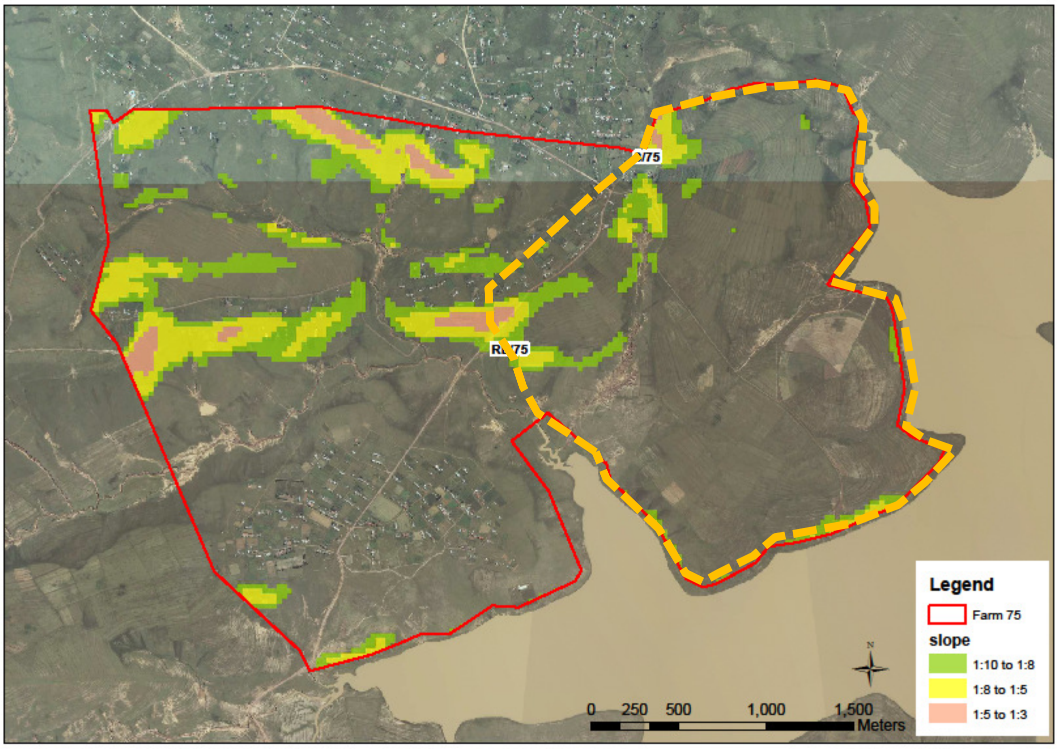


Figure 4 - Slope Analysis of Farm 75

The plan below shows the 20m contours on the land. It can be seen through this plan as well as through the slope analysis that the study area has a fairly flat landscape with approximately 80m height difference between the highest and lowest points on the site.

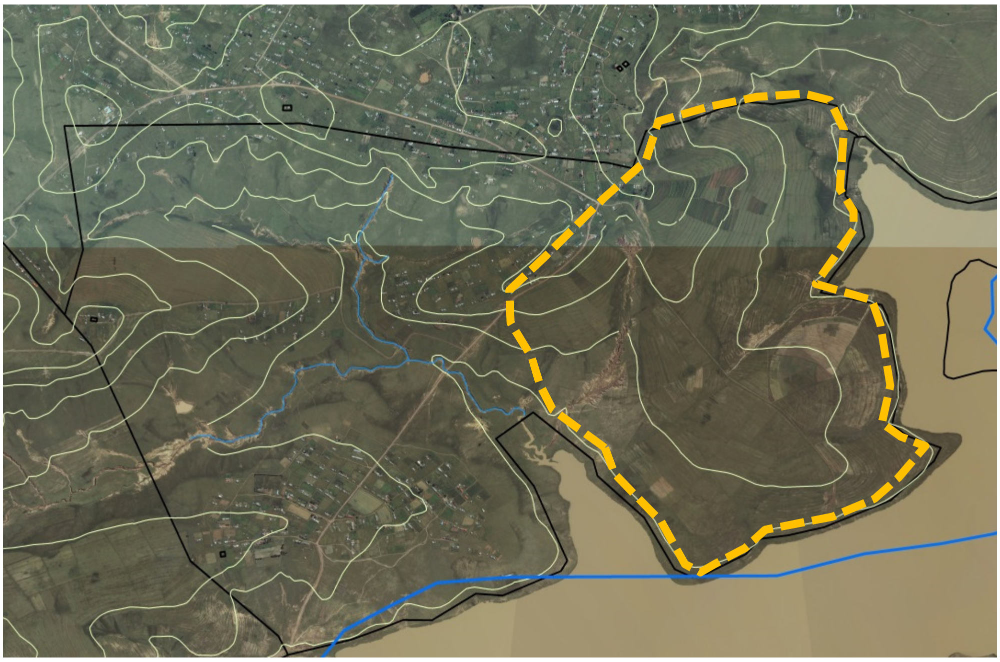


Figure 5 - 20m contours

5. Environmental Assessment

The Eastern Cape Biodiversity Conservation Plan (ECBCP) is a detailed, low-level conservation mapping for land-use planning purposes. Specifically, the aim of the Plan is to map critical biodiversity areas through a systematic conservation planning process. The current biodiversity plan includes the mapping of priority aquatic features, land-use pressures, and critical biodiversity areas which develops guidelines for land and resource-use planning and decision-making.

The main outputs of the ECBCP are "critical biodiversity areas" or CBAs. Two out of the four CBA areas were identified for the study area.

The following plan highlights the critical biodiversity areas within the study area.

Figure 6 - Critical Biodiversity Plan

CBA's	Recommended land use objective
CBA 1: Natural landscapes	Maintain biodiversity in as natural state as possible. Manage for no biodiversity loss.
CBA 2: Near natural landscapes	Maintain biodiversity in near natural state with minimal loss of ecosystem integrity. No transformation of natural habitat should be permitted.
CBA 3: Functional landscapes	Manage for sustainable development, keeping natural habitat intact in wetlands (including wetland buffers) and riparian zones. Environmental authorisations should support ecosystem integrity.
CBA 4: Transformed landscapes	Manage for sustainable development.

5.1 Developmental Potential

Through our above analysis, the size of the study area is approximately 459ha. The plan below shows the total developable land minus the dam buffer. The criteria for determining the "Theoretical Buffer Line" was that it should be the greater of the following two cases:

1. 1.5m vertical offset above 1:100 floodline
2. 15m horizontal offset to the 1:100 floodline

Thus, the total developable land amounts to approximately 417ha. The dam buffer is shown in the dark blue.

Size of study area	Excluding dam buffer	Total developable land
459ha	42ha	417ha

Figure 7 - Developmental Potential

6. Risk Assessment

The objectives of Risk Assessment are as follows:

- To conduct a full and suitably rigorous analysis of the risks associated with the project
- To develop and full risk register for the identified risks
- To allow the Client to monitor and manage the implementation and progress of mitigation actions
- To use quantitative risk assessment in order to determine the contingency range required for the project
- To enable an integrated understanding of any uncertainties that can impact on the project objectives

In general risks fall into one of five categories namely:

- External (political, social, environmental)
- Business, Legal, Financial & Commercial (strategic Risks, procurement)
- Project Management & Construction (project scope, health & safety, schedule)
- Technical Design (standards & specifications, design criteria)
- Operational Readiness (operations, logistics & support, sustainable development

Risks have been given a probability rating of Almost Certain, Likely, Possible, Unlike or Rare and a Consequence Rate of Insignificant, Minor, Moderate, Significant, Major or Catastrophic as illustrated below in Table 6.1:

Risks have been identified, expanded on and classified in Table 6.2. The risks that have been identified are primarily related to the bulk infrastructure.

Table 6.1 - Risk Rating

Risk probability of occurrence	Consequence Indicator: Insignificant	Minor	Moderate	Significant	Major	Catastrophic
Almost Certain	Tolerable 16	Tolerable 21	High 27	Intolerable 30	Intolerable 34	Intolerable 36
Likely	Tolerable 11	Tolerable 17	High 22	High 28	Intolerable 32	Intolerable 35
Possible	Broadly Acceptable (Low) 7	Tolerable 12	Tolerable 18	High 24	High 29	Intolerable 33
Unlikely	Broadly Acceptable (Low) 4	Broadly Acceptable (Low) 8	Tolerable 13	Tolerable 19	High 25	Intolerable 31
Rare	Broadly Acceptable (Low) 2	Broadly Acceptable (Low) 5	Broadly Acceptable (Low) 9	Tolerable 14	High 23	High 26
Unforeseen	Broadly Acceptable (Low) 1	Broadly Acceptable (Low) 3	Broadly Acceptable (Low) 6	Tolerable 10	Tolerable 15	Tolerable 20

Table 6.2 - Risk Assessment

References							Risk Rating		
Category	**ID**	**Opportunity or Threat**	**Risk Name & Description**	**Causes** (drivers or triggers)	**Primary Effect/s or Impact/s**	**Timing**	**Consequence Rating**	**Likelihood Rating**	**Inherent Risk Rating**
Technical	1	Threat	Inconsistent supply voltage from Eskom.	Inadequate capacity due to network strength	Plant can't operate as per operating philosophy	Operations	F Catastrophic	C Possible	33
Technical	2	Threat	Unknown Water Treatment requirements	Unknown quality of water in the Mthatha Dam	Insufficient treatment of water allowed for	Planning	F Catastrophic	C Possible	33
Technical	3	Threat	Successfully extract water out Dam, tie in to existing infrastructure	Existing infrastructure needs to be utilised to extract water	No water available, the project cannot be implemented	Planning	D Significant	C Possible	24
Technical	4	Threat	Fire	Fire	Damage to infrastructure as a result of fire	Operations	E Major	C Possible	29
Technical	5	Threat	Solid Waste Disposal: 1. Handling & Disposal of Fish Offal 2. Existing Mthatha Solid Waste Site unlicensed 3. Permission to construct a Solid Waste Site onsite unlikely	1. Large amounts of fish offal waste generated onsite must be disposed of 2. General waste from site will need to be disposed of	1. Inadequately designed wastewater treatment works and/or solid waste disposal site 2. High transport cost	Operations	D Significant	C Possible	24
References							Initial Risk Rating		

Category	ID	Opportunity or Threat	Risk Name & Description	Causes (drivers or triggers)	Primary Effect/s or Impact/s	Timing	Consequence Rating	Likelihood Rating	Inherent Risk Rating
Technical	6	Threat	Assumptions made for unit bulk demands	Incorrect assumptions for unit bulk demands made	Insufficient infrastructure capacity	Planning	D Significant	C Possible	24
Technical	7	Threat	Cost Estimate Class 5 (order of magnitude)	High level cost estimate	Insufficient accuracy in funding application	Planning	D Significant	C Possible	24
Project Management	9	Threat	Contractor Non-Compliance to Permits	Contractors not adhering to permit requirements	1. Contractor in breach of law 2. Project Owner and Engineer can be held liable 3. Project stoppages	Construction phase	D Significant	C Possible	24
Operational readiness	10	Threat	Insufficient knowledge about aquaponics in the area	Insufficient knowledge about aquaponics in the area	Project implementation delayed	Construction phase	E Major	B Likely	32

References							Initial Risk Rating		
Category	**ID**	**Opportunity or Threat**	**Risk Name & Description**	**Causes** (drivers or triggers)	**Primary Effect/s or Impact/s**	**Timing**	**Consequence Rating**	**Likelihood Rating**	**Inherent Risk Rating**
Operational readiness	11	Threat	Operational Readiness - Client: The handover from project to the client requires training of the operating system. There could be a situation that the resources who require training are not fully competent to operate the system. (Clients readiness and ability to accept the new system)	1. Operator not ready to take over and operate scheme 2. Lack of Training	Damage and vandalism to system whilst not in operation	Construction phase	D Significant	C Possible	24
External	12	Threat	Water Use Licence not granted	Where Dept Water Affairs rules that there is insufficient water	Not able to implement project	Planning	D Significant	C Possible	24
External	13	Threat	Environmental Authorisation not granted	Dept of Environmental Affairs does not grant authorisation	Not able to implement project	Planning	E Major	C Possible	29

References							Initial Risk Rating		
Category	ID	Opportunity or Threat	Risk Name & Description	Causes (drivers or triggers)	Primary Effect/s or Impact/s	Timing	Consequence Rating	Likelihood Rating	Inherent Risk Rating
External	14	Threat	Political Pressure on Project: Public mandates placed on the project. Project demands and expectations in the community.	Pressure from community demanding service delivery	1. Community action prevents delivery and construction, resulting in delays 2. Damage to property and persons	Construction phase	F Catastrophic	C Possible	33
External	15	Threat	Unsuitable Climate	High temperatures in Summer and Low temperatures in winter not ideal for aquaponics	Aquaponics system not functioning adequately	Operations	D Significant	C Possible	24
External	16	Threat	Land Claims	Land Claims instituted by local residents	Unable to procure land and therefore project cannot proceed	Planning	D Significant	A Almost Certain	30
External	17	Threat	Unsuitable Climate	Unsuitable Climate	Climate unsuitable to aquaponics	Operations	D Significant	C Possible	24

References							Initial Risk Rating		
Category	ID	Opportunity or Threat	Risk Name & Description	Causes (drivers or triggers)	Primary Effect/s or Impact/s	Timing	Consequence Rating	Likelihood Rating	Inherent Risk Rating
Business, legal, financial	18	Threat	Lack of Finance	Expense of Bulk Infrastructure	Not able to implement project	Planning	F Catastrophic	C Possible	33

7. Cost Estimate

In terms of the American Association of Cost Engineering the cost estimate produced is a Class 5 estimate based on high level project objectives. This estimating technique is the analogous technique which means that the information is based on similar projects. Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side and +30% to +100% on the high side.

Class 5 estimates are prepared for strategic business planning purposes.

Table 7.1 - Estimate Class Breakdown

	Primary Characteristic	*Secondary Characteristic*		
ESTIMATE CLASS	**MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges
Class 5	0% to 2%	Concept screening	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +100%
Class 4	1% to 15%	Study or feasibility	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

The total cost to upgrade water, wastewater, stormwater, roads, solid waste and electrical infrastructure is approximately **R400million**. A solid waste site has been included in these costs even though permission to situate one on the site may not be granted due to the proximity to the Mthatha Dam.

It is recommended that a further investigation be undertaken in order to ascertain the following:

- If the Dept of Water Affairs will allow abstraction of water from the Mthatha Dam
- If the Dept of Environmental Affairs will allow a solid waste site to be constructed on the site
- If Eskom will be able to supply sufficient electricity

Table 7.2 - Cost Estimate

Item		Cost
Water		
4.2Ml Water Treatment Works at Dam Wall	1	R 71 000 000
Pumping Main: Dam Wall to Site (200mm for 15km)	1	R 15 000 000
Raw Pump Station	1	R 1 600 000
Clear Water Pump Station	1	R 1 600 000
7 Ml Aquaponics Reservoir on Site	1	R 24 500 000
28 000m Aquaponics Water Reticulation on Site	1	R 16 300 000
1.7 Ml Clear Water Reservoir on Site	1	R 6 000 000
20 000m Clear Water Reticulation on Site	1	R 13 900 000
Wastewater		
2.9Ml/day Wastewater Treatment Works	1	R 40 000 000
20 000m Wastewater Network on site	1	R 11 600 000
Roads		
Upgrade R61 to 430ha (10.2km) to 7m wide surfaced	1	R 35 900 000
Internal Roads (gravel, 3m wide)	1	R 8 400 000
Solid Waste Site		
Solid Waste Site	1	R 51 000 000
Electricity		
Upgrade Electrical Infrastructure	1	R 50 000 000
		R 347 700 000

8. Recommendations

The total cost to upgrade water, wastewater, stormwater, roads, solid waste and electrical infrastructure is approximately R350million. A solid waste site has been included in these costs even though permission to situate one on the site may not be granted due to the proximity to the Mthatha Dam.

It is recommended that a further investigation be undertaken in order to ascertain the following:

- whether the Dept of Water Affairs will allow abstraction of water from the Mthatha Dam
- whether the Dept of Environmental Affairs will allow a solid waste site to be constructed on the site
- whether Eskom will be able to supply sufficient electricity

Appendix A : ATS Consulting Aquaponics Report

Aquaponics for Mthatha Dam

Aquaponics provides a solution to the main issues these two systems face; the need for sustainable ways of filtering or disposing of nutrient-rich fish waste in aquaculture and the need for nutrient-rich water to act as a fertilizer with all of the nutrients and minerals needed for plants grown through hydroponics. Combining these two systems provides an all-natural nutrient solution for plant growth while eliminating a waste product which is often disposed of as wastewater.

Water is pumped continuously through a recycling system – consisting of an automatic flood and drain cycle – which runs from the fish tanks through the plant grow beds. The plants remove the solid and dissolved waste – nitrate and phosphate, which are plant fertilisers but toxic to fish – before the 'clean' water is returned to the fish tanks. The correct management of such a system demands practical knowledge of aquaculture and hydroponic systems, and the way in which they are able to interact and complement each other within an aquaponics system.

Example of a system using a hydroponic tunnel of 30m X 10

The system was set up in Grahamstown to prove viability.

The aquaponics tunnel system cost him R350 000 to erect, the running and maintenance costs are relatively low. Only one manager is needed, plants and fish are produced from the same fish feed, and the system requires only 1,62kW of electricity, excluding heating costs. A 3,3kW heat pump is installed, but this is used only in winter. Water usage is relatively low at 2 000l per week in summer and approximately half of that in winter. Little space is needed to erect a facility.

The tilapia (Oreochromis mossambicus) is breed on site before introducing them into the aquaponics system at the age of one month. The fish are stocked at a density of 660 in each of the four 4 300l fish tanks. This ensures that adequate waste is produced to sustain the plants in the 2,8m2 grow beds.

The tilapias are harvested at a weight of 300g when they are approximately nine months old. Grow beds are filled with a gravel medium in which plants such as cucumbers and tomatoes can root themselves, even though they are trellised. Other plants, such as basil, are grown in floating polystyrene rafts through which their roots hang into the nutrient-rich water.

In addition to managing the balance between the production of fish waste and its effective absorption by plants, the temperature in the tunnel is kept at an average of 30°C. This provides optimal conditions for the production of almost all crop varieties. The herbs and vegetables derive all their nutrients from the water originating from the fish tanks. Moreover, no pesticides are used, as that would compromise the safety of the fish. Insect infestations on plants, such as red spider, are controlled by organic means – a garlic/chili/khaki bush spray is most commonly used.

Crops that can be grown

Some Fish species that may be used

- Red Tilapia
- Catfish
- Rainbow Trout
- Carp
- fresh water mussels
- fresh water prawns
- fresh water crayfish

Tilapia is the most common fish used because of their good growth rates and adaptability to the system of aquaculture. The white-fleshed meat of tilapia is popular due to its desirable culinary properties of taste and texture. It will be required to be grown under artificially controlled temperatures.

Different tilapia species have different temperature ranges required for optimal growth. None of the species can survive less than 10 ℃. They do well in a range of 17-32 ℃, depending on the species, but ideal growth occurs at 26.7 ℃ and higher In aquaponics, tilapia are usually raised between 22.2 and 23.3 ℃ in order that the needs of the fish, the nitrifying bacteria and the aquaponic plants are met, as plants perform better at slightly lower temperatures

Plants that can be used

- Tomatoes
- Onions
- Squash
- Peppers
- Cucumbers
- Lettuce
- Spinach
- Pak
- Choy
- Basil
- Begonias
- Impatiens
- Mints
- Black Seeded Simpson Beets
- Mustard
- Swiss chard
- Peas
- Arugula
- Watercress
- Chives
- Beans
- Watermelon
- Cabbage
- Taro
- Redina lettuce
- Endive

- Spinach
- Amaranth
- Celery
- Parsley
- Tatsoi
- Collard
- Kale
- Garlic
- chives
- Okra
- Dill
- Cilantro
- Recao
- Rice
- Zucchini
- Cantaloupe
- Common chives

Higher value crops need to be used because of the high cost of the infrastructure and running costs. The most important hydroponic crops are tomato, peppers and cucumber.

Design of a system

Fish and crops have differing optimum climatic growing requirements and it is recommended that the two systems are separated into a separate aquaculture and hydroponics system. These systems although separate they function as an aquaponics system

Warm-water fish – tilapia or carp – need to be housed within the confines of a tunnel to achieve significant body growth. To achieve the necessary temperature of 28°C to 30°C required for rapid fish growth requires an air temperature in excess of 40°C, excessive for most plants.

The aquaculture unit has self-cleaning tanks draining to a sediment tank and biological filter. It is no different to a standalone fish culture system. Most of the nutrients are captured in the sediment trap and use them for plants while the rest of the water passes through a traditional bio-filter and returns, warm and clean, to the fish.

The plant culture unit can be remote from the fish culture system, in its own shade house or ventilated tunnel. The only connection is that a portion of the concentrated fish waste is drained periodically by gravity from the sediment to a holding tank in the plant unit. A small pump then circulates the homogenised waste from this tank through the gravel beds in the typical manner, with bell-siphons keeping the beds moist and fertilised.

Plants can thus be grown in optimal temperature or humidity without affecting fish growth. The only additional cost is the construction of a bio-filtration tank for the fish to compensate for the loss of gravel-bed filtration.

Using such a system has many advantages:

- Fish growth is optimal, unaffected by ventilating the plants, and results in higher yield;
- Humidity is reduced to acceptable levels, limiting mould and fungal attacks;
- More space is available for the fish, with wider, shallower tanks that absorb more oxygen;
- The removal of all solid wastes means that relatively simple bio-filtration can be used;
- The design is effective at small or large commercial scale;
- A plant culture unit can easily be added to a fish culture system.

Generally, water losses of 10-20% can be expected per month.

The basic infrastructure design can use the following principles:

- Four fish rearing tanks, 7.8 m^3 each
- Two cylindro-conical clarifiers (waste water treatment), 3.8 m^3 each
- Four filter tanks, 0.7 m^3 each
- One degassing tank (water treatment), 0.7 m^3
- Six hydroponic tanks, 11.3 m^3 each minimum 30 cm deep
- Total plant growing area, 214 m^2
- One sump, 0.6 m^3
- Base addition tank, 0.2 m^3
- Total water volume, 110 m^3
- Land area - 0.05 ha

Management Process

- Air stones, 88 in rearing tanks, 144 in hydroponic tanks
- Solids removal, three times daily from clarifier, filter tank cleaning one or two times weekly
- Continuous degassing of methane, CO2 , H2S, N2
- Denitrification in filter tanks
- Direct uptake of ammonia and other nutrient by plants
- Nitrification in hydroponic tank
- Retention time: rearing tank, 1.37 h; clarifier, 20 min, hydroponic tanks, 3 h

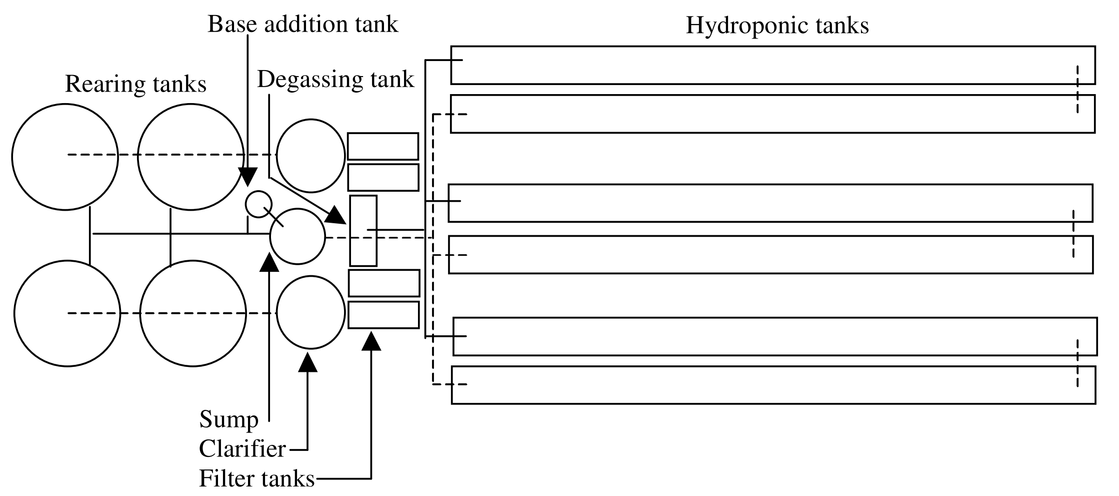
Important principles

- Optimum feeding rate, 60 - 100 g/day/m2 of plant growing area prevents nutrient accumulation or deficiency
- Slow removal of solids increases mineralization
- Frequency of filter tank cleaning controls
- nitrate levels through denitrification

Production Management

- Feeding: three times daily ad libitum
- 32% protein, floating, complete diet
- Stocking rate: Niles, 77 fish/m3; Reds, 154 fish/m3
- Stagger fish production, 24 week cycle, harvest every 6weeks

- Plant production – staggered or batch
- Use biological insect control
- Monitor pH daily, maintain pH 7-7.5 by alternate and equal additions $Ca(OH)_2$ and KOH
- Add chelated iron (2 mg/L) every 3 weeks
- Add makeup water daily, about 1.5% of system volume



Tank Dimensions	Pipe Sizes
Rearing tanks: Diameter: 3 m, Height: 1.2 m, Water volume: 7,800 L Clarifiers: Diameter: 1.8, Height of cylinder: 1.2 m, Depth of cone: 1.1 m, Slope: 45°, Water volume: 3,785 L Filter and degassing tanks: Length: 1.8 m, Width: 0.76 m, Depth: 0.61 m, Water volume: 700 L Hydroponic tanks: Length: 30.5 m, Width: 1.2 m, Depth: 41 cm, Water volume: 11,356 L Sump: Diameter: 1.2 m, Height: 0.9 m, Water volume: 606 L Base addition tank: Diameter: 0.6 m, Height: 0.9 m, Water volume: 189 L Total system water volume: 111,196 L Flow rate: 378 L/min, Pump: 0.37 kW Blowers: 1.1 kW (fish) and 0.74 kW (plants) Total land area: 0.05 ha.	Pump to rearing tanks: 7.6 cm Rearing tanks to clarifier: 10 cm Clarifiers to filter tanks: 10 cm Between filter tanks: 15 cm Filter tank to degassing tank: 10 cm Degassing to hydroponic tanks: 15 cm Between hydroponic tanks: 15 cm Hydroponic tanks to sump: 15 cm Sump to pump: 7.6 cm Pipe to base addition tank: 1.9 cm Base addition tank to sump: 3.2 cm

Water quality

Good water quality must be maintained at all times in a recirculating fish tank to maintain optimal growth conditions and health of the fish. Regular water quality testing is essential and can be performed using water quality testing kits obtained from aquacultural supply companies. The most critical water quality parameters to monitor are dissolved oxygen concentrations, temperature, pH, and nitrogen from ammonia, nitrate and nitrite. Nitrogen in the form of nitrate and nitrite usually does not present a water quality problem in aquaponic fish tanks as nitrite is quite quickly converted to nitrate and nitrate itself is only seriously toxic to fish at very high levels (300-400 mg/L). The bio-filtration mechanism in aquaponic systems also removes nitrates quite well and can keep their concentration at much lower levels than this.

Thus the most important water quality parameters to design and make practice recommendations for are temperature, dissolved oxygen and ammonia. Other important parameters include salinity, phosphate, chlorine and carbon dioxide. Other factors that influence the quality of fish tank water include the stocking density of the fish, their growth rate, the rate at which they are fed, the volume of water in the system and environmental conditions.

The ideal values for tilapia water quality parameter requirements critical for the design of aquaponic systems (which are explained below) are summarized in Table below.

Parameter	**Optimal Range for Fish Tank in Aquaponic Systems**
Dissolved Oxygen	6.0-7.0 mg/L
Temperature	22.2-23.3 ℃
pH	6.5 - 7
NO_3^-	<150 mg/L
Ammonia NH_3	<0.04 mg/L
NH_4^+	<1.0 mg/L

The most important quality factor for plants is the PH and the salt content.

Feed requirements

All plants may have different nutritional requirements; for instance leafy green vegetable require more nitrates than fruiting plants. However all plants in aquaponic systems need 16 essential nutrients for maximum growth. These come in the form of macronutrients, which in addition to carbon, hydrogen, and oxygen, which are supplied by water, carbon dioxide, and atmospheric air, include nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), phosphorous (P), and sulphur (S). There are seven micronutrients necessary as well and they are chlorine (Cl), iron (Fe), magnesium (Mn), boron (B), zinc (Zn), copper (Cu), and molybdenum (Mo). These nutrients have to be balanced, as an excess of one may interfere with the uptake of another, as is the case when potassium affects the bioavailability of magnesium or calcium. Iron concentrations in aquaponic wastewater are insufficient for plant growth and therefore iron has to be supplemented to a concentration of 2 mg/L.

In aquaponic systems, tilapia fish grow best when fed three times daily ad libitum the amount of food that they will eat in 30 minutes, where the feed is composed of 32% protein.

Size of fish (grams)	Amount of daily feed (% of fish weight)
0–1	30–10
1–5	10–6
5–20	6–4
20–100	4–3
larger than 100	3–1.5

Bacteria
Autotrophic bacteria that convert fish waste into nutrients for plant uptake are crucial and without them, an aquaponic system will not function. Appropriate environmental conditions must be maintained to ensure the abundant growth of microbial populations in the bio-filter. Nitrifying bacteria growing on the large surface of the bio-filter media and in association with the plant roots will perform all of the necessary nutrient conversions for the feeding of plants and for the filtration of fish tank effluent. The grow bed media in media-filled aquaponics system functions as a fluidized bed bioreactor - it removes dissolved solids and houses nitrifying bacteria involved in the conversion of nutrients through a process known as the nitrogen cycle.

Fish tank effluent will contain total ammonia (NH3 and NH4+) excreted through fish urine and gills and formed from the decomposition of organic solids such as fish waste and uneaten food. Nitrifying bacteria, particularly Nitrosomonas sp. convert the toxic ammonia, using it as an energy source to nitrite (NO2-) - another compound toxic to fish - by using oxygen in an oxidation process. The nitrite is then quickly oxidized by another type of nitrifying bacteria, namely Nitrobacter sp. to form nitrate (NO3-), the preferred form of nitrogen for plant uptake.

When fish are initially introduced into an aquaponic system, the ammonia levels in the water increase for the first week or so, after which they begin to decrease while nitrite levels rise. Once two weeks to 20 days have passed, the nitrite levels will fall as well, while nitrate levels increase. At four weeks or between 20 and 30 days, the nitrogen compounds will relatively stabilize in concentration.

Nitrifying bacteria need oxygen for their metabolic processes, therefore the bio-filter media that they are housed in needs to be porous and well aerated. They also require a certain pH range. This is from pH 7 to 8, where the performance of the microbes in oxidizing unwanted compounds begins to decrease below a pH of 6.8. The optimal conversion of toxic to non-toxic compounds occurs at 25 °C.

Water Flow Rate
The rate of water turnover should be designed to ensure good water quality. Water should be passed through the hydroponic grow media enough times per day to be adequately filtered and therefore to ensure appropriate removal of waste compounds that are toxic to fish. Excessively high flow rates,

however will reduce to too great of an extent the amount of time toxic wastes in fish tank effluent spend in contact with microbes in the bio-filter. This will cause some of these compounds to be flushed back into the fish tank before they are converted to safer forms or assimilated by the hydroponic plants.

For a 150 lt fish tank, the flow rate needs to be 0.3m^3 per hour.

Hydraulic loading rate of a system is calculated by dividing the flow rate of water, Qw through the system by the surface area of the grow bed, the flow rate of water is 0.3 m^3/hr and the grow bed surface area is 6 m^2.

$HLR = Q_w / A_{grow\ bed} = 0.3\ m3hr /\ 6m2 * 24\ hrday = 1.2\ mday$ A Hlr close to the ideal

The hydraulic loading rate (HLR) of the fish tank effluent onto the surface of the grow media will determine the rate at which fish wastewater enters the coconut husk grow medium. Although hydraulic loading rates have shown to have no significant effect on fish production performance, the specific growth rates of fish or the efficiency with which fish utilize food for biomass growth (feed conversion ratio), research experiments in Malaysia have concluded that plant growth is significantly affected by the rate at which water is supplied to the surface of the grow bed in recirculating aquaponics systems Since the largest proportion of the capital a backyard aquaponics grower can earn comes in the form of plant outputs, designing for plant growth is recommended and this includes having an appropriate HLR.

Overly high hydraulic loading rates decrease the contact time between microbes in the grow bed and the nutrients they are supposed to convert. Therefore plant growth decreases significantly with very high HLR. The hydraulic loading rate at which optimal plant growth occurred was 1.28 m/day. At this HLR, the highest fish production and highest overall percentage of nutrient removal was observed as well.

Aeration System

An aeration system will be put in place in order to maintain adequate oxygen levels throughout the system. The gradual compaction of grow bed media (and its decomposition if the media is organic in nature) in media-filled aquaponics system combined with its constant submergence in water creates anaerobic zones in the grow bed which interfere with the aerobic activities of the nitrifying bacteria and potentially causes the destruction of plant roots.

Fish Tank Aeration

The silicone rubber air distribution tube that aerates the fish tank is further divided into four and each of the four tubes is placed vertically into one cohort section of the tank for even air distribution Air flow to the fish tank is controlled by a valve on the main tank tube and can be increased over the 6-week growing period of the fish. To diffuse the air coming out of the tubes and maximize aeration of the water, air stones are attached to the bottom of each thin silicone rubber air tube.

PH Regulation

The pH should be maintained close to 7 and this can be achieved with the additions of bases such as calcium hydroxide ($Ca(OH)2$) and potassium hydroxide (KOH). These bases should be applied several times weekly on an alternating basis. The frequency with which they are to be added can be determined by monitoring water pH to see how quickly it changes. The amount of base to be added can be determined by performing acid-base titrations on the fish tank water and seeing what quantity of base will produce the desired increase in pH. These tests are provided in water quality testing kits available for sale from aquacultural supply companies.

One base that should never be used for pH control in these systems is sodium bicarbonate (NaHCO3) as a high concentration of sodium ion (Na+) in the presence of chloride ions (Cl-) forms salt (NaCl). Sodium concentrations above 50 mg/L are toxic to fish and they interfere with the uptake of several nutrients

Appendix B : Title Deed Registration & Land Claims

ATT: DARSHIKA – 043 743 8485

| Property | Owner | Deed/Document | LPI Enquiry | Interdict | Document Request | Transfers | Bulk Properties | User Admin | Billing

Property Enquiry Details

Property enquiry results for "umtata, 75, Ncise, 0" in the Deeds Registry at "UMTATA"

Property detail:

Deeds registry	UMTATA
Property type	FARM
Farm name	NCISE
Farm number	75
Portion	0 (REMAINING EXTENT)
Province	EASTERN CAPE
Registration division/Administrative district	UMTATA RD
Local authority	KING SABATA DALINDYEBO MUNICIPALITY
Previous description	-
Diagram deed number	-
Extent	3314.7788 H
LPI Code	C11000000000007500000

Title Deeds detail:

No data found for this query!

Owners detail:

No data found for this query!

Endorsements / Encumbrances:

Endorsement / Encumbrance	Holder	Amount	Image Scanned reference	Document copy?
I-924/2010LG	KING SABATA DALINDYEBO MUNICIPALITY	-	20100917 10:12:44	Yes

History:

No data found for this query!

Back to top of page

Requested by **a0022084** with user reference **None** on: Thursday, 21 April 2016 09:35

DeedsWeb Version 4.0.1

Appendix C : Operational Analysis Mthatha System

DEVELOPMENT OF OPERATING RULES FOR WATER SUPPLY AND DROUGHT MANAGEMENT FOR STAND-ALONE DAMS/SCHEMES (SOUTH)

OPERATIONAL ANALYSIS MTHATHA SYSTEM

BY

IWR WATER RESOURCES

APPROVAL

Report Title		Operational analysis of Mthatha System
Study Name		The development of operating rules for water supply and drought management for stand-alone dams/schemes (South)
DWA Report No.		**P RSA 000/00/20114/2: Southern Cluster: Umtata Dam**
DWA Project number		WP10778
Submitted by		IWR Water Resources Reg. Number 2009/007495/07 Postnet Suite 40 Private Bag X4 Menlo Park 0102
Authors		**F Ballim**
Report Status	**:**	Draft 1.3
Date	**:**	April 2015

Professional Service Provider: IWR Water Resources (Pty) Ltd.
Approved on behalf of the Professional Service Provider by:

……………………………….
S Mallory
Director

DEPARTMENT OF WATER AFFAIRS
Directorate:
Approved for Department of Water Affairs:

……………………………….	**……………………………………**
Ms J Pashkin	Dr B Mwaka
Project Manager	Director

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

TERMINOLOGY AND ACRONYMS

BWSS	Bulk Water Supply Scheme
DM	District Municipality
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
DWS	Department of Water and Sanitation
EWR	Ecological Water Requirement
FSA	Full Supply Area
FSC	Full Supply Capacity
IAP	Invasive Alien Plants
LM	Local Municipality
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NIAPS	National Invasive Alien Plant Survey
PSP	Professional Service Provider
RF	Return Flow
RWSS	Regional Water Supply Scheme
WMA	Water Management Area
WR90	The Water Resources (Hydrology) of South Africa (Midgely et al. 1994)
WR2005	The Water Resources (Hydrology) of South Africa (Middleton and Bailey, 2008)
WReMP	Water Resources Modelling Platform
WSDP	Water Services Development Plan
WTW	Water Treatment Works
WUL	Water Use Licence
ha	hectares
km^2	square kilometres
ℓ/c/day	litres per capita per day
ℓ/s	litres per second

mm	millimeters
Mℓ	Megalitres
m^3/a	Cubic metres per annum
m^3/s	Cubic metres per second

1 INTRODUCTION

The development of operating rules for the Mthatha system is undertaken through a support project by the Department of Water Affairs (DWA) to ‘Develop water supply operating rules for stand-alone dams or schemes for the South region’. Umtata Dam is on the Mthatha River in the Eastern Cape Province within the OR Tambo District Municipality. The purpose of the dam is to supply water for municipal and industrial use for the town of Mthatha and surrounding areas as well as for hydroelectric power generation. OR Tambo DM is the Water Services Authority and Provider responsible for the provision of water in its jurisdiction.

The objective of an operational analysis is to improve and or develop operating rules and guidelines of a water resource system so that water-related demands are met by the system to its full potential and to enhance the reliability of the water supply by the system to meet its allocated water requirements within an applicable time horizon, in most cases for the short to medium term (1 to 5 years). Operational analyses were undertaken on the Umtata Dam and the results are discussed in this report.

2 CATCHMENT INFORMATION

Umtata Dam on the Mthatha River is in the Mzimvubu to Tsitsikamma Water Management Area (WMA 7) in the Eastern Cape Province (see **Figure 2.1**). Mthatha River flows out to sea on the Eastern Coast of South Africa. The dam is located in the OR Tambo Disctrict municipal area and within the King Sabata Dalindyebo Local Municipality. The northern catchment area upstream of the dam falls in the Mhlontlo LM area. Umtata Dam (also spelled as Mtata Dam) is in the T20C quaternary catchment (**Figure 2.2**), although most of the storage surface area is in the T20B quaternary catchment.

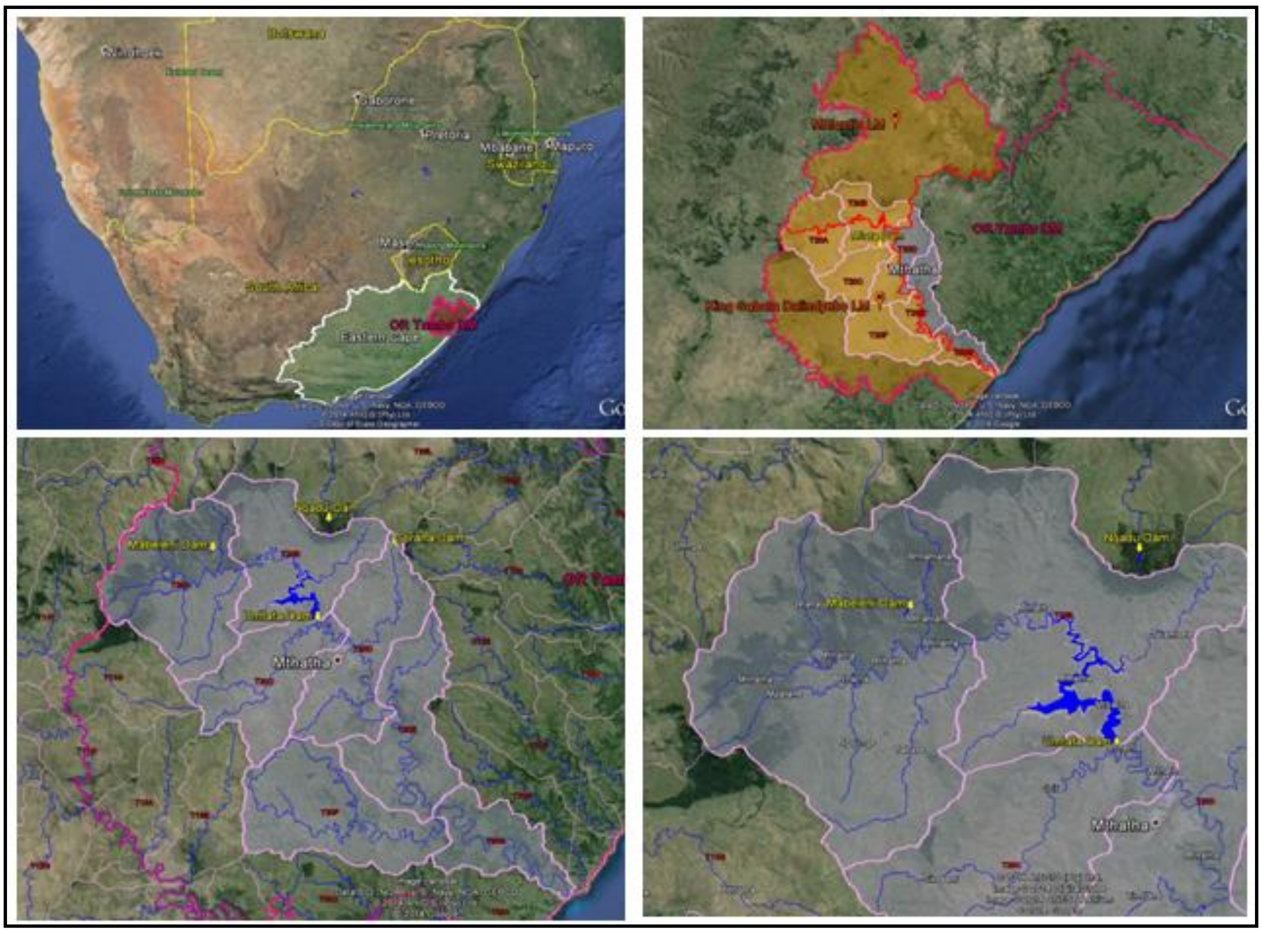


Figure 2.1 Location of Umtata Dam catchments in the Eastern Cape Province

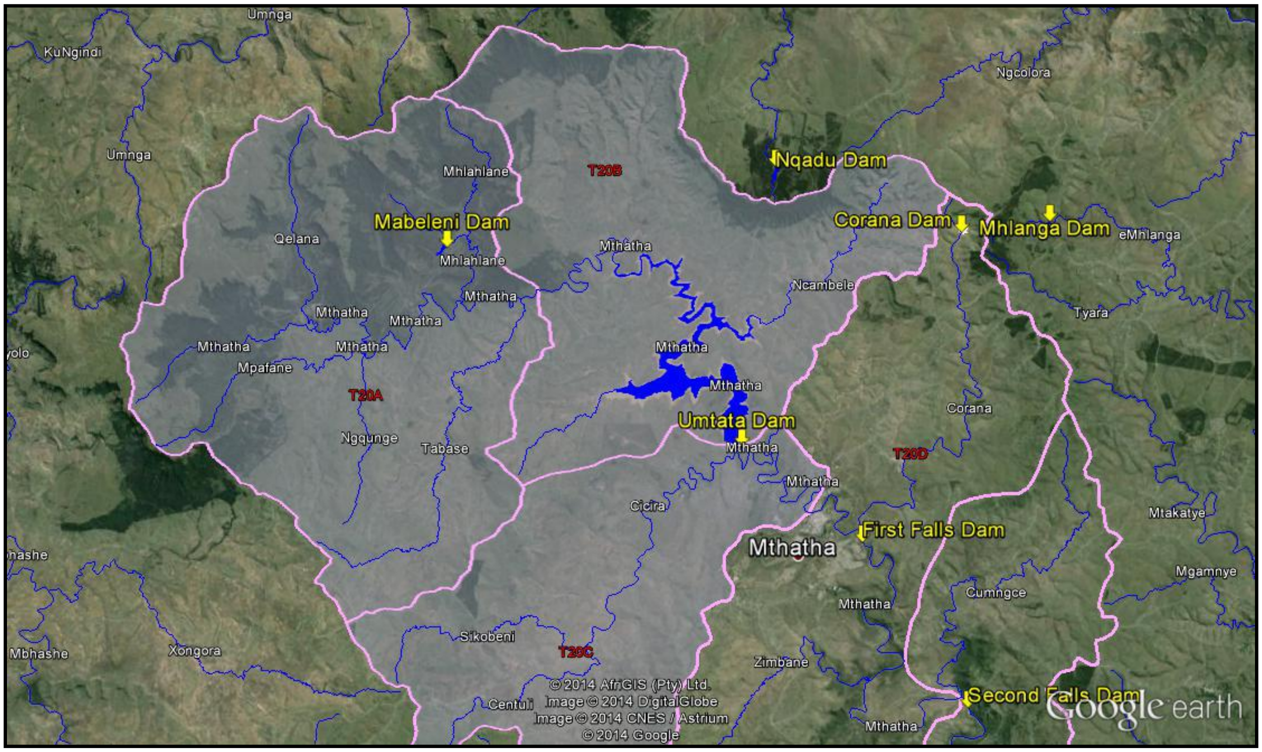


Figure 2.2 Location of Umtata Dam in the T20C quaternary catchment

2.1 Hydrology

Table 2.1 summarises the hydrology for the quaternary catchments contributing to the dam as sourced from Middelton and Bailey (2008). This latter source of data, generally referred to as WR2005, was prepared for the Water Research Commission as part of a national study to update the hydrology of the whole country at a quaternary catchment scale. The Mean Annual Runoff (MAR) indicated in **Table 2.1** refers to the natural runoff from the catchment, that is, the runoff before any water use. The WR90 MAR (Midgely *et al*. 1994) is also presented in **Table 2.1** for comparative purposes.

Table 2.1 Hydrology and catchment information

Quaternary Catchment	Catchment Area (km^2)	Mean Annual Evaporation (mm)	Mean Annual Precipitation (mm)	Mean Annual Runoff (million m^3)	
				(WR2005)	(WR90)
T20A	481	1300	940	131.23	128.90
T20B	405	1250	844	91.99	89.10
T20C	320	1250	685	46.49	43.90
T20D	388	1200	764	31.17	28.90

T20E	350	1200	829	36.76	34.50

There are differences in the MAR values of the two hydrology datasets with the WR2005 seeming to be less conservative.

3 WATER RESOURCES INFRASTRUCTURE

Upstream of Umtata Dam is Mabeleni Dam. Umtata Dam is the largest dam in the catchment. First and Second Dams are part of a hydropower scheme. The major and minor dams in the Mthatha catchment is tabulated in **Table 3.1** and shown in **Figure 3.1**.

Table 3.1 Registered major and minor dams (2013 List of registered dams, DWA)

Dam	River	Surface Area (ha)	Gross Capacity (million m^3)	Quaternary catchment	Owner	Purpose
Umtata	Mthatha	2541.7	253.674	T20C	DWA	Municipal; Industrial
Corana	Corana Tr.	14	0.950	T20D	DWA	Municipal; Industrial
Mabeleni	Mhlahlane	52.1	2.100	T20A	DWA	-
First Falls	Mthatha	27	0.789	T20D	Eskom	Hydropower
Second Falls	Mthatha	33	1.200	T20E	Eskom	Hydropower

For the purpose of the study, the net capacity of Umtata Dam as tabulated in **Table 3.2** below will be used.

Table 3.2 Storage Capacity of Umtata Dam (T2R001) as per the DWA Survey Services

Date	Surface Area (ha)	Net Capacity (million m^3)	Gross Capacity (million m^3)	Source
01/09/1977	2542.00	252.17	258.23	From mainframe
01/10/1987	2542.00	251.41	257.10	Basin survey
01/10/1997	2541.70	248.33	253.67	Basin survey
01/10/2010	2541.60	244.67	249.710	Re-calculated

The catchment area of Umtata Dam is 886 km^2, Mabeleni Dam is 10 km^2 and Corana Dam, 5.4 km^2. The catchment area of First Falls Dam that falls within the T20D quaternary catchment is 219.37 km^2. The total catchment area of First Falls Dam is 1425.37 km^2. The proportion of the T20E catchment that flows into the Second Falls dam is 120.22 km^2. The total area of the second falls catchment is 1714.22km^2.

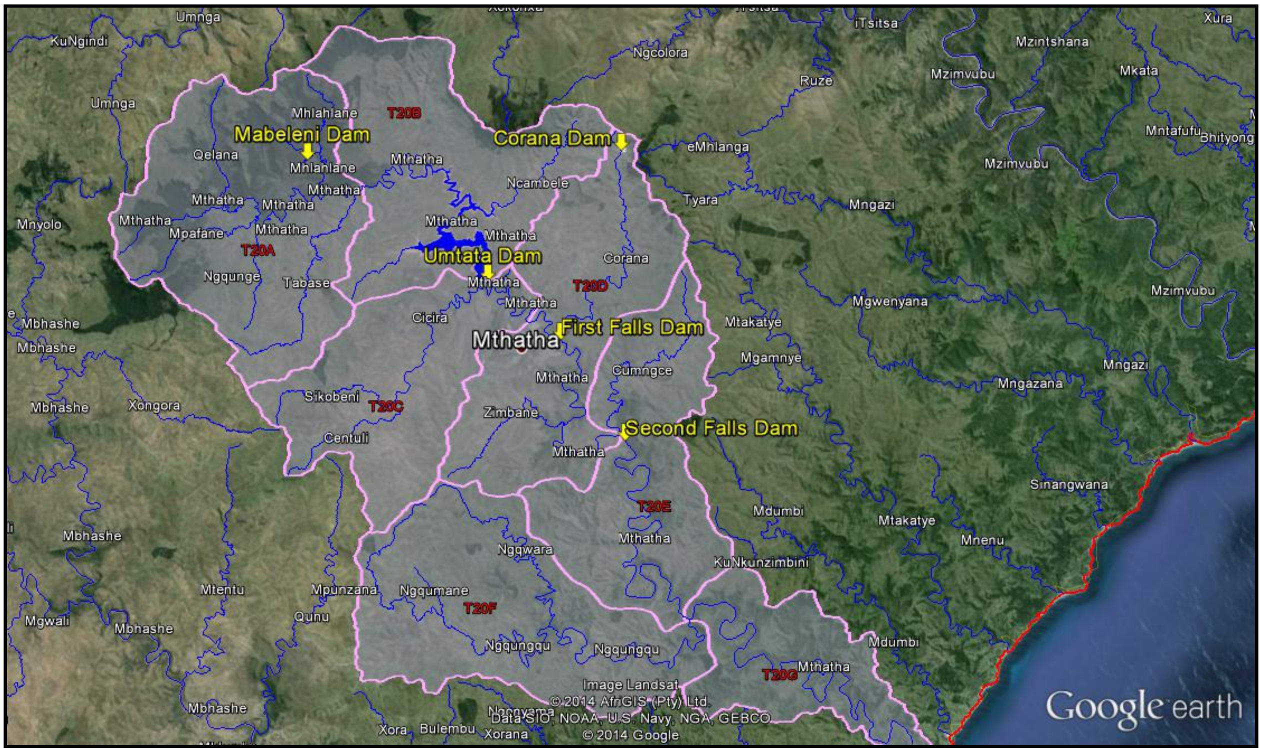


Figure 3.1 Location of registered dams in the Mthatha catchment

Table 3.3 lists the gauging stations in the Mthatha catchment (see **Figure 3.2**).

Table 3.3 Gauging stations in the Mthatha catchment

DWA Station Number	River and Station Name	Period of Record as at end July 2014
T2H001	Mtata River at Dumasi Loc 5	1953-06-15 1956-08-31
T2H002	Mtata River at Norwood	1957-12-11 2006-06-08
T2H003	Mtata River at Kambi Forest Res	1984-12-12 1994-07-19
T2H004	Mtata River at Ku Ngobozi	No data
T2H005	Mtata River at Sidabadabeni	No data
T2H006	Mtata River @ Ntsunguzini	No data
T2H007	Gate To Turbine From Mtata River @ Norwood	1953-06-01 1954-11-30
T2H008	Mtata River @ Umtata	2002-05-14 2014-06-03
T2H009	Pipeline to Purification Works at Umtata	2003-01-02 2014-05-30
T2H010	Cicira River at Roode Heuvel	2003-07-25 2014-04-25

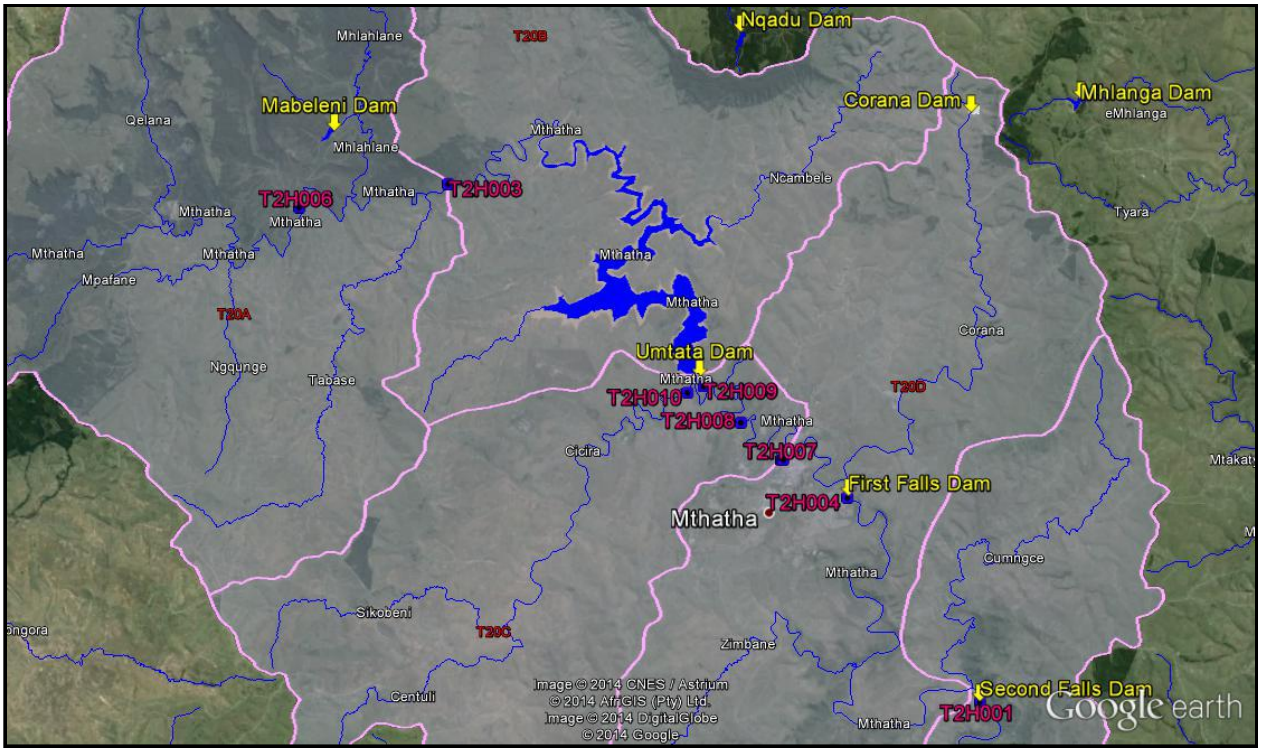


Figure 3.2 River gauging stations in the study area

4 WATER USE REQUIREMENTS

The purpose of Umtata Dam is to primarily provide water for municipal and industrial use for the town of Mthatha and surrounding peri-urban villages. The dam was also built to supply water for power generation at two of Eskoms hydro power schemes at First and Second Falls.

4.1 Domestic water use requirement

4.1.1 Mhlahlane WSS

Water for villages in the vicinity of Mabeleni Dam is supplied by the Mhlahlane WSS. The registered water use from the dam is 0.944 million m^3/a, however the actual metered use from the dam for the past two years has been 1.130 million m^3/a (2012/13) and 1.378 million m^3/a (2013/14).

4.1.2 Mthatha WSS

- Water is treated at the Thornhill WTW which now has a design capacity of 80 Ml/day (29.22 million m^3/a) and could be expanded to a capacity of 115 Ml/day (42 million m^3/a).
- OR Tambo DM has a registered water use of 13.505 million m^3/a from Umtata Dam for the Mthatha Town WSS. The actual metered use for the past two years has been 21.928 million m^3/a (2012/13) and 21.688 million m^3/a (2013/14).
- A further water use licence has been issued to the DM to abstract 55.08 million m^3/a of water from the Umtata System at a point downstream of the Second Falls weir. The licence issued places the abstraction point at Umtata Dam and should be corrected. Refer to the **Figure 4.1** below and **Appendix A** for the WUL

4.1.3 Rosedale Water Use

OR Tambo DM also have a licence to abstract 1.162 million m^3/a for domestic water supply (WUL No: 27088865) from Umtata Dam. There are plans to upgrade the Rosedale WTW, from 25 Ml/day (9.13 million m^3/a) to a capacity of 50Ml/day (18.26 million m^3/a) works for future planning.

4.1.4 Corana Regional WSS

The scheme supplies water to surrounding rural communities and has a capacity of 0.22 million m^3/a. At present, the meter is out of order and is due to be replaced by the Department. The yield of the dam is reported to be 0.26 million m^3/a (DWA, 2013)

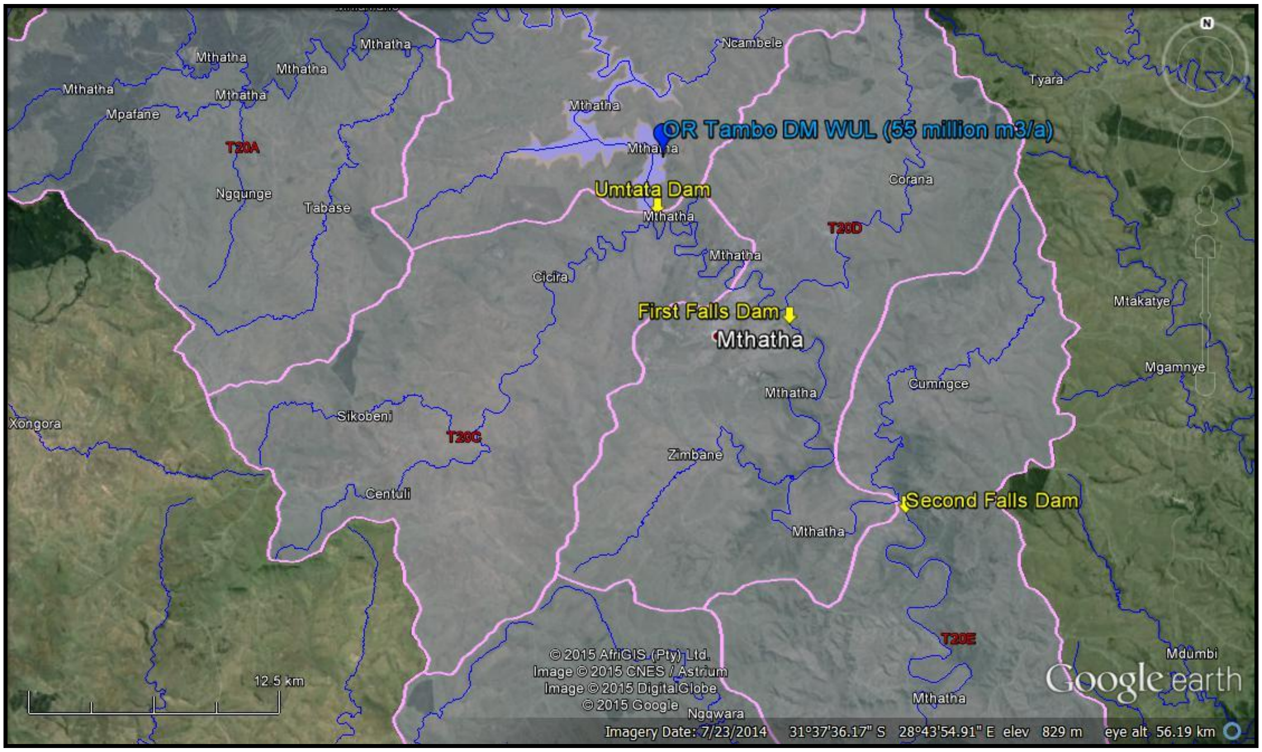


Figure 4.1 Map showing the location of 55.08 million m^3/a WUL

4.1.5 Future water requirements

Growth scenarios sourced from the All Towns report (DWA, 2011) are given in **Table 4.1**.

Table 4.1 Future Gross Annual Water Demand

Growth Scenario	Annual population growth (%)	Future developments realized	Gross Annual Demand (million m^3/a)		
			2020	2030	2035
Low	0.0	None	22.10	22.10	22.10
Medium	0.5	None	23.13	23.96	24.39
High	1.0	None	24.21	26.04	27.02

4.2 Hydropower Generation

According to DWA (2011), the remainder of the yield of Umtata Dam is allocated to Eskom for power generation at the two hydropower stations located at First and Second Falls Dams. There is no information on the water requirement or use by Eskom and no registered water use. The water allocation for hydropower generation from Mtata Dam is 126 million m^3/a. Water is measured at the T2H008 gauging station which is reflected in **Figure 4.2** below.

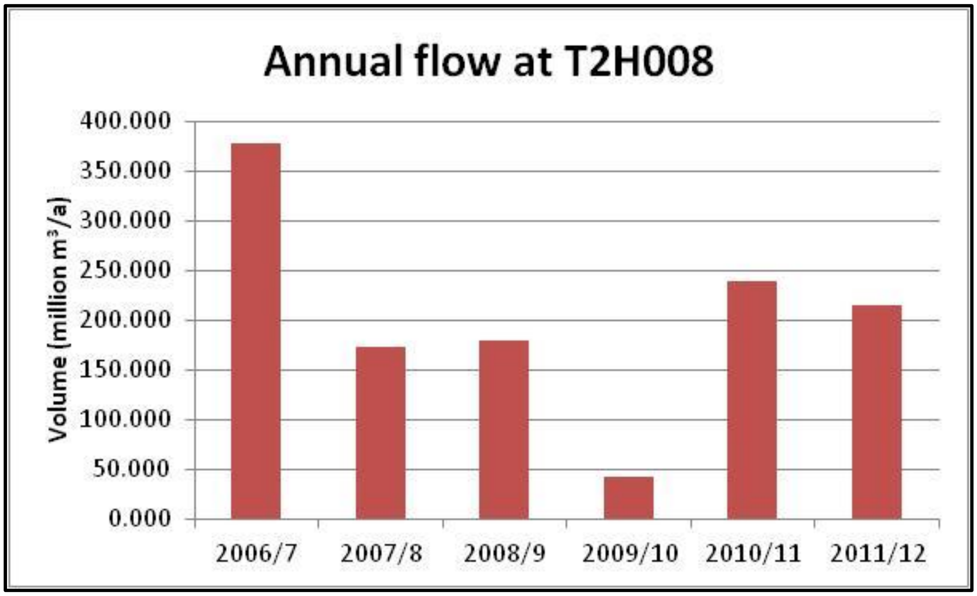


Figure 4.2 Annual flow at gauging station T2H008

Second Falls hydropower station has the capacity to produce 11MW of electricity and First Falls 5 MW. At full load, $25m^3/s$ is used at Second Falls and $28m^3/s$ at First Falls. Water discharged at First Falls takes 8 hours to reach Second Falls.

4.3 Afforestation

The areas of forestry documented in the WR2005 study (Middleton and Bailey, 2008) for the quaternary catchments relevant to this study are tabulated in **Table 4.2**.

Table 4.2 Area of forestry in the Umtata dam catchment (Middleton and Bailey, 2008)

Quaternary Catchment	WR2005 Forestry Area (km^2)
T20A	204.60
T20B	26.30
T20C	3.30
T20D	3.80
T20E	0.00

4.4 Invasive Alien Plants

Invasive Alien Plants (IAP) reduces the volume of water that is available for other uses. The area covered by IAP's is required in order to compute the volume of water that is used by these plants. The area of AIP's in the quaternary catchments as reflected in the WR2005 dataset (Middleton and Bailey, 2008) in tabulated in **Table 4.3**. The National Invasive Alien Plant Survey (NIAPS) project (Kotzé et al., 2010) was initiated by the Working for Water Programme and implemented by the Agricultural Research Council. The project objective was to establish and implement a cost effective, objective and statistically sound IAP monitoring system for South Africa, Lesotho and Swaziland at a quaternary catchment level. The data are provided in terms of landscape and riparian IAP areas and the density (as a percentage) of the IAP for the area in each quaternary catchment. The IAP area contributing to the reduction in runoff was then obtained by multiplying the area of the IAP by the density. The ARC distinguished between riparian and non-riparian invasive alien plants. This is important because riparian infestations use much more water than upland plants since the plants will generally have access to water all the time while upland plants have limited water. The area of IAP's in the Umtata Dam catchment is reflected in **Table 4.3**

Table 4.3 Area of AIP's in Umtata Dam catchment (NIAPS database, 2010)

Quaternary Catchment	WR2005 AIP (km^2)	AIP Upland Area (km^2)	AIP Riperian Area (km^2)
T20A	20.8	49.48	0.59
T20B	2.40	16.25	0.25
T20C	2.10	0.73	0.07
T20D	0.60	28.50	0.04
T20E	0.00	0.84	0.07

The difference between the WR2005 and NIAPS databases is significant but establishing which database is more accurate is beyond the scope of this project. This is an uncertainty and needs further clarification. Thus, for the purpose of this study, the NIAPS database areas will be included in the model.

4.5 Ecological Water Requirements

The ecological Reserve is also a function of the ecological management class (EMC) assigned to a particular stretch of river with classes varying from A to D. 'A' being pristine and 'D' being the lowest acceptable level.

The present ecological status (PES) of the Mthatha catchment was derived from the Desktop PESEIS information through a study undertaken for the DWA in 2013 which assessed various rivers in the country. As shown in **Figure 4.3**, the PES for the Mthatha River catchment is generally at a class C but ranges from a class C to E for the entire reach. The EWR determined for a class C/D for the Mthatha system is 17.58% of the MAR

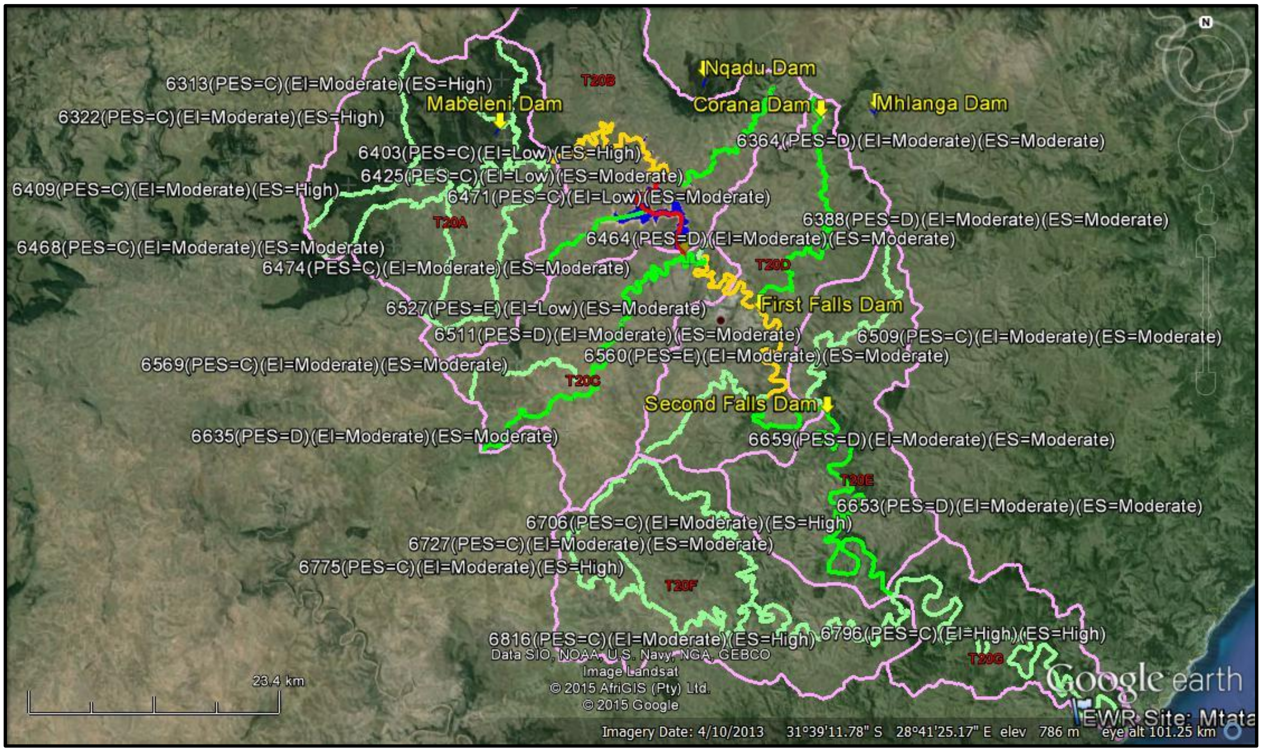


Figure 4.3 PES status of the Mthatha River catchment

5 WATER RESOURCES ANALYSIS

5.1 Historical Yield Analysis

The Umtata dam system was modelled using the Water Resources Modelling Platform (WReMP) (Mallory *et al*., 2011) to undertake the yield assessment. A yield analysis determines how much water can be abstracted from a dam (or river) on a sustainable basis. The historical firm yield is the quantity of water that can be abstracted from a dam on a sustainable basis assuming a constant abstraction and based on the historical flow record. Information from the Reconciliation Strategy Study for Mthatha and surrounding village cluster reports that the yield of Umtata Dam is 145 million m^3/a and a historical yield of 144 million m^3/a was computed in this study. The system was setup according to the diagram illustrated in **Figure 5.1**

Table 5.1 Historical Yield of Umtata Dam

Source	Yield (million m^3/a)	Assurance
DWA (2011) All Town Studies	145	
This study (2014)	144.36	Historical
This study (2014)	145	98%
This study (2014) *Revised dead storage	142	Historical

* Refer to section 6.4 of this report

Table 5.2 Historical Yield of Mabeleni Dam

Source	Yield (million m^3/a)	Assurance
DWA (2011) All Town Studies	1.7	
This study	1.37	Historical

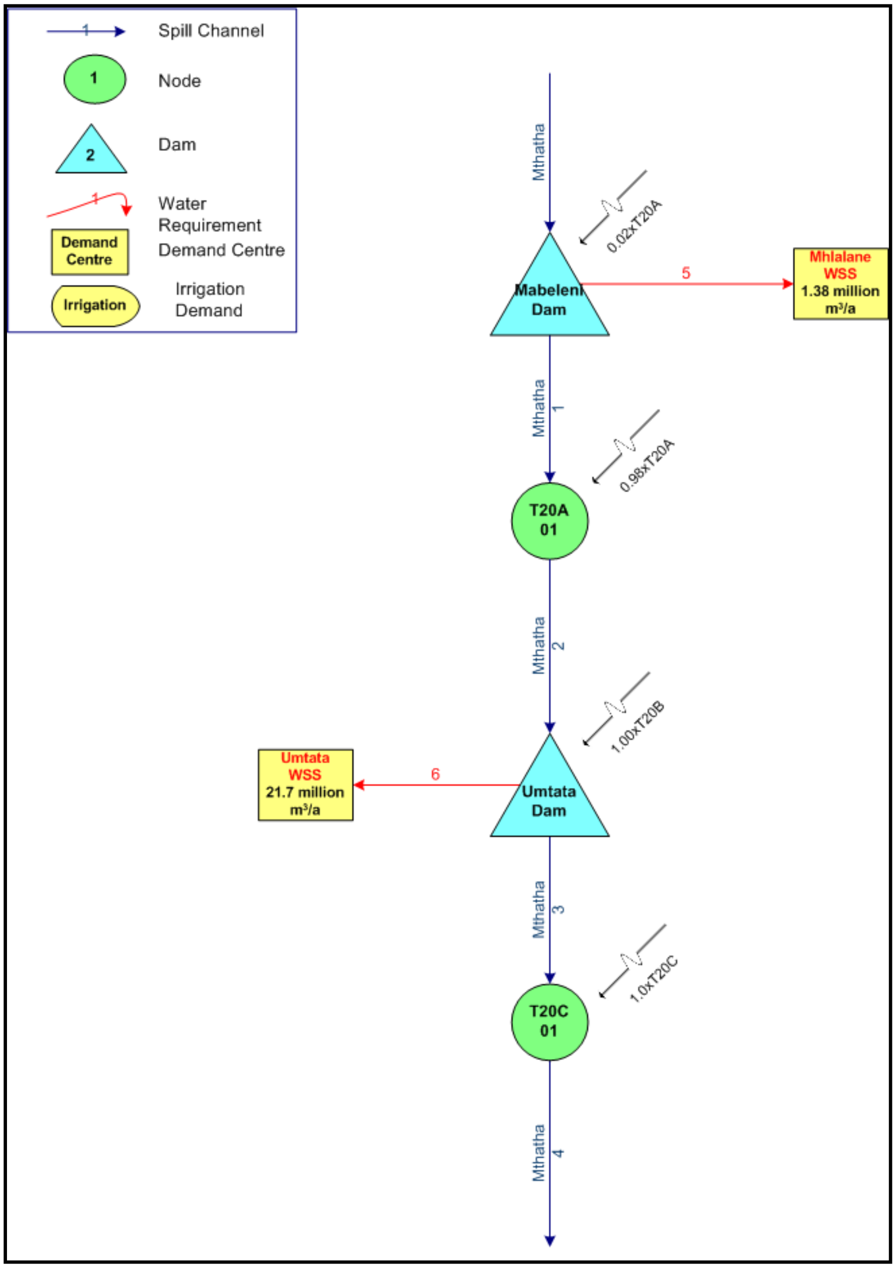


Figure 5.1 Network representation of the system

5.2 Long term Yield Analysis

A historic yield analysis gives an indication of how much water can be abstracted from a dam on a continual basis. However, this is based on the historical flow record. In accepting the historic yield for operational purposes the assumption is implicitly made that history will repeat itself and that we will not experience worse droughts in the future than we have in the past. This is however an optimistic assumption and experience shows that worse droughts are likely to occur in future.

To overcome this problem, the concept of stochastic analysis was introduced in South Africa in the 1980's. This entails generating a number of statistically plausible natural flow sequences. Analysing the performance of the dam (or system) with all the stochastic hydrology time series results in a large range of plausible dam levels into the future, some of which will be better than the simulation carried out using the historical hydrology time series while others could be worse. In order to present all these possible water levels, or storage trajectories, they are presented as long-term or short-term yield curves and probability trajectories or box plots which are simply statistical representations of all the possible storage time series. The long term yield curve for Umtata Dam computed from 201 stochastically generated hydrological sequences is presented in **Figure 5.2**

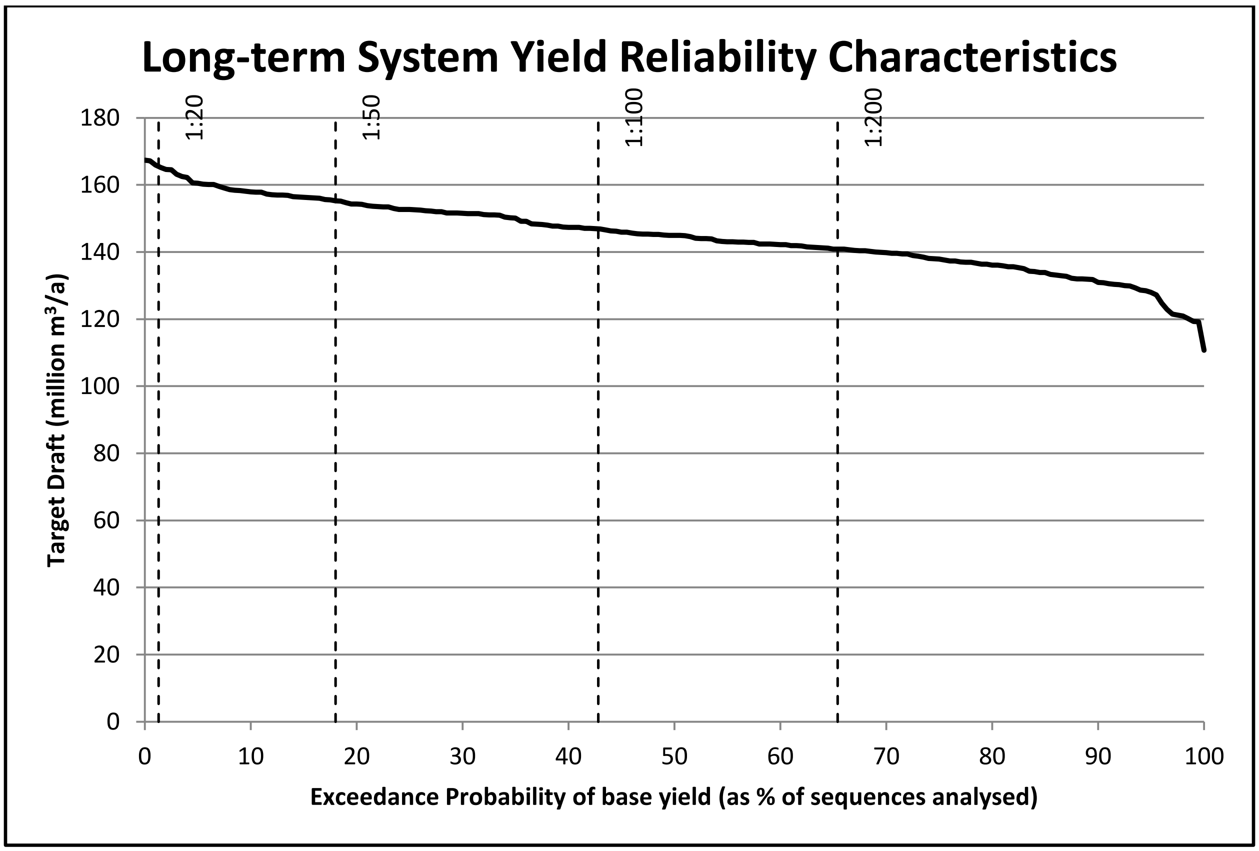


Figure 5.2 Long-term yield reliability characteristics for Umtata Dam

5.3 Short-term Yield Analysis

The short-term yield analysis was computed using 501 stochastically generated sequences. See **Figure 5.3** for the resultant curves.

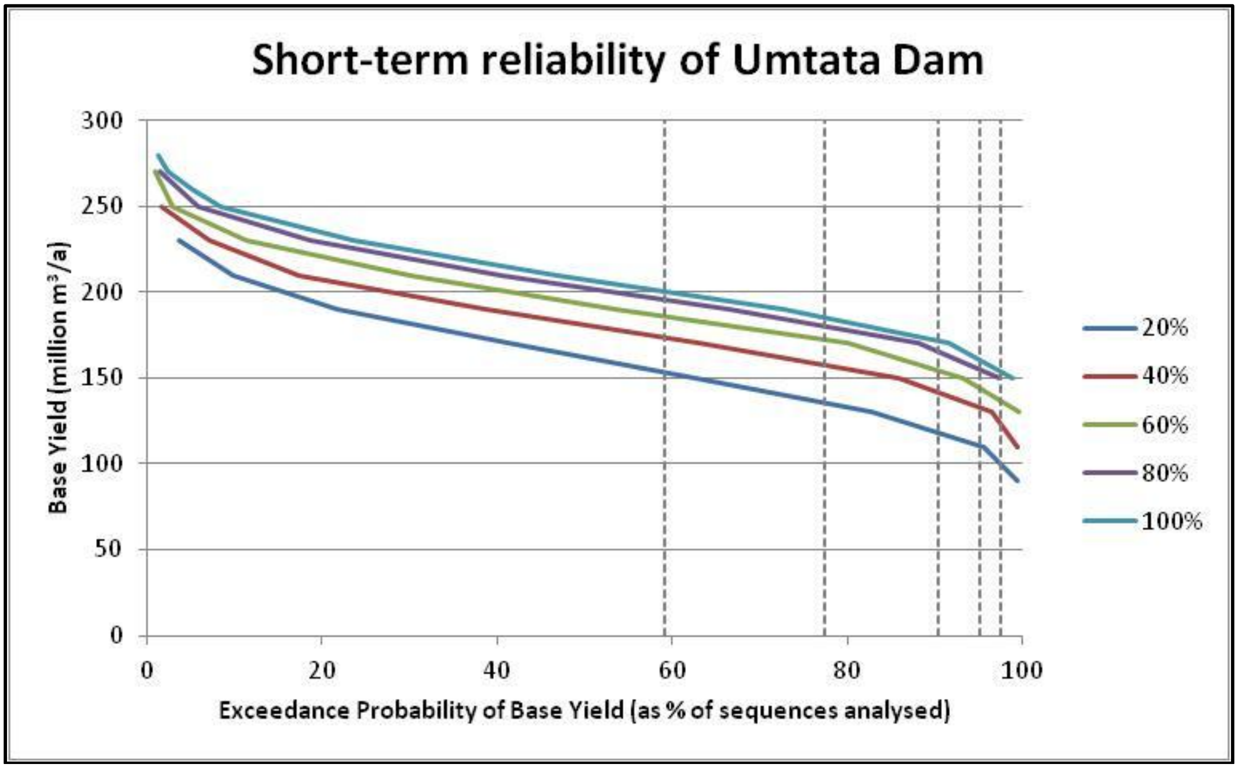


Figure 5.3 Short-term reliability curves for Umtata Dam

6 OPERATIONAL STRATEGY

6.1 Current Operating Rule

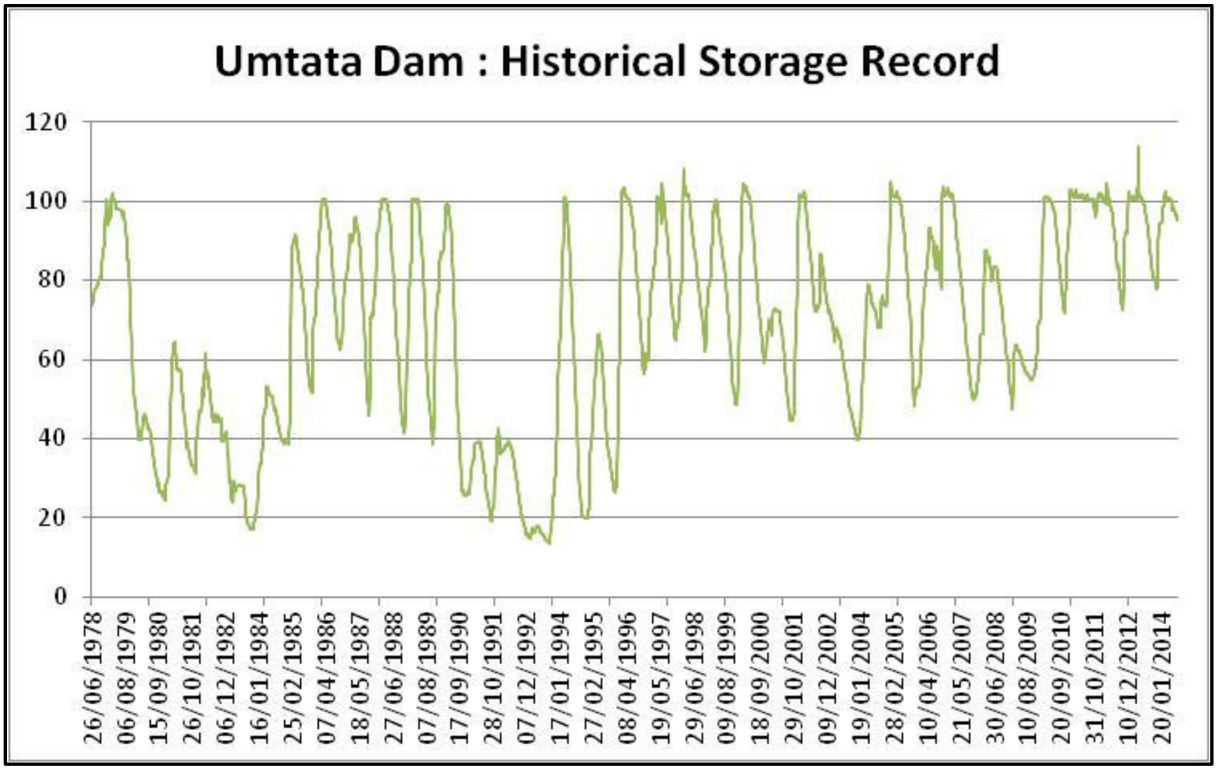


Figure 6.1 Historical storage record for Umtata Dam

In operating the Umtata Dam, the main water user, Eskom is notified when the level of the dam reaches 60% of its FSC, and is restricted completely when the dam reaches 22% of its FSC. Restriction to the urban and industrial water use sectors is effected when the level of the dam reaches 25% of its FSC.

6.2 Assurance of supply and degree of restrictions applied

In order to be consistent with the typical levels of assurance placed on urban sectors, the following assurances are set as targets:

Urban: 98%

Hydropower: High

This level of assurance indicates the percentage of time that each sector receives their full requirement. The restrictions can be in several steps of increasing restrictions. This concept is typically described by means of a Priority Classification table, as shown in **Table 6.1**.

Table 6.1Priority classification table

Sector	**Recurrence Interval**				
	1:5	**1:10**	**1:20**	**1:50**	**1:100**
Urban	0%	0%	0%	80%	20%
Hydropower	0%	0%	0%	70%	30%

6.3 Development of operating rules

Through a modelling procedure using 501 stochastically generated time series, the Umtata Dam water levels were determined at which restrictions must be applied in order to obtain the desired target assurance of supply. Probabilistic trajectory curves are used to illustrate what the dam storage levels will be based upon the stochastic hydrology used and the water user requirements. The 0% line indicates very wet conditions over the simulation period and the 100% line would be a result of the minimum inflow into the dam over the simulation period. Restriction rules are developed if the trajectory curves indicate that the targeted assurance levels are not met. Dam operators would monitor the dam storage to create an observed trajectory curve. This observed trajectory curve can then be used to envisage how the dam is expected to empty in the short-term (5 years) period. The dam operators can then assess when and the level of restriction that will be necessary to ensure a sustainable use of the dam during the drought period.

6.3.1 Scenarios

Scenario 1 : The modelling analysis is based on the domestic water use registrations and or water use licences from the dam of 13.51 million m^3/a for the Umtata BWSS and 1.16 million m^3/a for the Rosedale WTW, abstracted directly from the dam. Eskom's water use requirement is released from the dam and the additional 55.08 million m^3/a for domestic use is abstracted from below second falls weir.

Scenario 2 : The modelling analysis is based on the present day domestic water use requirement from the dam of 21.7 million m^3/a for the Umtata BWSS and 1.16 million m^3/a for the Rosedale WTW, abstracted directly from the dam. Eskom's water use requirement is released from the dam and the additional 55.08 million m^3/a for domestic use is abstracted from below second falls weir. **Figure 6.2** presents the systems or network diagram for the modelling setup.

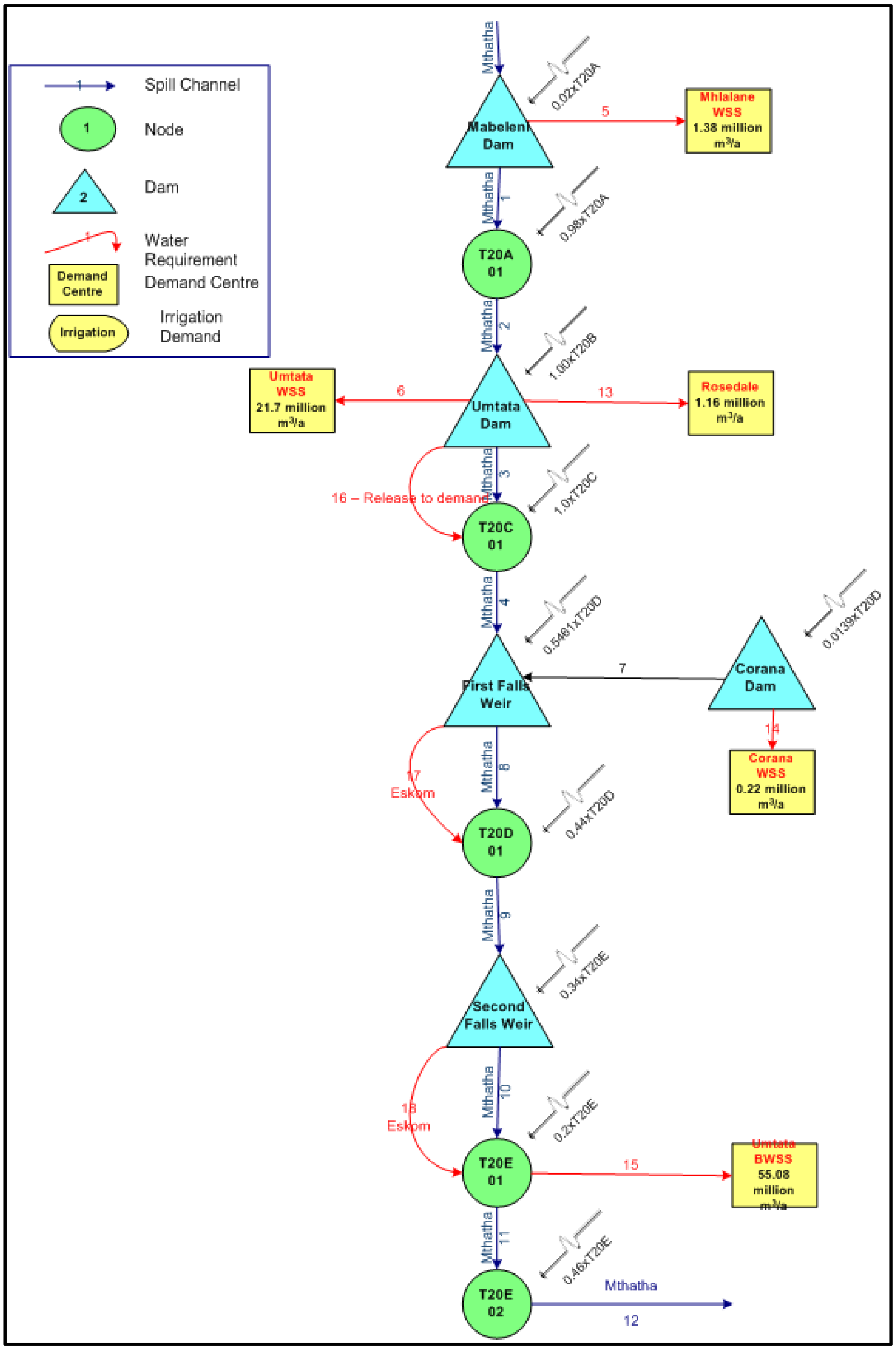


Figure 6.2 Network representation of the Umtata System

Scenario 3 : The modelling analysis is based on the domestic water use registrations and or water use licences from the dam of 77.78 million m^3/a for the Umtata BWSS and 1.16 million m^3/a for the Rosedale WTW, abstracted directly from the dam. The operating rule restricts hydropower water use completely when the dam storage level reaches 25% of its full supply capacity and urban use is restricted by 10% when the dam gets to 30% FSC and 20% when the dam gets to 25%.

Scenario 4 : The modelling analysis is based on the present day domestic water use requirement from the dam of 21.7 million m^3/a for the Umtata BWSS and 1.16 million m^3/a for the Rosedale WTW, abstracted directly from the dam. The additional 55.08 million m^3/a for domestic use is abstracted from below first falls weir.

6.3.2 Results of the operating rule modelling analysis

Figure 6.3 below compares the historical dam storage trajectory for the first three scenarios. The dam fails several times under the scenario 3 option i.e. all the domestic water is abstracted from the Umtata Dam directly.

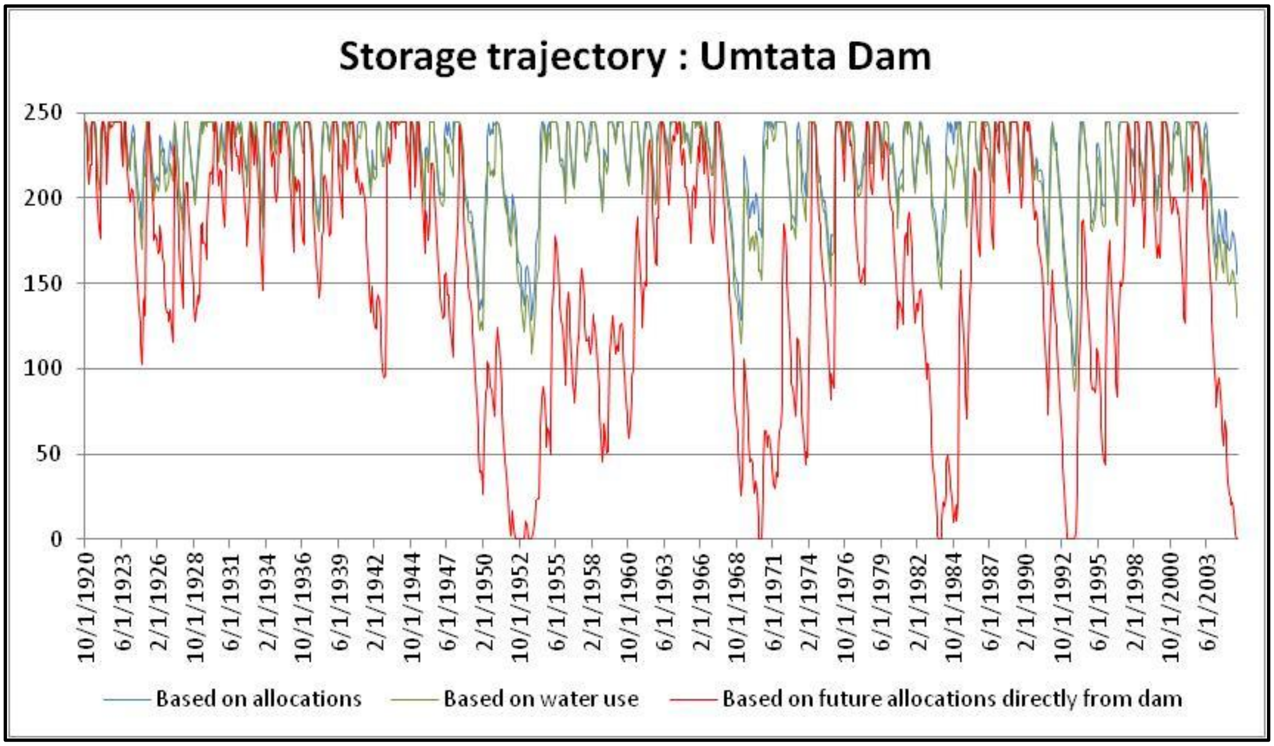


Figure 6.3 Historical storage trajectory of Umtata Dam for the different scenarios

6.3.2.1 Scenario 2

The operating rule restricts hydropower water use completely when the dam storage level reaches 25% of its full supply capacity and urban use is restricted by 10% when the dam level is between 25 and 30% of its FSC. Restrictions of 20% are applicable when the dam is below 25% of its FSC **Tables 6.2** and **6.3** presents the proposed restriction rules for the water use sectors and is based on the storage of the Umtata Dam. The probabilistic trajectories with the restrictions are shown in **Figures 6.4 and 6.5.**

Table 6.2 Proposed restriction rule for the Hydropower sector

Dam Storage Level (% of FSC)	Hydropower Restriction (%)	Hydropower Supply (%)
Above 25	None	100
Below 25	100	0

Table 6.3 Proposed restriction rule for the Urban and Industrial sector

Dam Storage Level (% of FSC)	Domestic and Industrial Restriction (%)	Domestic and Industrial Supply (%)
Above 30	None	100
25 to 30	10	90
Below 25	20	80

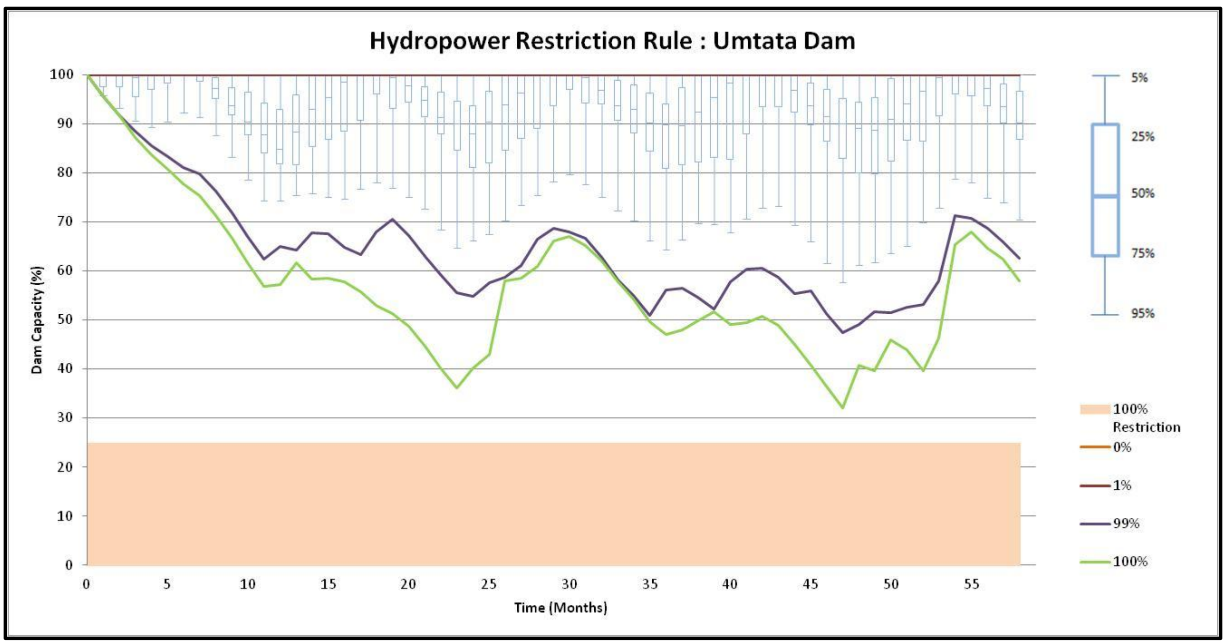


Figure 6.4 Probability trajectory of Umtata Dam with the hydropower restriction rule

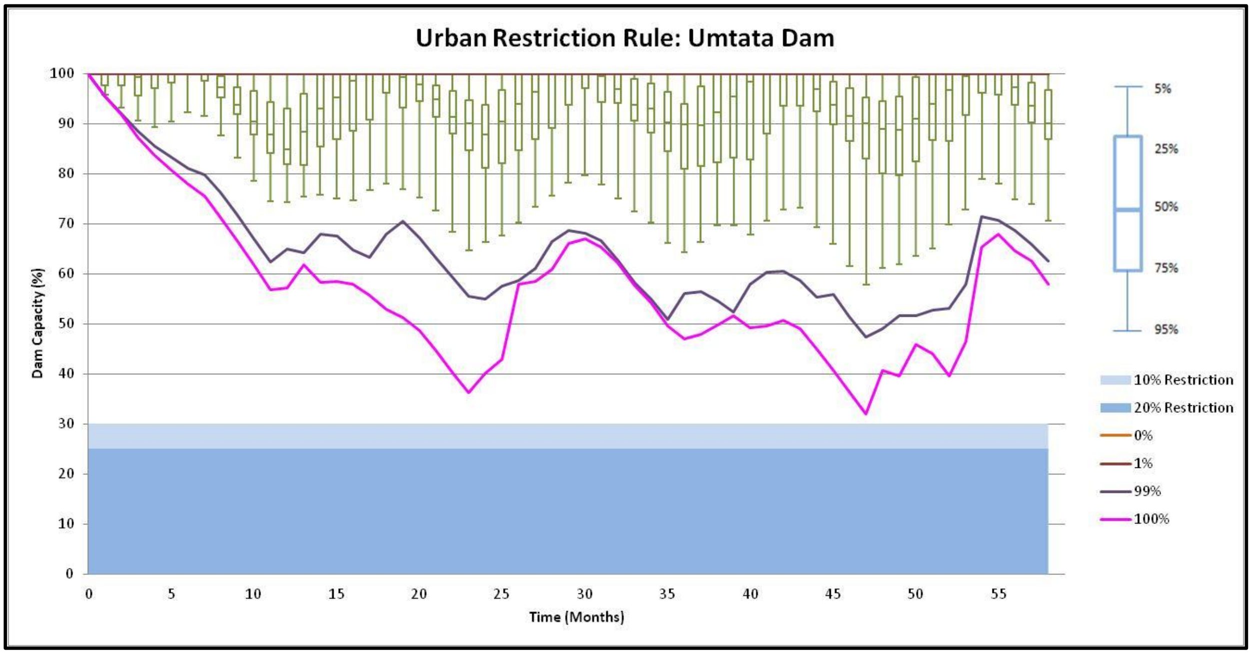


Figure 6.5 Probability trajectory of Umtata Dam with the urban restriction rule

6.3.2.2 Scenario 3

Applying the same restrictions as for scenario 2, as was presented in **Tables 6.2** and **6.3**, the probabilistic trajectories are shown in **Figures 6.6** and **6.7**.

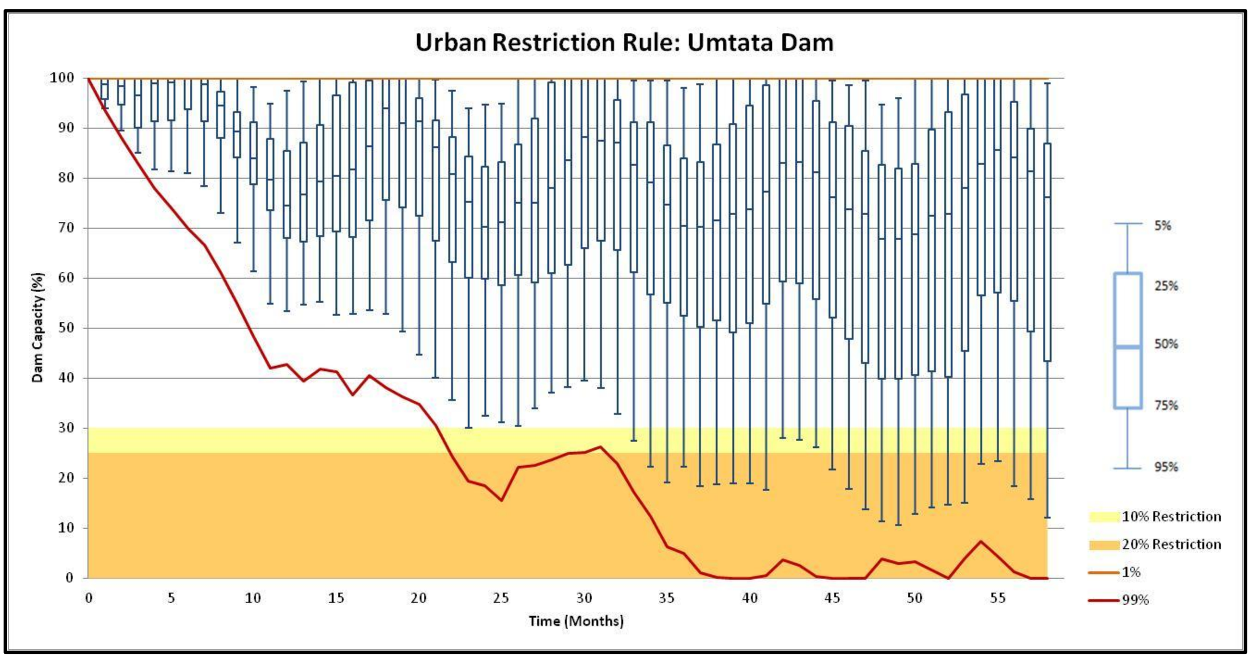


Figure 6.6 Probability trajectory of Umtata Dam with the urban restriction rule

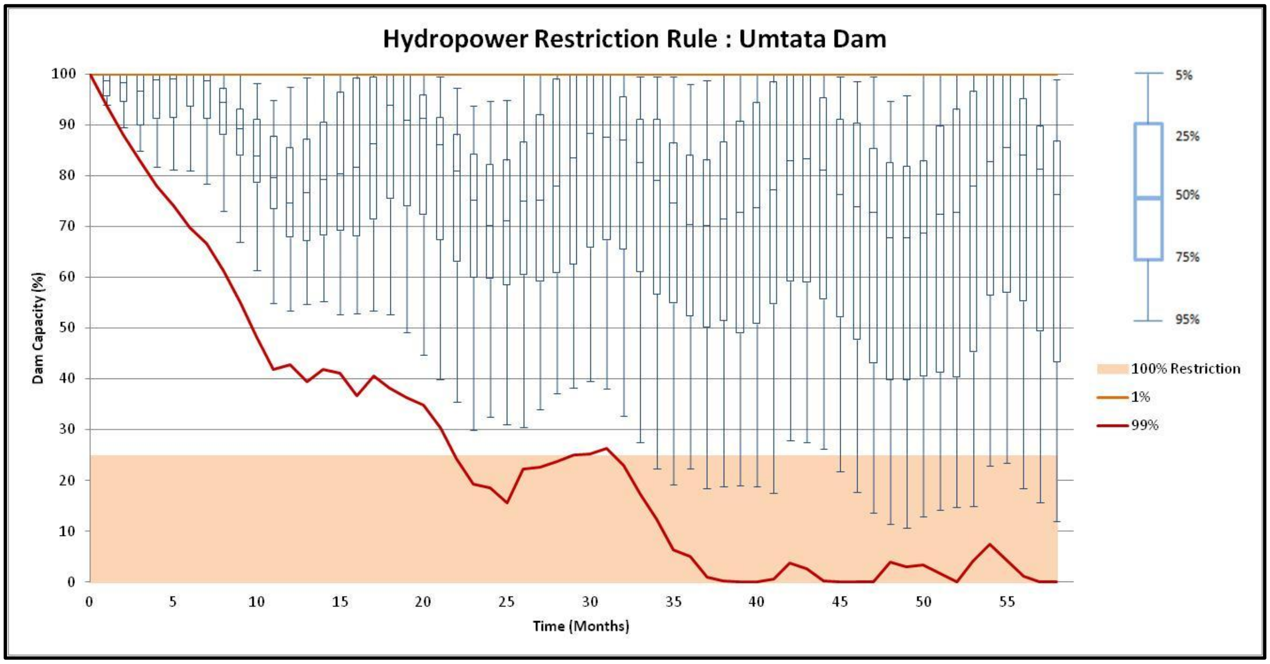


Figure 6.7 Probability trajectory of Umtata Dam with the hydropower restriction rule

Figure 6.8 Curtailment frequency for urban water use (black) and for hydropower water use (blue)

6.3.2.3 Scenario 4

This purpose of this scenario is to enable a decision on the possibility of siting the abstraction of the 55.08 million m^3/a for domestic water use below first falls weir. For this scenario, Eskom would receive an estimated 85% of its water requirement (about 107 million m^3/a of the 126 million m^3/a requirement) at second falls weir.

6.4 Revised operating rules

Following the third Steering Management Committee meeting in the Eastern Cape and subsequent site visit, the following amendments to the analysis were proposed.

- In order to be consistent with other dams in the region that support hydropower, viz Ncora Dam, the restriction level proposed for Hydropower use is to restrict the supply completely when the Umtata Dam level reaches 50% of its FSC.
- Revise the dead storage level to be 15.5 million m^3 taking the level of the outlet works into consideration. The nett capacity of the Umtata Dam is then taken as 234.21 million m^3.
- The total domestic water use currently licenced and in licence applications with the DWS is in the order of about 69.75 million m^3/a which the WSA would like to be supplied directly from the dam.
- Additionally, the discharge from the WWTW is for 32Ml/day (11.69 million m^3/a) (e-mail N Muller, Amatola Water). A return flow component of 30% has been included in the analysis.

Revised Scenario: The modelling analysis is based on domestic water use registrations and or water use licences from the dam of 69.75 million m^3/a and abstracted directly from the dam. The operating rule restricts hydropower water use completely when the dam storage level reaches 50% of its full supply capacity as tabulated in **Table 6.4** and urban use is restricted by 10% when the dam gets to 30% of its FSC and 20% when the dam gets to 25% of the FSC as is tabulated in **Table 6.3**.

Table 6.4 Proposed restriction rule for the Hydropower sector

Dam Storage Level (% of FSC)	Hydropower Restriction (%)	Hydropower Supply (%)
Above 50	None	100
Below 50	100	0

Figure 6.9 presents the storage trajectory based on historical data. **Figures 6.10 and 6.11** show the probabilistic storage trajectories of Umtata Dam with the restriction rules for each

sector. With the restriction rules proposed above, Eskom is likely to receive about 90% of its current annual requirement (114 million m^3/a). To be noted is that the assumption undertaken for the revised rule was conservative in the percent of return flow used. Based on historical data, the dam does not fail if the percent return flow is increased to 50%. Eskom would then receive 95% of its current annual requirement. Since the above analyses are sensitive to the return flow component, it is recommended that the amount of return flow to the system be investigated further.

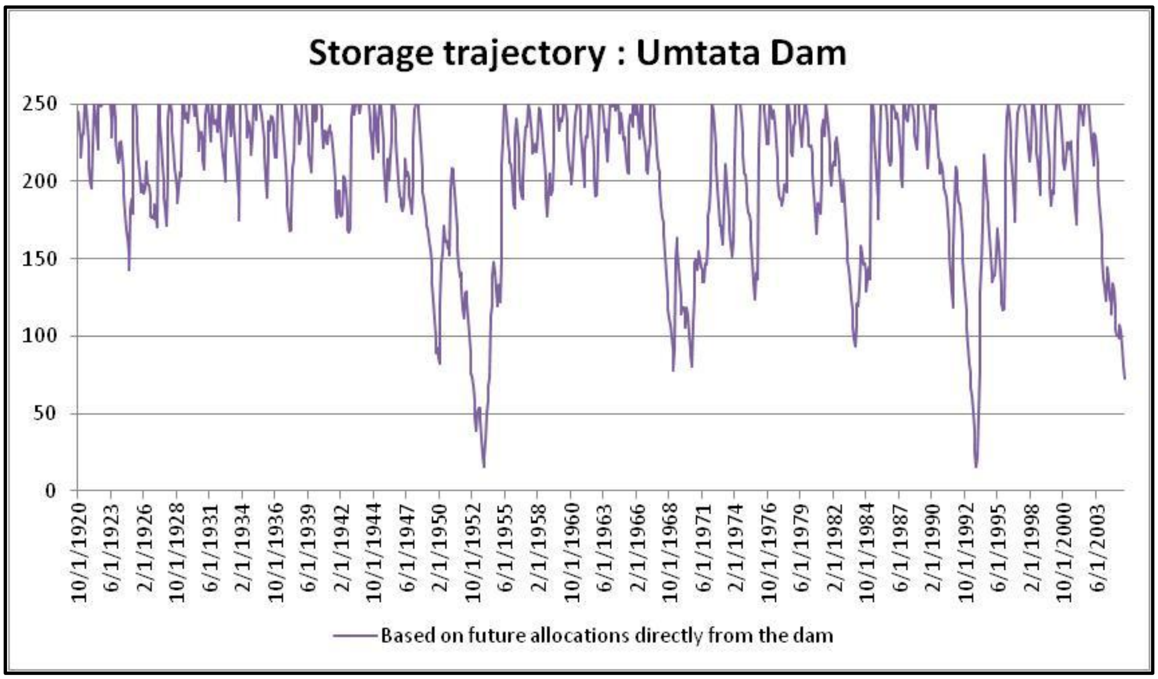


Figure 6.9 Historical storage trajectory of Umtata Dam for the revised operating rule

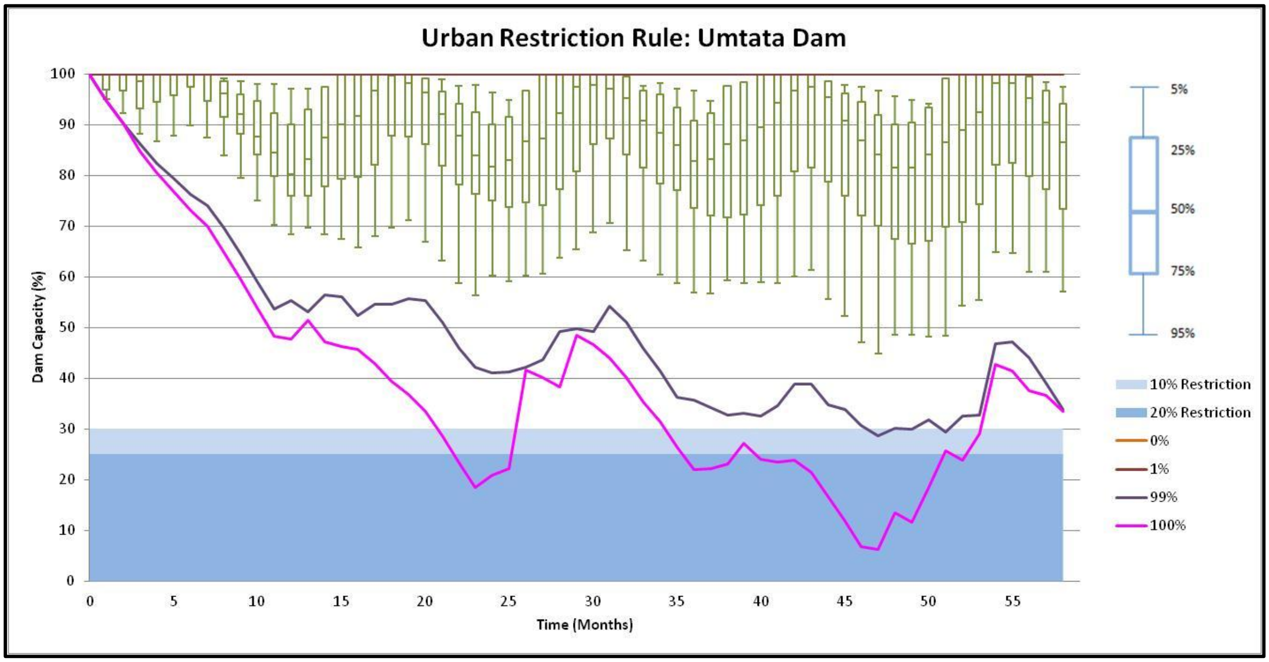


Figure 6.10 Probability trajectory of Umtata Dam with the urban restriction rule

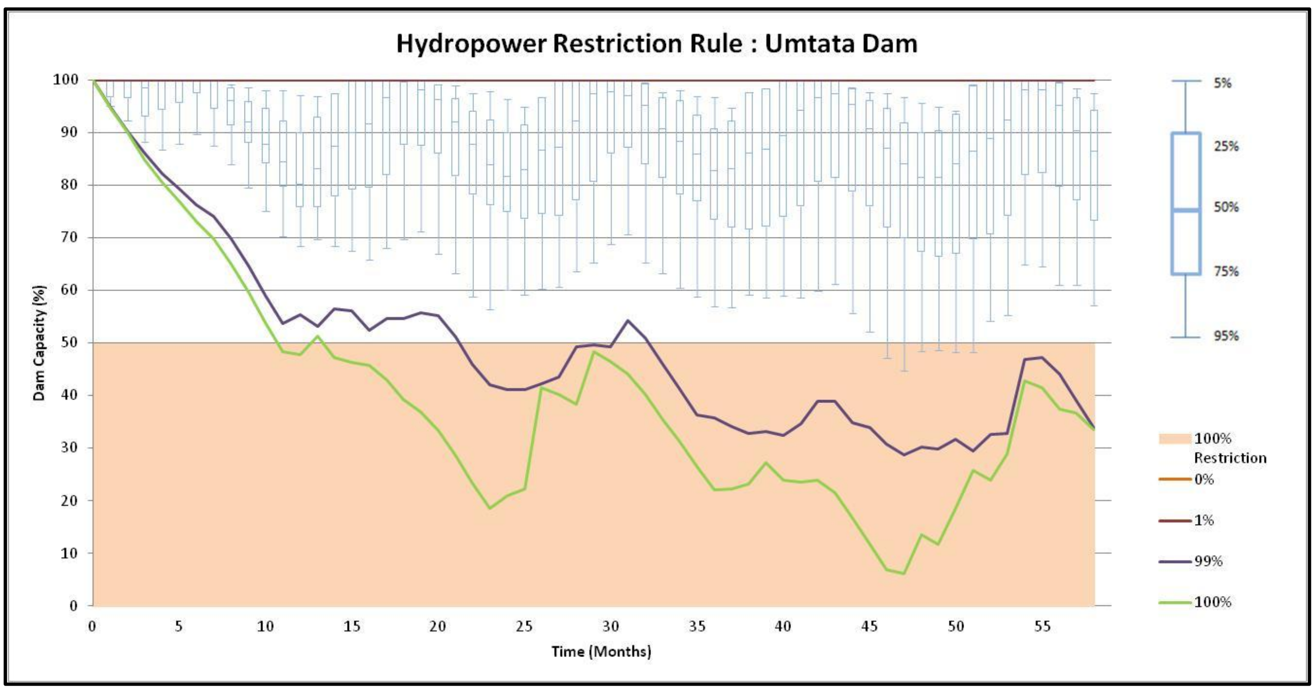


Figure 6.11 Probability trajectory of Umtata Dam with the hydropower restriction rule

7 CONCLUSION AND RECOMMENDATIONS

The purpose of Umtata Dam is to provide water for municipal and industrial use for the town of Mthatha and surrounding peri-urban villages. The dam was also built to supply water for power generation at two of Eskoms hydro power schemes at First and Second Falls. At present, the domestic water use requirement from the dam is 21.7 million m^3/a. The DWS has issued a licence of 55.08 million m^3/a. The licence needs to be amended to correctly represent the abstraction point. The total future domestic water use requirement from the scheme is 69.75 million m^3/a. The water use requirement for Eskom used in the study is 126 million m^3/a.

Several scenarios were run for the Mthatha system, which, for the purposes of these analyses include the Umtata, Mabeleni and Corana Dams as well as the weirs at First and Second Falls weirs. The Water Resources Modelling Platform (WReMP, Mallory *et al*., 2010) was used to setup the system to undertake a water resources analysis and to prepare an operating strategy which includes restriction rules based on the storage level of the Umtata Dam. An historical yield of 144 million m^3/a for Umtata Dam was computed in this study. The recommended restriction rule for urban users based on the revised assessment is as follows :

Domestic and Industrial Users

Dam Storage Level (% of FSC)	Domestic and Industrial Restriction (%)	Domestic and Industrial Supply (%)
Above 30	None	100
25 to 30	10	90
Below 25	20	80

In keeping with the water restrictions levels recommended for hydro power generation from other water resources in the province, the recommended restriction rule for the sector from Umtata Dam is as follows :

Hydro power users

Dam Storage Level (% of FSC)	Hydropower Restriction (%)	Hydropower Supply (%)
Above 50	None	100
Below 50	100	0

Ideally, from a water resources perspective, the location of the abstraction of the 55.08 million m^3/a is best placed below the Second Falls weir. Should the DWS decide to licence the abstraction point between First and Second Falls weirs, the water available to Eskom at the Second Falls weir will be in the order of about 85% of its current requirement. In scenario 3, which models the current operating scenario, Eskom would receive about 86% of its water requirement. Additionally, depending on the inflow, if it is negligible, the dam could fail in three years. Should the abstraction be from the Umtata Dam directly, and with the restriction rules proposed above, Eskom would be able to receive about 90% of its current annual requirement. The assumption undertaken for the revised rule was conservative in the percent of return flow used. Based on historical data, the dam does not fail if the percent return flow is increased to 50%, and Eskom would then receive 95% of its current annual requirement. Since the above analyses are sensitive to the return flow component, it is recommended that the amount of return flow to the system be investigated further.

Mabeleni Dam's historical yield computed in this study is 1.37 million m^3/a. The 2013/2014 water use requirement from the scheme was 1.38 million m^3/a. To be consistent throughout the system, the same restriction rules as presented above are applicable for domestic users from the dam.

8 REFERENCES

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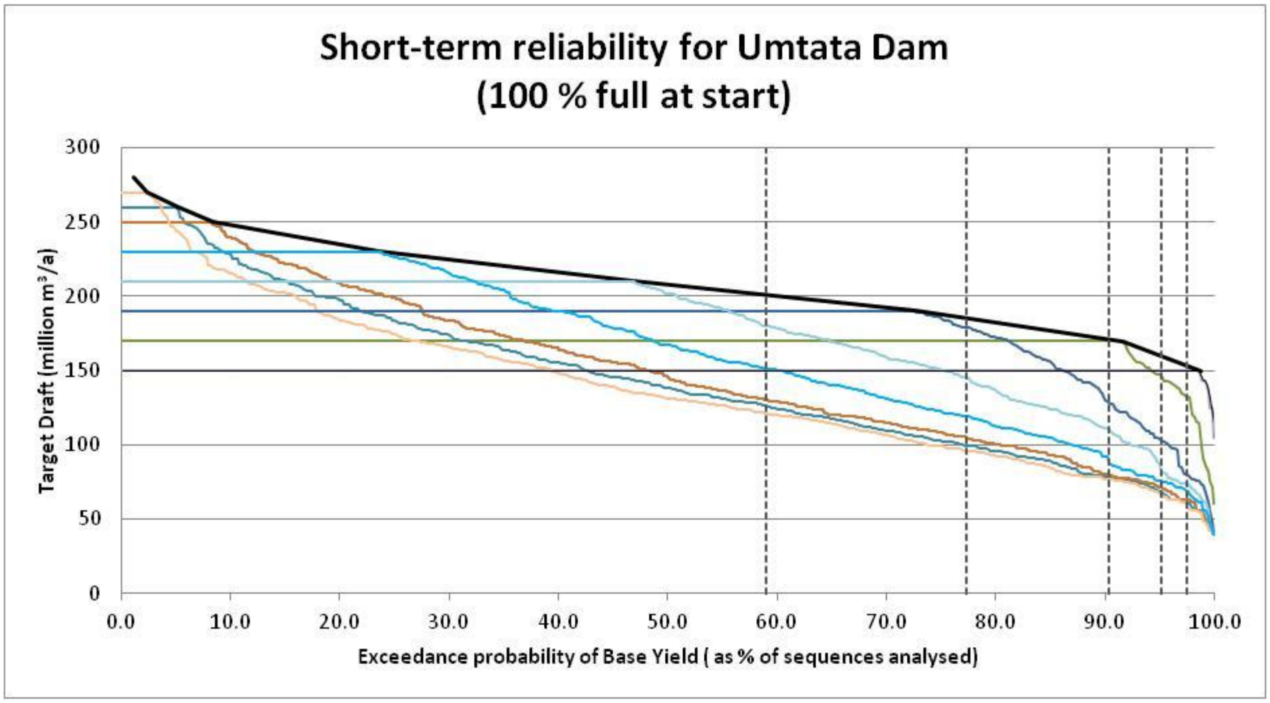
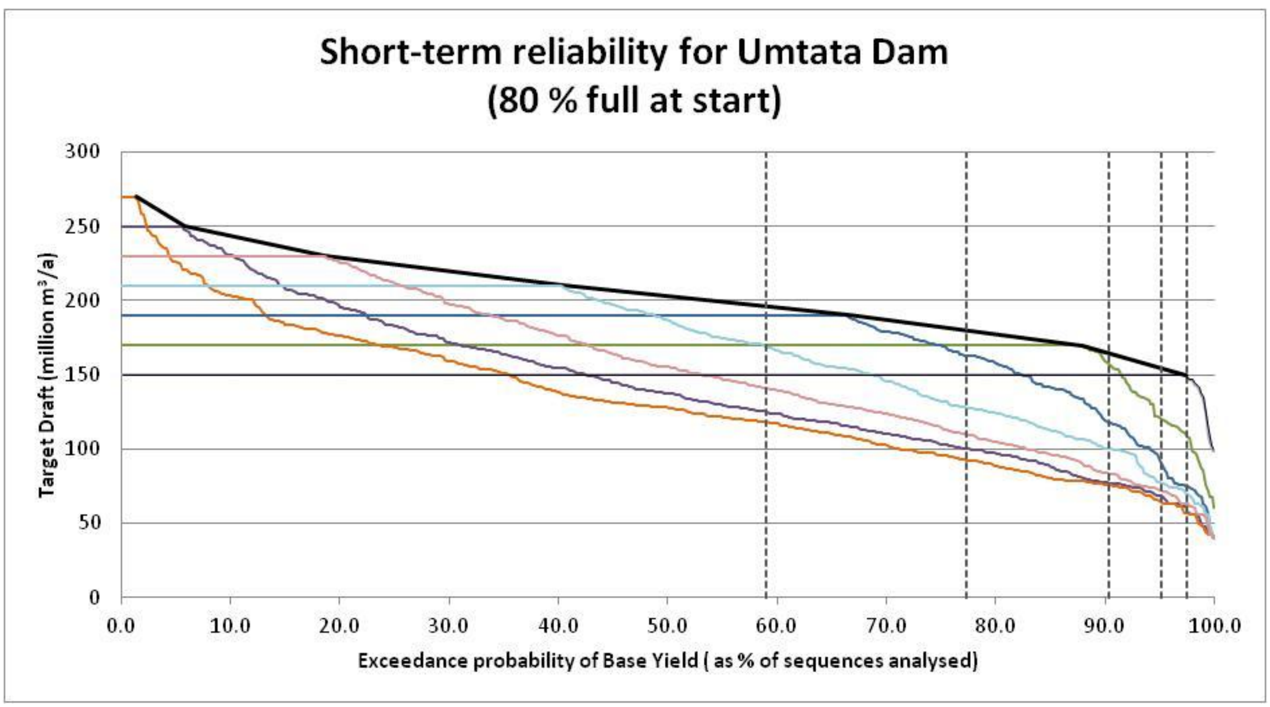
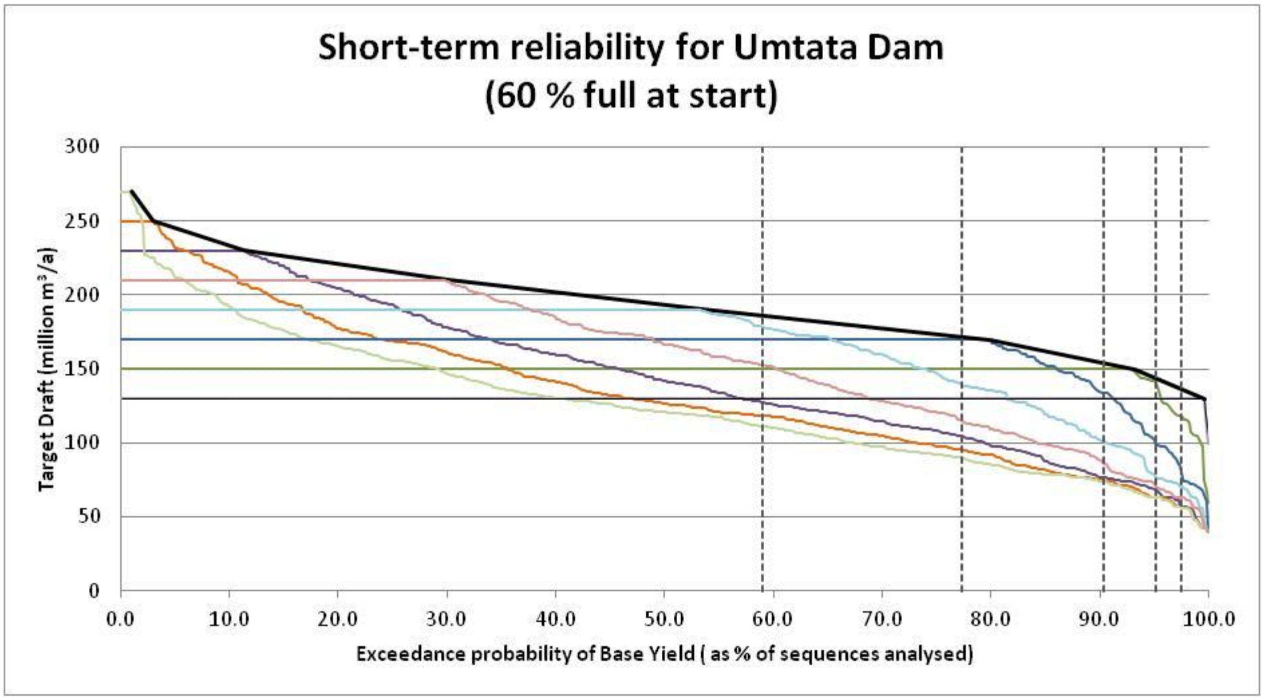
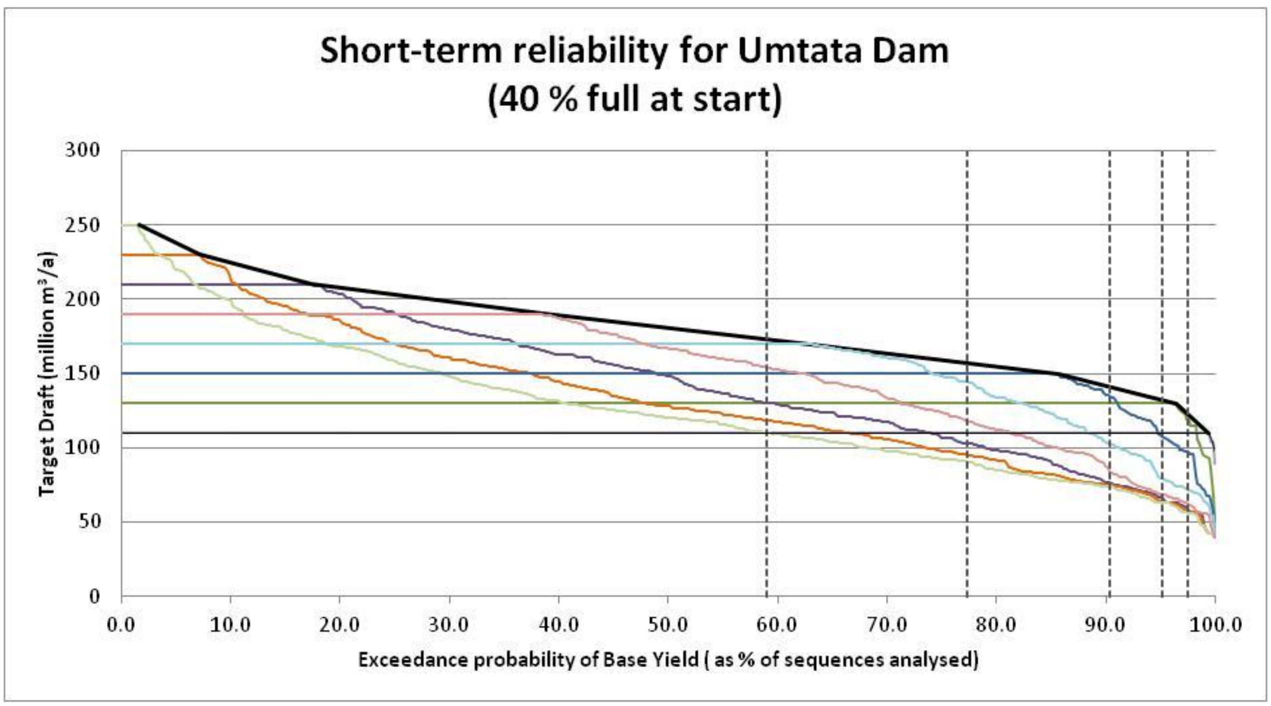
APPENDIX A : WATER USE LICENCES

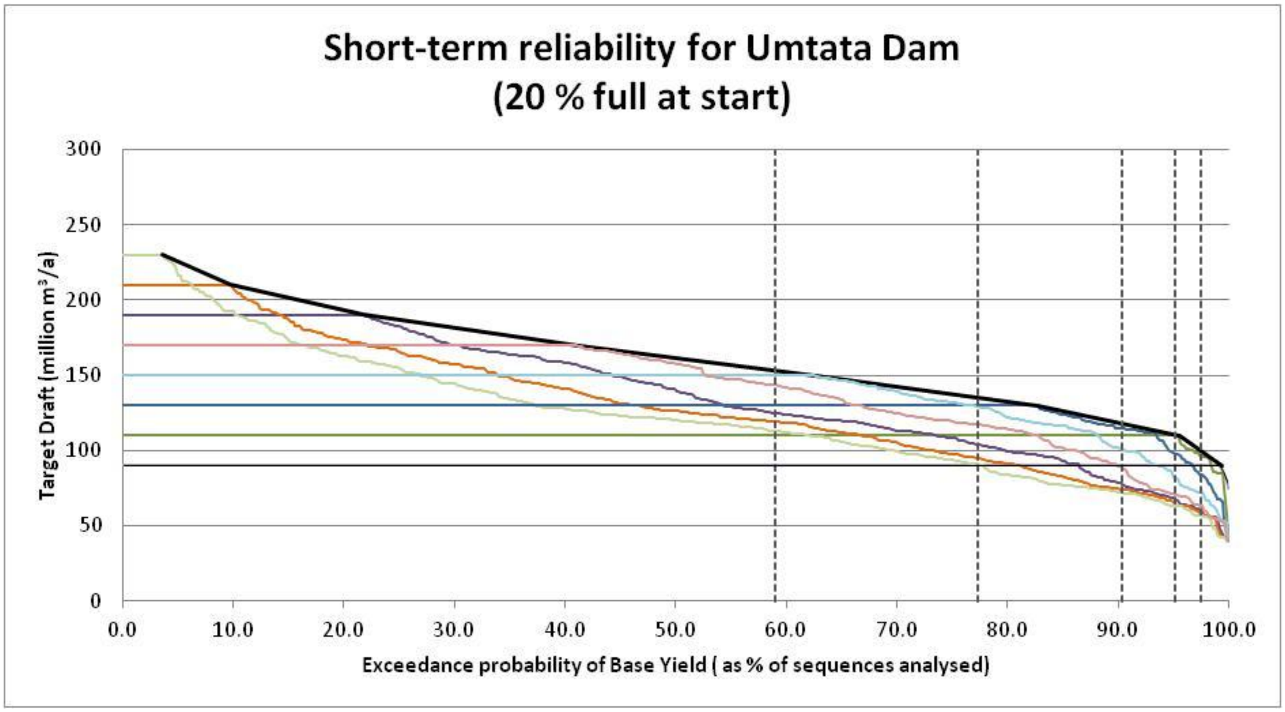
APPENDIX B : SHORT TERM YIELD CURVES






Short-term reliability for Umtata Dam
(60 % full at start)
Target Draft (million m³/a)
300
250
200
150
100
50
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Exceedance probability of Base Yield (as % of sequences analysed)


Short-term reliability for Umtata Dam
(40 % full at start)
Target Draft (million m³/a)
300
250
200
150
100
50
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Exceedance probability of Base Yield (as % of sequences analysed)


Short-term reliability for Umtata Dam
(20 % full at start)
Target Draft (million m³/a)
300
250
200
150
100
50
0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
Exceedance probability of Base Yield (as % of sequences analysed)