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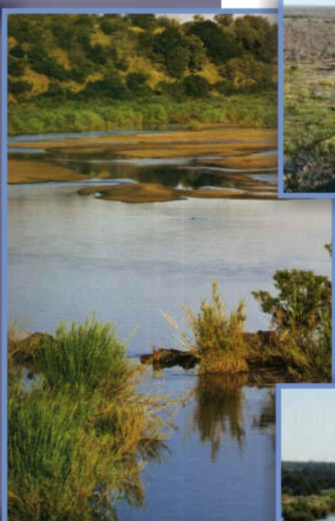
Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

PLANNING ANALYSIS



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DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM

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Prepared by:

WRP Consulting Engineers DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting.

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Authors: *HG Maré and C Seago*

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Consultants: WRP Consulting Engineers(Pty) Ltd in association with DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting

Approved for the Consultants by:

....

P G van Rooyen

Study Leader

DEPARTMENT OF WATER AFFAIRS

Directorate: National Water Resource Planning

Approved for DWA by:

....

T Nditwani

Acting Director: National Water Resource Planning

(Project Manager)

LIST OF REPORTS

The following reports form part of this study:

Report Title	Report number
Inception Report	P WMA 02/B810/00//1412/1
Literature Review Report	P WMA 02/B810/00//1412/2
Water requirements and Return Flow Report	P WMA 02/B810/00//1412/3
Rainfall analysis report	P WMA 02/B810/00//1412/4
Hydrology report (includes IAP)	P WMA 02/B810/00//1412/5
Water Conservation and Water Demand Management Report	P WMA 02/B810/00//1412/6
Water re-use report	P WMA 02/B810/00//1412/7
Water Quality Assessment Report	P WMA 02/B810/00//1412/8
Groundwater utilization scenarios	P WMA 02/B810/00//1412/9
Yield Analysis Report (include EWR)	P WMA 02/B810/00//1412/12
Planning Analysis Report	**P WMA 02/B810/00//1412/13**
Water Supply Schemes, Social and Environmental Aspects	P WMA 02/B810/00//1412/14
Final Reconciliation Strategy Report	P WMA 02/B810/00//1412/15
Executive Summary of Final Reconciliation Strategy	P WMA 02/B810/00//1412/16
Demographic and Economic Development Potential	P WMA 02/B810/00//1412/17

DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LUVUVHU AND LETABA WATER SUPPLY SYSTEM

Planning Analysis Report

(January 2015)

EXECUTIVE SUMMARY

The Department of Water Affairs (DWA) has identified the need for the Reconciliation Study for the Luvuvhu-Letaba catchment. The study area is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba catchment is mainly provided by Middle Letaba, Ebenezer and Tzaneen Dams. In the Luvuvhu catchment the recently completed Nandoni Dam will be used in combination with Albasini, Vondo and Damani dams to be managed as one system. It is expected that the total yield from this combined system will be fully utilized by around 2030, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shingwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (wastewater) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

To achieve the above objectives, the following main aspects will be covered in the study:

- *Update the current and future urban and agricultural water requirements and return flows;*
- *Assess the water resources and existing infrastructure;*
- *Configure the system models (WRSM2005, WRYM, WRPM) in the Study Area at a quaternary catchment scale, or finer where required, in a manner that is suitable for allocable water quantification;*
- *To firm up on the approach and methodology, as well as modelling procedures, for decision support to the on-going licensing processes;*
- *To use system models, in the early part of the study, to support allocable water quantifications in the Study Area and, in the latter part of the study, to support ongoing licensing decisions, as well as providing information for the development of the Reconciliation Strategy;*
- *Formulate reconciliation interventions, both structural and administrative/regulatory;*

- *Document the reconciliation process including decision processes that are required by the strategy; and*
- *Conduct stakeholder consultation in the development of the strategy.*

***The Planning Analysis provides valuable input to the reconciliation strategy** and the related timing of the proposed intervention options. The scenarios developed and defined for the purpose of the reconciliation strategy were analysed using the Water Resources Planning Model (WRPM) and results compared based on the projected risk of curtailments. The allocation module of the WRPM requires multi-risk user priority definitions for each of the water use sectors and priority class definitions as the basis for simulating drought curtailment rules. Results from the analysis were used to indicate when intervention is required based on the defined risk criteria. These results were then used to adjust water balances at key points in the system.*

System description

The study area comprises of the water resources of the catchment of the Luvuvhu, Mutale, Letaba and Shingwedzi rivers, linked to adjacent systems by inter-basin transfers.

The Groot Letaba River catchment utilize water from the Groot Letaba River and its tributaries with existing storage dams such as Dap Naude, Ebenezer, Magoebaskloof, Vergelegen, Hans Merensky, Tzaneen, Thabina and Modjadji dams to supply water to various towns including Polokwane, Tzaneen, Haenertsburg, Modjadjiskloof and also to a number of rural villages. Water use in the Groot Letaba catchment is dominated by irrigation. In the Middle and Klein Letaba River catchment the water supply schemes are the Sekgopo and Tshitale/Sekgosese borehole schemes, as well as the Middle Letaba and Giyani water schemes using Middle Letaba and Nsami dams as their main resource of water. Some of the Middle Letaba water supply schemes also supply potable water to other sub-catchments, being Groot Letaba River and Luvuvhu/Vondo River catchments. The surface water resources within the Letaba catchment are extensively developed. Faced with water shortages of increasing severity and frequency over the years, the main consumptive users of water have from time to time compete for the limited supplies and experienced significant levels of restrictions. This has resulted in the degradation of the riverine ecosystem. The water resources of the Groot Letaba are not sufficient to meet all its requirements all of the time.

A Feasibility Study of the Development and Management Options for the Letaba catchment proposed several options for augmenting water supply from the Groot Letaba River. These included some management interventions, as well as the construction of a dam at Nwamitwa and the possible raising of Tzaneen Dam. The Minister of Environmental and Water Affairs approved the implementation of the Groot Letaba Water Development Project (GLeWaP) and a notice in accordance with Section 110 of the National Water Act declaring the Minister's intent to implement the GLeWaP was gazetted on 21 December 2012.

Due to significant water supply shortages already experienced in the Middle Letaba Nsami dam sub-system, the construction of a pipeline from Nandoni Dam in the Luvuvhu River to Nsami Dam has already commenced. This pipeline will convey raw water from Nandoni Dam to the treatment plant at Nsami Dam.

The Luvuvhu River Catchment is located in the north-eastern corner of South Africa. It rises near to Louis Trichardt (Makhado) and flows in a north-easterly direction to its junction with the Limpopo River near to Pafuri.

Nandoni Dam and Xikundu Weir together with the existing Albasini, Vondo, Phiphidi and Tshakhuma dams and the associated bulk purified water supply infrastructure are known as the Luvuvhu River Government Water Scheme. Nandoni Dam started to store water during 2002/03 and was able to augment the flow in the river from the winter of 2003. This scheme is managed as an integrated system to supply water for domestic/industrial, irrigation and for the ecological component of the reserve. Current planning is that the Nandoni system will in future partly of fully support a large number of Rural Water supply Schemes and towns. The main bulk distribution pipeline is still under construction and most of these areas are not yet supported from Nandoni Dam.

Significant irrigation developments from surface and groundwater upstream of Albasini Dam resulted in a decrease in the yield available from Albasini Dam, to such and an extend that the irrigation scheme downstream of Albasini Dam can very seldom be supplied with water from the dam, as the dam struggles to meet the urban/industrial demand of Louis Trichardt (Makhado). As result of land claims large areas that were previously irrigated is currently not utilised, although these areas still have allocations from several of the existing dams. It is currently not clear whether these allocations will in future again be utilised for irrigation purposes.

There are no major dams in the Shingwedzi basin due to the limited water resources and the non-availability of suitable dam sites. Rural Water Schemes that operate in this catchment includes North and South Malamulele East RWS, which has its source as the Malamulele Weir, Xikundo Weir and Minga Weir in the Luvuvhu River. Parts of the Middle Letaba RWS Malamulele West, Giyani sub-systems F1 & F2 are located within the Shingwedzi catchment, currently receiving water from the Middel Letaba – Nsami sub-system. Water for a small irrigation area of 270ha is sourced from the Makuleke Dam on the Mphongolo River a tributary of the Shingwedzi River.

The water resources in the Mutale catchment are still underdeveloped as limited storage structures exist in this sub-catchment. Mukumbani Dam in the upper reaches of the Tshirovha River supplying water to the Mukumbani Tea Estate is the only dam in this catchment. The surface water appears to be of reasonable quality and has not been polluted to any great extent by the present developments. The Vondo North Rural RWS and the Damani RWS are both partly located in the Mutale catchment and are supplied with water from Vondo and Damani dams respectively, which are both located in the Luvuvhu River catchment.

The remainder of the Rural Water Supply Schemes are supplied from Mutale surface (50%) and groundwater resources (50%), almost similar volumes used from both sources. Some irrigation did exist in the past, it is however uncertain how much of the irrigation is currently still practised.

The Reserve

The Reserve is that portion of the natural flow that has to be available in a river or stream in order to sustain the aquatic ecology, and also to provide for basic human needs. The work carried out in the Letaba Classification Study consolidated the Ecological Water Requirement

(EWR) scenarios for application in the water balances assessment of this study. EWR scenarios were formulated to reflect the implication on the available yield as shown later in the document and further details will be given in the main document.

Hydrological Analysis

There were quite a number of uncertainties around the previous available hydrology such as low confidence water use assumptions, losses in the systems, impact of groundwater use on the available surface water flows etc. The recently completed Groot Letaba Water Development Project (GLeWaP) study strongly recommended the complete update and recalibration of the Groot Letaba hydrology to confirm the yield results for the proposed Nwamitwa Dam and the raising of Tzaneen Dam. For the first time groundwater-surface water interaction was taken into account in the generation of the natural flow sequences, by applying the techniques and simulation models that have been developed by DWS and the Water Research Commission.

A detailed Water Resources Simulation (WRSM2000) hydrological model was configured and calibrated as well as verification of simulated flows was done at the 23 sites throughout the Study Area. Details on the hydrology and related processes are captured in the Hydrology report produced as part of this study.

Current and projected water requirements

To determine the volume of water needed, information was gathered on the water requirements of the different sectors. The water use Validation Study served as the primary source of historical water use data. Groundwater resources play an important role in the water supply within this study area with approximately 22% of the total water requirement imposed on groundwater. The irrigation sector uses most of the groundwater with 29% of the irrigation supplied from groundwater. The total groundwater requirement is estimated to be almost 160 million m^3/a at the 2010 development level.

***Table i** summarises the water requirement for the Luvuvhu and Letaba River System for the all the user sectors, listing the 2010 water use as well as estimates for the indicated components up to the year 2040.*

Table i: Total High growth water requirements (values in million m^3/a)

Catchment & Description	User description	Demand projection (million m^3/a)						
		2010	2015	2020	2025	2030	2035	2040
Groot Letaba	All users	332.7	338.7	345.1	351.9	355.4	358.9	362.7
Klein Letaba	All users	129.7	135.9	142.6	149.8	152.9	156.1	159.5
Luvuvhu/Singwedzi	All users	126.04	132.9	176.6	191.4	196.6	201.0	204.3
Mutale	All users	8.2	8.9	9.5	10.2	10.6	11.1	11.6
Total Demand in study area		**596.70**	**616.31**	**673.73**	**703.27**	**715.53**	**727.04**	**738.06**
Total study area	Reduction in runoff due to IAP	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Total study area	Forestry reduction in runoff	79.7	79.7	79.7	79.7	79.7	79.7	79.7
Total Demand and runoff reduction requirements in study area		**687.70**	**707.31**	**764.73**	**794.27**	**806.53**	**818.04**	**829.06**

The possible estimated savings through WC/WDM in the urban and rural domestic sector was determined for each of the Water Services Schemes and for the larger towns in the study area. This was estimated to be in the order of 9 million m^3/a, representing an overall saving of 8%.

Within the irrigation sector very limited (if any) savings can be achieved, as most of the irrigation schemes are already experiencing severe water shortages. In the case of commercial irrigation schemes, irrigators have in most cases already improved their irrigation efficiency to get maximum use from the available water.

Water availability

Yield analyses were undertaken based on the revised hydrology for all major dams and relevant sub-systems. ***Table ii*** *provides a summary of the yield results for existing and possible future infrastructure, indicating the high assurance yield (1 in 50 year or 98% assurance) and the low assurance yield (1 in 20 year or 95% assurance). Details on the yield analysis and related scenarios analysed are given in the Yield Analysis Report produced as one of the deliverables from this study.*

The Water Resources Planning Model (WRPM) requires short-term yield-reliability characteristic curves as part of the system operating rules used to determine appropriate water allocations (and therefore restrictions), to be applied in the short-term, based on the priority classification of water users supplied from the system (or sub-system) in question. However, unlike the long-term yield capability of a system, the short-term yield is greatly influenced by the volume of water in storage at the beginning of the period under consideration and is it generally possible to allocate more water in situations when the system storage is high, while the opposite is true in low storage situations.

As part of the planning analysis short-term yield-reliability characteristic curves were produced for selected dams and sub-systems. For this purpose, short-term stochastic yield analyses were undertaken based on 501 5-year stochastically generated streamflow sequences and with the start month set to May. Furthermore, separate analyses were undertaken with the dam at a variety of starting storage levels corresponding with 100%, 80%, 60%, 40%, 20% and 10% of its live full supply capacity (FSC).

Table ii: Existing and possible future System yield results

Dam name	FSV (million m^3)	Yield (million m^3/a)		
		HFY$^{)}$	1 in 20 year	1 in 50 year
1) Dap Naude plus Ebenezer	72.8	36.2	43.8	40.5
2) Magoebaskloof plus Vergelegen	9.9	6.4	14.7	12.9
3) Hans Merensky	1.2	1.0	2.2	1.7
4)Tzaneen raised	182.4	45	60.0	51.7
5) Tzaneen raised plus Nwamitwa	369.0	61		
6) Tzaneen raised plus Nwamitwa & EWR	369.0	49		
7) Thabina	2.6	3.1	4.1	3.7
8) Middel Letaba plus Nsami	206.1	20.6	31.0	24.3
9) Thapane	1.07	1.1	1.6	1.4
10) Modjadji	7.2	3.5	4.4	3.8
11) Makuleke	13.0	0.1		
12) Albasini	28.4	1.4	3.7	2.5

Dam name	FSV (million m^3)	Yield (million m^3/a)		
		HFY)	1 in 20 year	1 in 50 year
13) Vondo	30.6	16.8	25.0	21.9
14) Phiphidi	0.19	0.2		
15) Damani	12.9	4.8	5.7	5.3
16) Nandoni plus weirs	166.1	62	83.0	70.0
17) Tshakuma	2.47	1.4	1.8	1.5
Possible Future dams				
1) Paswane dam	90.0	43.0	64.5	55.0
2) Xikundu Dam	139.0	51.0	71.5	62.5
3) Crystalfontein Dam with EWR	96.0	5.4	-	-
4) Majosi Dam with EWR	29.0	4.6	-	-
5) Rambuda Dam	13.5	12.6	18.7	16.7
6) Tswera Dam	131	53.0	69.4	62.1
7) Thengwe Dam	116	51.0	-	-

*Details of the short-term yield characteristics are summarised in **Table 3.1** of **Section 3** in this report.*

Reconciling the Water Requirements with the Water Resource

The three major sub-systems, the Groot Letaba, the Middle Letaba Nsami and the Luvuvhu sub-system, are currently managed as individual systems. Within each of these major sub-systems there are a number of smaller sub-systems which are in some cases linked to the main sub-system. As part of the Reconciliation Strategy separate reconciliation balances and strategies covering each sub-system within the study area was prepared. This was done to identify the particular timeline and magnitude of interventions required during the planning horizon. The proposed intervention options as listed below were used as the basis for the WRPM setup.

<u>The Groot Letaba Main system</u> water balance contains the following proposed intervention options:

- *Water Conservation and Water Demand Management saving 0.8 million m^3/a in urban sector (to be in place by 2015).*
- *Irrigation restriction policy to reduce the average irrigation water use. This is an existing policy which was developed by the irrigation users to be able to protect the resources. This option reduces the average irrigation water use to approximately 38% below the full allocation.*
- *The raising of Tzaneen Dam by 2017 resulting in an increased assurance of supply and a yield increase of 1 million m^3/a.*
- *Construction and implementation of Nwamitwa Dam by 2019 adding 5.5 million m^3/a to the high assurance yield and 0.7 million m^3/a to the low assurance yield.*

- *Additional groundwater development, increasing the system yield by at least 2.5 million m^3/a by 2018.*
- *To be able to protect the environment, the classification study agreed EWR need to be implemented once Nwamitwa Dam is in place (2020)*

<u>Intervention options recommended for the Modjadji Water Supply sub-system include</u>:

- *Water conservation and demand management in urban sector by 2015 – saving of 0.3 million m^3/a.*
- *Construction of bulk supply infrastructure to augment the supply from the Middle Letaba System.*

<u>The Middle Letaba Nsami System</u> water balance includes the following intervention options:

- *Water conservation and water demand management from 2015 onwards (reduction in demand 2.8 million m^3/a)*
- *Pipeline to replace the canal between Middle Letaba and Nsami dams, to be in place by 2016. Eliminate canal losses estimated at 4 million m^3/a.*
- *Pipeline from Nandoni Dam to the Giyani WTW. Support of 5 million m^3/a from Nandoni Dam, available from 2016 onwards.*
- *Supply some of the RWS committed for support from Nandoni by 2017 (2 million m^3/a)*
- *Supply the remaining areas committed for support from Nandoni Dam by 2025 (6.6 million m^3/a).*
- *Additional development of groundwater use by 2021 (12.9 million m^3/a)*

<u>The Luvuvhu System</u>, comprising of several sub-systems of which some are already linked. Nandoni Dam is the largest storage dam in this system and was completed in 2004. Nandoni Dam is currently used to supply part of the Greater Thohoyandou sub-system as well as the RWS downstream of Nandoni Dam. Most of the links between all the sub-systems within this supply area are already in place. This water supply area comprises of the following water resources:

- *Albasini Dam*
- *Damani Dam*
- *Nandoni Dam **
- *Vondo Dam **
- *Phiphidi Dam **
- *Tshakhuma Dam **
- *Two package plants abstracting water directly from the river – Dzindzi & Dzingae **
- *Abstractions from three weirs located in the Luvuvhu River downstream of Nandoni Dam – Malamulele Weir, Xikundu Wei and Mhinga Weir. **

*Note * - All these water resources form part of the Integrated Nandoni System*

<u>The proposed intervention options to be considered for the Damani Sub-system</u> includes:

- *Water conservation and water demand management in the rural domestic sector to be implemented by 2015, reducing the demand by 0.20 million m^3/a.*
- *Support from Nandoni Dam from 2017 by a maximum of 0.6 million m^3/a.*
- *Utilise additional groundwater resources by 2018 (1.9 million m^3/a)*
- *Receive support of 5.1 million m^3/a, from a dam in the Mutale River from 2030 onwards.*
- *No irrigation supplied over the analysis period*

<u>The proposed intervention options to be considered for the Albasini Sub-system</u> includes:

- *Water conservation and water demand management in the urban and rural domestic sectors to be implemented in 2015, reducing the demand by 0.97 million m^3/a.*
- *Nandoni Dam start to support the Albasini Dam sub-system from 2016 onwards*
- *Albasini Dam to supply 2.5 million m^3/a in support of the Makhado RWS (base on the 98% assurance long term yield)*

<u>Proposed intervention options for the Nandoni System</u> comprise of the following:

- *Water conservation and water demand management in urban and rural domestic sectors of 1.7 million m^3/a by 2015*
- *Utilise additional groundwater resources of 5.14 million m^3/a by 2025*
- *Support (7 million m^3/a) received from a future dam in the Mutale River by 2030*
- *The supply to EWR (desktop) downstream of Nandoni Dam.*
- *Several areas located outside the Luvuvhu catchment were also committed to receive water from Nandoni Dam. These areas include Sinthumule/Kutama, Louis Trichardt (Makhado), Giyani, Matoks, Middle Letaba supply areas as well as areas currently supplied from Damani Dam of which the bulk is located in the Mutale catchment*

<u>Mutale River System</u> water balance includes the following intervention options:

- *Implementation of Water Conservation and Demand Management in the urban sector rural domestic sector of 0.74 million m^3/a by 2015*
- *Developing additional groundwater resources of 2.7 million m^3/a by 2015.*
- *Construction of a dam in the Mutale River (different possible options but Rambuda possible dam 16.7 million m^3/a yield, was selected for the purpose of the WRPM analysis)*

For the purpose of the WRPM analysis the priority classification was selected to be aligned with the water balances as prepared for the water balances, based on the long-term stochastic yield results. For the purpose of the water balances the domestic water use was supplied at a 98% assurance (recurrence interval 1 in 50 years) and irrigation was supplied at 90% assurance (recurrence interval of 1 in 10 years).

As result of the over utilization of the Groot Letaba System severe and complicated restriction rules were developed and used by the users. This rule for example requires that the irrigators are cut to 50% of their allocations once Tzaneen Dam drops to below 98.3%. This rule equates to a 68% supply on average to the irrigators and 99% to urban use with the irrigation requirement representing more than 80% of the total demand imposed on the system. To ensure that the irrigators in the Groot Letaba system still receives at least their current *assurance of supply in future, it was decided to use the Groot Letaba existing restriction rules in the WRPM analysis for all related Groot Letaba analysis. For the remainder of the systems the short-term stochastic yield characteristics were used as the basis of the operating rules.*

WRPM Analyses Results

The Groot Letaba Main system WRPM analysis in general provided fairly similar results than those obtained from the long-term yield analyses and related water balances. The main differences are the fact that Nwamitwa Dam take quite some time to stabilise (approximately 8 to 10 years) and will therefore not be able to deliver its full yield within one or two years after inundation started. The assurance of supply to the urban and rural domestic users were in general slightly lower than the 98% (1 in 50 year) as was used for the water balances. In general 85% of the Tzaneen Demand is supplied at an assurance of 98% (1 in 50 year) and the assurance of supply started to decrease again from 2033 onwards. The upper 50% of the irrigation was supplied at a very low assurance due to the restriction rule used and the lower 50% at a reasonably good assurance for irrigation purposes, similar to that obtained for the domestic supply.

Due to the complicated restriction rules currently used for the Groot Letaba System that were also adopted for use in the WRPM, it was not possible to always obtain the same assurance of supply to all users within the same priority class, as would be possible when short-term stochastic yield characteristics were used as the basis for the operating rule. Further refinement of this operating rule are required for future analysis to obtain an improved balance in the supply assurance and to protect the dams against total failure.

The water balance as used for the reconciliation strategy indicated that a positive water balance could only be achieved up to 2030. The WRPM analysis results showed a reduction in the assurance of supply from about 2033/2034 onwards. Further refinement of the priority classification can also contribute to an improved water supply over the analysis period.

The Modjadji Dam sub-system utilized short-term stochastic yield characteristics as part of its operating rule to protect the dam from failures. Due to the over allocation of Modjadji Dam the demand growth from 2020 onwards was allocated to the Middle Letaba system. The Middle Letaba system was able to support this growth in demand fairly well until 2033, where after the assurance of supply started decreasing towards unacceptable levels. The non-growth portion of the water requirement imposed on Modjadi Dam was set equal to the long-term 98% assurance yield. Modjadji Dam was however able to on average only supply approximately 75% of this requirement at a 98% assurance.

This is a typical result when short-term stochastic yield characteristics is used to protect the resource, as it generally produces more conservative results. The short-term yield characteristics are used to protect the resource from total failure (dam being empty) as evident from the storage projection plots. When the long-term yield is however determined, the maximum possible volume is taken from the resource leading to supply failures in the process of determining the long-term yield, thus deriving a more optimistic yield result.

Middle Letaba Nsami sub-system was analysed as a combined system using short-term stochastic yield characteristics as part of the operating rule to protect the system from failures.

The results from the WRPM analyses were fairly similar to those from the water balance based on the long-term yield results. Due to reasonable storage levels in both dams at the start of the analysis it was possible to overcome the initial deficit from 2014 to 2015 as indicated from the water balances. The WRPM results showed that it was not necessary to change any of the given dates as indicated by the water balances for the required intervention options. The short term deficit around 2018 to 2020 indicated in the water balances was also evident from the WRPM analysis results, although slightly more severe deficits were showed. From about 2034 the assurance of supply (98%) was starting to reduce to unacceptable low levels, indicating that another intervention option will be required by then. This is 6 years earlier than the time estimated from the water balances using the long term yield characteristics. This is partly as result of the fact that short-term characteristics were used to protect the resource from total failure (dam being empty) as evident from the storage projection plots as was explained for the Modjadji Dam sub-system. Further refinement of the operating rule and the priority classification can be used to improve or optimize the water supply assurance.

<u>The Luvuvhu System</u>, comprise of several sub-systems of which some are already linked and other will be linked in the near future as already described above in the paragraphs under the "Reconciling the Water Requirements with the Water Resource" heading. Two of the water resources are currently not yet linked to the greater Nandoni System and will thus be discussed separately as stand-alone systems before the results for the Integrated Nandoni System are given. These two resources or sub-systems are Albasini and Damani dams.

<u>The Damani sub-system</u> is currently not fully utilized as the irrigation (4 million m^3/a) allocated to this resource, has not yet been developed. The long-term yield water balances clearly showed that Damani Dam will not be able to support both the rural domestic and irrigation requirements. For the purpose of the WRPM analysis it was decided to exclude the irrigation component and use the WRPM results to indicate the time in the future (when other intervention options are in place) when there might be surplus available in the system to be used for irrigation purposes.

Short-term stochastic yield characteristics were used as part of the operating rule for Damani Dam to protect the dam against complete failure. Results from the WRPM analyses showed that by 2026 when the rural domestic requirement increased to just over 7 million m^3/a, the demand supply plot showed that the sub-system started to have difficulties to maintain the rural domestic supply at a 98% assurance. By 2030 when support was obtained from a dam in the Mutale River, the storage in Damani Dam recovered significantly, indicating that this should be a good time to start with the implementation of the irrigation developments.

<u>The Albasini sub-system</u> is totally over utilized and was for several years not able to supply the irrigation requirements allocated to this sub-system. The Nandoni system will be used to supply the bulk of the urban/industrial and rural domestic requirements from 2016 onwards. Nandoni Dam will however not be used to support the irrigation requirements imposed on Albasini Dam. The only way to significantly improve the Albasini Dam yield that will allow supply to its irrigation allocation, is to reduce the current upstream developments. The Validation/Verification study by DWS is not yet completed and it's thus not known if any of the upstream developments are lawful or not. The scenario selected to for the purpose of the

WRPM analysis assumed no supply to the irrigation allocated to Albasini Dam, and no removal of upstream water use related developments. The 98% assurance long-term yield from Albasini Dam under these conditions is 2.5 million m^3/a. The operating rule used dictated that the 2.5 million m^3/a from Albasini Dam always be supplied to the domestic users whenever it's available. The remainder of the requirement will then be supplied from Nandoni Dam and short-term yield characteristics will be used to protect Nandoni Dam from failing.

The results from the WRPM analyses showed that the total water requirement of Makhado RWS, Sinthumele Kutana RWS and the Air Force Base, were well supplied until 2039 with only an almost negligible portion of the demand that could not be fully supplied at the 98% assurance from 2035 onwards.

<u>The Integrated Nandoni System</u> comprise of several dams, the Albasini, Nandoni, Vondo, Phiphidi, Tshakhuma and Damani dams. Short-term stochastic yield characteristics were used as the basis of the operating rule for all these dams with the exception of Albasini Dam. Nandoni Dam is the only dam with a significant portion of its yield not yet utilized, although it was already allocated to various future users.

The water balances that were based on the long-term stochastic yield results as previously prepared, showed that the Integrated Nandoni System requires that the additional groundwater resources be in place by 2031, that allow the system to be in balance until 2035, thereafter support will be required from a future dam in the Mutale River.

Results from the WRPM analyses revealed that the supply to the domestic users from this system achieved the given 98% assurance fully until 2025. There after approximately 10% to 15% of the demand were supplied at a slightly lower assurance, with the remainder still supplied at the required 98% assurance.

To obtain this result it was required to move the additional groundwater support forward to 2025 and the support from a future Mutale dam to 2030, thus earlier than that indicated from the long-term yield water balances. The combined storage projection plot representing the total system storage showed that the available storage was not fully utilized as the given operating rules is probably too strict and will need to be refined.

The refinement of the operating rules enabling the system to utilize the total system storage will thus improve the assurance of the supply to the Integrated Nandoni System users and should reduce the 10% to 15% of the demand not fully supplied at the 98% assurance from 2025 onwards.

<u>The Mutale System currently</u> uses river runoff and groundwater to supply the water requirements in this catchment as there is currently no storage dam available in this system to support the rural domestic requirements. Due to uncertainties regarding which of the proposed future dam options to use, as well as the required size of the future dam, short-term yield characteristics were not developed for any of the possible future dams. A very basic operating rule was used which allowed supply directly from the possible future dam for users close to the dam and for the recommended future support to Nandoni and Damani dams. The users located downstream of the future Mutale dam will first utilize the available runoff in the river and any

deficit in supply will be supported by means of releases from the Mutale Dam. For the purpose of the WRPM analyses the Rambuda possible future dam was used as the resource.

The demand supply graph produced from the WRPM analysis for the total system representing all the demands domestic and irrigation as well as the transfers to the Nandoni and Damani systems is included in this graph and showed no deficits over the total simulation period, even before Rambuda Dam was in place. For this scenario the total demand imposed on the dam by the end of the analysis period was almost equal to the system yield. This exceptionally good supply as obtained from the analysis is as result of the high incremental inflows downstream of the dam, while the downstream demands are relative small. On a monthly basis the flows in the river is for most of the time sufficient to always supply in the required demand without releasing water from Rambuda Dam and thus saves the storage in the dam, resulting in an almost full dam over the analysis period.

Conclusions and Recommendations

Groot Letaba

- *The water balances prepared from the long-term stochastic yield analysis indicated that a next intervention option is required by 2030 to be able to maintain the required water balance for the Groot Letaba Main System. The WRPM analyses showed that intervention will be required by 2033 to 2034, thus a few years later. The restriction and operating rules as used for the WRPM analysis purposes however do require refinements, which will impact on the given dates for the next intervention option.*
- *The strict restriction rules imposed on the Groot Letaba Main System is clearly demonstrated when examining the supply to irrigation, showing an extremely low assurance of supply to the upper 50% of the irrigation demand. The remaining 50% are however supplied at a similar assurance as that evident for urban/industrial requirements, which is higher than what is normally required for irrigation purposes. This also indicates that the existing restriction rules need some refinement to achieve a more optimal use of this resource.*
- *Nwamitwa Dam improved the assurance of supply to the users. It however took approximately 5 to 6 years for Nwamitwa Dam to fill and for the storage levels to stabilise before the advantage of Nwamitwa Dam was evident. This is due to the fact that the Groot Letaba Main System is over utilized which is clearly illustrated by the results and the fact the existing operating rule cut the supply to irrigation by 50% when the storage in the dam drops to below 95%.*
- *Modjadji Dam is able to supply the growing demand imposed on the dam until 2018, where after the assurance of supply started to reduce to below the 98% target assurance. The protection of Modjadji Dam against complete failure by means of the short-term stochastic curves was well achieved, although the protection obtained is somewhat on the conservative side. Some refinement can therefore be done on the short-term curves that should also improve the assurance of supply from Modjadji Dam. From 2021 onwards the growth in demand imposed on Modjadji Dam was supplied from the Middle Letaba system, to be able to reduce the load on Modjadji Dam. The Middle Letaba system was able to support this growing demand at the required assurance of 98% until 2033 thereafter the assurance of supply was decreasing towards unacceptable low levels. The demand*

component to be supplied from Modjadji Dam only from 2021 onwards, seems a bit too high and will require some refinement.

<u>*Middle and Klein Letaba*</u>

- *The water supply results for the Middle Letaba Nsami System indicated that another intervention option will be required by about 2034. The water balances that were based on the long-term stochastic yield results as previously prepared, however showed that the system should be in balance until 2040, which is 6 years later than the date from the WRPM analysis. This is a typical result when short-term stochastic yield characteristics is used to protect the resource, as it produces more conservative results. The WRPM simulates what is happening in reality more closely, and should rather be used as the final result for decision and planning purposes. Further refinements of the operating rules can also assist towards a more optimal use of the resource.*
- *The development of additional groundwater resources is crucial and a feasibility study to confirm the availability of these resources need to take place as soon as possible.*

<u>*Luvuvhu River System*</u>

- *The Integrated Nandoni System is the only system in the Luvuvhu River catchment which is currently not yet fully utilised. Volumes for future use were however already allocated to various users, mainly for domestic water use purposes but also for irrigation downstream of Nandoni Dam.*
- *These allocations were included as demands imposed on the Integrated Nandoni System at assumed dates, due to the lack of proper planning dates available. When all these allocated and existing demands as well as the related growth projections were imposed on the system, it was clear that the Integrated Nandoni system is already over allocated and will require further intervention options from 2025 onwards, depending on the timing when the different future demand centres are going to be phased in, including the possible future irrigation developments.*
- *The EWR imposed on Nandoni Dam was obtained from a desk top estimate and can be significantly different from the reserve, still to be determined. This can result in quite a change in the water balance than that obtained from the current WRPM analysis.*
- *Increasing the storage capacities of the weirs downstream of Nandoni Dam, can due to the large incremental inflows, significantly increase the system yield and should be investigated in comparison with appropriate operating rules.*
- *The future link from Nandoni Dam to the Damani Dam supply area will not be worth wile for the scenario when a future dam in the Mutale River is considered, as the Damani RWS is largely located within the Mutale River basin and reasonably close to the possible Mutale River Dam sites. The link from the Nandoni Dam to Damani Dam will the only be of use for two or three years.*

<u>*Mutale River System*</u>

- *Although the total demand imposed on the possible future Ramabuda Dam slightly exceeded the long-term yield, the Ramabuda storage projection plot clearly showed that the dam was not fully utilized. This is due to incremental flows generated downstream of the possible Ramabuda Dam which is partly used to supply the downstream requirements.*
- *More detailed and refined analysis will be required for the Mutale River system which should take place:*
  - *once more information of the actual location of all abstraction points are available and*
  - *the proposed layout and required infrastructure of the future supply system is known*
- *Based on the WRPM analysis with Ramabuda Dam in place it seems that sufficient water will be available to supply all the projected future demands. It is possible that the transfer volume to the integrated Nandoni System can be increased to improve the water supply in the Nandoni System from 2035 onwards.*

General

- *In all the sub-systems where short-term stochastic yield results were used as part of the operating rule, a very simple priority classification was used. All urban and rural domestic requirements were allocated to a 98% (1 in 50 year) assurance and irrigation requirements to a 90% (1 in 10 year) assurance. These assurances need to be clarified with the users as some of the urban and rural domestic use can be supplied at a higher assurance and some at a lower assurance than the 98% used in all the analysis carried out for this study. The same also apply to the irrigation sector. Applying a more detailed user priority classification to the model will also impact on the water supply situation and implementation dates of future intervention options.*

Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

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Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System

Planning Analyses Report

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs (DWA) has identified the need for the Reconciliation Study for the Luvuvhu-Letaba WMA. The WMA is almost fully developed and demands from the Letaba River currently exceed the yield capability of the system. Regulation for the Letaba is mainly provided by Middel Letaba, Ebenezer and Tzaneen Dams. The recently completed Nandoni Dam located in the Luvuvhu basin will be used in combination with Albasini, Vondo and Damani dams to manage the system as one. It is expected that the total yield from this combined system will be fully utilized by around 2020, considering only the current planned projected demands. The yield of the Albasini Dam has reduced over the years and as a consequence the dam is over allocated. The Shingwedzi catchment is situated almost entirely in the Kruger National Park and for all practical purposes, no sustainable yield is derived from surface flow in the Shingwedzi catchment.

The main urban areas in these catchments are Tzaneen and Nkowakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment and Thohoyandou and Makhado (Louis Trichardt) in the Luvuvhu catchment. An emergency water supply scheme to transfer water from Nandoni Dam is currently under construction to alleviate the deficits of the stressed Middle Letaba sub-system in the Letaba River basin. Other future developments planned to be supplied from Nandoni Dam will already utilize the full yield available from the Nandoni sub-system by 2021, without supporting Giyani. Supporting Giyani from Nandoni will bring this date forward to approximately 2018.

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middel Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele Rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg. The area, particularly the Groot Letaba sub-area, is a highly productive agricultural area with mixed farming, including cattle ranching, game farming, dry land crop production and irrigated cropping. Agriculture, with the irrigation sector in particular, is the main base of the economy of the region. Large scale utilization of the groundwater resource occurs mostly downstream of the Albasini Dam in the Luvuvhu catchment, where it is used by irrigators as well as in the vicinity of Thohoyandou where it is used to supply rural communities. The limited mineral resources in the Luvuvhu basin are dominated by deposits of cooking coal in the northeast near Masisi. In addition to irrigation water supply from the dams in the study area, towns, villages and rural settlements are also supplied with potable water.

DWA and other institutions involved in the management of the water resource and supply systems of the Luvuvhu-Letaba catchments, have in the past carried out various studies on intervention measures to improve the water supply situation. The knowledge base that has been created by these studies provides a sound and essential platform from which the Reconciliation Strategy will be developed. In order to harness this information a Literature Review Report (DWA, 2013a) was compiled to summarise the available information in one document and also present a synthesis of the information by highlighting the pertinent aspects of Integrated Water Resource Management that will be assessed and incorporated in the Reconciliation Strategy.

1.2 MAIN OBJECTIVES OF THE STUDY

The main objective of the study is to compile a Reconciliation Strategy that will identify and describe water resource management interventions that can be grouped and phased to jointly form a solution to reconcile the water requirements with the available water for the period up to the year 2040 and to develop water availability assessment methodologies and tools applicable to this area that can be used for decision support as part of compulsory licensing to come. The development of the strategy requires reliable information on the water requirements and return flows (wastewater) as well as the available water resources for the current situation and likely future scenarios for a planning horizon of thirty years.

To achieve the above objectives, the following main aspects will be covered in the study:

- Update the current and future urban and agricultural water requirements and return flows;
- Assess the water resources and existing infrastructure;
- Configure the system models (WRSM2005, WRYM, WRPM) in the Study Area at a quaternary catchment scale, or finer where required, in a manner that is suitable for allocable water quantification;
- To firm up on the approach and methodology, as well as modelling procedures, for decision support to the on-going licensing processes;
- To use system models, in the early part of the study, to support allocable water quantifications in the Study Area and, in the latter part of the study, to support ongoing licensing decisions, as well as providing information for the development of the reconciliation strategy;
- Formulate reconciliation interventions, both structural and administrative/regulatory;
- Document the reconciliation process including decision processes that are required by the strategy; and
- Conduct stakeholder consultation in the development of the strategy.

1.3 PURPOSE OF THIS REPORT

The objective of this task and report is to configure the Water Resources Planning Model (WRPM) using the updated hydrology of the study area and to carryout planning analyses on the system. The report also presents the results of the short term yield analyses.

2 STUDY AREA AND DEFINED INCREMENTAL SUB-CATCHMENTS

2.1 GENERAL

The study area comprises of the water resources of the catchment of the Luvuvhu, Mutale, Letaba and Shingwedzi rivers linked to adjacent systems as indicated by the inter-basin transfers on Error! Reference source not found.. This area represents the entire WMA 2 and includes tertiary catchments A91, A92, B81, B82, B83 and B90. Adjacent areas supplying water to this WMA or getting water from this WMA are also part of the study area.

The Luvuvhu-Letaba water management area (WMA) is located in the north-eastern corner of South Africa, where it borders on Zimbabwe in the north and on Mozambique along the eastern side. It falls entirely within the Northern Province, and adjoins the Olifants and Limpopo WMAs to the south and west respectively. The Luvuvhu-Letaba WMA forms part of the Limpopo River Basin, an international river shared by South Africa, Botswana, Zimbabwe and Mozambique.

Approximately 35% of the land area of the WMA along the eastern boundary falls within the Kruger National Park. The rivers flowing through the park are of particular importance to the maintenance of ecosystems.

The confluence of the Luvuvhu and Limpopo rivers forms the common point where South Africa borders on both Zimbabwe and Mozambique. The Shingwedzi River first flows into the Rio des Elephantes (Olifants River) in Mozambique, which then joins the Limpopo River.

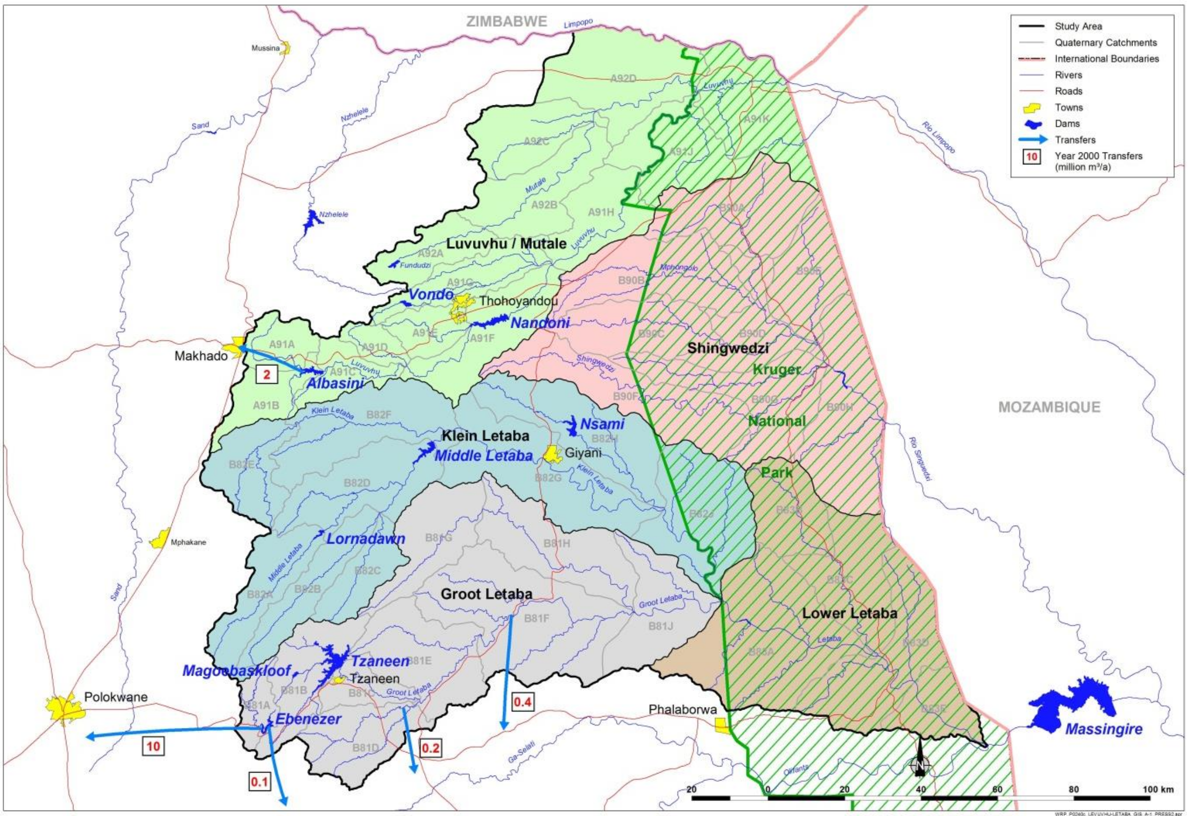

Figure 2-1: Study Area

The two main branches of the Letaba River, the Klein and Groot Letaba, have their confluence on the western boundary of the Kruger National Park. The Letaba River flows into the Olifants River just upstream of the border with Mozambique (Error! Reference source not found.).

The topography is marked by the northern extremity of the Drakensberg range and the eastern Soutpansberg, which both extend to the western parts of the water management area, and the characteristic wide expanse of the Lowveld to the east of the escarpment. Climate over the water management area is generally sub-tropical, although mostly semiarid to arid. Rainfall usually occurs in summer and is strongly influenced by the topography.

Along the western escarpment rainfall can be well over 1 000 mm per year, while in the Lowveld region in the eastern parts of the water management area rainfall decreases to less than 300 mm per year and the potential evaporation is well in excess of the rainfall. Grassland and sparse bushveld shrubbery and trees cover most of the terrain, marked by isolated giant Boabab trees.

The geology is varied and complex and consists mainly of sedimentary rocks in the north, and metamorphic and igneous rocks in the south. High quality coal deposits are found near Tsikondeni and in the northern part of the Kruger National Park. The eastern limb of the mineral rich Bushveld Igneous Complex touches on the southern parts of the WMA. With the exception of sandy aquifers in the Limpopo River valley, the formation is of relatively low water bearing capacity. A wide spectrum of soils occurs in the WMA, with sandy soils being most common.

For the purpose of this study, 66 sub-catchments have been defined in the following catchments, 38 in the Letaba, 14 in the Luvuvhu, 5 in the Mutale and 9 in the Shingwedzi main catchments. The geographical location of each of the 66 sub-catchments is presented in **Appendix A, Figure A-1**.

2.2 SUB-CATCHMENTS AND RELATED HYDROLOGY

Table 2-1 provides a summary of the hydrology sub-catchments (DWA, 2014) that the study area has been divided into for the purposes of the systems analyses. The order number that each hydrology appears in the parameter file (DWA, 2014b) is also presented in the table. It should be noted that the MAR provided in **Table 2.1** is the purely natural MAR, excluding all groundwater abstractions. Various selected catchments were modelled explicitly in the WRYM historic analyses using the recently included groundwater module. For the WRPM simulations, all catchments affected by groundwater abstractions included this effect in a reduced incremental hyrology file as obtained from the Pitman model. The groundwater abstractions were therefore already included in the "natural" inc file as used for the WRPM analyses.

Table 2-1: Summary of sub-catchments and related MAR within the study area)

Catchment name	Hydrology reference name	Catchment area(km^2)	MAR (million m^3/a)	No. in param.dat file
1. Letaba River		8214		
a. Ebenezer Dam catchment		170		
	B81ADN	14	9.53	24
	B81agw	156	66.17	25
b. Tzaneen Dam catchment		481		
	B81b10_16	124	29.43	26
	B81b30gw	89	27.67	27
	B81b20	62	33.64	28
	B81b01_a	23	4.83	29
	B81b01gw	183	38.67	30
c. Letsitele Tributary		477		
	B81D1GW	178.3	20.88	32
	B81D2GW	269	80.63	33
	B81D3	29.7	6.34	68
d. Klein Letaba		5462		
	B82AGW	467	28.2	11
	B82B	365.4	20.35	12
	B82BSFR	40.6	2.78	43
	B82C	240	13.11	13
	B82CSFR	60	4.11	44
	B82D	600	19.59	14
	B82DSFR	32	1.26	45
	B82EGW	432	11.28	15
	B82FGW	760	22.59	16
	B82GGW	921	15.21	17
	B82H	749	11.71	18
	B82J	795	14.36	19
e. Letaba downstream Tzaneen Dam		7086		

Catchment name	Hydrology reference name	Catchment area(km^2)	MAR (million m^3/a)	No. in param.dat file
	B81C	208	28.7	31
	B81E10GW	254	10.68	34
	B81E2GW	172	7.21	35
	B81E1GW	201.5	8.35	36
	B81E3	37.5	4.76	69
	B81F1	186	3.67	37
	B81F2GW	584	11.52	38
	B81G1	80.1	12	39
	B81G2GW	436.9	13.6	70
	B81HGW	664	9.68	40
	B81J10	568	9.04	41
	B81F1020GW	430	8.48	42
	B83A	1252	19.63	20
	B83BC	1031	17.42	21
	B83D	714	10.31	22
	B83E	267	4.73	23
2. Shingwedzi River		5113		
	B90A	611	7.21	58
	B90B	754	12.07	59
	B90C	535	9.03	60
	B90D	447	5.87	61
	B90E	474	5.85	62
	B90F	819	19.11	63
	B90G	698	15.46	64
	B90H1	229	4.99	65
	B90H2	546	11.84	66
3. Mutale River		1909		
	A92A1	282	90.52	67
	A92A2	47	15	46
	A92B	565	44.52	47
	A92CGW	455	4.64	48
	A92D	560	0.8	49
4. Luvuvhu River		3743		
a. Albasini Dam catchment		507		
	A91A	232	22.44	1
	A91B	275	10.77	2
b. Nandoni Dam catchment		781		
	A91C1	107	22.46	3
	A91C2	175	23.54	4
	A91EGW	223	69.43	7
	A91F1	276	30.26	8

Catchment name	Hydrology reference name	Catchment area(km^2)	MAR (million m^3/a)	No. in param.dat file
c. Latonyanda tributary		132		
	A91D1	84.7	40.82	5
	A91D2	47.3	23.56	6
d. Mutshindudi tributary		406		
	A91G1	48	49.45	10
	A91G2GW	358	79.31	54
e. Lower Luvuvhu River		1917		
	A91F2	272	13.74	9
	A91H1	450	27.26	55
	A91J	625	6.23	56
	A91K	570	3.24	57

All hydrometeorological information, including streamflow, rainfall and evaporation, is described in the separate Water Resources Yield Analyses Report (DWA, 2014b) and is therefore not repeated here.

3 SYSTEM YIELD

3.1 LONG-TERM YIELD

The historic and long-term stochastic yield for the various sub-systems were determenined as part of the yield analysis task and result were documented in the Yield Analysis Report (DWA, 2014b) produced as part of this study.

Table 3-1: Existing and possible future System yield results

Dam name	FSV (million m^3)	Yield (million m^3/a)		
		HFY)	1 in 20 year	1 in 50 year
1) Dap Naude plus Ebenezer	72.8	36.2	43.8	40.5
2) Magoebaskloof plus Vergelegen	9.9	6.4	14.7	12.9
3) Hans Merensky	1.2	1.0	2.2	1.7
4)Tzaneen raised	182.4	45	60.0	51.7
5) Tzaneen raised plus Nwamitwa	369.0	61		
6) Tzaneen raised plus Nwamitwa & EWR	369.0	49		
7) Thabina	2.6	3.1	4.1	3.7
8) Middel Letaba plus Nsami	206.1	20.6	31.0	24.3
9) Thapane	1.07	1.1	1.6	1.4
10) Modjadji	7.2	3.5	4.4	3.8
11) Makuleke	13.0	0.1		
12) Albasini	28.4	1.4	3.7	2.5

Dam name	FSV (million m^3)	Yield (million m^3/a)		
		HFY)	1 in 20 year	1 in 50 year
13) Vondo	30.6	16.8	25.0	21.9
14) Phiphidi	0.19	0.2		
15) Damani	12.9	4.8	5.7	5.3
16) Nandoni plus weirs	166.1	62	83.0	70.0
17) Tshakuma	2.47	1.4	1.8	1.5
Possible Future dams				
1) Paswane dam	90.0	43.0	64.5	55.0
2) Xikundu Dam	139.0	51.0	71.5	62.5
3) Crystalfontein Dam with EWR	96.0	5.4	-	-
4) Majosi Dam with EWR	29.0	4.6	-	-
5) Rambuda Dam	13.5	12.6	18.7	16.7
6) Tswera Dam	131	53.0	69.4	62.1
7) Thengwe Dam	116	51.0	-	-

3.2 SHORT TERM YIELD

Short-term yield-reliability characteristic curves (YRCs) are applied in the Water Resources Planning Model (WRPM) for the purpose of determining appropriate water allocations (and therefore restrictions), to be applied in the short-term, based on the priority classification of water users supplied from the system (or sub-system) in question. However, unlike the long-term yield capability of a system, its short-term yield is greatly influenced by the volume of water in storage at the beginning of the period under consideration and is it generally possible to allocate more water in situations when the system storage is high, while the opposite is true in low storage situations.

Short-term yield-reliability characteristic curves were produced for selected dams and sub-systems. For this purpose, short-term stochastic yield analyses were undertaken based on 501 5-year stochastically generated streamflow sequences and with the start month set to May. Furthermore, separate analyses were undertaken with the dam at a variety of starting storage levels corresponding with 100%, 80%, 60%, 40%, 20% and 10% of its live full supply capacity (FSC).

For each of the starting storage analyses undertaken, the results were produced for period lengths of 1, 2, 3, 4 and 5 years and the corresponding yield-reliability curves compared so that the most conservative result could be selected. In general, it is found that as the starting storage decreases, so does the likelihood increase of a failure near the start of the analysis and, therefore, that the shorter period lengths provide more conservative results.

The final short-term yield-reliability curves are shown in **Figures B-1** to **B-60** of **Appendix B** for all of the starting storage levels analysed. Plots of the firm yield lines obtained for each starting storage are presented in Error! Reference source not found. to **Figure 3-8**. A summary of the characteristics is shown in Error! Reference source not found. which also provides a comparison with the long-term yield-reliability characteristics of the system as presented in the WRYM report (DWA, 2014b).

Table 3-2: Short term characteristics

Starting storage (as % of live FSC[1])	Selected period length (years) [2]	Yield million m^3/annum at indicated RI [3]				
		1:200	1:100	1:50	1:20	1:10
Thabina Dam						
100	5	3.33	3.54	3.78	4.20	4.63
80	5	3.29	3.48	3.72	4.10	4.53
60	2	2.95	3.08	3.30	3.89	4.36
40	2	2.60	2.75	2.96	3.37	3.78
20	1	2.04	2.11	2.24	2.44	2.78
10	1	1.48	1.60	1.73	1.92	2.37
Long term yield [4]		3.2	2.4	3.7	4.1	
Thapane Dam						
100	5	1.29	1.36	1.51	1.72	2.04
80	5	1.23	1.33	1.48	1.70	2.03
60	2	1.08	1.20	1.37	1.66	1.90
40	2	0.93	1.06	1.21	1.41	1.63
20	1	0.70	0.77	0.86	0.97	1.14
10	1	0.53	0.59	0.61	0.73	0.92
Long term yield [4]		1.2	1.3	1.4	1.6	
Modjadji Dam						
100	5	3.79	4.05	4.34	4.99	5.70
80	5	3.55	3.86	4.15	4.75	5.51
60	3	3.04	3.33	3.64	4.26	5.11
40	2	2.50	2.62	2.94	3.48	4.20
20	2	1.65	1.85	2.14	2.64	3.05
10	1	1.38	1.45	1.57	1.82	1.96
Long term yield [4]		3.2	3.4	3.8	4.4	
Middel Letaba – Nsami Subsystem						
100	5	36.85	39.35	41.75	49.05	62.00
80	5	30.53	32.70	35.36	43.27	51.63
60	5	23.77	26.31	28.57	36.50	44.57
40	3	23.74	25.53	27.11	32.41	38.12
20	3	13.13	13.90	15.69	20.04	24.43
10	2	18.68	18.80	19.28	21.47	23.35
Long term yield [4]		18.6	21.5	24.3	31.0	
Vondo-Phiphidi Subsystem						
100	5	20.95	22.13	23.52	27.10	30.60
80	5	19.23	21.10	22.82	26.09	30.01
60	4	16.49	17.77	20.30	24.46	28.28

Starting storage (as % of live FSC[1])	Selected period length (years) [2]	Yield million m^3/annum at indicated RI [3]				
		1:200	1:100	1:50	1:20	1:10
40	2	13.40	14.33	16.09	19.83	22.33
20	1	8.47	9.43	10.02	10.60	11.85
10	1	3.82	3.98	4.50	4.96	5.52
Long term yield [4]		18.9	20.5	21.9	25.0	
Tshakhuma Dam – Dzingae WTW, Dzindzi WTW						
100	5	2.80	2.86	2.97	3.26	3.52
80	5	2.68	2.75	2.89	3.17	3.44
60	3	2.53	2.62	2.76	2.98	3.22
40	2	2.38	2.48	2.56	2.72	2.95
20	1	2.13	2.24	2.31	2.44	2.53
10	1	1.85	1.92	1.98	2.05	2.17
Long term yield [4]		1.20	1.30	1.50	1.80	
Damani Dam						
100	5	5.43	5.79	6.21	6.96	7.86
80	5	4.94	5.31	5.72	6.56	7.53
60	4	4.29	4.66	5.09	6.07	7.03
40	3	3.52	3.84	4.31	5.13	5.91
20	2	2.79	3.03	3.26	3.85	4.45
10	2	2.00	2.30	2.57	3.03	3.45
Long term yield [4]		4.5	4.8	5.3	5.7	
Nandoni Subsystem						
100	5	71.08	76.00	80.73	96.96	112.09
80	5	65.05	69.91	77.04	92.46	106.18
60	4	57.27	61.59	68.39	81.82	94.77
40	3	47.79	52.02	56.56	65.69	78.93
20	2	34.00	35.78	39.95	48.88	54.50
10	1	22.40	23.47	25.01	27.75	31.00
Long term yield [4]		58.0	64.0	70.0	83.0	

Note: (1) Live full supply capacity (FSC) of Dam.
(2) Selected period length, from 1 to 5 years, that provides the most conservative result.
(3) Recurrence interval of failure, in years.
(4) From a WRYM analysis of 301 85-year stochastically generated streamflow sequences.

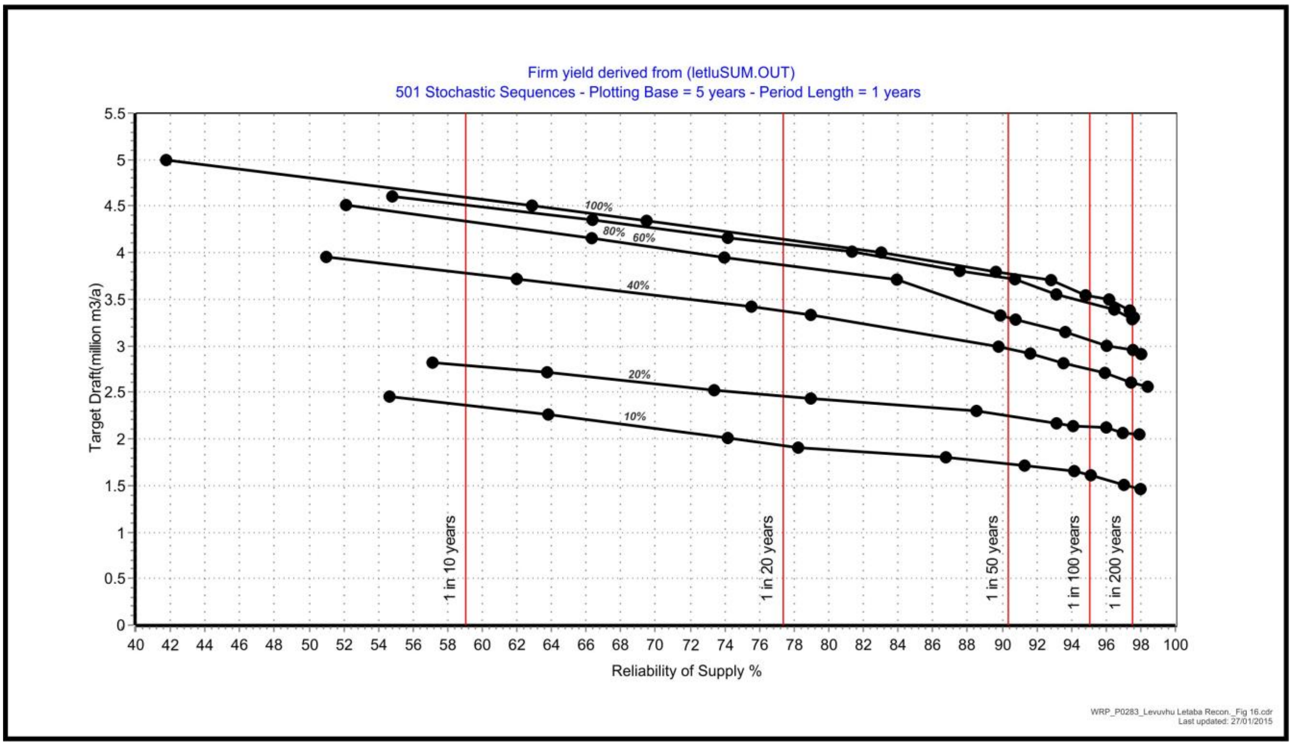

Figure 3-1: Firm yield line curve set: Thabina Dam

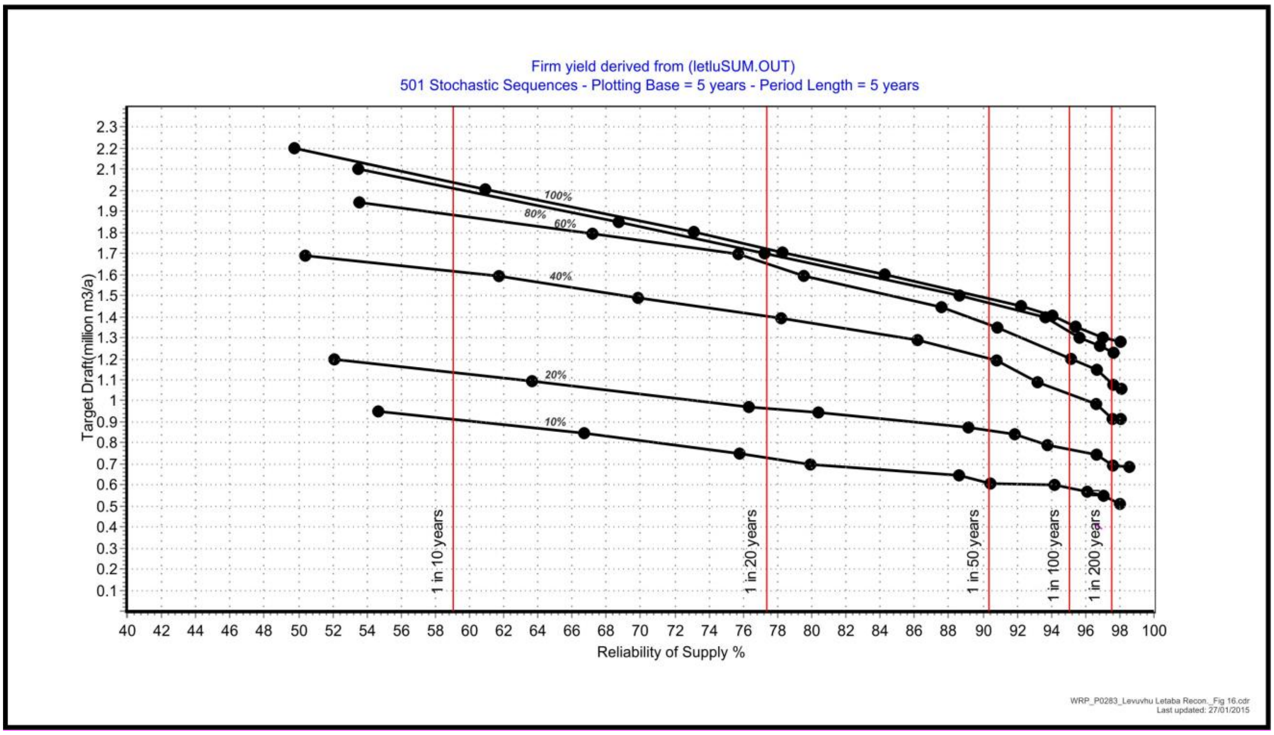

Figure 3-2: Firm yield line curve set: Thapane Dam

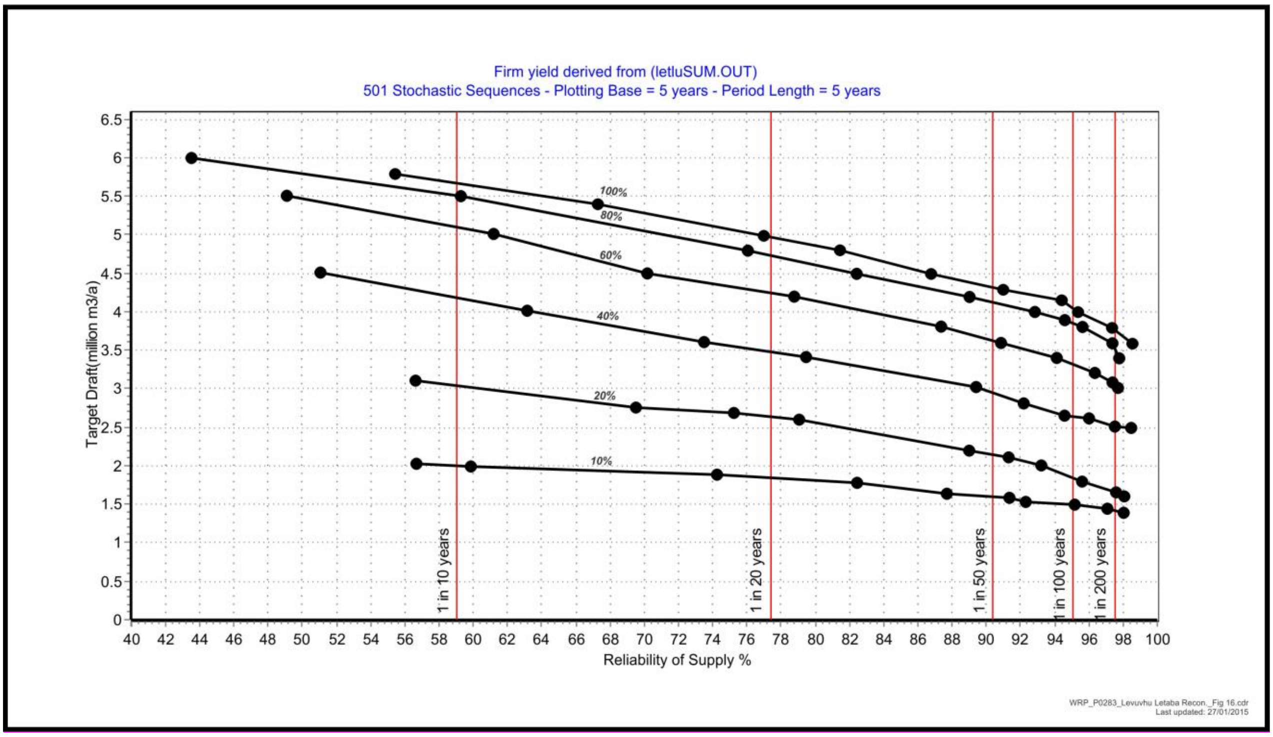

Figure 3-3: Firm yield line curve set: Modjadji Dam

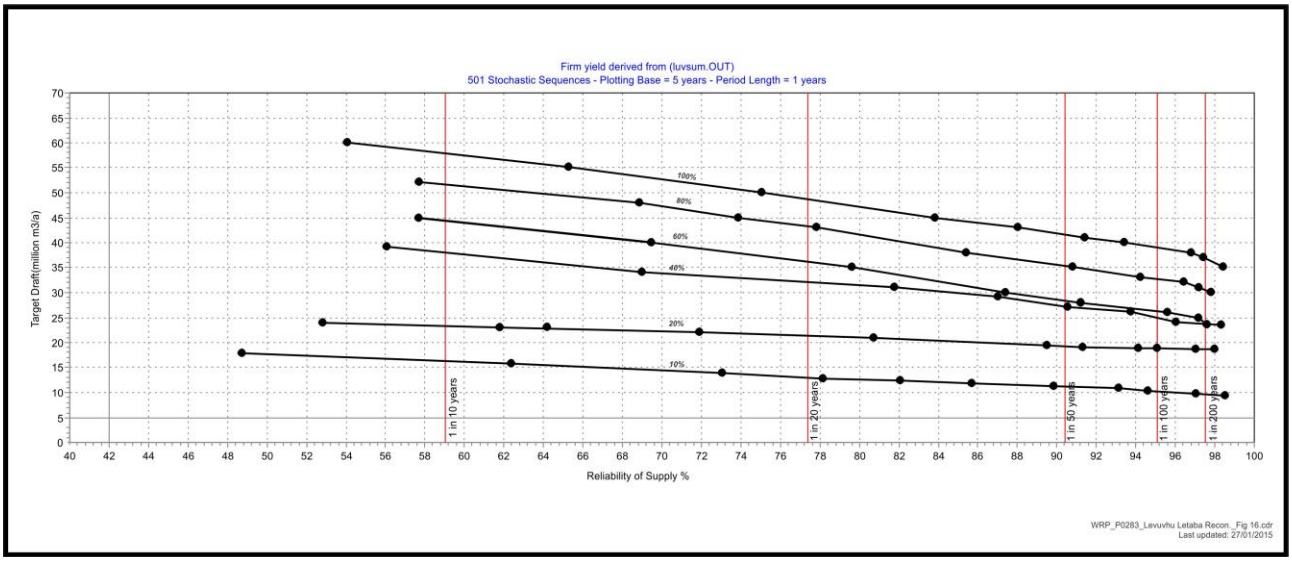

Figure 3-4: Firm yield line curve set: Middel Letaba - Nsami Subsystem

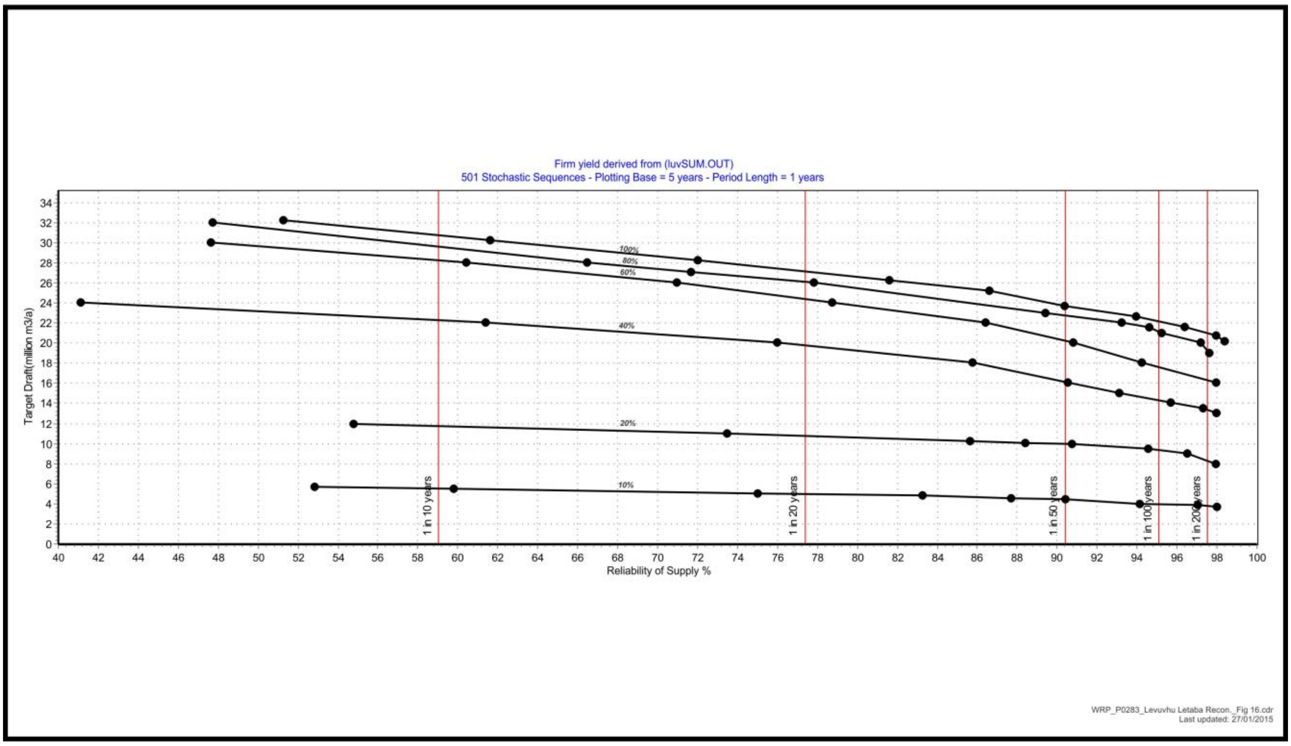

Figure 3-5: Firm yield line curve set: Vondo-Phiphidi Subsystem

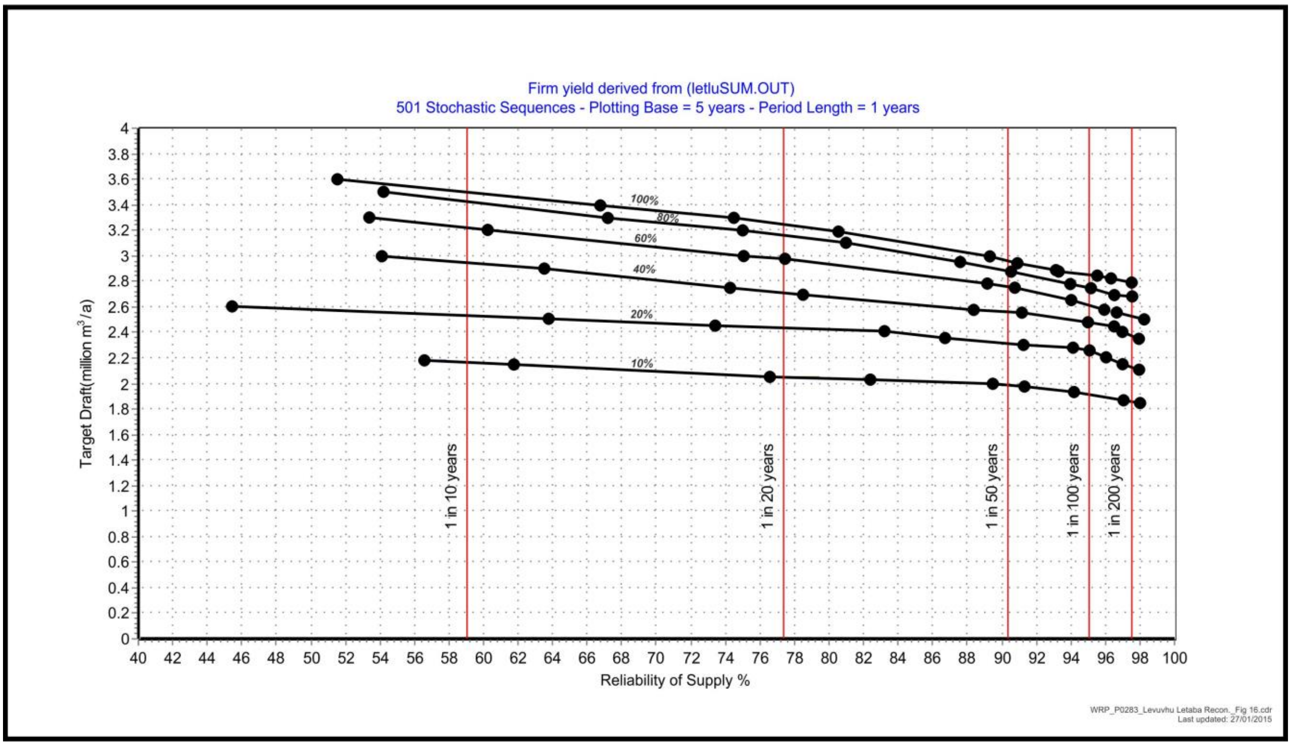

Figure 3-6: Firm yield line curve set: Tshakhuma Dam, Dzingae WTW, and Dzindzi WTW

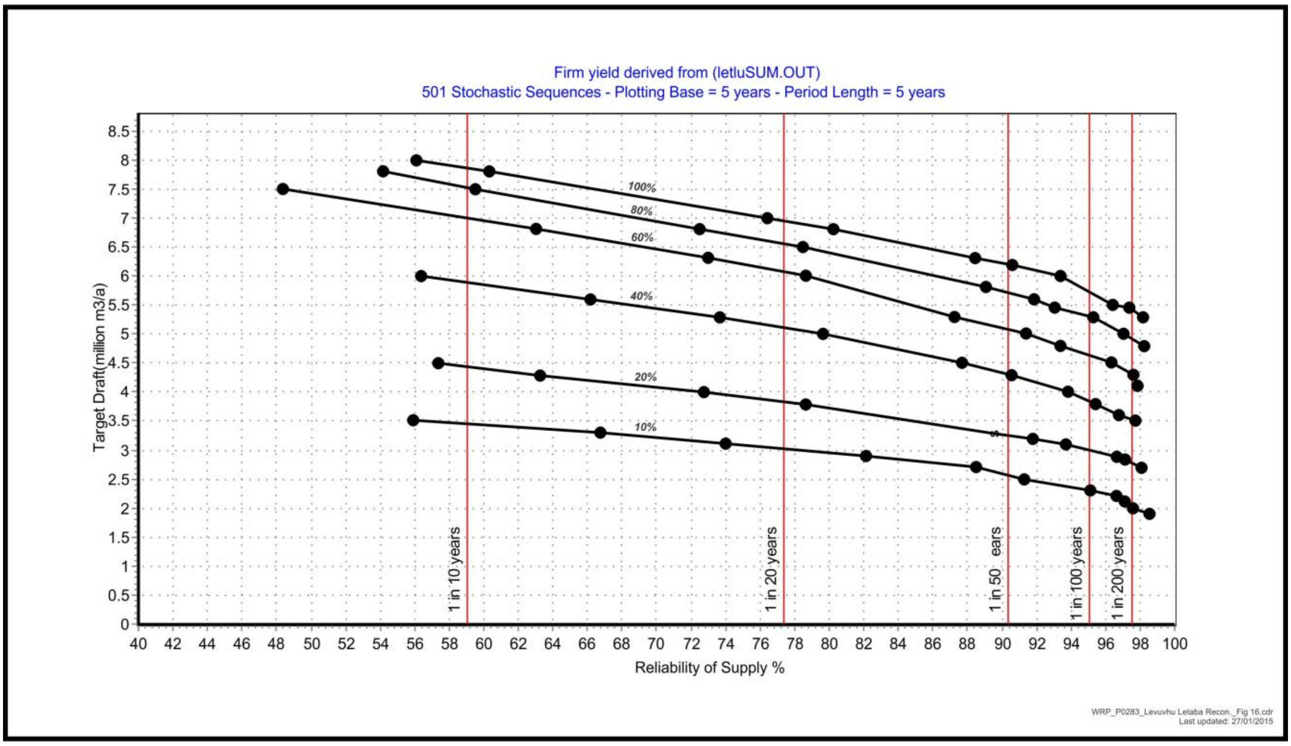

Figure 3-7: Firm yield line curve set: Damani Dam

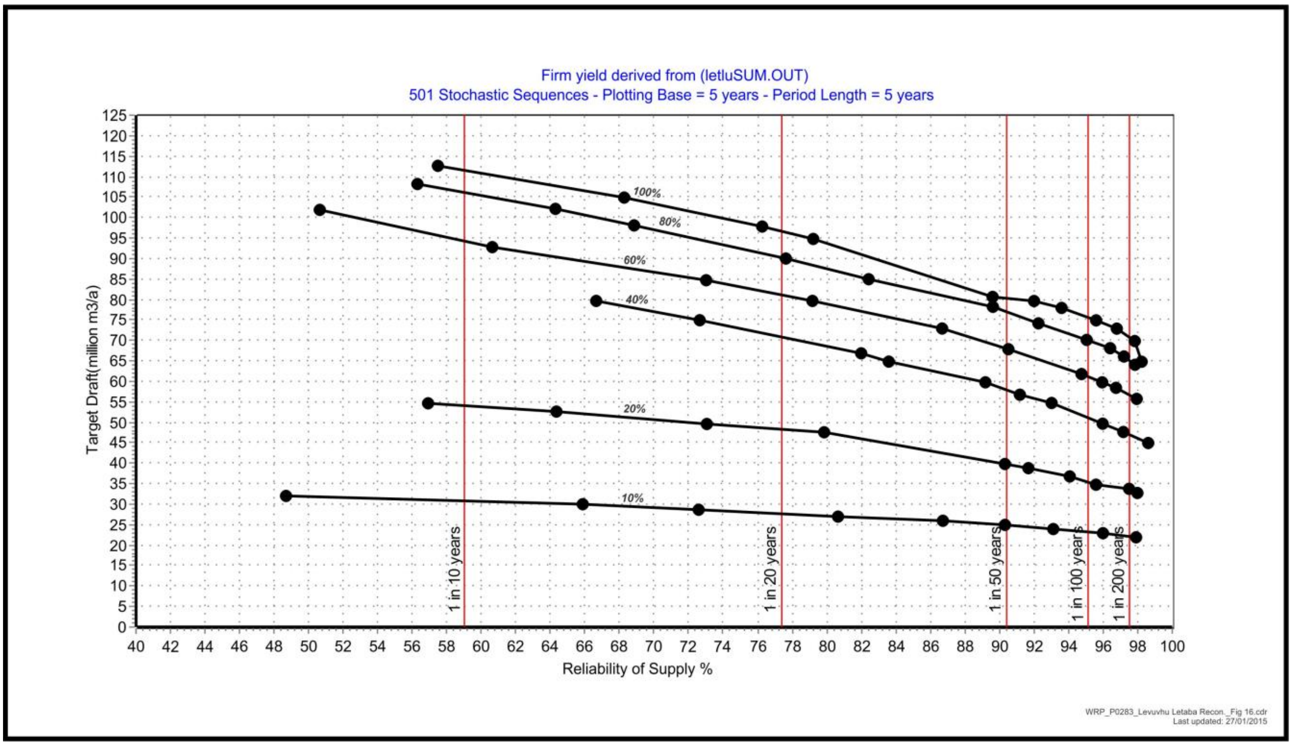

Figure 3-8: Firm yield line curve set: Nandoni Subsystem

Finally, short-term yield-reliability characteristics are incorporated into the WRPM system configuration by means of sets of coefficients, each which describes the shape of the base yield line for a particular analysed target draft in terms of a fitted fourth-order polynomial function. The WRPM uses the short term yield characteristics as a basis for the operating rule. The model tests the rule and results indicate whether or not the rule is too strict, i.e. the dams are over protected, or too lenient, i.e. the dams are insufficiently protected. The coefficients are shown in **Table C-1** of **Appendix C**.

4 WATER REQUIREMENTS

Again, the WRYM report (DWA, 2014b) already presented the information on all the present day water requirements simulated in the system. This section deals only with a summary of the main requirements from the system and their projected growths. A detailed spreadsheet was prepared (DWA, 2014d) in order to deal with the requirements, and a printout of this is presented in **Appendix D**.

Table 4.1 presents a summary of the system demand projections for the main water supply systems within the study area.

Table 4-1: Summary of system water requirement projections

Resource	WRPM channel no.	Description	WRPM TYPE	2014 Demand	2020 Demand	2025 Demand	2030 Demand	2035 Demand	2040 Demand
Luvuvhu River catchment									
Vondo & Phiphidi dams, Dzingae & Dzindzi package plants	877	Greater Thohoyandou surface water	Master Control	20.31	26.40	32.05	34.26	36.52	38.94
Tshakhuma Dam	1132	Tshakhuma Dam urban	Master Control	1.60	1.90	2.16	2.36	2.56	2.77
Damani Dam	1198	Damani RWS	Master Control	3.18	5.31	7.25	7.77	8.30	8.86
Nandoni Dam & Xikundu Weir	1105	Xikundu	Master Control	4.59	6.74	8.68	9.37	10.08	10.83
Nandoni Dam & Mhinga Weir	1106	Mhinga	Master Control	0.73	0.73	0.73	0.73	0.73	0.73
Nandoni Dam & Malamule Weir	1107	Malamule	Master Control	4.73	6.69	8.47	9.05	9.64	10.27
Nandoni Dam	889	Support to Giyani	Master Control	0.00	5.00	5.00	5.00	5.00	5.00
Nandoni Dam	874	Sinthumele Surface water	Master Control	0.00	1.30	3.88	3.88	3.88	3.88
Nandoni Dam	875	Air force Surface water	Master Control	0.30	0.30	0.30	0.30	0.30	0.30
Nandoni Dam	803	Valdezia RWS	Master Control	0.00	0.10	0.15	0.19	0.23	0.27
Albasini Dam	1161	Makhado from Albasini	Master Control	1.00	1.00	1.00	1.00	1.00	1.00
Nandoni Dam	893	Makhado from Nandoni	Master Control	1.62	1.96	2.24	2.42	2.60	2.79
Nandoni Dam	894	Levubu CBD WS	Master Control	0.05	0.07	0.09	0.11	0.13	0.15
Nandoni Dam	898	Support to Middle Letaba RWSs	Master Control	0.00	2.33	6.87	7.07	7.29	7.51
Nandoni Dam	899	Support Matoks area	Master Control	3.29	4.98	6.54	7.11	7.69	8.30

Luvuvhu total Urban/industrial and Rural domestic Requirements				**41.39**	**64.81**	**85.42**	**90.62**	**95.95**	**101.61**
Vondo Dam	1098	Vondo Irrigation	Master Control	0.00	2.80	2.80	2.80	2.80	2.80
Damani Dam	896	Damani Irrigation	Master Control	0.00	3.96	3.96	3.96	3.96	3.96
Albasini Dam	1088	Albasini Irrigation Surface Water Irrigation	Irrigation Block	4.88	4.88	4.88	4.88	4.88	4.88
Levubu weir	1086	Albasini Irrigation Surface Water Irrigation	Irrigation Block	2.70	2.70	2.70	2.70	2.70	2.70
Latonyanda canal	1046	Latonyanda canal	Irrigation Block	2.54	2.54	2.54	2.54	2.54	2.54
Latonyanda canal	1080	Latonyanda canal	Irrigation Block	2.54	2.54	2.54	2.54	2.54	2.54
Barotta canal	1044	Barotta canal	Irrigation Block	1.03	1.03	1.03	1.03	1.03	1.03
Luvuvhu total Irrigation Requirements				**13.68**	**20.44**	**20.44**	**20.44**	**20.44**	**20.44**
Luvuvhu total Requirements				**55.08**	**85.25**	**105.86**	**111.06**	**116.39**	**122.05**
Mutale River Catchment									
Mutale River	1005	Mutale Town	Master Control	1.50	2.18	2.55	2.80	3.06	3.30
Mutale River	1039	Mutale Mukuya RWS	Master Control	0.18	0.26	0.30	0.34	0.37	0.41
Mutale & Mbodi River	1041	Luphephe / Nwanedzi Main RWS	Master Control	0.00	0.35	0.53	0.64	0.76	0.88
Mutale River	1048	Masisi RWS & Mining	Master Control	0.49	0.64	0.72	0.78	0.83	0.89
Mutale total Urban/industrial and Rural domestic Requirements				**2.17**	**3.43**	**4.11**	**4.56**	**5.02**	**5.47**
Tshirovha River	1036	Mukumbani Tea Estates	Master Control	3.30	3.30	3.30	3.30	3.30	3.30
Mutale River	1035	Tshiombo Irrigation scheme	Master Control	2.70	2.70	2.70	2.70	2.70	2.70
Mutale total Irrigation Requirements				**6.00**	**6.00**	**6.00**	**6.00**	**6.00**	**6.00**
Mutale total requirements				**8.17**	**9.43**	**10.11**	**10.56**	**11.02**	**11.47**
Middle Letaba River									

catchment									
Middle Letaba Dam (Middle Letaba WTW)	615	Babangu, Bolebedu, Magoro, Majosi, Vyeboom, Elim Vleifontein Waterval	Master Control	6.04	8.81	8.76	10.37	12.03	12.97
Middle Letaba Dam (Mapuve WTW)	871	Mapuve, Middle Letaba Malamulele West	Master Control	0.71	1.12	1.49	1.61	1.74	1.87
Middle Letaba & Nsami dam (Giyani WTW)	887	Giyani system	Master Control	13.87	13.99	18.65	20.70	22.80	25.03
Middle Letaba & Nsami dam	872	Middle Letaba canal losses	Master Control	4.00	4.00	4.00	4.00	4.00	4.00
Middle Letaba total Urban/industrial and Rural domestic Requirements and losses				**24.63**	**27.92**	**32.89**	**36.68**	**40.56**	**43.86**
Middle Letaba & Nsami dam (irrigation)	618	Irrigation from Middle Letaba main canal	Master Control	0.63	0.63	0.63	0.63	0.63	0.63
Middle Letaba total requirements				**25.26**	**28.56**	**33.53**	**37.32**	**41.20**	**44.50**
Groot Letaba River catchment									
Dap Naude Dam	202	Polokwane abstraction from Dap Naude	Master Control	4.00	4.00	4.00	4.00	4.00	4.00
Vergelegen Dam	167	Politsi, Duiwelskloof, Gakgapane	Master Control	2.34	2.62	2.86	3.10	3.35	3.61
Ebenezer Dam	220	Polokwane abstraction from Ebenezer	Min Max	16.17	16.17	16.17	16.17	16.17	16.17
Ebenezer Dam	66	Tzaneen Town	Min Max	2.38	2.58	2.74	2.89	3.04	3.20
Tzaneen dam	68	Tzaneen Town	Min Max	1.28	1.28	1.28	1.28	1.28	1.28
Tzaneen Dam	543 / 995	Ritavi / Letaba RWS	Min Max	2.88	3.46	3.98	4.30	4.64	4.99
Tzaneen & Nwamitwa dams	69	Ritavi II RWS excl Nkowankowa	Min Max	11.32	14.56	17.54	18.95	20.40	21.96
Tzaneen & Nwamitwa dams	686 / 996	Siluwane - Nondweni Extended RWS	Min Max	0.27	0.40	0.52	0.56	0.60	0.65
Tzaneen & Nwamitwa dams	885	Support to Tapane RWS	Min Max	0.00	0.38	0.69	0.91	1.14	1.38
Tzaneen & Nwamitwa dams	884	Support to Thabina RWS	Min Max	0.00	1.97	3.74	4.41	5.08	5.80
Tzaneen Dam	674	Industrial	Min Max	4.08	4.08	4.08	4.08	4.08	4.08
Thabina Dam	67	Thabina RWS Total (SW)	Master Control	4.33	4.30	4.30	4.30	4.30	4.30

Thapane Dam	901	Thapane RWS Total (SW)	Master Control	1.54	1.53	1.53	1.53	1.53	1.53
Support from Middle Letaba	886	Mojadji RWS	Master Control	0.00	0.00	0.94	1.33	1.73	2.16
Modjadji Dam	544	Mojadji RWS	Master Control	3.02	4.04	3.72	3.64	3.56	3.47
Groot Letaba total Urban/industrial and Rural domestic Requirements				**53.62**	**61.37**	**68.10**	**71.46**	**74.91**	**78.58**
Magoebaskloof Dam	900	Tea Plantation (growth uncertain)	Master Control	0.00	5.00	9.10	9.10	9.10	9.10
Magoebaskloof Dam	39	Politsi tea plantation scheme	Irrigation Block	3.20	3.20	3.20	3.20	3.20	3.20
Hans Merensky Dam	45	Westfalia Estates & other irrigators	Irrigation Block	4.51	4.51	4.51	4.51	4.51	4.51
Ebenezer Dam	189	Georges Valley Canal Irrigation supply	Irrigation block	0.50	0.50	0.50	0.50	0.50	0.50
Ebenezer Dam	187	Georges Valley Canal Irrigation supply	Irrigation block	0.42	0.42	0.42	0.42	0.42	0.42
Ebenezer Dam	185	Georges Valley Canal Irrigation supply	Irrigation block	1.40	1.40	1.40	1.40	1.40	1.40
Ebenezer Dam	183	Georges Valley Canal Irrigation supply	Irrigation block	0.22	0.22	0.22	0.22	0.22	0.22
Ebenezer Dam	195	Pusela Canal irrigation supply	Irrigation block	2.08	2.08	2.08	2.08	2.08	2.08
Ebenezer Dam	197	Pusela Canal irrigation supply	Irrigation block	4.19	4.19	4.19	4.19	4.19	4.19
Ebenezer Dam	199	Pusela Canal irrigation supply	Irrigation block	0.36	0.36	0.36	0.36	0.36	0.36
Ebenezer Dam	193	Pusela Canal irrigation supply	Irrigation block	0.37	0.37	0.37	0.37	0.37	0.37
Ebenezer Dam	191	Ebenezer M/S Scheme	Irrigation block	0.72	0.72	0.72	0.72	0.72	0.72
Tzaneen Dam	346	Irrigation directly from Tzaneen Dam	Irrigation block	0.92	0.92	0.92	0.92	0.92	0.92
Tzaneen Dam	104	Irrigation from River d/s of Tzaneen Dam	Irrigation block	2.84	2.84	2.84	2.84	2.84	2.84
Tzaneen Dam	79	Irrigation from River d/s of Tzaneen Dam	Irrigation block	2.10	2.10	2.10	2.10	2.10	2.10

Tzaneen Dam	71	Irrigation from River via Noord canal d/s of Tzaneen Dam	Irrigation block	4.36	4.36	4.36	4.36	4.36	4.36
Tzaneen Dam	160	Irrigation from River via Noord canal d/s of Tzaneen Dam	Irrigation block	2.78	2.78	2.78	2.78	2.78	2.78
Tzaneen Dam	81	Irrigation from River via Noord canal d/s of Tzaneen Dam	Irrigation block	12.32	12.32	12.32	12.32	12.3 2	12.32
Tzaneen Dam	517	Irrigation from River via Noord canal d/s of Tzaneen Dam	Irrigation block	9.34	9.34	9.34	9.34	9.34	9.34
Tzaneen Dam	85	Irrigation from River via N&N canal d/s of Tzaneen Dam	Irrigation block	3.42	3.42	3.42	3.42	3.42	3.42
Tzaneen Dam	519	Irrigation from River via N&N canal d/s of Tzaneen Dam	Irrigation block	9.61	9.61	9.61	9.61	9.61	9.61
Tzaneen Dam	83	Irrigation from River d/s of Tzaneen Dam	Irrigation block	0.74	0.74	0.74	0.74	0.74	0.74
Tzaneen Dam	344	Irrigation from River d/s of Tzaneen Dam	Irrigation block	0.34	0.34	0.34	0.34	0.34	0.34
Tzaneen Dam	375	Irrigation from River d/s of Tzaneen Dam	Irrigation block	2.22	2.22	2.22	2.22	2.22	2.22
Tzaneen & Nwamitwa dams	379	Irrigation from River at Nwamitwa Dam	Irrigation block	2.22	2.22	2.22	2.22	2.22	2.22
Tzaneen & Nwamitwa dams	405	Irrigation from River d/s Nwamitwa Dam	Irrigation block	4.75	4.75	4.75	4.75	4.75	4.75
Tzaneen & Nwamitwa dams	403	Irrigation from River d/s Nwamitwa Dam	Irrigation block	3.09	3.09	3.09	3.09	3.09	3.09
Tzaneen & Nwamitwa dams	545	Irrigation from River d/s Nwamitwa Dam	Irrigation block	2.23	2.23	2.23	2.23	2.23	2.23
Tzaneen & Nwamitwa dams	411	Irrigation from River d/s Nwamitwa Dam	Irrigation block	2.18	2.18	2.18	2.18	2.18	2.18
Tzaneen & Nwamitwa dams	902	Irrigation from River d/s Nwamitwa Dam	Master Control	31.33	31.33	31.33	31.33	31.3 3	31.33
Tzaneen & Nwamitwa dams	425	Irrigation from River d/s Nwamitwa Dam	Irrigation block	0.47	0.47	0.47	0.47	0.47	0.47
Tzaneen & Nwamitwa dams	427	Irrigation from River d/s Nwamitwa Dam	Irrigation block	0.47	0.47	0.47	0.47	0.47	0.47
Tzaneen & Nwamitwa dams	431	Irrigation from River at Nondweni Weir	Irrigation block	3.27	3.27	3.27	3.27	3.27	3.27
Tzaneen & Nwamitwa dams	433	Irrigation from River d/s Nondweni Weir	Irrigation block	0.47	0.47	0.47	0.47	0.47	0.47

Tzaneen & Nwamitwa dams	435	Irrigation from River d/s Nondweni Weir	Irrigation block	2.57	2.57	2.57	2.57	2.57	2.57
Groot Letaba total Irrigation Requirements				**122.00**	**127.00**	**131.10**	**131.10**	**131.10**	**131.10**
Groot Letaba total Water Requirements				**175.62**	**188.37**	**199.20**	**202.56**	**206.01**	**209.68**
Total study area urban/industrial and rural domestic requirements				**121.81**	**157.53**	**190.52**	**203.33**	**216.44**	**229.51**
Total study area irrigation requirements				**142.32**	**154.08**	**158.18**	**158.18**	**158.18**	**158.18**
Total Sudy area requirements				**264.13**	**311.61**	**348.70**	**361.50**	**374.62**	**387.69**

5 CONFIGURATION OF THE WRPM

The planning analysis of the study area was undertaken using the Water Resources Planning Model (WRPM). The WRYM network was used as a basis for the WRPM, with slight adjustments included to switch the model to planning and projection mode. System schematic diagrams of the WRPM configuration of the study area are presented in **Figures E-1** to **E-4** of **Appendix E**. The yield model outputs in the form of the updated short term yield reliability curves were included into the WRPM where applicable.

5.1 OVERVIEW OF THE WRPM

The WRPM is similar to the WRYM, but uses short term yield reliability relationships of sub-systems to determine for a specific planning horizon what the likely water supply volumes will be, given starting storages, operating rules, user allocation and curtailment rules. The model is used for operational and future planning of reservoirs and inter-dependant systems, and provides insight into infrastructure scheduling, probable curtailment interventions and salt blending options.

A unique feature of the analysis methodology is the capability of the WRPM to simulate drought curtailments for water users with different risk requirements (profiles) receiving water from the same resource. This methodology makes it possible to evaluate and implement adaptive operating rules (transfer rules and drought curtailments) that can accommodate changing water requirements (growth in water use) as well as future changes in infrastructure (new transfers, dams and/or dam raisings) in a single simulation model. By combining these simulation features in one model gives the WRPM the ability to undertake risk based projection analysis for **operation** and **development** planning of water resource systems. The WRPM therefore simulates all the interdependencies of the aforementioned variables and allow management decisions (operational and/or developmental) to be informed by results where all these factors are properly taken into consideration.

5.2 WRPM SETTINGS

Run control settings in the WRPM are used to define general information on how the system will be analysed for a particular model run. For the planning analysis of the study area, this includes, most importantly, the following:

- For the projection run, 501 sequences were analysed.
- A 26 year projection run was carried out, starting in May 2014.
- The major dams were set to start the analysis at their actual observed levels on 1 May 2014.
- Demands were set to grow according to their projections till the year 2040
- The priority classifications presented in **Table 5.1** were used for the various types of users included in the system.

The priority classification was selected to be aligned with the water balances that were prepared based on the long-term stochastic yield results. For the purpose of the water balances the domestic water use was supplied at a 98% assurance (recurrence interval 1 in 50 years) and irrigation was supplied at 90% assurance (recurrence interval of 1 in 10 years).

Table 5-1: Priority Classification used in the WRPM analysis

User category	Priority Classification			
	High (99.5% assurance) 1 in 200 year	**Medium High (99% assurance) 1 in 100 year**	**Medium Low (98% assurance) 1 in 50 year**	**Low (90% assurance) 1 in 10 year**
Irrigation	00	0	0	100
Urban	0	0	100	0
Losses	100	0	0	0

5.3 SUB-SYSTEMS, OPERATIING AND RESTRICTION RULES

A decision was made to either simulate the dams and subsystems using the short term curve restriction rules or the existing operating rules used in practice, depending on the existence of such rules. For the purpose of the WRPM analyses, the following types of rules were applied for the indicated sub-systems:

- <u>Existing operating and restriction rules used:</u>
    - Dap Naude Dam
    - Ebenezer Dam
    - Tzaneen Dam
    - Albasini Dam
- <u>Stand-alone systems operated using short term curve</u>:
    - Thapane Dam
    - Modjadji Dam
    - Thabina Dam
    - Middel Letaba – Nsami sub-system
- <u>Complex system made up of various sub-systems using short term curve</u>:
    - Damani Dam
    - Tshakhuma Dam and WTWs
    - Vondo and Phiphidi Dams
    - Nandoni Dam and downstream weirs

5.3.1 Existing Operating Rules

No upstream dam supports a downstream dam, except in the following cases:

- Ebenezer Dam was set to support Tzaneen Dam when Tzaneen Dam reached 15% operating level.

- Dap Naude has a court order release schedule, which is currently not implemented. The required releases are that 0.028 m^3/s be released from the dam in the months from November to July, and that all inflows to the dam be released in August, September and October.
- Tzaneen Dam will start to support Nwamitwa Dam when Nwamitwa reaches 5% or lower levels.

5.3.2 Existing Restriction Rules

A complex restriction rule applies to users obtaining water from Ebenezer and Tzaneen Dams. The rules are as follows:

- **Tzaneen Dam urban users:** The existing rule for urban users is that they are allowed their full allocation until Tzaneen Dam reaches a 15% storage level, at which time they are restricted to 70% of their allocation. When testing this rule, it was shown to be too strict, and the dam was not fully utilized when the rule was implemented. The 15% level was dropped to 5%, and in so doing, the dam was utilized better.
- **Tzaneen Dam irrigators:** Irrigators from Tzaneen Dam only obtain their full allocation when the dam is above 98.3%. The irrigators are cut to 50% of their allocation when the dam is below 95%, and are cut to zero when the dam reaches 15%. The irrigators are allocated 60% of their allocation between 95% and 96.7% dam levels and 70% of their allocation between 96.7% and 98.3% dam levels. When testing this rule, it was shown to be too strict, and the dam was not fully utilized when the rule was implemented. The zero allocation at 15% level was dropped to 5%, and in so doing, the dam was utilized better.
- **Ebenezer Dam urban users:** The existing rule for urban users is that they are allowed their full allocation until Ebenezer Dam reaches a 20% storage level, at which time they are restricted to 70% of their allocation.
- **Ebenezer Dam irrigations:** The Ebenezer irrigators are restricted based on the same restrictions and storage levels of Tzaneen Dam, however additionally, they are restricted to 0% of their allocation when Ebenezer Dam reaches the 20% operating level.
- **Users from proposed Nwamitwa Dam:** The irrigators and urban users that fall downstream of Nwamitwa Dam were still restricted based on the rule of Tzaneen Dam.

6 WRPM RESULTS

6.1 GROOT LETABA RIVER SYSTEM AND SUB-SYSTEMS

The Groot Letaba system comprise of the:

- Groot Letaba Main system that includes the large storage dams, Ebenezer, Tzaneen Dam and the future Nwamitwa Dam
- Several smaller sub-systems which are operated as stand-alone systems such as:
    - Thapane Dam
    - Thabina Dam
    - Modjadji Dam
    - Magoebaskloof & Vergelegen dams
    - Hans Merensky Dam

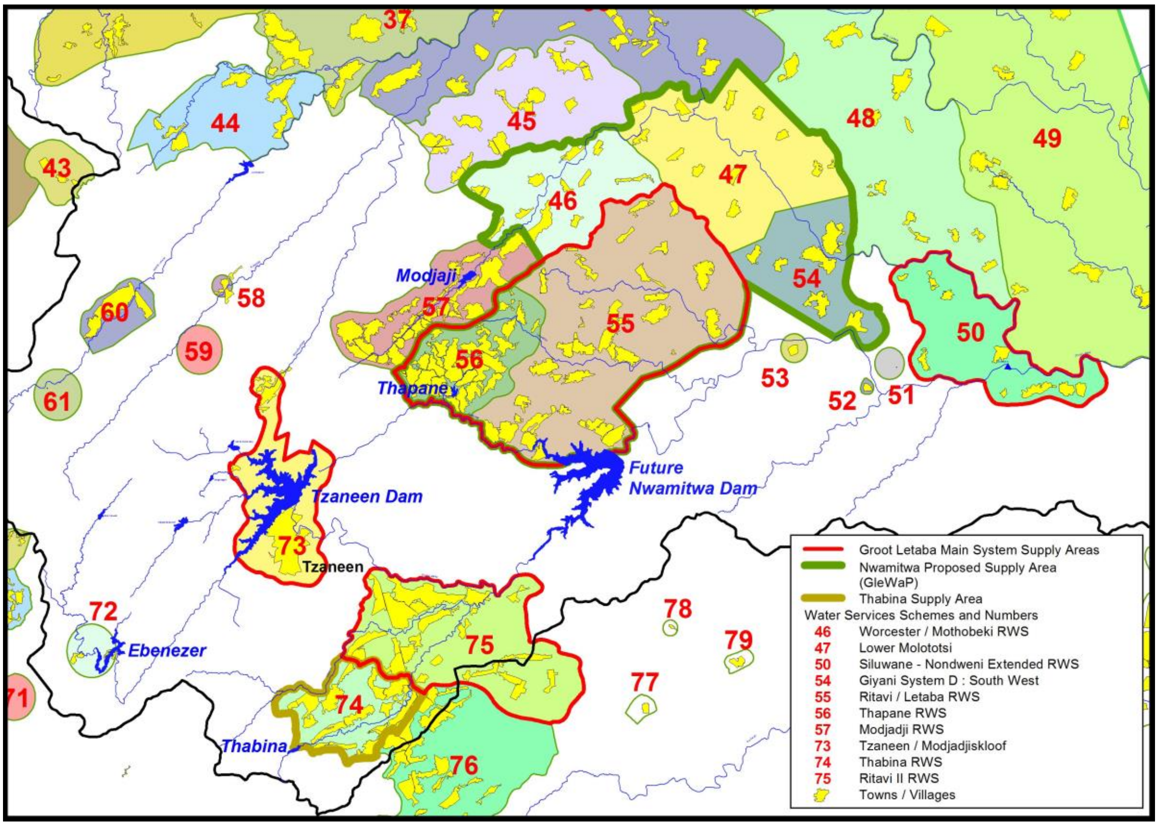

Figure 6-1: Groot Letaba water supply area

Details and results for the Groot Letaba Main System will be discussed in **Section 6.1.1** and for the stand alone small systems in **Section 6.1.2**.

6.1.1 Groot Letaba Main System

The Groot Letaba main system comprising of Dap Naudé, Ebenezer, Tzaneen and the future Nwamitwa Dam was analysed based on the operating rules as described in **Sections 5.3.1 & 5.3.2**.

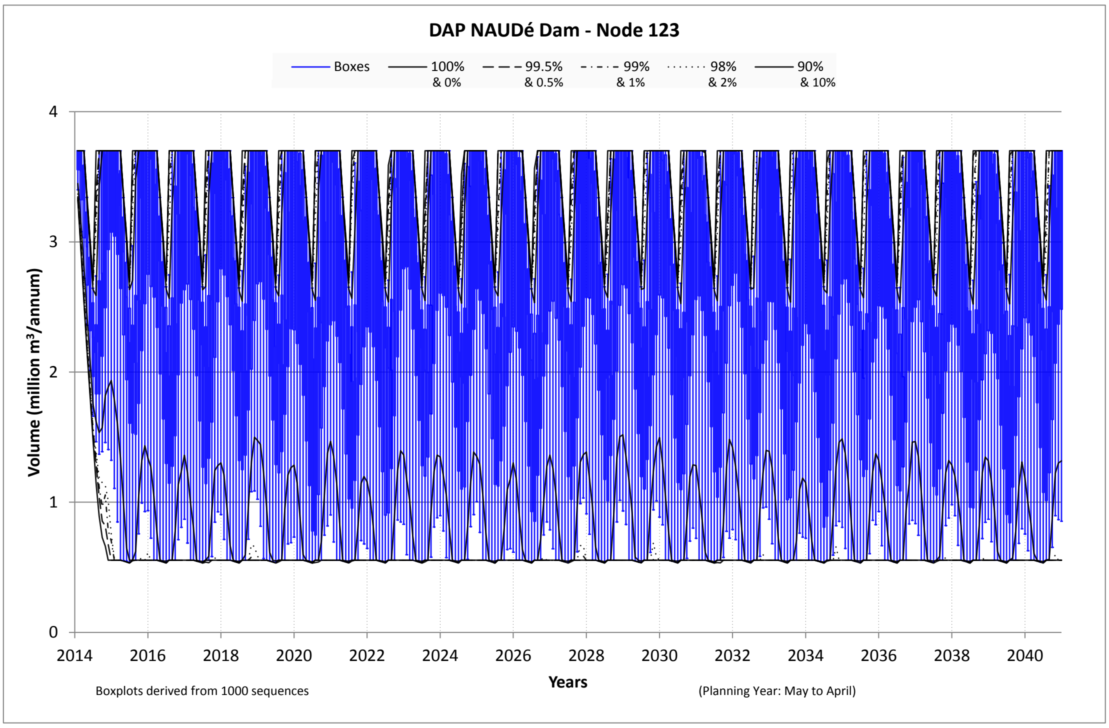

Figure 6-2: Dap Naudé Dam storage projection

Both Dap Naudé and Ebenezer dams are used to supply part of the Polokwane water requirement. Dap Naudé is not used to support Ebenezer except for the court order releases. Polokwane draw on average about 4 million m^3/a from Dap Naudé Dam while the 98% assurance (1 in 50 year) yield available from the dam is only 2.7 million m^3/a. This is the reason why Dap Naudé Dam is failing quite often. This is however not a concern as Ebenezer Dam is supplying the bulk of the 20.16 million m^3/a support to Polokwane and will ensure that the combined transfer will be at an acceptable reliability. This rule enable Polokwane to obtain the maximum possible supply from Dap Naudé Dam.

Releases from Ebenezer Dam in support of Tzaneen Dam and from Tzaneen Dam in support of the future Nwamitwa Dam only take place once Tzaneen and Nwamitwa dams are at very low storage levels of 15% and 5% respectively. Due to this rule it is clearly evident from **Figure 6.3** that Ebenezer Dam is for most of the time fairly full as it is the last resource of water for the Greater Letaba Main Water Supply System. The total system is overloaded as can be seen from the 99.5%, 99% and 98% exceedance probability levels, showing failures when severe droughts are experienced.

The intervention options that were recommended (DWA, 2014c) to improve the water supply situation within this system are:

- Water conservation and Water demand management saving 0.8 million m^3/a in urban sector (to be in place by 2015).
- Irrigation restriction policy to reduce the average irrigation water use. This is an existing policy which was developed by the irrigation users to be able to protect the resources. This option reduces the average irrigation water use to approximately 38% below the allocation.
- The raising of Tzaneen Dam by 2017 resulting in an increased assurance of supply and a yield increase of 1 million m^3/a.
- Construction and implementation of Nwamitwa Dam by 2019 adding 5.5 million m^3/a to the high assurance yield and 0.7 million m^3/a to the low assurance yield.

- Additional groundwater development, increasing the system yield by at least 2.5 million m^3/a by 2018.
- To be able to protect the environment, the classification study agreed EWR need to be implemented once Nwamitwa Dam is in place (2020)

Nwamitwa Dam started to store water in 2019 and due to the significant demand load on the Groot Letaba Main System, Nwamitwa Dam struggles to fill initially, and only reach a balanced state from about 2024 onwards (See **Figure 6.9**).

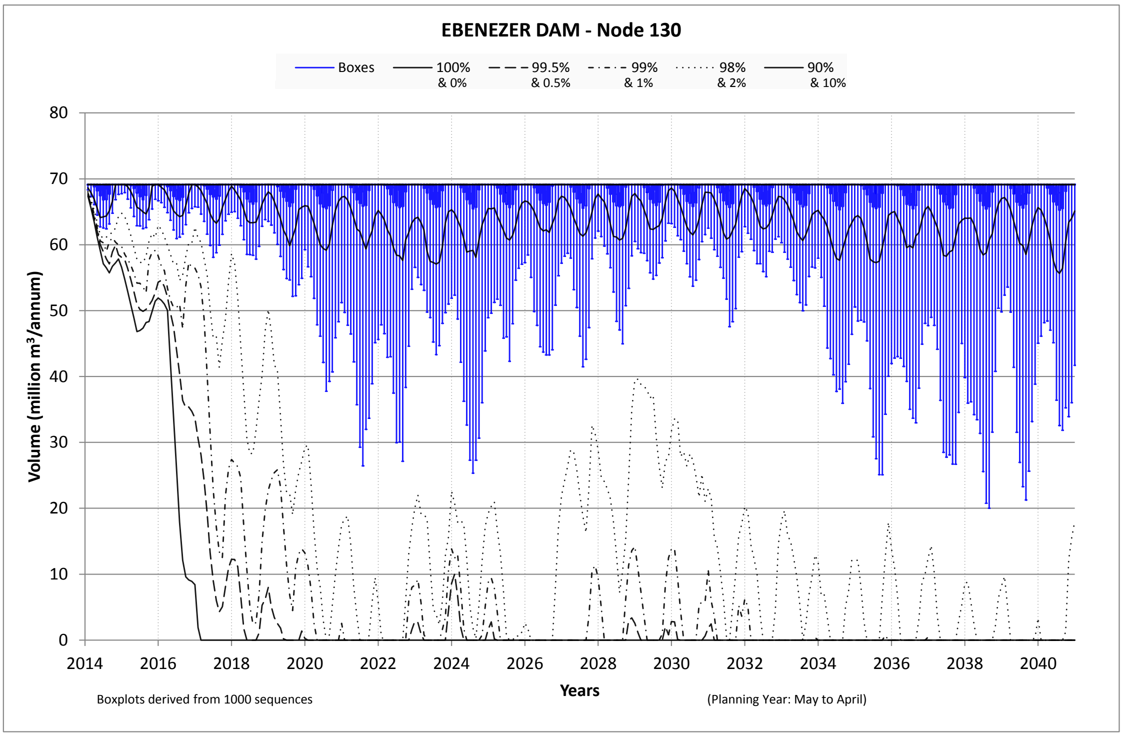

Figure 6-3: Ebenezer Dam storage projection

Once Nwamitwa Dam storage stabalised from 2024 onwards, the positive impact of Nwamitwa Dam on the entire system is clearly evident in the increased storage levels in both Ebenezer and Tzaneen dams.

The combined water supply from Ebenezer and Dap Naudé dams (**Figure 6.4**) shows that 83% of the total transfer volume is supplied at a 98% (1 in 50 year) assurance or higher. The supply from Ebenezer to Tzaneen Town (**Figure 6.5**) is slightly better than the supply to Polokwane as the poor supply from Dap Naudé dam is not impacting on the system downstream of Ebenezer Dam. From 2033 onwards the assurance of supply is decreasing again which is fairly in line with the water balances prepared from the WRYM analysis, using 98% (1 in 50 year) yield for urban/industrial and rural domestic water supply purposes.

The Tzaneen Dam storage projection plot (**Figure 6.6**) clearly shows the impact on the storage due to the raising of Tzaneen Dam in 2017, followed by a recovery in the storage also as result of the inclusion of Nwamitwa Dam, which evident from 2024 onwards. The supply from Tzaneen Dam to Tzaneen Town is very similar to the water supply received from Ebenezer Dam as it still forms part of the larger Groot Letaba main water supply system. In general 85% of the Tzaneen Demand is supplied at an assurance of 98% (1 in 50 year). Similar to the supply from Ebenezer the assurance of supply is starting to decrease again from 2033 onwards. Over the entire analysis period at least 40% of the total demand could be supplied at a very high assurance 99.5% (1 in 200 year) which is fairly acceptable. The supply from Tzaneen Dam to Ritavi 2 is very similar but also include growth in the demand over the analysis period.

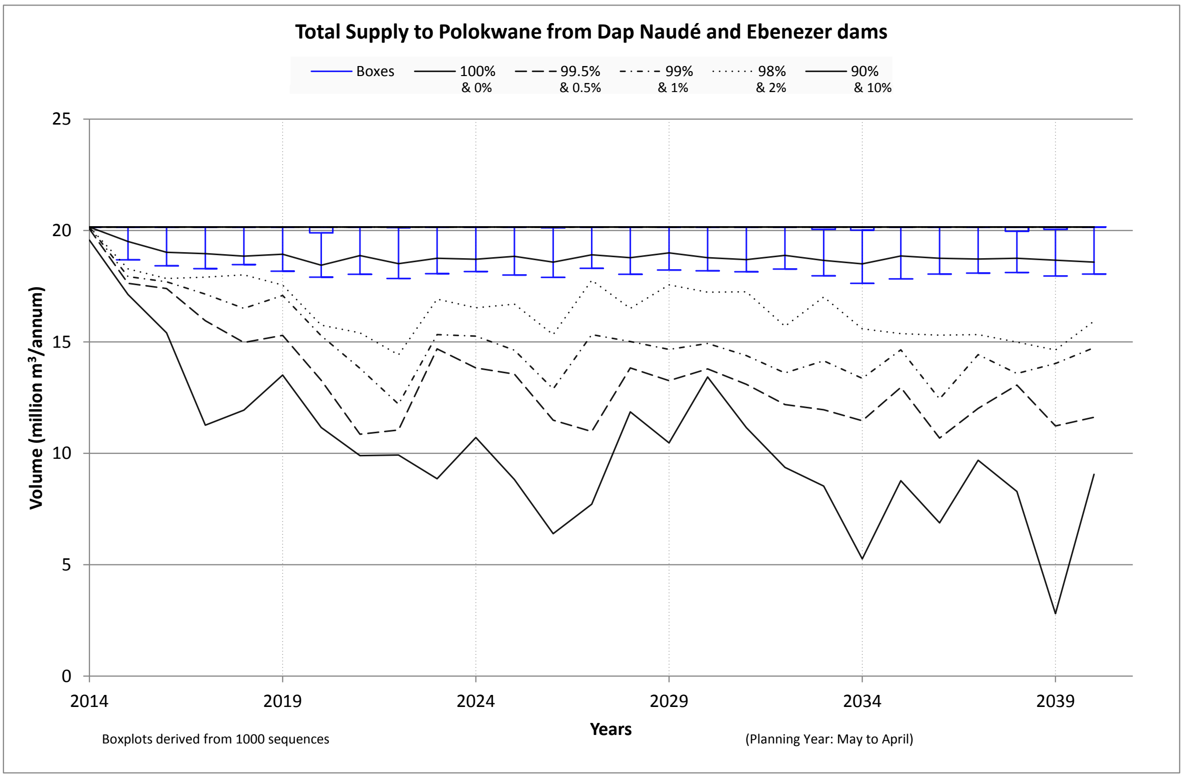

Figure 6-4: Combined transfer to Polokwane from Ebenezer and Dap Naudé dams

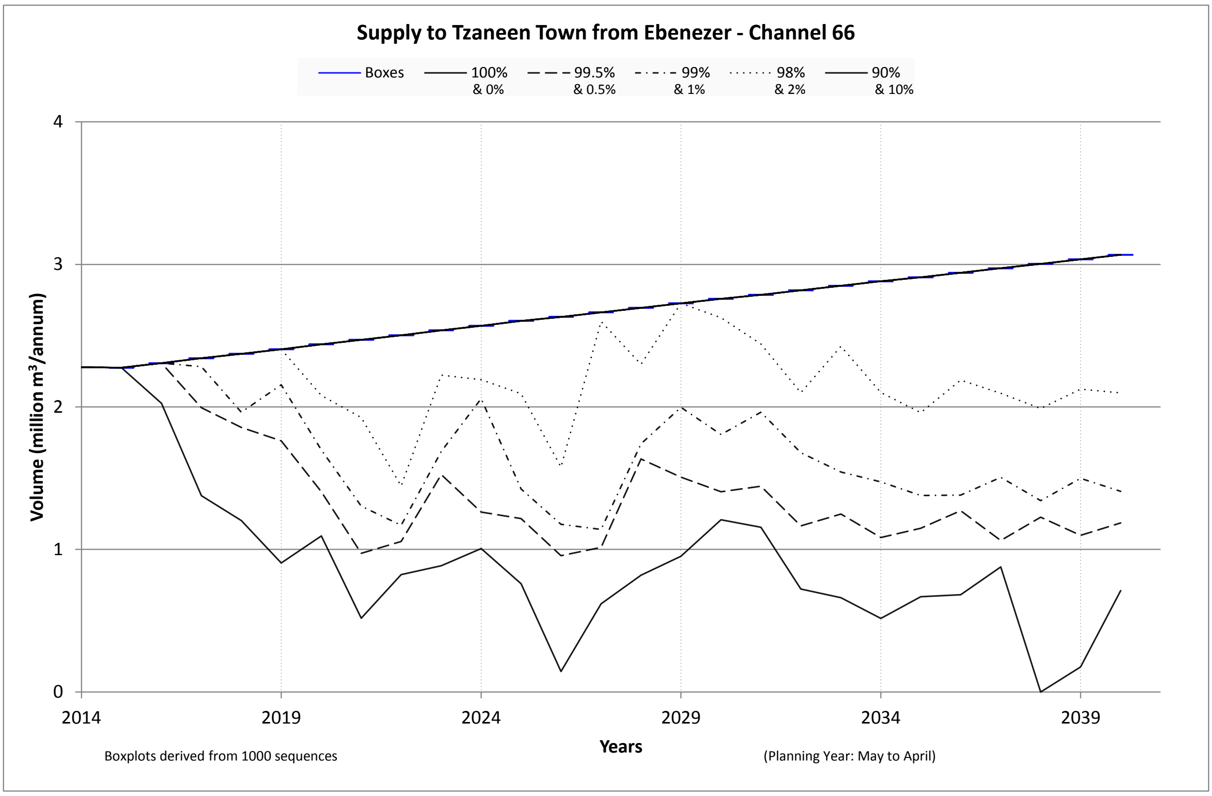

Figure 6-5: Supply to Tzaneen from Ebenezer Dam

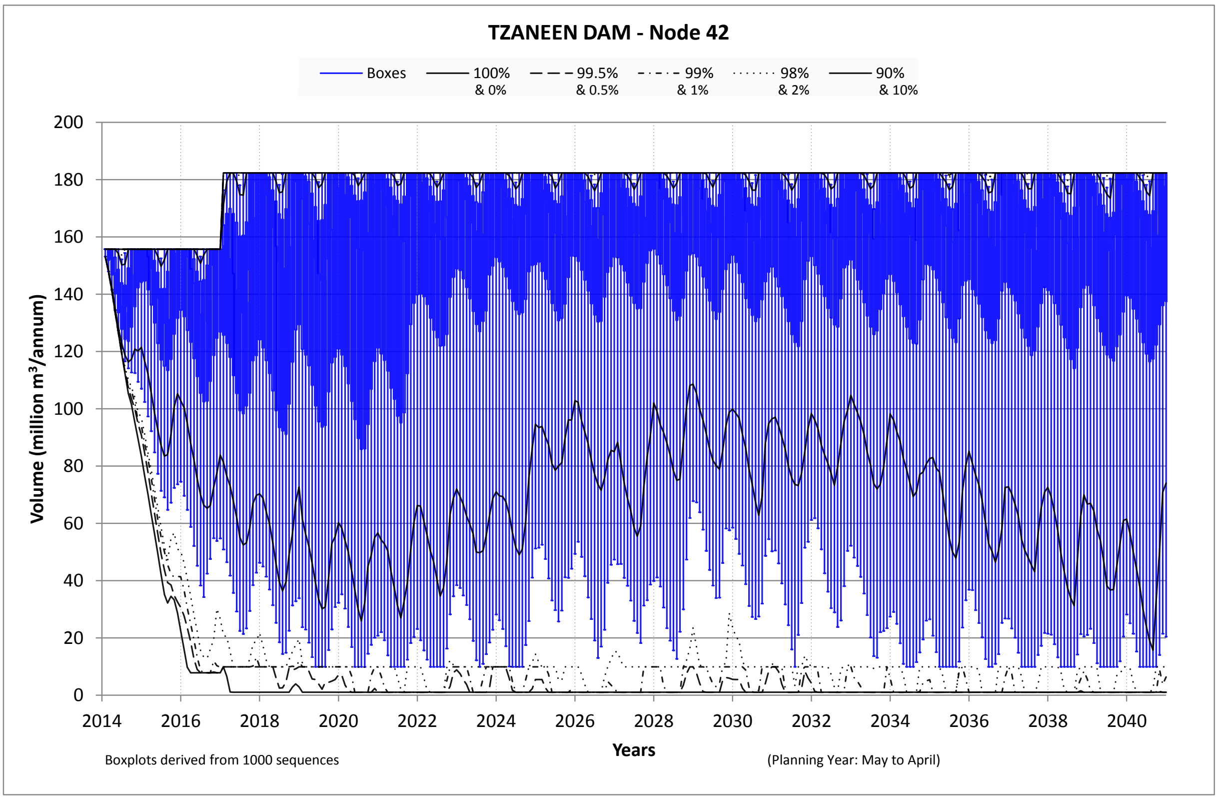

Figure 6-6: Tzaneen Dam storage projection

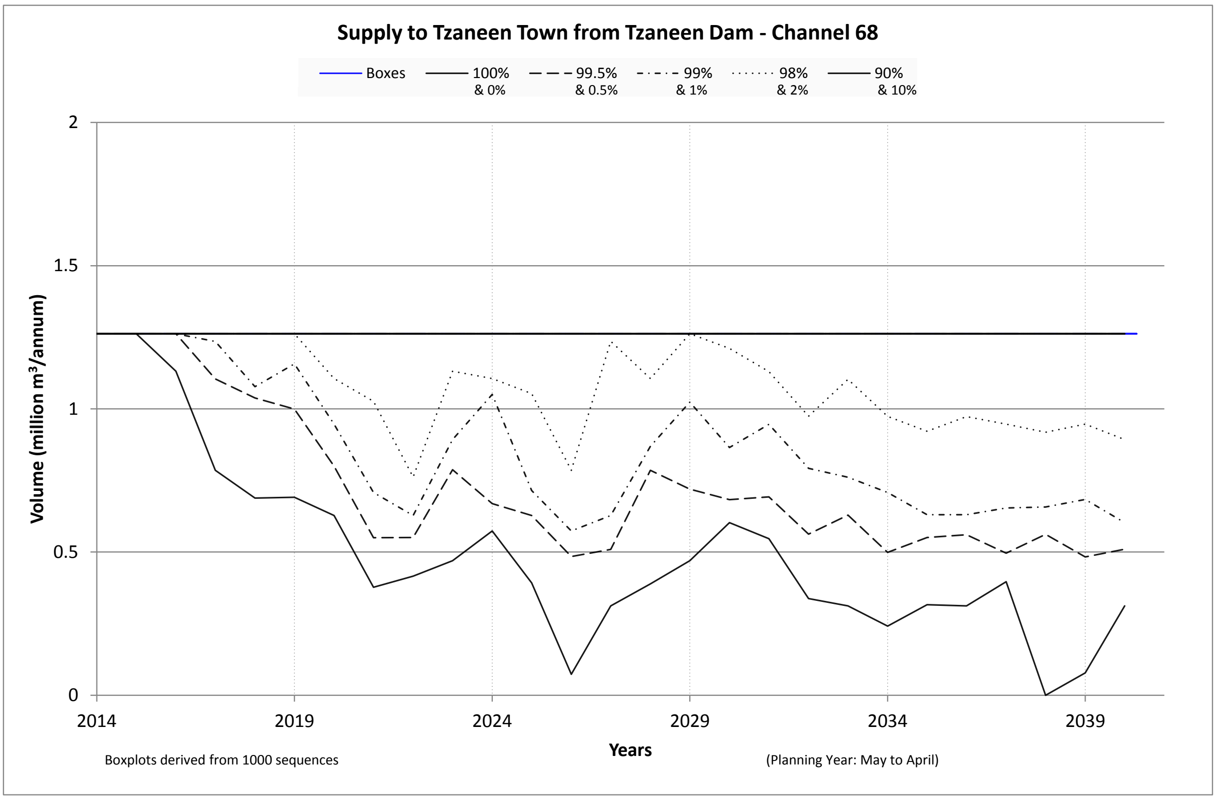

Figure 6-7: Supply to Tzaneen from Tzaneen Dam

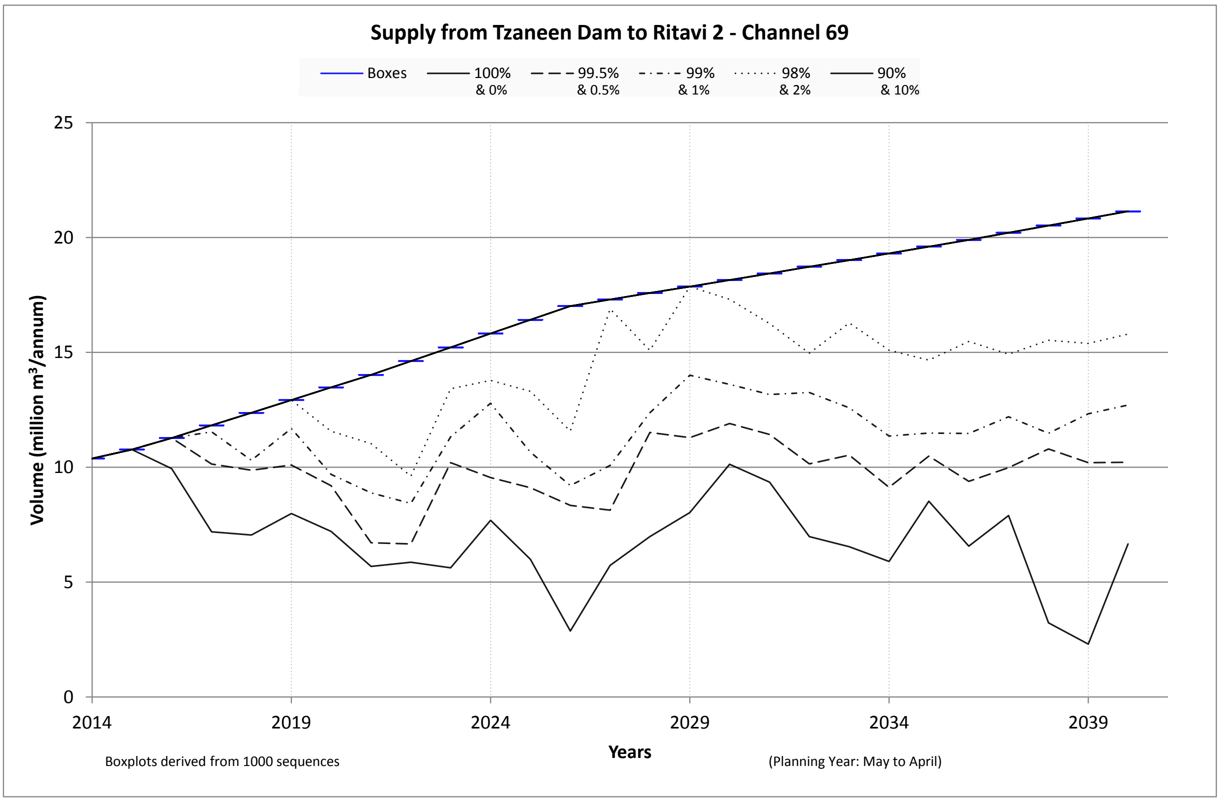

Figure 6-8: Supply to Ritavi 2 from Tzaneen Dam

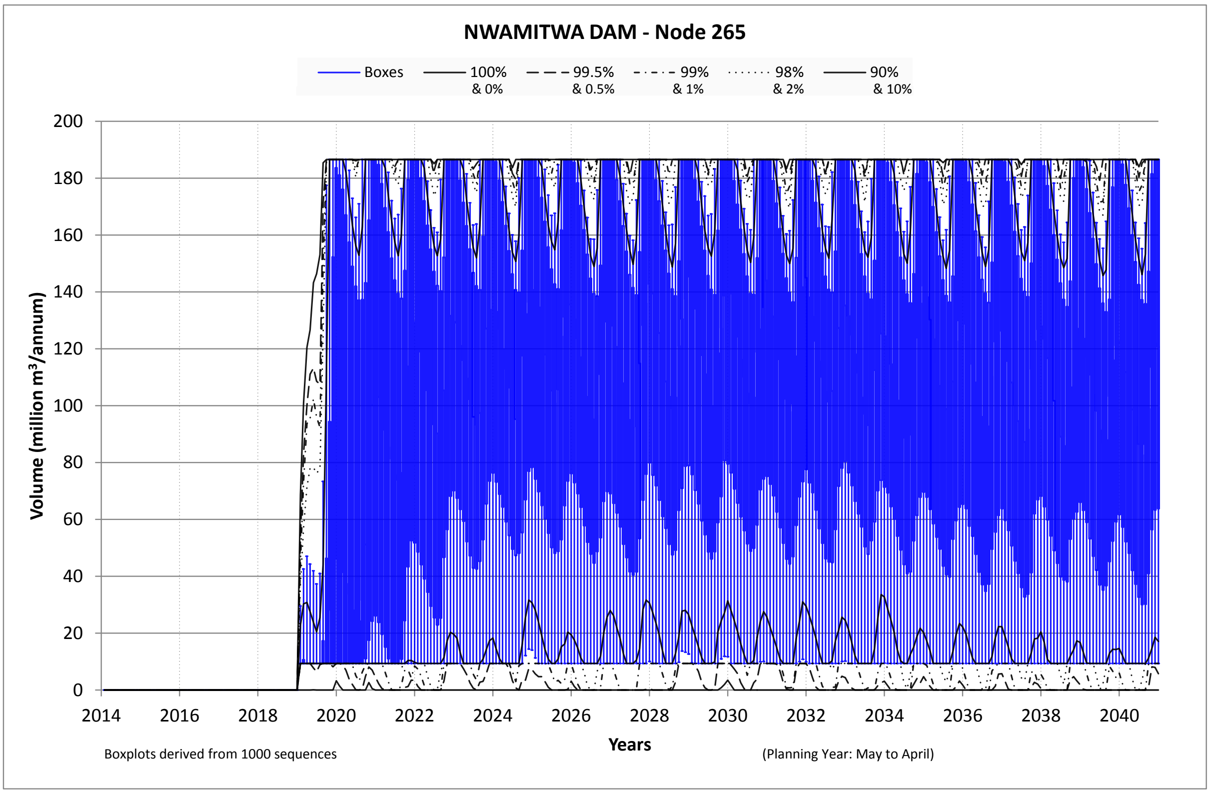

Figure 6-9: Nwamitwa Dam storage projection

Figure 6.10 shows the typical supply to domestic users from Nwamitwa Dam, which is fairly in line with the required assurance until 2034, where after it starts to deteriorate.

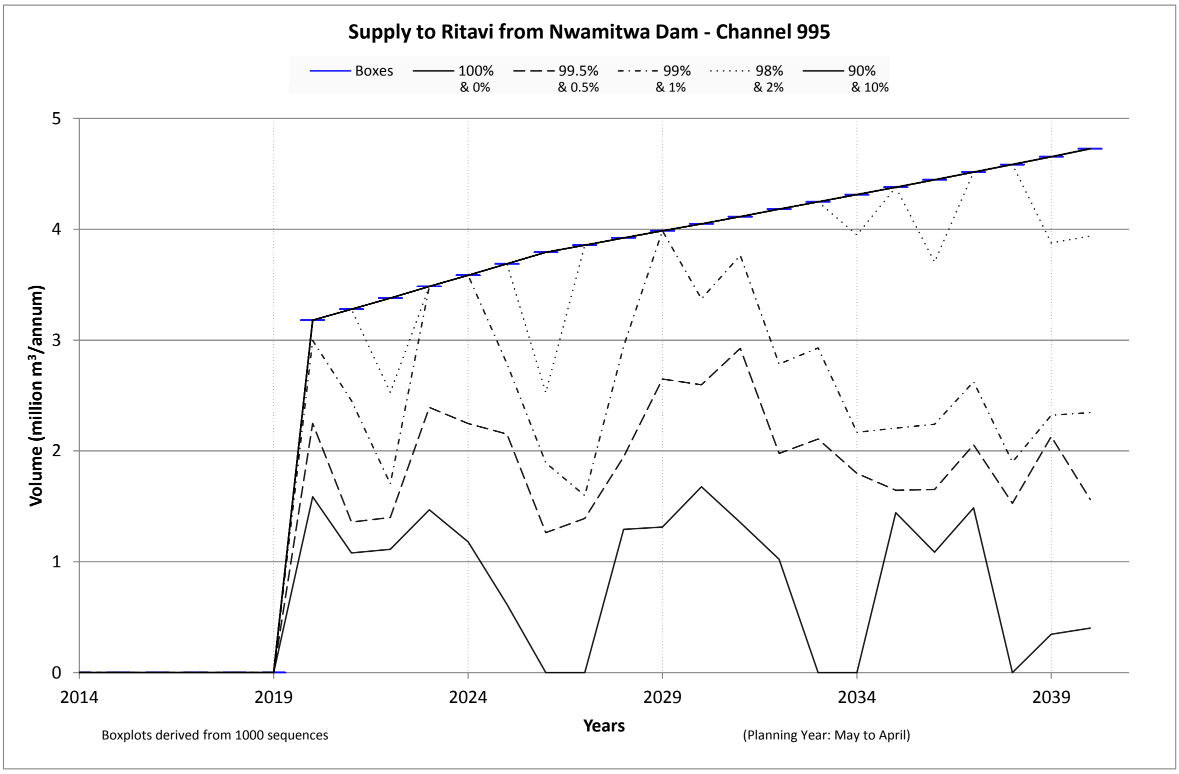

Figure 6-10: Supply to Ritavi from Nwamitwa Dam

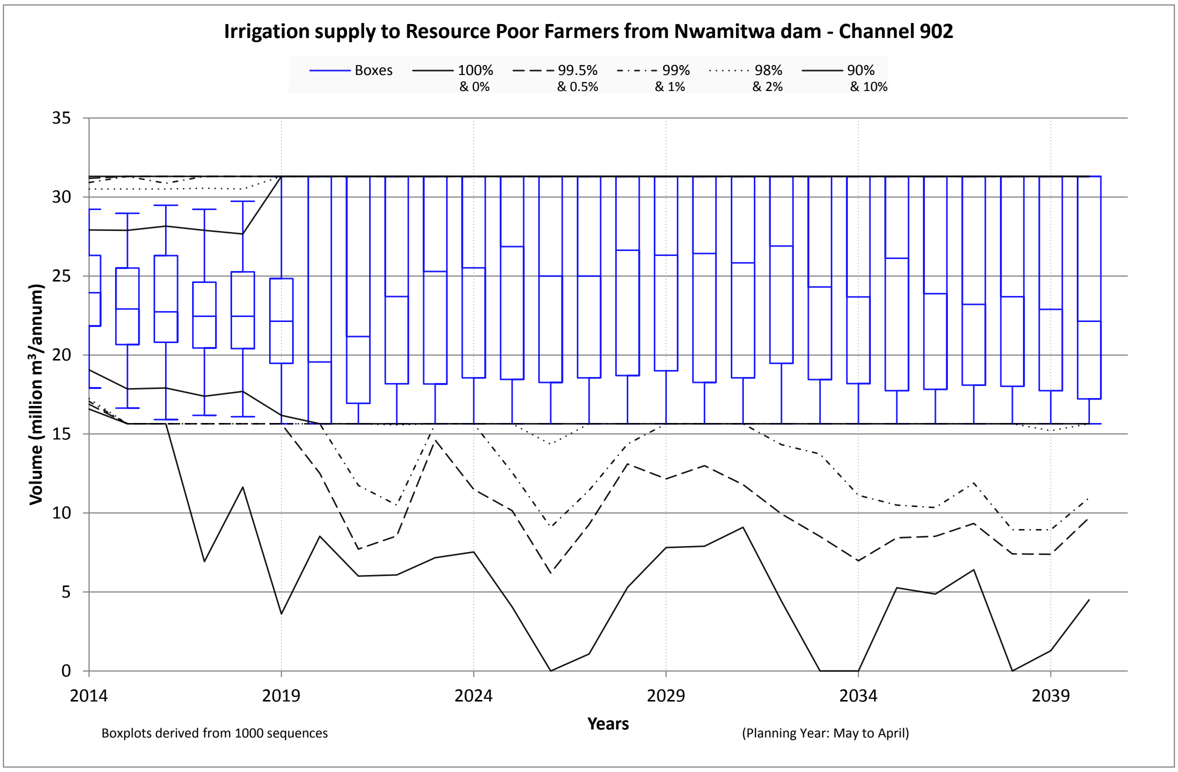

Figure 6-11: Supply to Irrigation from Nwamitwa Dam

The irrigation restriction rules dictate that when the Nwamitwa Dam is below 95%, then irrigation water supply is cut to 50% and cut to zero when the dam reaches 5%. This rule also applies to Tzaneen Dam for irrigation supplied from Tzaneen Dam. The impact on the supply to irrigation due to this rule is clearly evident from the irrigation to Resource Poor Farmers as shown in **Figure 6.11**. The upper 50% of the irrigation is supplied at a very low assurance and the lower 50% at a reasonably good assurance for irrigation purposes, just slightly worse than that obtained for the domestic supply.

6.1.2 Smaller Stand-alone sub-systems

The Magoebaskloof Vergelegen Dam Sub-system is one of the larger stand-alone sub-systems and is used to supply water to both domestic and irrigation users. Magoebaskloof Dam supports Vergelegen Dam which largely plays the role of a balancing dam, from where water is delivered to the Politsi Water Treatment Works. The expected domestic/Industrial growth in demand for Politsi, Duiwelskloof and Ga-Kgapane was imposed on the system with 2 million m^3/a in 2014 to 3.2 million m^3/a by 2040.

When Magoebaskloof Dam was built, the intention was to supply irrigation water to the Tzaneen Irrigation Board and Sapekoe Tea Estates. The Sapekoe Tea Estate comprised of almost a 1 000 ha of which almost none is currently irrigated as the production of tea is not viable anymore. Of the 1000ha, 70 ha have been bought by Donald Properties (ZZ2) and 930ha is under the control of the Magoeba Tribe who might exercise their allocation for irrigation at some time. For the purpose of the analysis a possible growth in irrigation was allowed for starting with the current irrigation water use of 4.5 million m^3/a increasing to 11.03 million m^3/a by 2040.

The Magoebaskloof storage projection show a steady decline over time as result of the increasing demand imposed on the system. When considering the supply assurance to the domestic component (**Figure 6.14**) it is evident that 98% supply assurance failures start to occur from 2033.

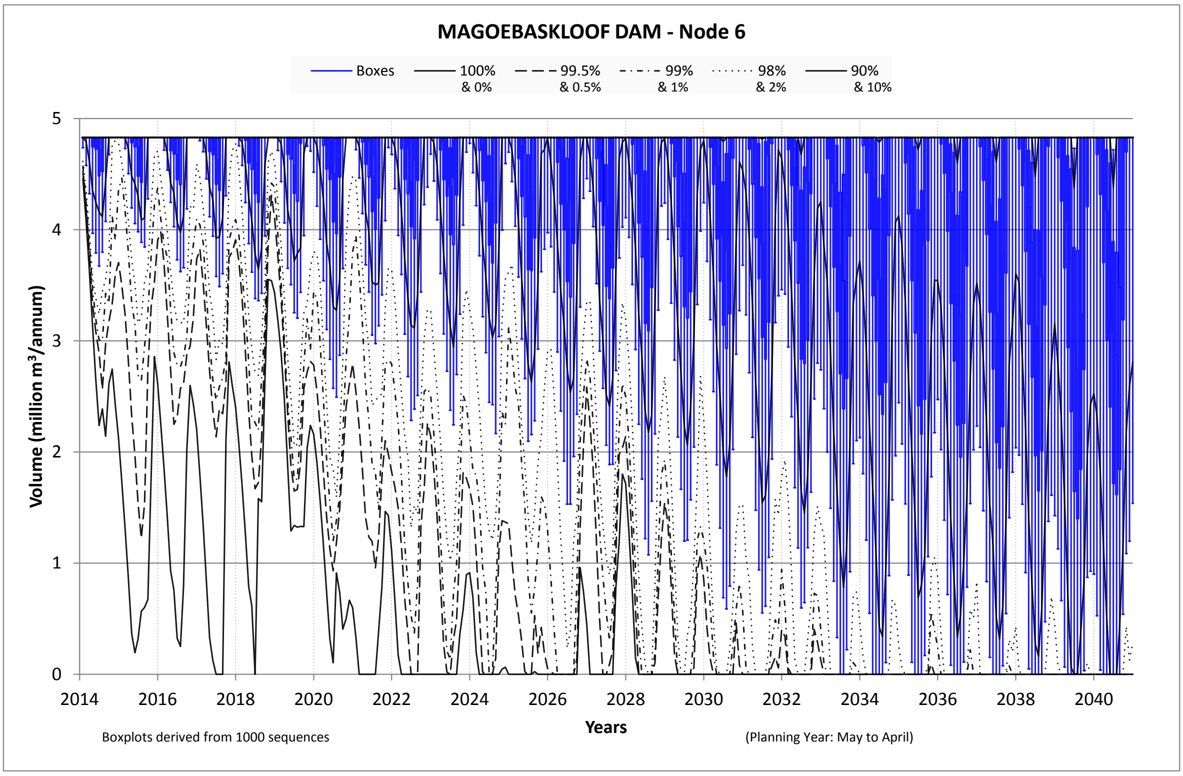

Figure 6-12 : Magoebaskloof Dam storage projection

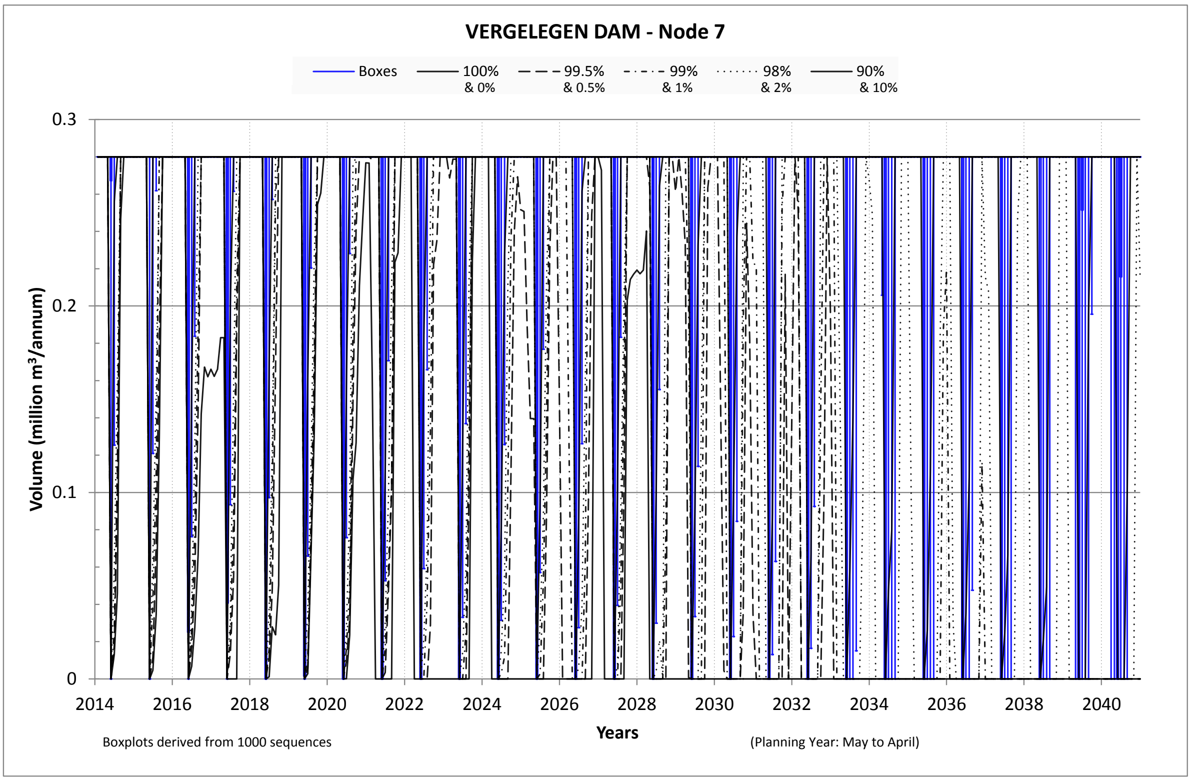

Figure 6-13 : Vergelegen Dam storage projection

This also apply to irrigation where 95% assurance failures is evident from 2033 onwards.

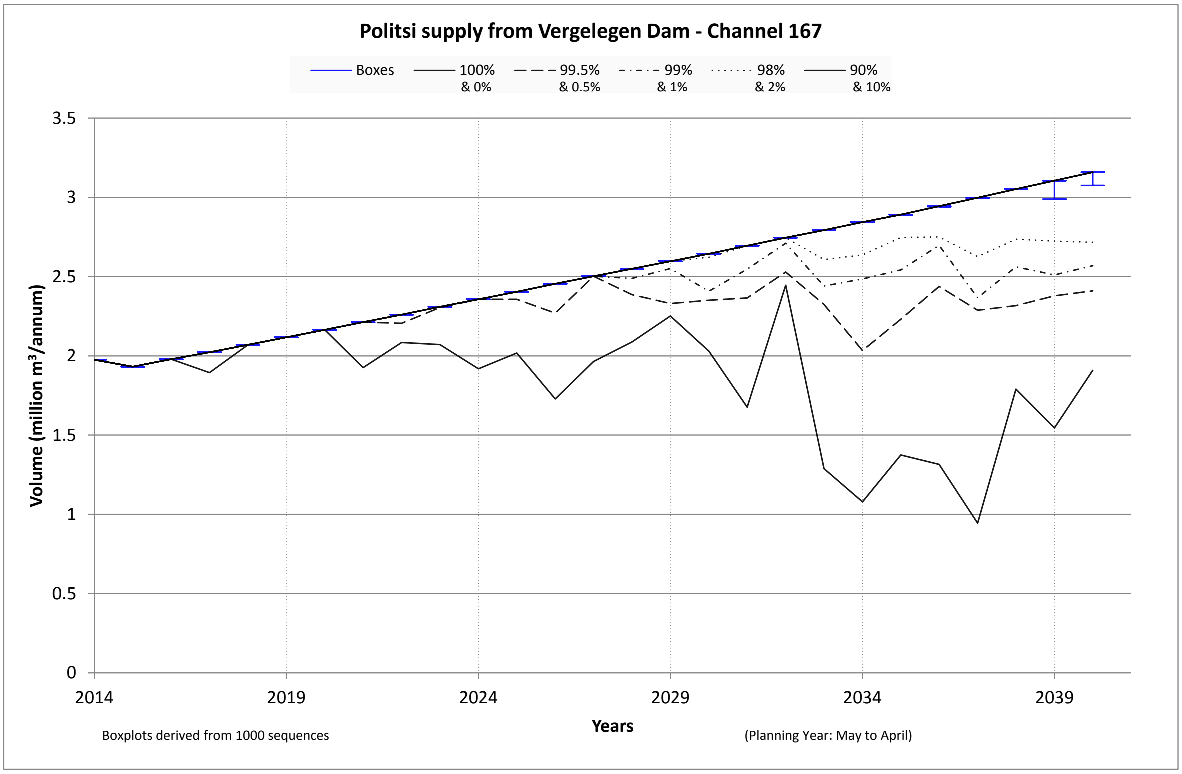

Figure 6-14 : Domestic supply from Magoebaskloof Vergelegen dam sub-system

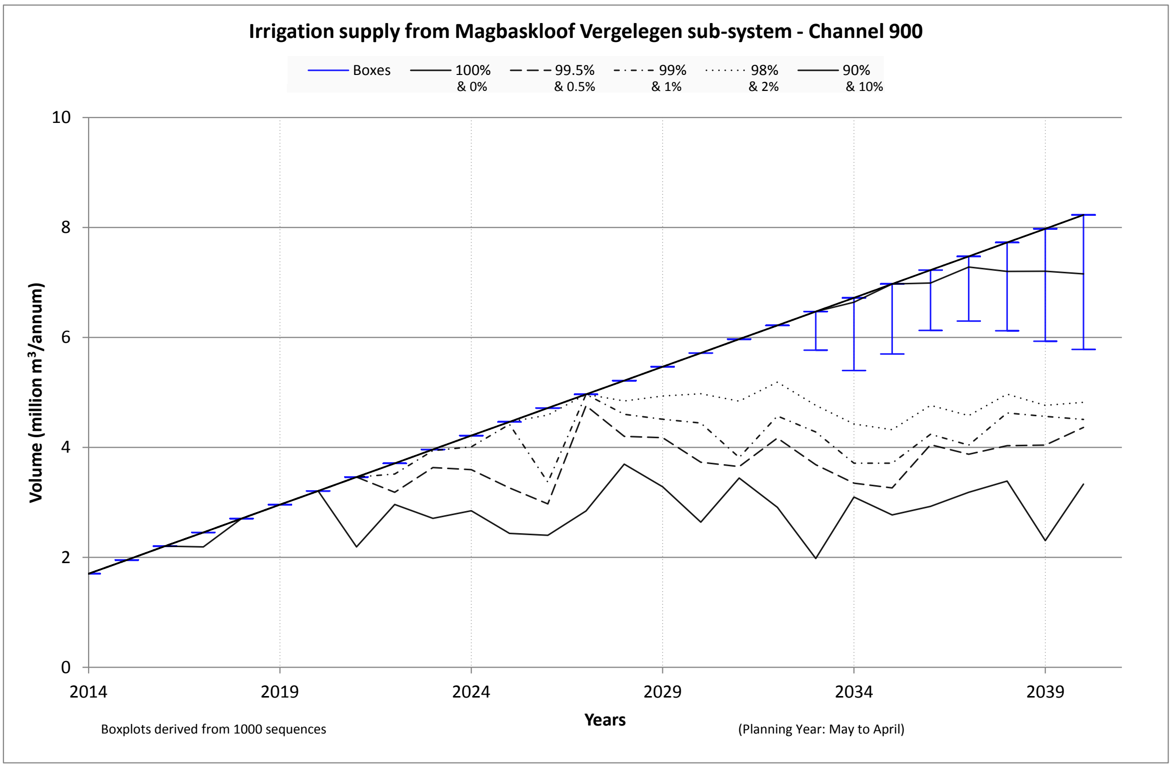

Figure 6-15 : Irrigation supply from Magoebaskloof Vergelegen dam sub-system

Hans Merensky Dam is only used for Irrigation purposes with a total water requirement of 4.5 million m^3/a. From the dam storage projection plot it is clear that the dam is struggling to support the demand and failures often occurs.

Need supply plot???

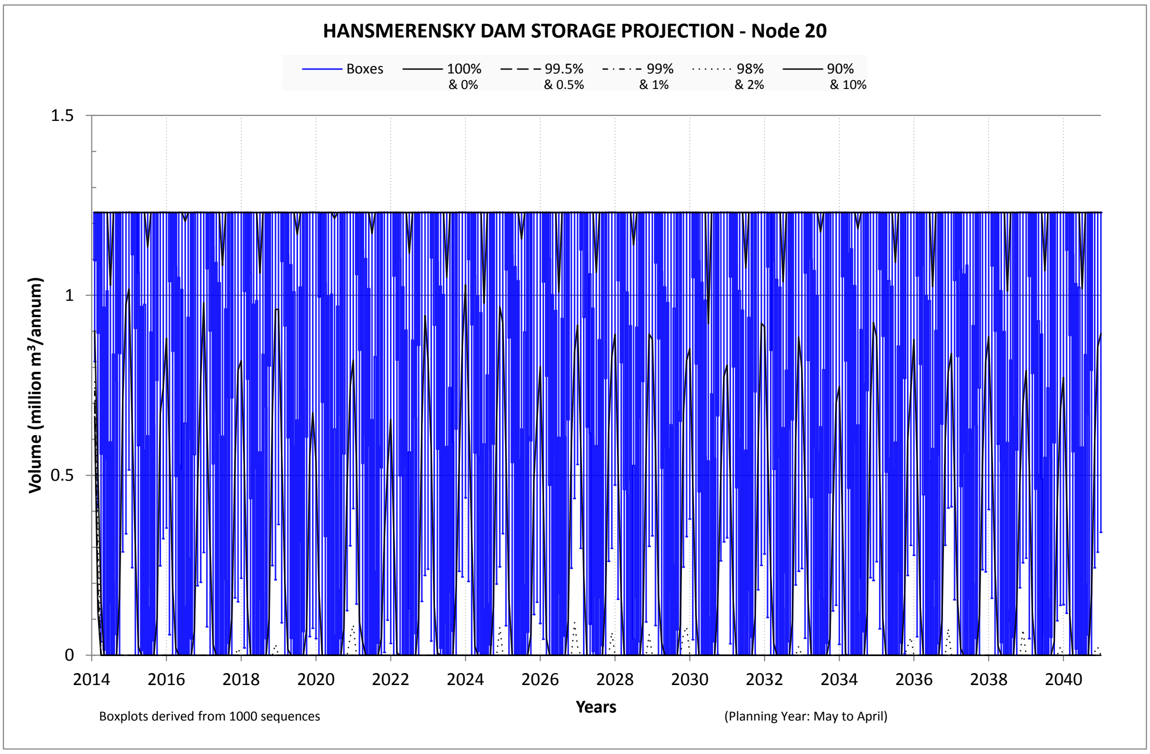

Figure 6-16: Hans Merensky Dam storage projection

Thabina Dam is used to supply rural domestic water requirements within the Thabina RWS. The dam is located in the upper reaches of the Thabina River, which is a tributary of the

Letsitele River flowing into the Groot Letaba River upstream of the future Nwamitwa Dam. This dam was operated using short-term stochastic yield curves to protect the dam from running empty by imposing restrictions on the water use when required. The operating rule worked well and one can see from **Figure 6.17** that the dam never empties when considering the 98% exceedance probability. The 98% (1 in 50 year) assurance was applied to the water supply for the rural domestic use. Intervention options recommended for this sub-system include:

- Water conservation and demand management in urban sector by 2015 – a saving of 0.3 million m^3/a.
- Construction of bulk supply infrastructure to augment the supply from Nwamitwa Dam by 2019.

From the water supply plot (**Figure 6.18)** it is evident that the growing demand imposed on Thabina dam until 2019 is too high and the dam is not able to meet the required assurance of supply (98%). From 2020 onwards part of the Thabina RWS demand as well as the demand growth were allocated to the new Nwamitwa Dam. This significantly improved the water supply from Thabina Dam, but not enough to maintain the assurance of supply at 98% although a large portion of the demand (81%) was supplied at a 98% assurance for most of the time. The water supply of the Thabina RWS demand allocated to Nwamitwa Dam is fairly well supplied (**Figure 6.19)** with the entire demand component supplied at the 98% assurance for most of the time.

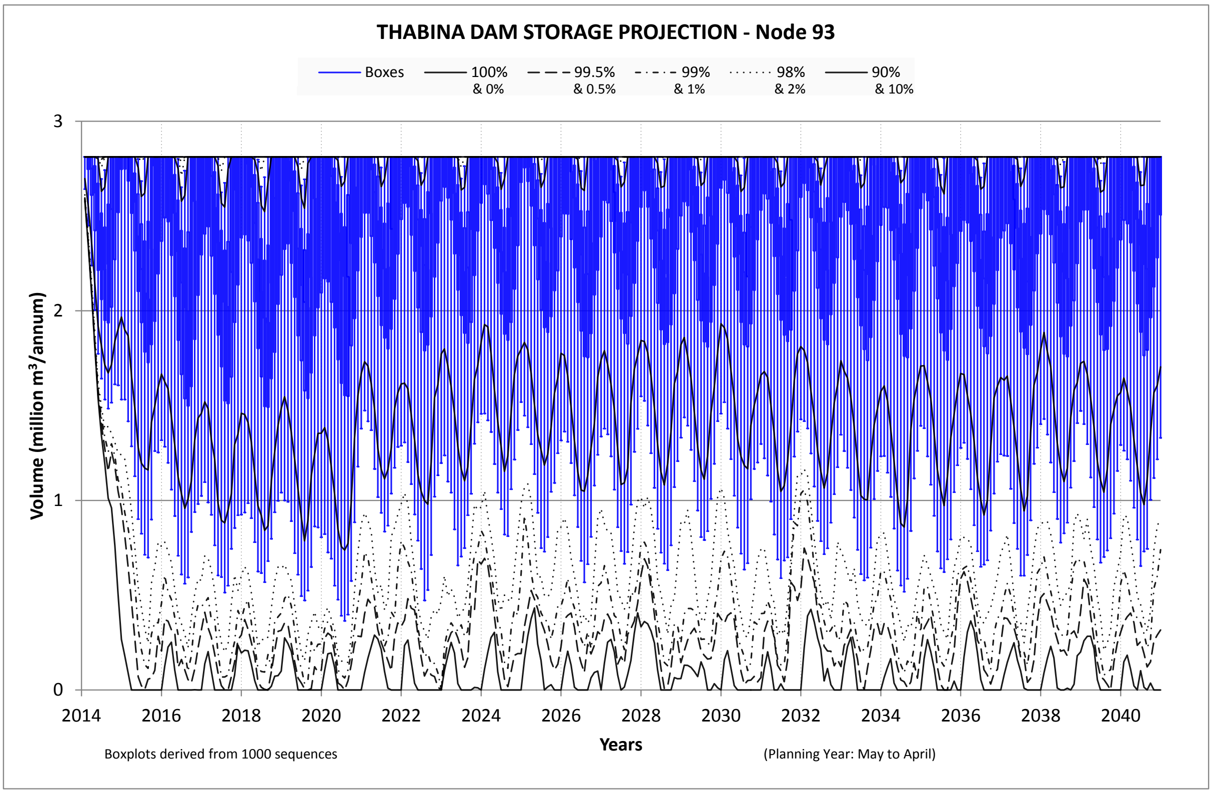

Figure 6-17 : Thabina Dam storage projection

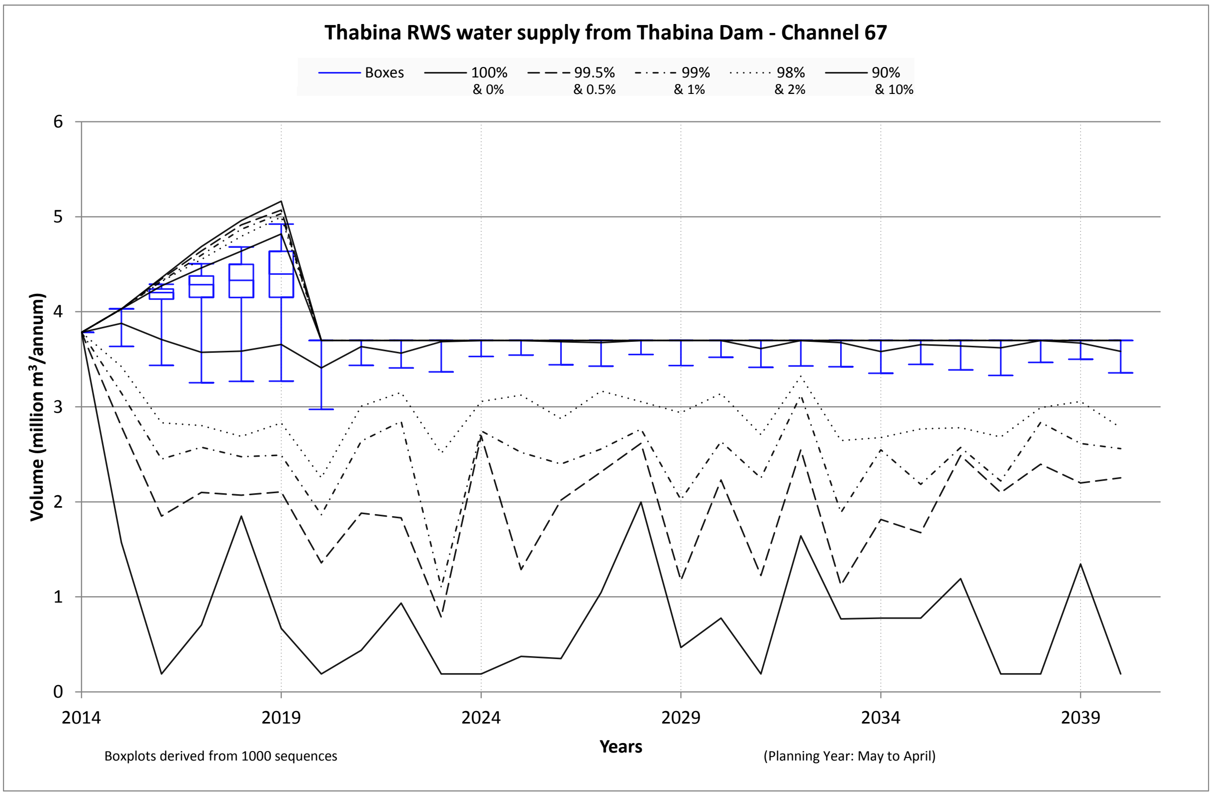

Figure 6-18 : Thabina water supply from Thabina Dam

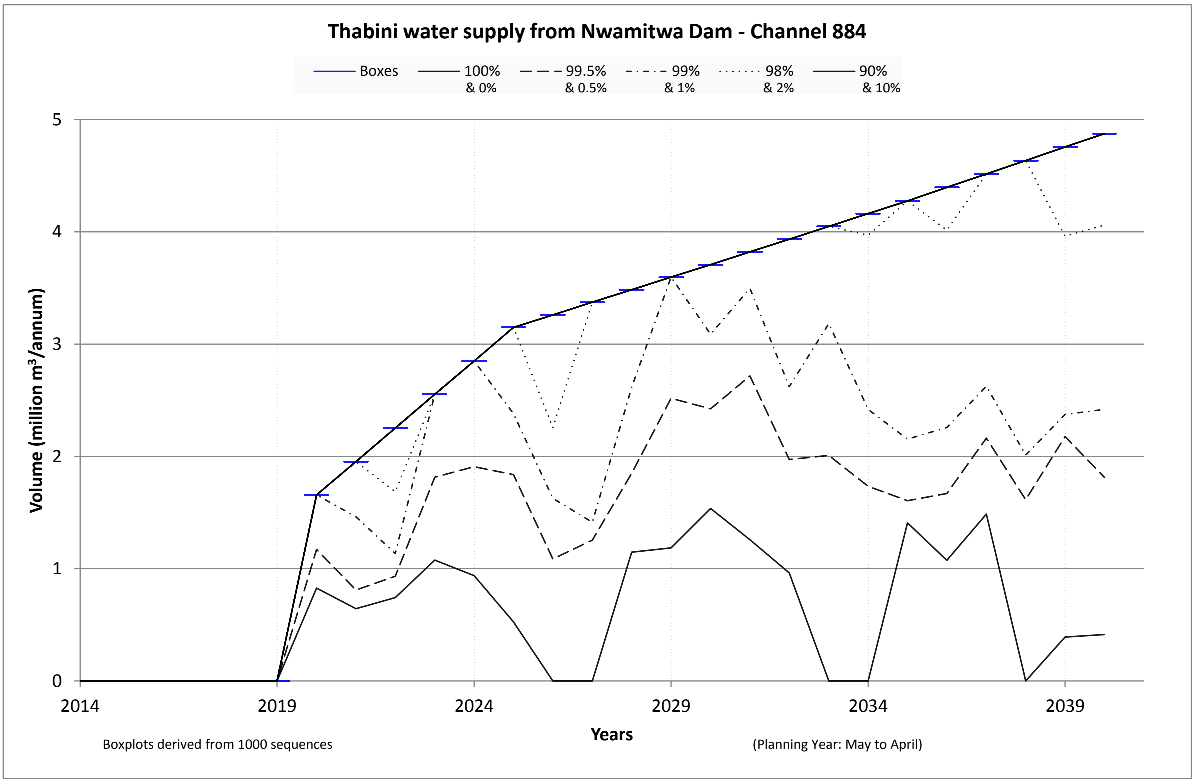

Figure 6-19 : Thabina water supply from Nwamitwa Dam

<u>Thapane is a relative small dam</u> and is used to supply part of the rural domestic water requirements of Thapane RWS. The dam has a full supply volume of 1.07 million m^3 and is located in the upper reaches of the Nwandezi River which flows into the Groot Letaba River just upstream of the future Nwamitwa Dam. The intervention options recommended for this sub-system include:

- Water conservation and demand management in urban sector by 2015 – saving of 0.1 million m^3/a.
- Construction of bulk supply infrastructure to augment the supply from Nwamitwa Dam by 2019.

Thapane Dam is already over allocated as can be seen from the poor supply (**Figure 6.21**) until 2019 just before Nwamitwa Dam starts to support part of the demand as well as the growth in demand of the Thapane RWS over time. From 2020 onwards the assurance of supply improved, but not to the extent that the demand could always be supplied at the 98% assurance. Approximately 85% of the demand could however be supplied at the required assurance with the remainder of the demand supplied between 98% and 95%. Thapane Dam used the short-term stochastic yield curves as part of its operating rule to protect the resource from total failure. This was achieved as evident from **Figure 6.20** showing that the 98% exceedance probability storage level never reaches empty over the analysis period.

The Thapane RWS demand component supplied from Nwamitwa Dam was in general well supplied at 98% assurance for most of the time. The demand split thus require some refinement, by allocating slightly less to Thapane Dam and a bit more to Nwamitwa Dam.

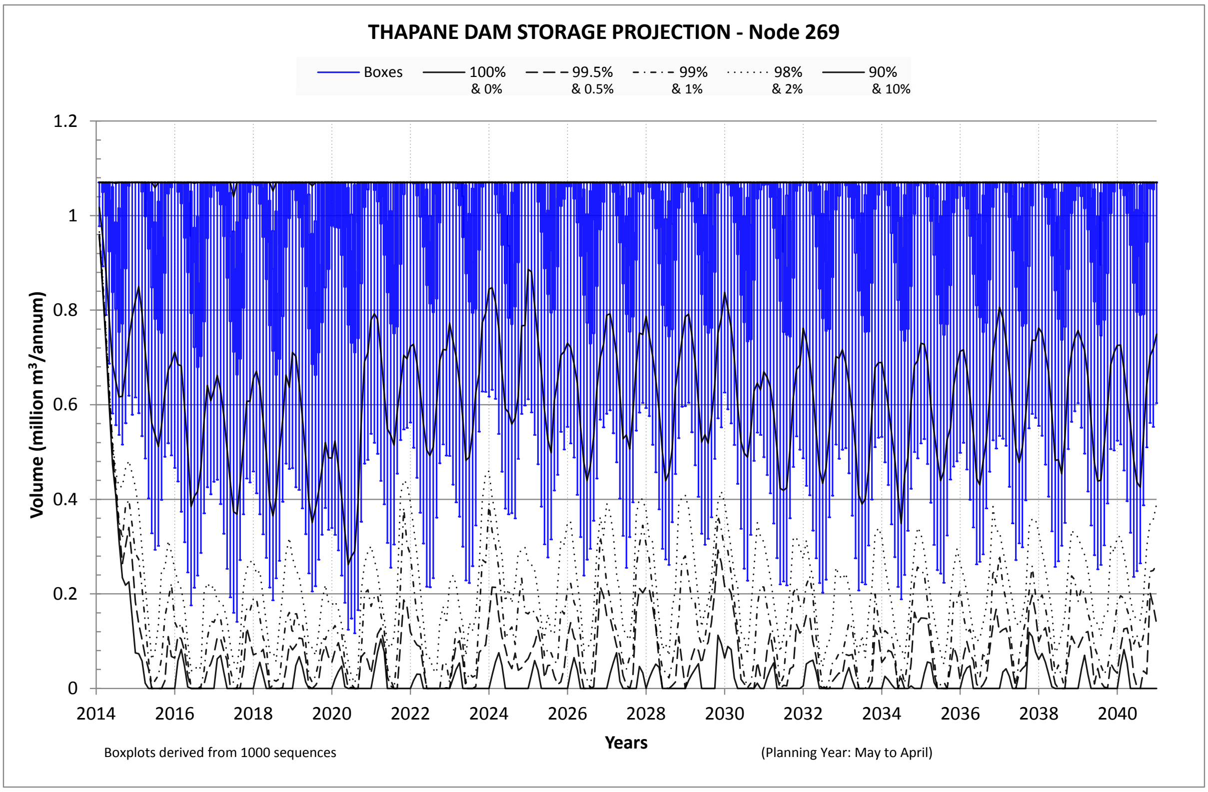

Figure 6-20 : Thabina Dam storage projection

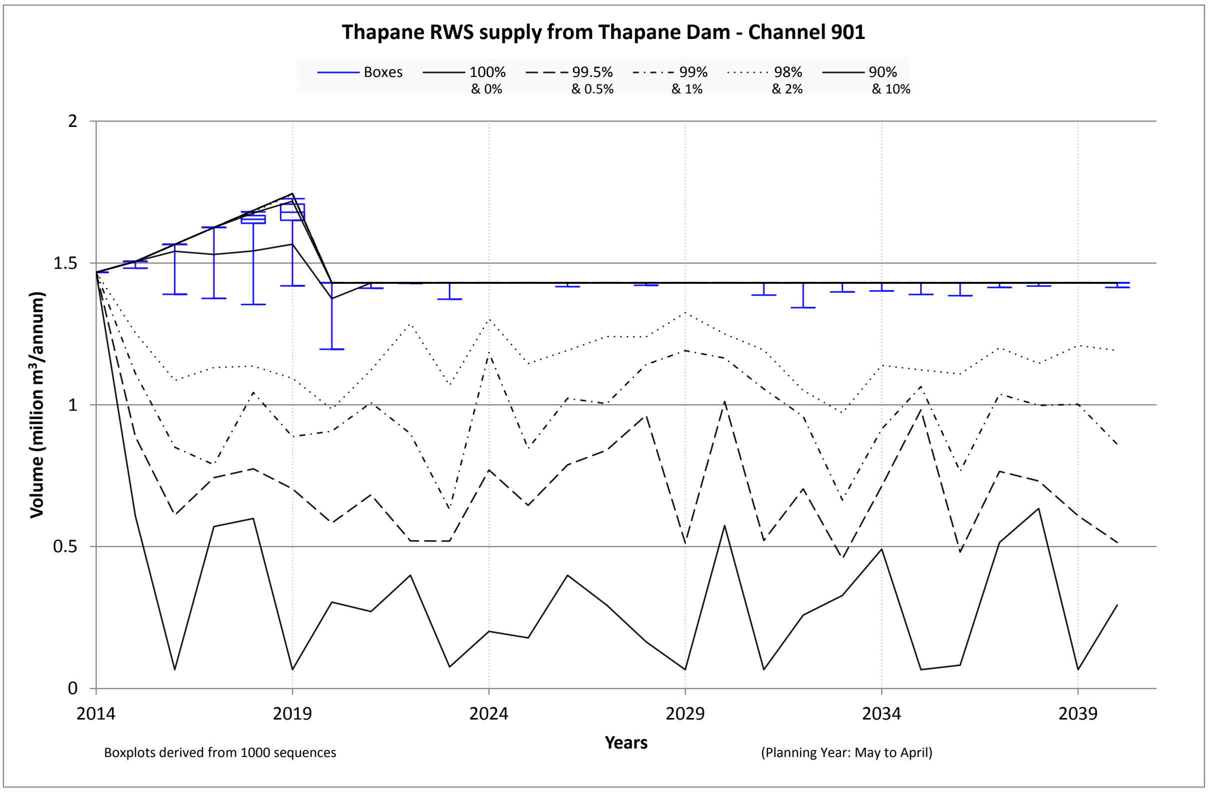

Figure 6-21: Thapane RWS water supply from Thapane Dam

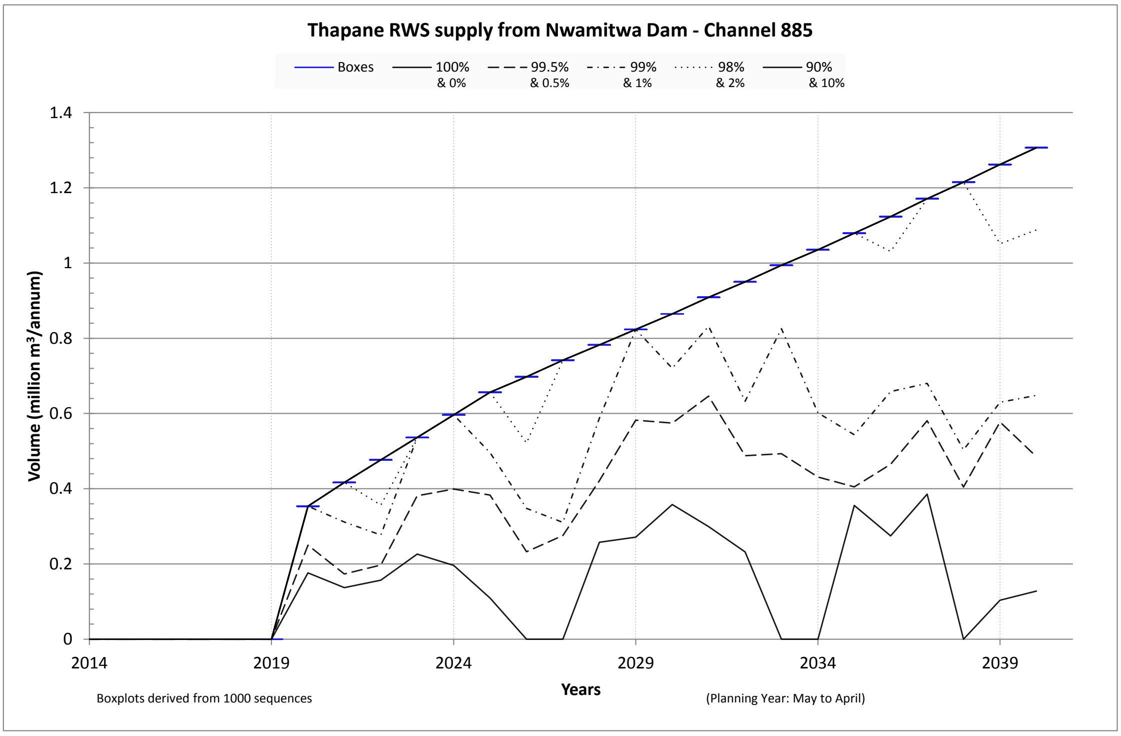

Figure 6-22 : Thapane RWS water supply from Nwamitwa Dam

The Modjadji Dam is located in the upper Molototsi River and supply water to the rural areas within the Modjadji RWS. The Modjadji sub-system is already over utilised as evident from **Figure 6.24**. The Modjadji sub-system utilised short-term stochastic yield characteristics as part of its operating rule to protect the dam from failures as can be seen from **Figure 6.23**.

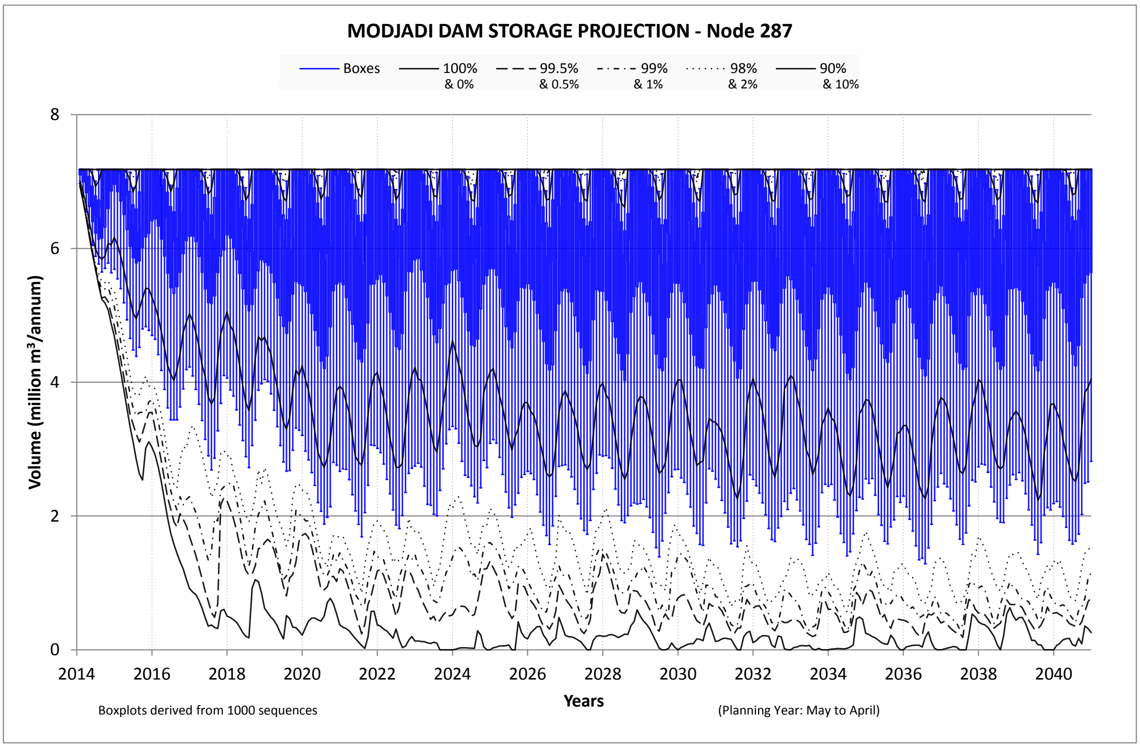

Figure 6-23: Modjadji Dam storage projection

The protection of Modjadji Dam against complete failure by means of the short-term stochastic curves was achieved, although the storage protection obtained indicates that the operating rule is somewhat on the conservative side. Some refinements can therefore be made to the short-term curves and should also improve the assurance of supply from Modjadji Dam.

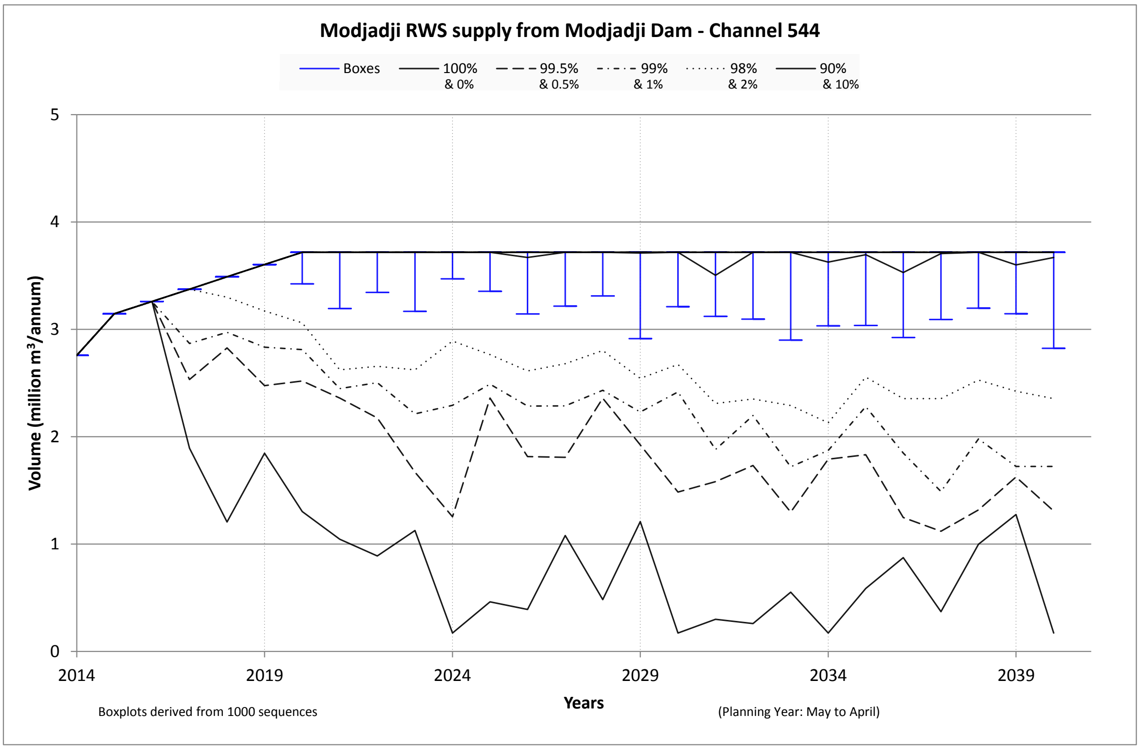

Figure 6-24: Modjadji RWS water supply from Modjadji Dam

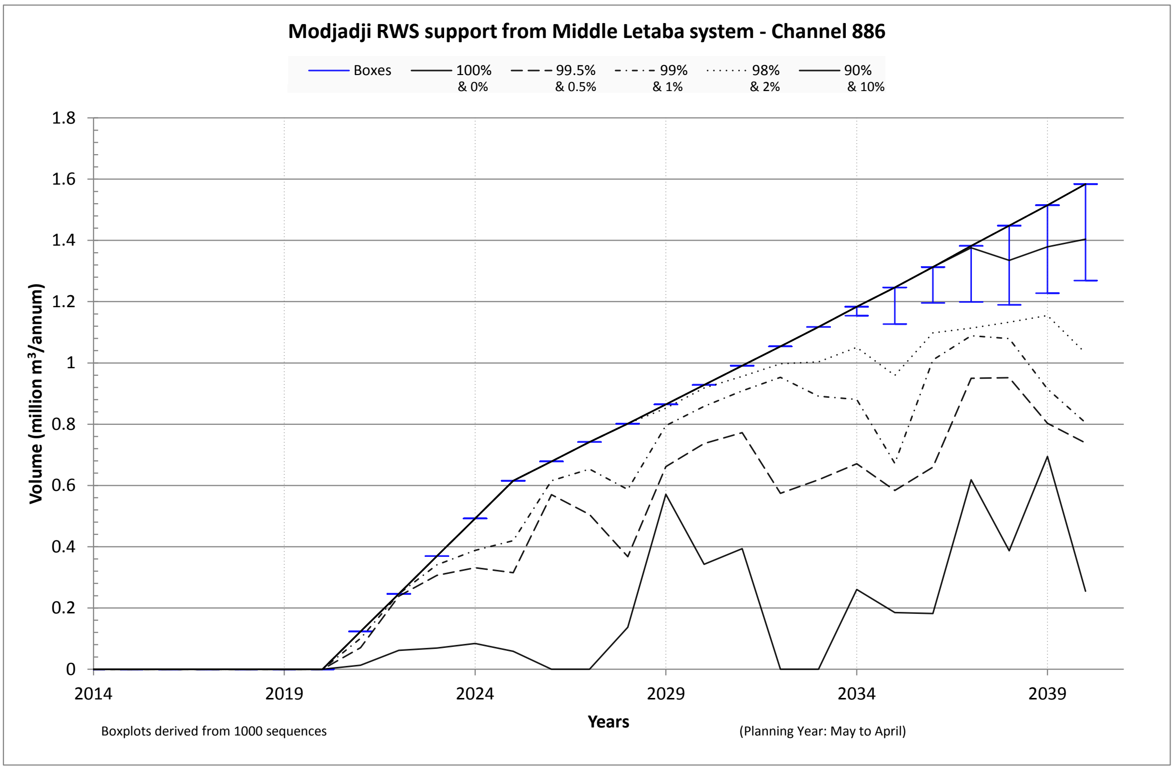

Figure 6-25 : Modjadji RWS water supply from the Middle Letaba System

The intervention options recommended for the Modjadji Water Supply sub-system include:

- Water conservation and demand management in urban sector by 2015 – saving of 0.3 million m^3/a.
- Construction of bulk supply infrastructure to augment the supply from the Middle Letaba System.

Due to the over allocation of Modjadji Dam the demand growth from 2020 onwards was allocated to the Middle Letaba system. The Middle Letaba system was able to support this growth in demand fairly well until 2033 hereafter the assurance of supply started decreasing towards unacceptable levels (See **Figure 6.25**).

6.2 MIDDLE LETABA NSAMI SYSTEM

The Middle Letaba Nsami Systems comprises of two storage dams, Middle Letaba Dam (181 million m^3 gross storage) and Nsami Dam (21.8 million m^3 gross storage) with canal linking the two dams allowing Middle Letaba Dam to support Nsami Dam and its related demand centres (See **Figure 6.26**).

From the Middle Letaba Dam WTW the following RWS are supplied with water, Babangu (36), Bolebedu (45), Magoro (37), Majosi (38), Vyeboom (30), Elim Vleifontein and Waterval (29). The Mapuve WTW located next to the Middle Letaba Nsami canal, supplies water to the Mapuve RWS (35), the Middle Letaba Malamulele West RWS(32) as well as a portion of Malamulele West RWS(21) via the canal from Middle Letaba Dam. From the Giyani WTW located at Nsami Dam several RWS are supplied with water which includes, Giyani System F1 (33), Giyani System F2 (34), Giyani System C/D (48), Giyani System A/B (49) and Giyani System D (54).

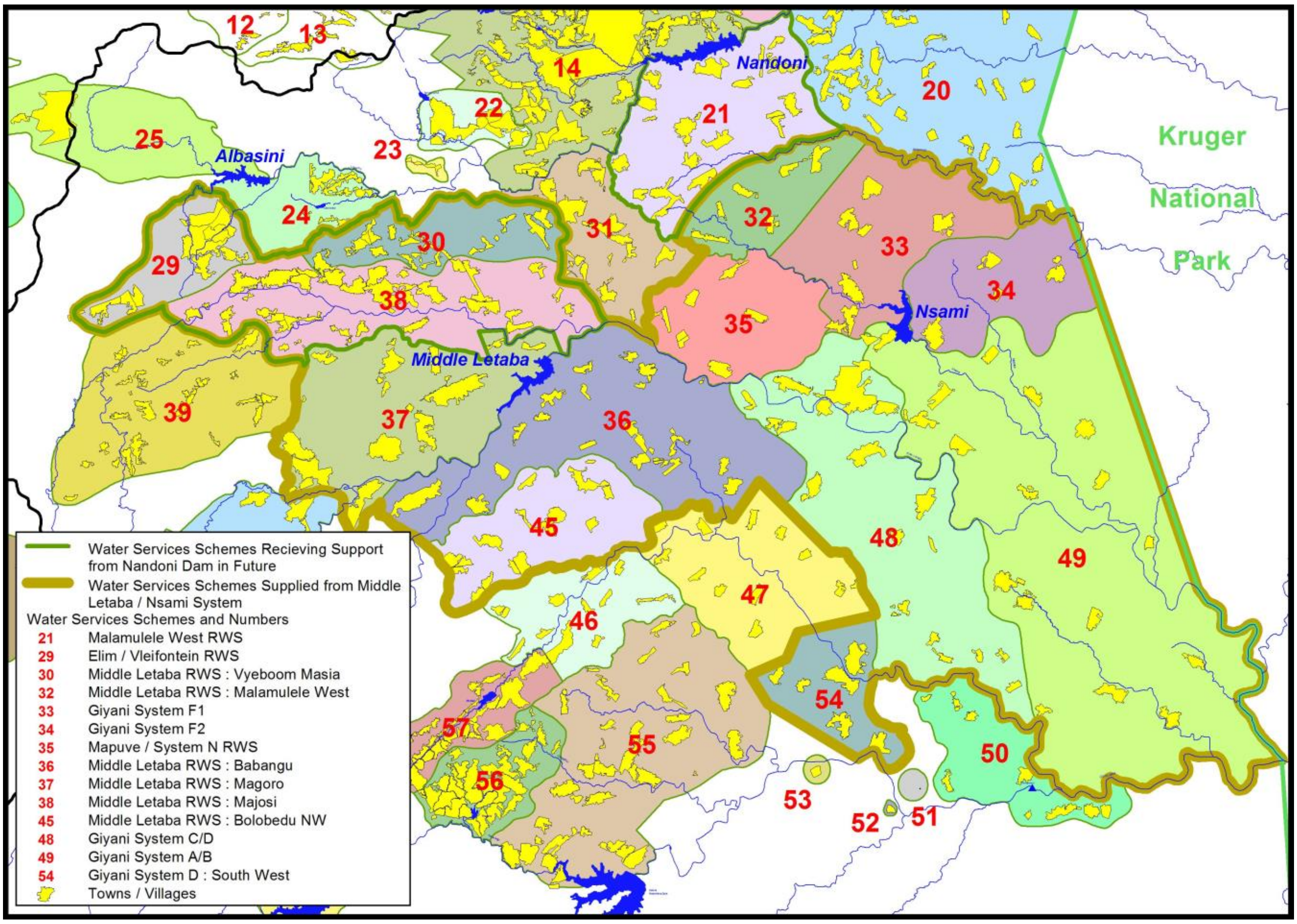

Figure 6-26 : Middle Letaba/Nsami System water supply area

Nandoni Dam in the Luvuvhu River is already utilised to supply Malamulele West RWS (21) with water. Some of the other RWS will in future also be supplied from the Nandoni System and includes, Elim/Vleifontein RWS (29), Middle Letaba RWS Vygeboom Masia (30) as well as Middle Letaba RWS Majosi (38).

The storage projection plots for Middle Letaba Dam, Nsami Dam and for the combined system is shown in **Figures 6.27**. **6.28** & **6.29** respectively. Short-term stochastic yield characteristics were used as part of the operating rule to impose restrictions on the water use during dry periods to protect the resource from total failure.

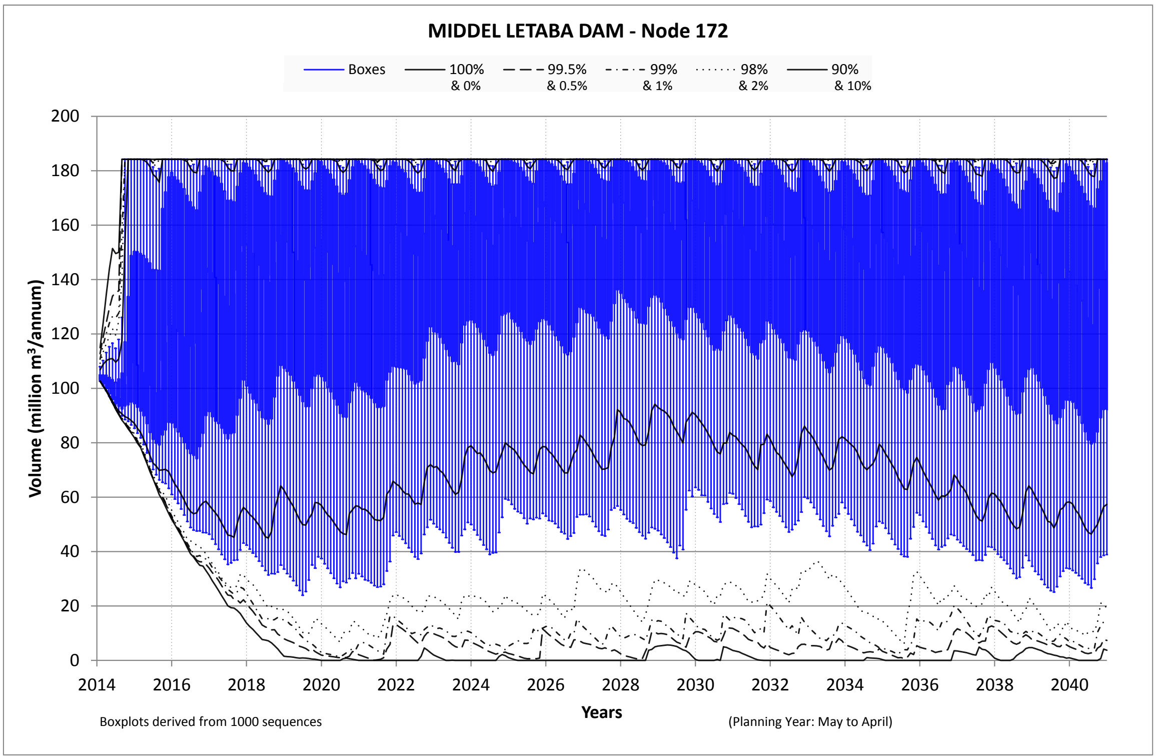

Figure 6-27 : Middle Letaba Dam storage projection

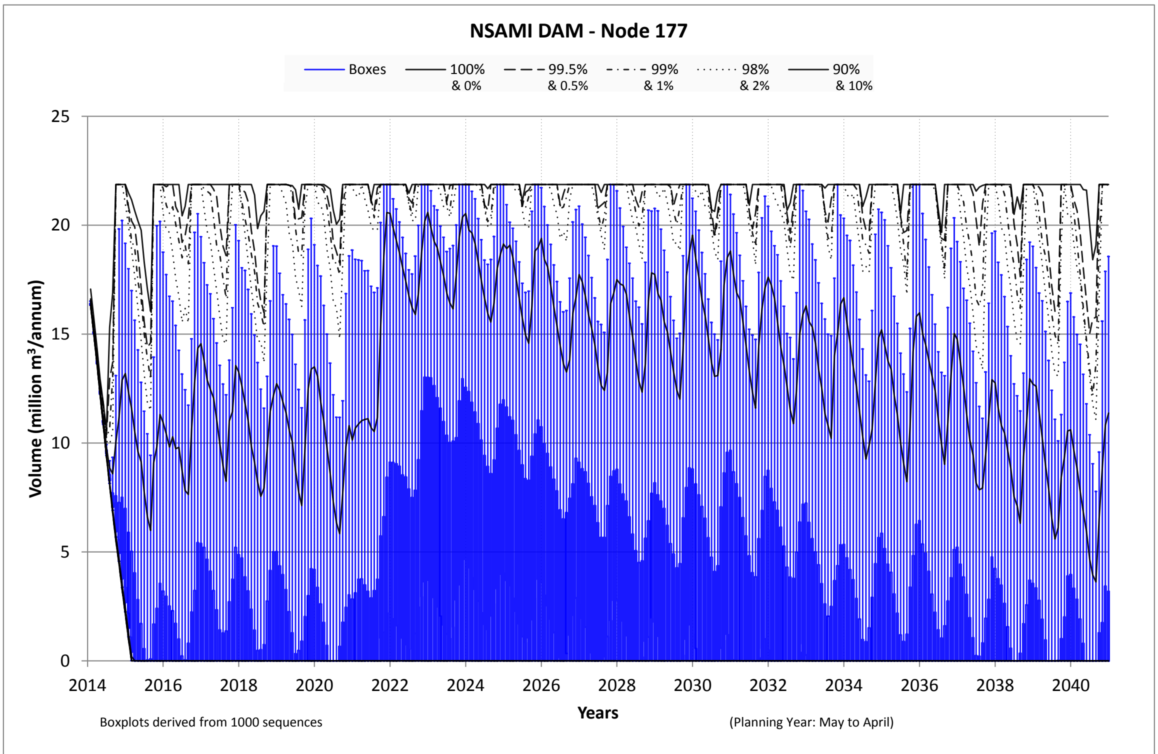

Figure 6-28 : Nsami Dam storage projection

It is evident from the storage projection plots that the total system storage was well protected as the 98% exceedance probability level for the combined system never emptied over the analysis period. Nsami Dam do however emptied quite often. This is purely due to the operating rule, taking water first from Nsami Dam to be able to utilise the maximum possible from Nsami Dam. For the first eight years the system struggled as evident from the continuous reduction in the high exceedance probability storage until 2021, where after it started to show improvement.

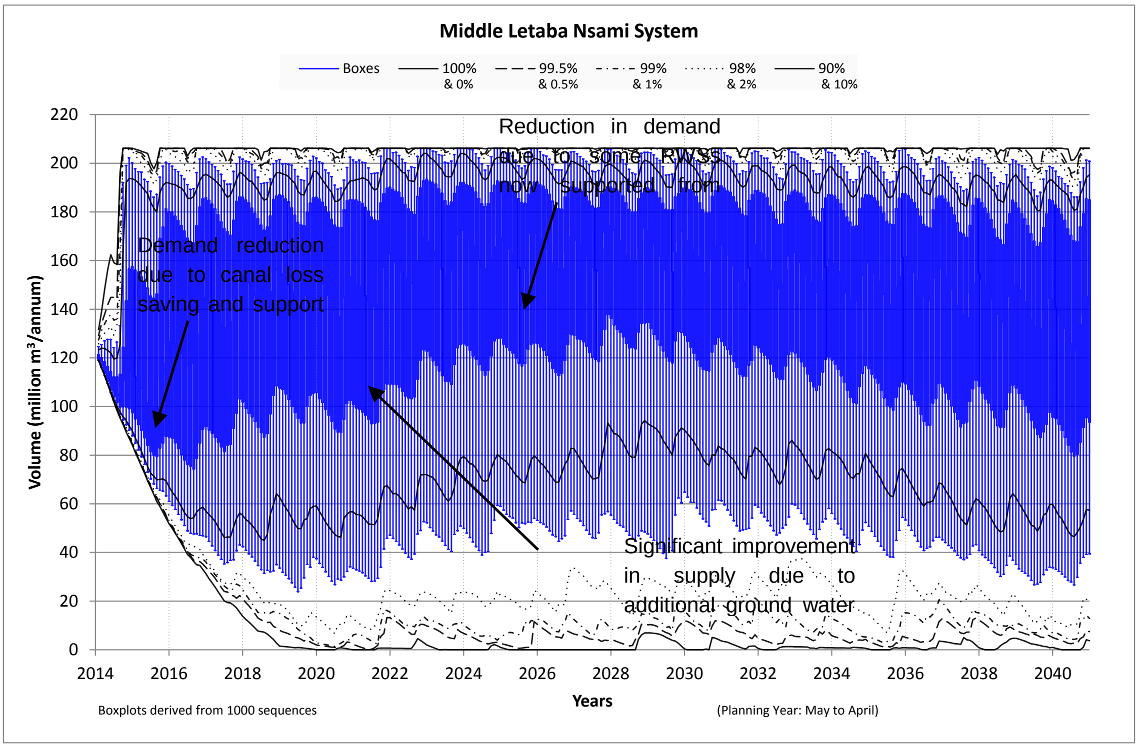

Figure 6-29 : Middel Letaba/Nsami system storage projection

This behaviour is also evident from the water supply plot (**Figure 6.30**) where the system struggled to supply the demands at the required assurance of 98% between 2017 and 2021.

The following intervention options were included in the scenario analysed for the Middle Letaba Nsami System:

- Water conservation and water demand management from 2015 onwards (reduction in demand 2.8 million m^3/a)
- Pipeline to replace the canal between Middle Letaba and Nsami dams, to be in place by 2016. Eliminate canal losses estimated at 4 million m^3/a.
- Pipeline from Nandoni Dam to the Giyani WTW. Support of 5 million m^3/a from Nandoni Dam, available from 2016 onwards.
- Supply some of the RWS committed for support from Nandoni by 2017 (2 million m^3/a)
- Supply the remaining areas committed for support from Nandoni Dam by 2025 (6.6 million m^3/a).
- Additional development of groundwater use by 2021 (12.9 million m^3/a)

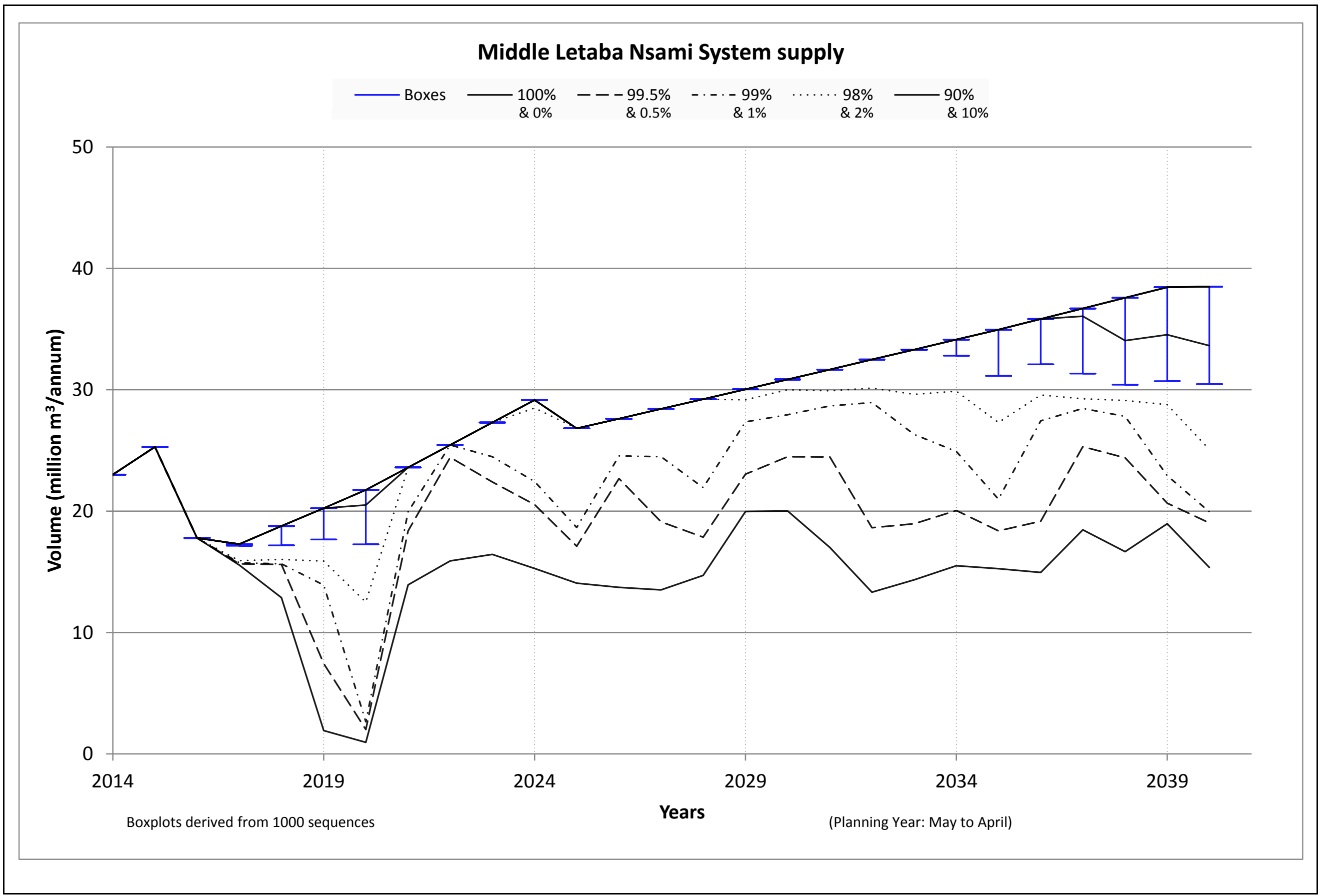

Figure 6-30 : Middel Letaba/Nsami system storage projection

From about 2034 the assurance of supply (98%) is again starting to reduce to unacceptable low levels indicating that another intervention option will be required by then.

6.3 LUVUVHU RIVER SYSTEM AND SUB-SYSTEMS

6.3.1 Background

The Luvuvhu system comprises of several sub-systems of which some are already linked. Nandoni Dam is the largest storage dam in this system and was completed in 2004. Nandoni Dam is currently used to supply part of the Greater Thohoyandou sub-system as well as the RWS downstream of Nandoni Dam. Most of the links between all the sub-systems within this supply area are already in place. This water supply area is shown in **Figure 6.31** and comprises of the following water resources:

- Nandoni Dam
- Vondo Dam
- Phiphidi Dam
- Tshakhuma Dam
- Two package plants abstracting water directly from the river – Dzindzi & Dzingae
- Abstractions from three weirs located in the Luvuvhu River downstream of Nandoni Dam – Malamulele Weir, Xikundu Wei and Mhinga Weir.

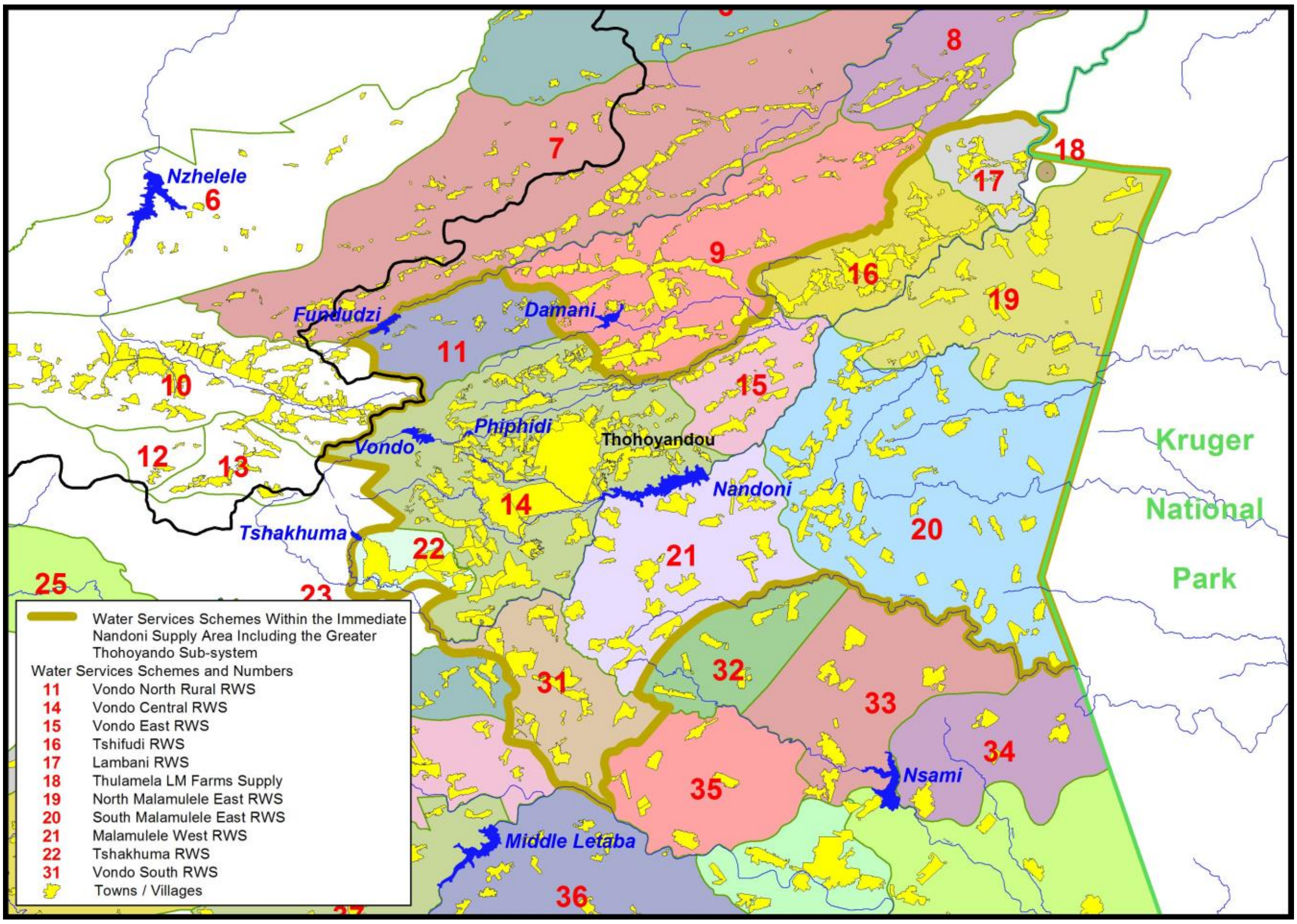

Figure 6-31 : Greater Thohoyandou system and the RWS downstream of Nandoni Dam

Most of the RWS located in the area as defined in **Figure 6.31** already receive water from Nandoni Dam with mainly the high lying areas that is mainly supplied by the existing resources such as Vondo, Phiphidi and Tshakhuma dams.

Pipelines are currently in the process to be installed to service several other areas, mainly to the west and south of the Greater Thohoyandou water supply system, as indicated in **Figure 3.32**. This is referred to as the Integrated Nandoni Water Supply System and includes Albasini Dam in the Upper Luvuvhu River that is currently still being operated as a stand-alone dam. The Integrated Nandoni Water Supply System also includes the transfer to the Giyani WTW to reduce the load on the Middle Letaba/Nsami system as well as support to the Damani water supply sub-system used to supply rural domestic users of which most are located in the Mutale catchment.

Before showing and discussing results from the Integrated Nandoni Water Supply System it is important to obtain an understanding of the Albasini and Damani sub-systems, which is currently still operated as stand-alone sub-systems, with details given in **Section 6.3.2** and **6.3.3** respectively.

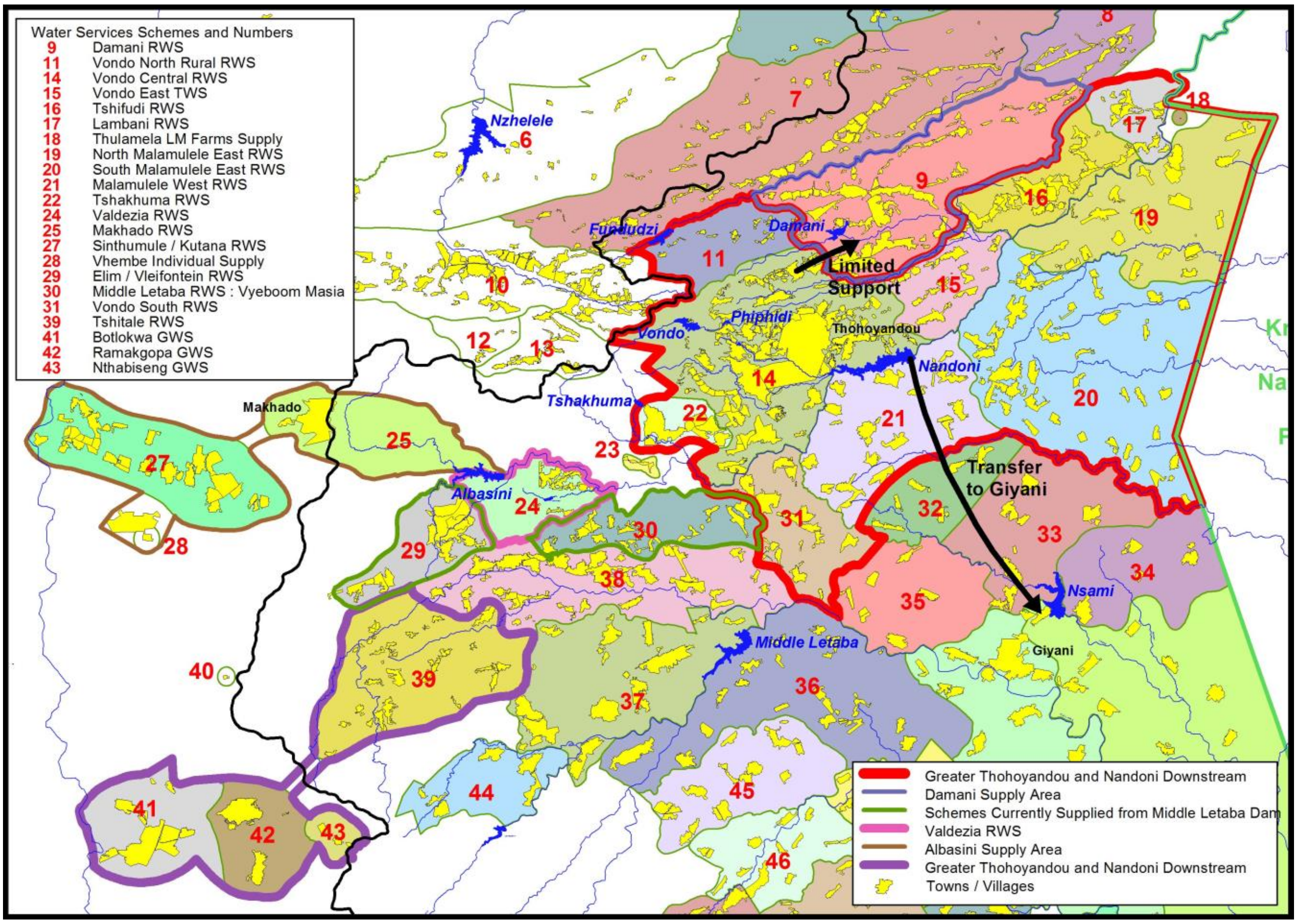

Figure 6-32 : Location of the urban/industrial and rural domestic water services schemes within the Integrated Nandoni Water Supply System

6.3.2 Albasini Dam sub-system

The Albasini Dam sub-system is one of the most stressed sub-systems within the Luvuvhu system. The location of this sub-system and the water services schemes receiving water from the dam is shown in **Figure 6.33**. Over and above these water services schemes, water is also released into a canal system supplying water to irrigation downstream of Albasini Dam. This dam is currently totally over allocated and as a result very seldom supplies any water to the irrigation users with an allocation of 7.3 million m^3/a. Due to the lack of surface water resources, the irrigators have over time started to increase their dependence on groundwater resources in the area. There are limited links from the Makhado RWS to the Sinthumele Kutana RWS and these links are seldom used to supply water to Sinthumele Kutana RWS, due to the stressed resource.

A pipeline is currently under construction to link the Albasini and Nandoni systems, and will allow support from Nandoni Dam to the Makhado RWS, Sinthumele Kutana RWS as well as to the Air Force Base located just south of Sinthumele Kutana. The support from Nandoni Dam will only be used in support of urban/industrial and rural domestic requirements, and is not available to support irrigation requirements.

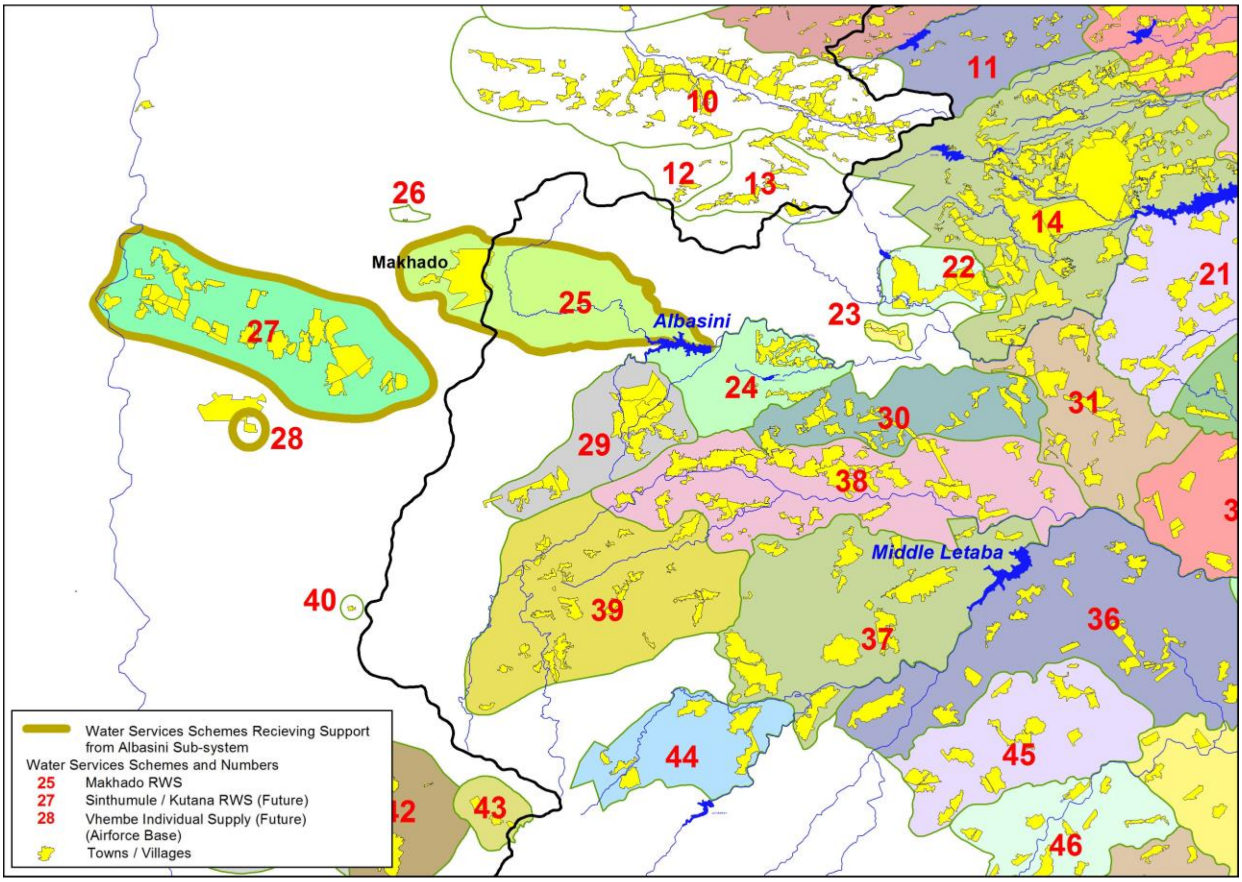

Figure 6-33 : Location of the urban/industrial and rural domestic water services schemes supplied from the Albasini sub-system

The impact of the existing current irrigation from both surface and groundwater resources upstream of Albasini Dam on the water available from Albasini Dam is quite significant, and resulted in a decrease in the Albasini Dam yield of in the order of 8 million m^3/a. Some of this irrigation might be unlawful developments and should be removed once the current validation verification process has been completed. For the purpose of the WRPM analysis the following scenario was considered for the Albasini Sub-system.

- Upstream developments remain as is.
- No irrigation to be supplied from Albasini Dam
- Water conservation and water demand management in the urban sector to be implemented in 2015, reducing the demand by 0.97 million m^3/a.
- Nandoni Dam start to support the Albasini Dam sub-system from 2016 onwards
- Albasini Dam to supply 2.5 million m^3/a in support of the Makhado RWS (98% assurance long term yield)
- Short-term stochastic yield characteristics were not used as part of the Albasini operating rule.
- The maximum possible volume up to 2.5 million m^3/a to be used from Albasini Dam in support of the Makhado RWS, with the remainder of the requirement supplied from Nandoni Dam.

From the Albasini Dam storage projection it is evident that the dam is still slightly over utilised and the 98% exceedance probability storage line from 2025 onwards starts to touch and remain at the m.o.l. for a couple of months on a regular basis. This is due to the fact that this resource was not protected by the use of short-term stochastic yield curves.

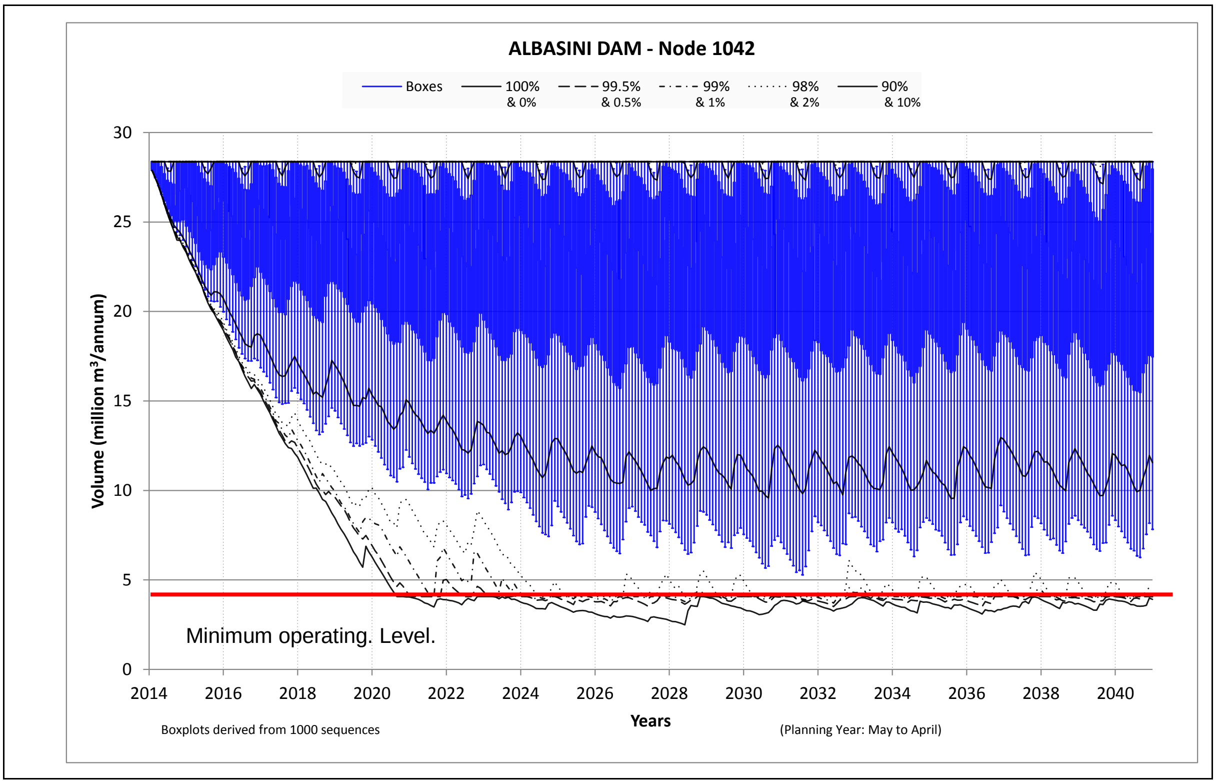

Figure 6-34 : Albasini Dam storage projection

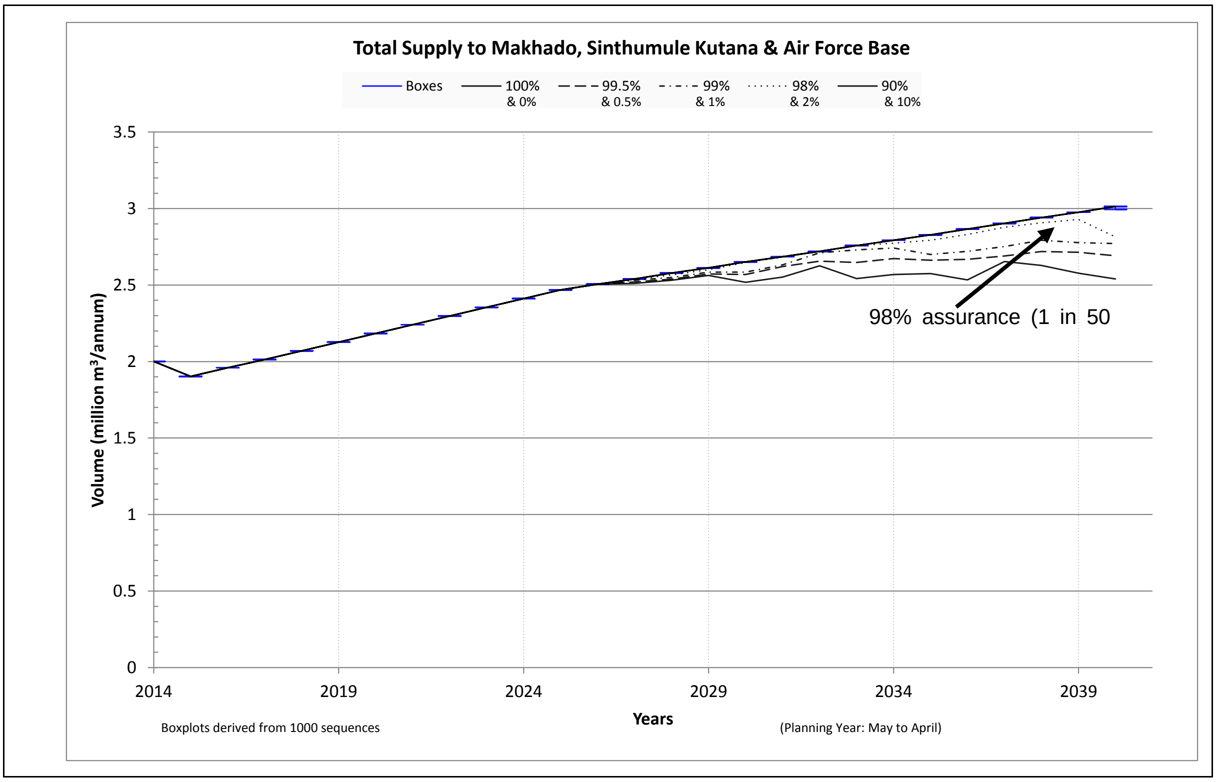

Figure 6-35 : Combined supply from Albasini and Nandoni dams to the extended Albasini water supply system

The demand supply plot (**Figure 6.35**) showing the total supply to Makhado RWS, Sinthumele Kutana RWS as well as to the Air Force Base, indicated that the demands were well supplied until 2039 with only a very small component of the demand that could not be fully supplied at the 98% assurance from 2035 onwards.

6.3.3 Damani Dam sub-system

Damani Dam is located in the Luvuvhu catchment and is used to support both rural domestic and irrigation requirements. The irrigation allocation is 4 million m^3/a, but is currently not yet utilised. The Damani RWS (rural domestic requirement) is supplied from Damani Dam, with the bulk of the scheme located within the Mutale River catchment and a small portion located in the Luvuvhu River catchment.

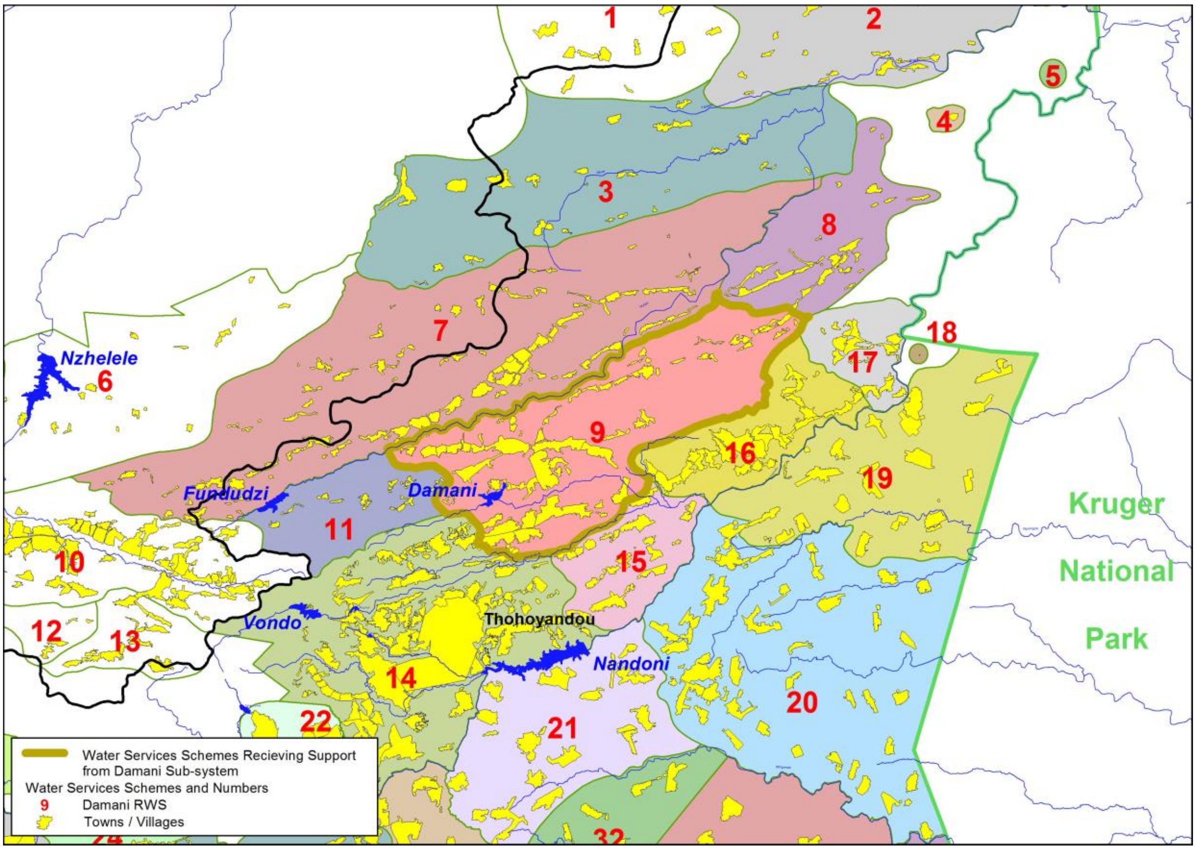

Figure 6-36 : Location of the Damani rural domestic water services scheme supplied from the Damani Dam

For the purpose of the WRPM analysis the following scenario was considered for the Damani Sub-system.

- Water conservation and water demand management in the urban sector to be implemented in 2015, reducing the demand by 0.20 million m^3/a.
- Support from Nandoni Dam from 2017 by a maximum of 0.6 million m^3/a.
- Utilise additional groundwater resources by 2018 (1.9 million m^3/a)
- Receive support of 5 million m^3/a, from a dam in the Mutale River from 2030 onwards.
- No irrigation supplied over the analysis period
- Use short-term stochastic yield characteristics as part of the operating rule of this dam to protect the dam against complete failure.

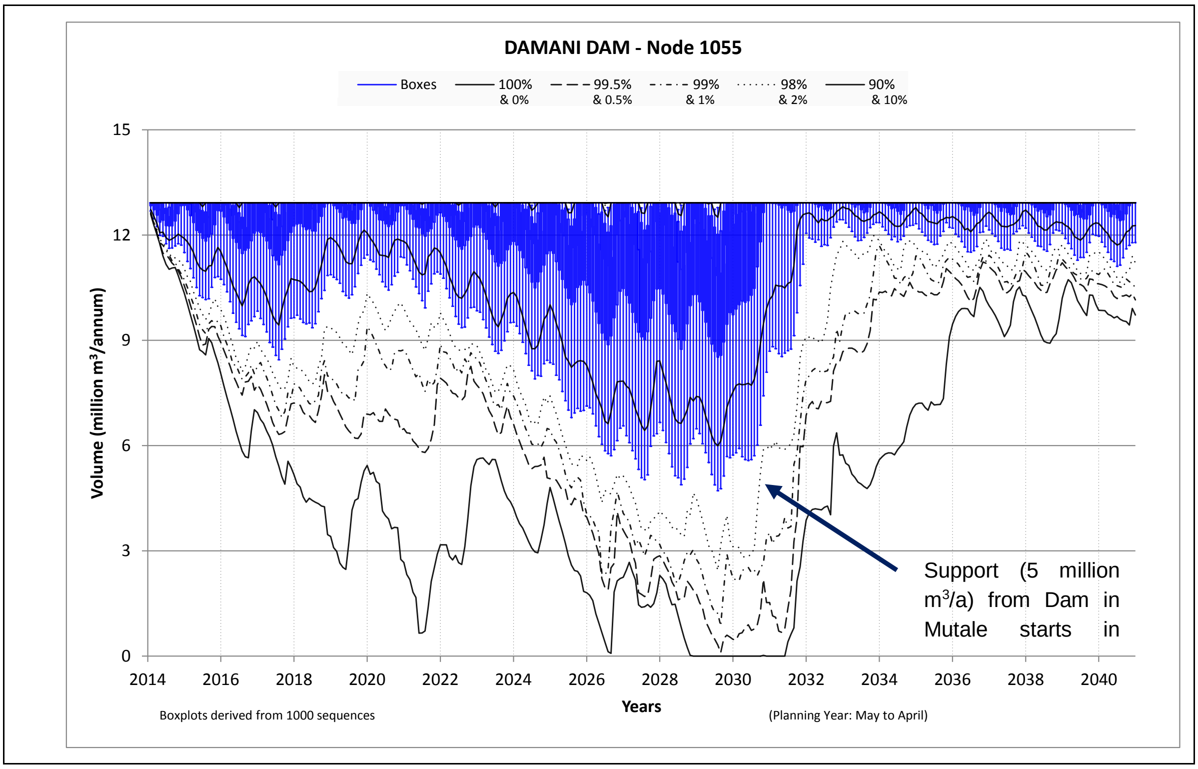

Figure 6-37 : Damani Dam storage projection

From the storage projection plot it is clear that Damani Dam is doing quite well when the irrigation allocation of 4 million m^3/a, is not imposed on the dam. By 2026 the rural domestic requirement increased to just over 7 million m^3/a, and from the demand supply plot one can see the sub-system is starting to have difficulties to maintain the rural domestic supply at a 98% assurance. By 2030 when support is obtained from a dam in the Mutale River, the storage in Damani Dam recovers significantly, indicating that this should be a good time to start with the implementation of the irrigation developments. The small deficits in the 98% assurance supply after 2030 is as result of operating rule impacts related to the Integrated Nandoni System, which requires an intervention option by 2034/35, as Damani Dam was included as part of the set of dams used to support the Integrated Nandoni System.

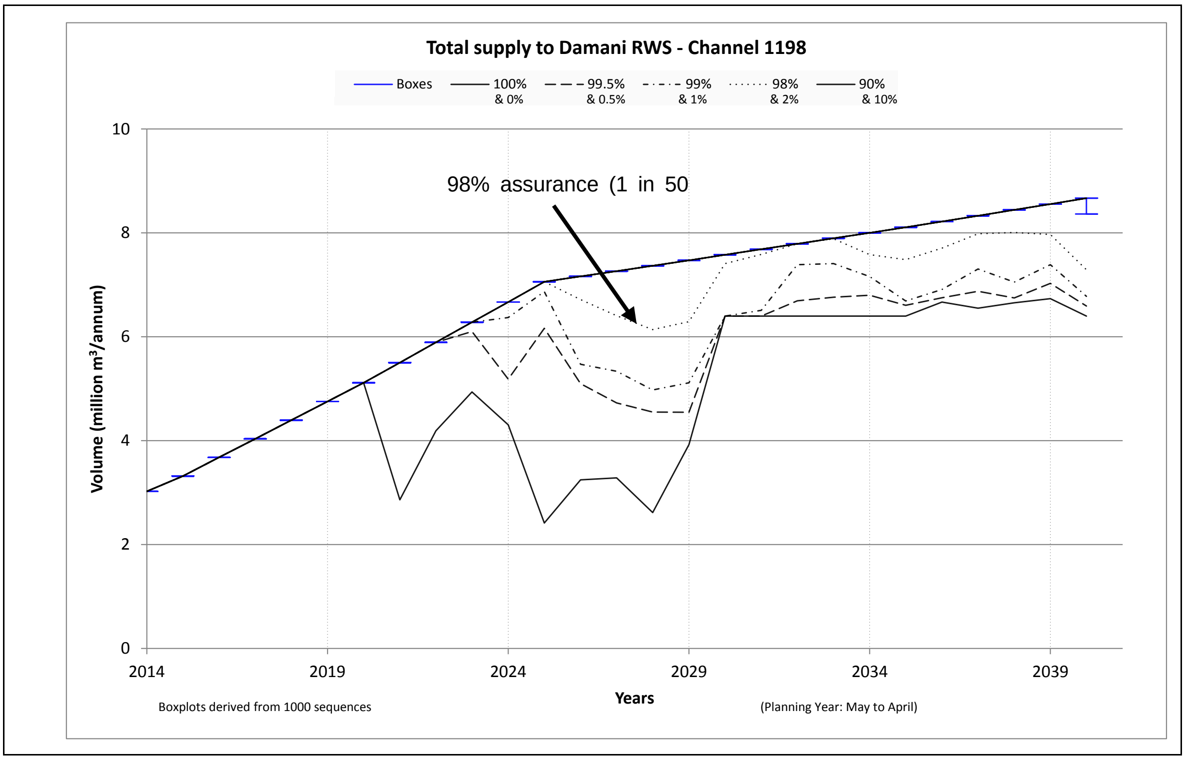

Figure 6-38 : Supply to the Damani RWS from Damani, Nandoni and a Mutale River Dam

6.3.4 Integrated Nandoni Water Supply System

Background to the Integrated Nandoni system was already given in **Section 6.3.1**. The Integrated Nandoni System includes the Albasini Dam and Damani Dam sub-systems as described in **sections 6.3.2** and **6.3.3** respectively.

Intervention options included for the Integrated Nandoni System scenario as analysed with the WRPM comprise of the following:

- Water conservation and water demand management in urban sector of 1.7 million m^3/a by 2015
- Utilise additional groundwater resources of 5.14 million m^3/a by 2025
- Support (7 million m^3/a) received from a future dam in the Mutale River by 2030
- The supply to EWR downstream of Nandoni Dam was included in this scenario over the total analysis period.

The Integrated Nandoni Water Supply System was analysed using short-term stochastic yield characteristics as part of the operating rule to protect the system from total failure. This is evident from the storage projection plot for Nandoni and Vondo dams as the 98% exceedance probability storage levels did not drop to the m.o.l over the analysis period.

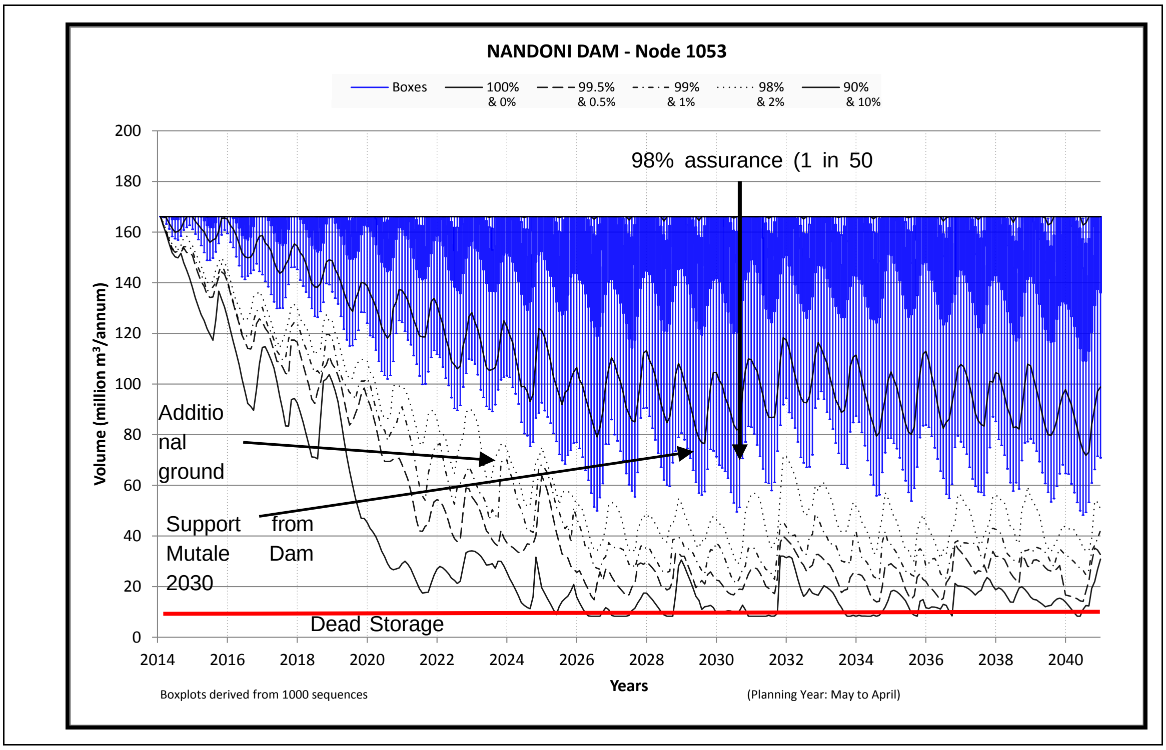

Figure 6-39 : Nandoni Dam storage projection

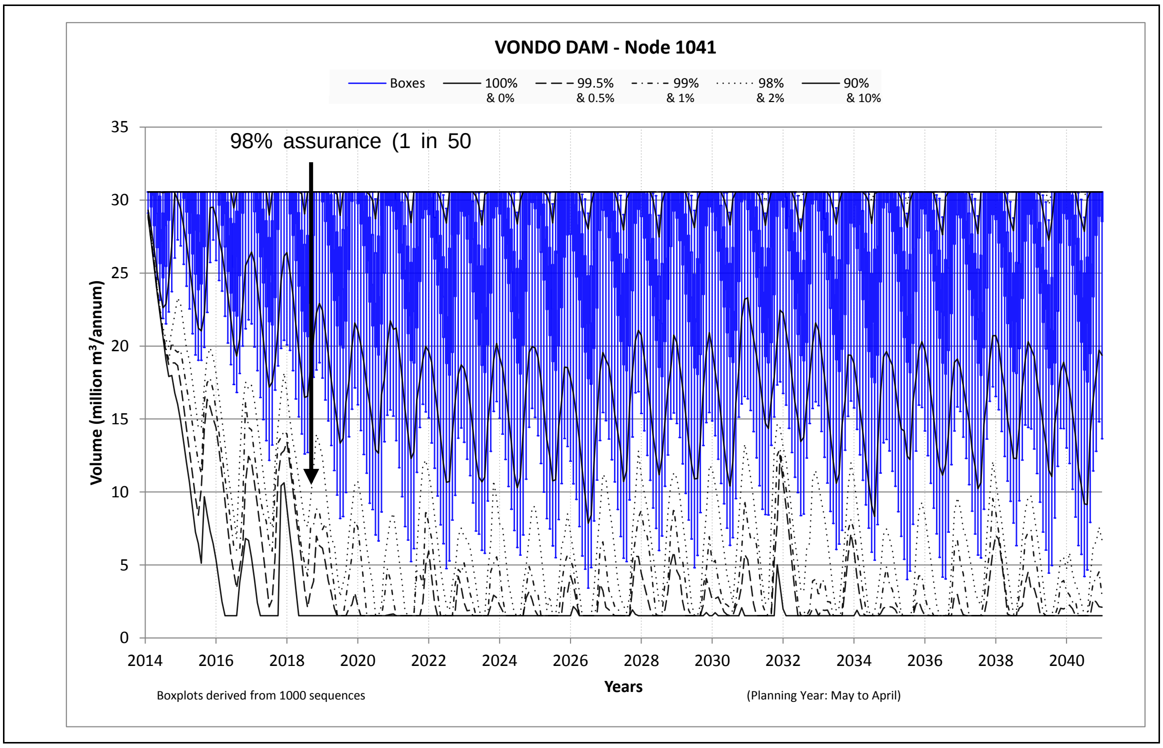

Figure 6-40 : Vondo Dam storage projection

The operating rule dictated that Vondo Dam be used first before Nandoni Dam as less pumping is required from Vondo Dam. This is the reason why Vondo Dam is in general running at lower storage levels than Nandoni Dam. Vondo Dam do need to be protected against total failure as Vondo Dam is the only resource for the irrigation demand to be supplied from the dam. The increase in the Nandoni Dam storage when the additional groundwater resources are utilised is only visible for the one year and is as result of a significant increase in demand imposed on the Integrated Nandoni System in 2025. The increase in the Nandoni storage projection is evident from 2030 to 2034 as result of the 7 million m^3/a support from a future Mutale Dam from 2030 onwards.

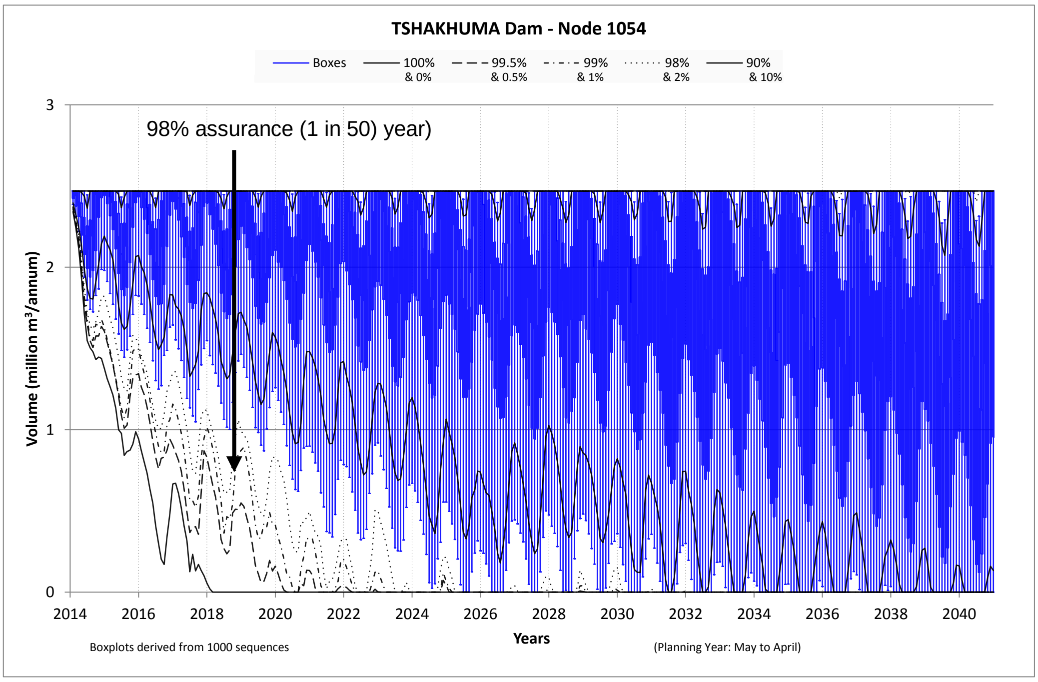

Figure 6-41 : Tshakhuma Dam storage projection

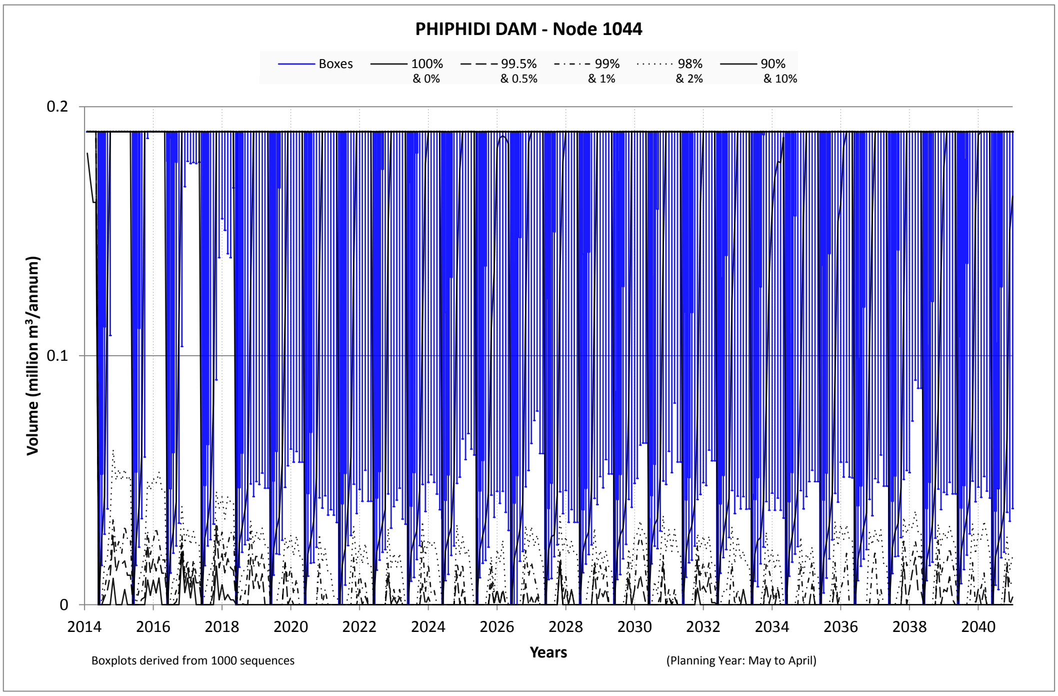

Figure 6-42 : Phiphidi Dam storage projection

Tshakhuma and Phiphidi dams were allowed to be over utilised by the operating rules included in the WRPM, as the demands imposed on these two dams can in most cases also be supplied from Nandoni and/or Vondo dams. These operating rules could however in future be refined to provide an improved balance between the dams.

The combined storage projection of all the dams forming part of the Nandoni Integrated System is given in **Figure 6.43.** As for Nandoni Dam on its own, the storage projection plot for Nandoni Integrated System was well protected by the operating rules as the 98% exceedance probability storage levels did not drop to the m.o.l over the analysis period. In fact these levels were still well above the m.o.l., indicating that the operating rules is too strict and need to be refined.

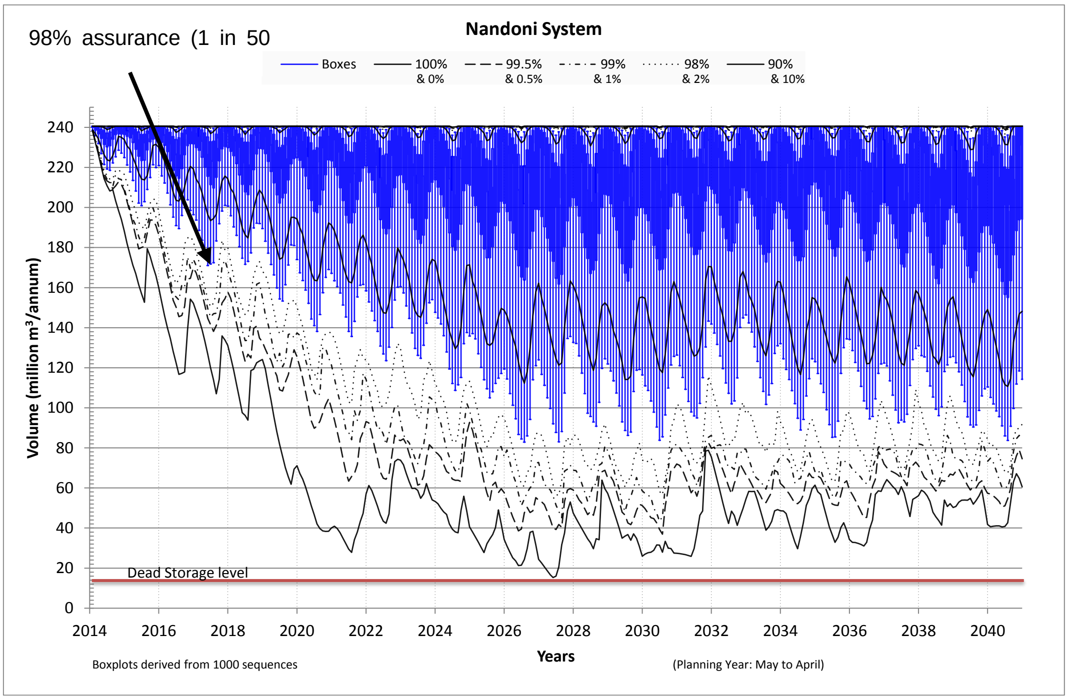

Figure 6-43 : Integrated Nandoni system combined storage projection

The supply to the domestic users from the Integrated Nandoni System achieved the given 98% assurance fully until 2025 (see **Figure 6.44**), where after 10% to 15% of the demand were supplied at a slightly lower assurance, with the remainder still supplied at the required 98% assurance. The refinement of the operating rules enabling the system to utilise the total system storage will improve the assurance of the supply to the Integrated Nandoni System users which should reduce the 10% to 15% of the demand not fully supplied at the 98% assurance from 2025 onwards.

The water balances that were based on the long-term stochastic yield results (DWA, 2014c) as previously prepared, however showed that the integrated system requires the additional groundwater resources to be in place by 2031 to allow the system to be in balance until 2035, thereafter support will be required from a future dam in the Mutale River.

Results from the WRPM analysis required additional groundwater support from 2025 onwards and support from a future Mutale dam from 2030 onwards, thus earlier than that indicated from the long-term yield water balances. This is typically found when the short-term stochastic yield characteristics are used to protect the resources, as it produces more conservative results. The short-term yield characteristics is used to protect the resource from total failure (dam being empty) as evident from the storage projection plots. When a long-term yield result is determined, the maximum possible volume of water is taken from the resource, leading to failures in this process of determining the long-term yield. As result of this approach a more optimistic yield result is produced. The WRPM analysis suggested a slightly higher support from the future Mutale Dam of 7 million m^3/a in comparison with the 5 million m^3/a support obtained from the long-term yield balance.

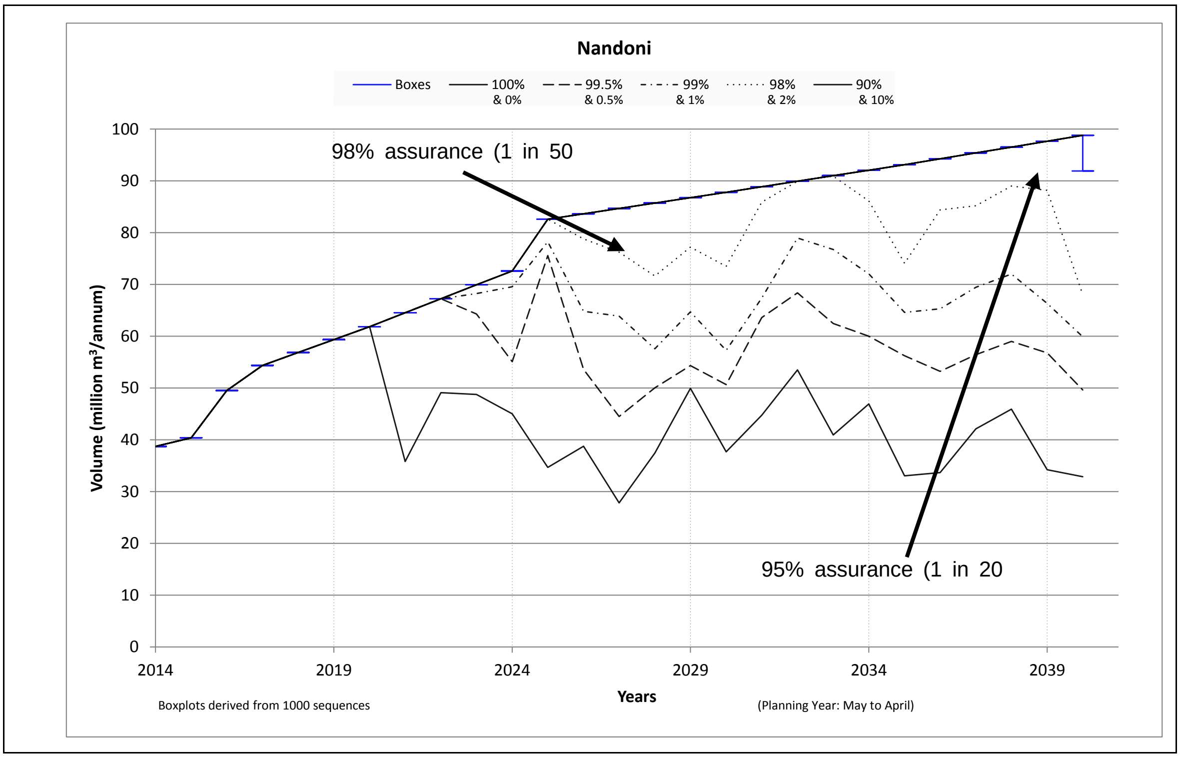

Figure 6-44 : Integrated Nandoni System domestic supply

By using the WRPM in combination with the short-term stochastic yield results, the system simulates what is happening in reality more closely, and should rather be used as the final result for decision and planning purposes than the long-term yield balances.

The supply to the rural domestic users from the Xikundu Weir (See **Figure 6.45**) is slightly better than those for the Integrated Nandoni System as a whole, and is most probably as result of significant incremental inflows into the Luvuvhu River between Nandoni Dam and Xikundu Weir.

The supply to the existing and future irrigation developments allocated to Integrated Nandoni System were supplied at the required assurance of 95% until 2034, but significantly reduced by 2039. Most of the irrigation allocated to Nandoni Dam still need to be developed. There is however uncertainty about the expected rate of the irrigation development and if the total allocated volume in the end will be fully utilised.

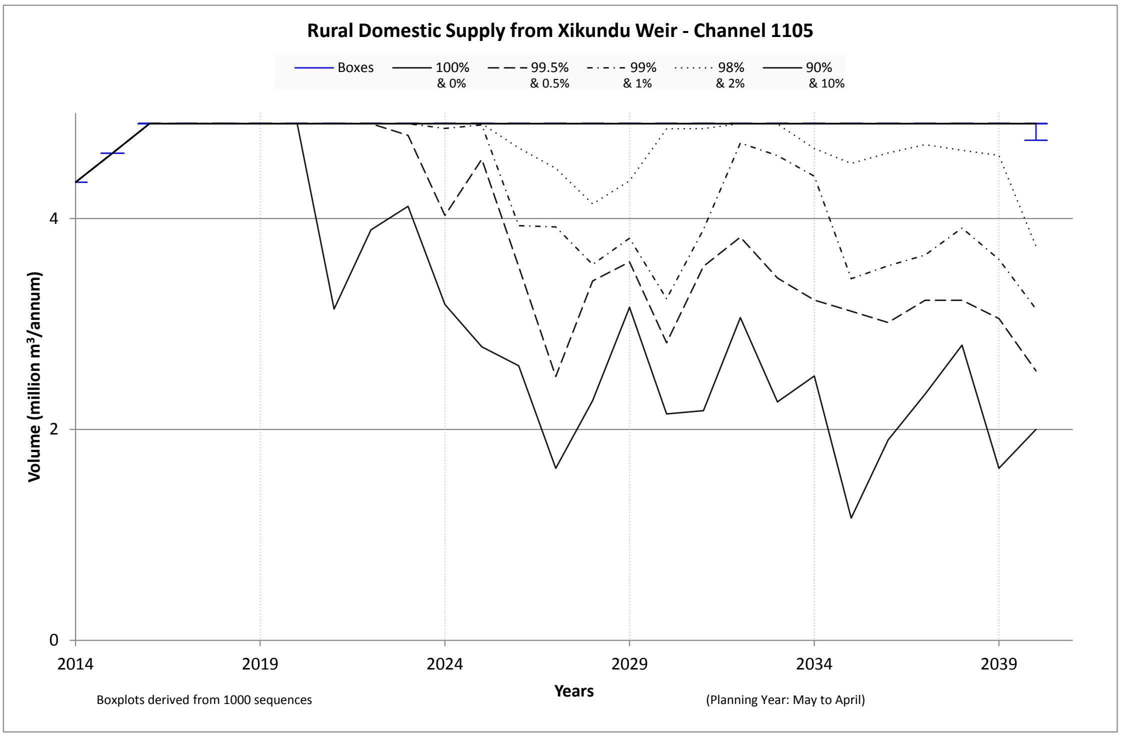

Figure 6-45 : Rural domestic supply from Xikundu Weir with support from Nandoni Dam

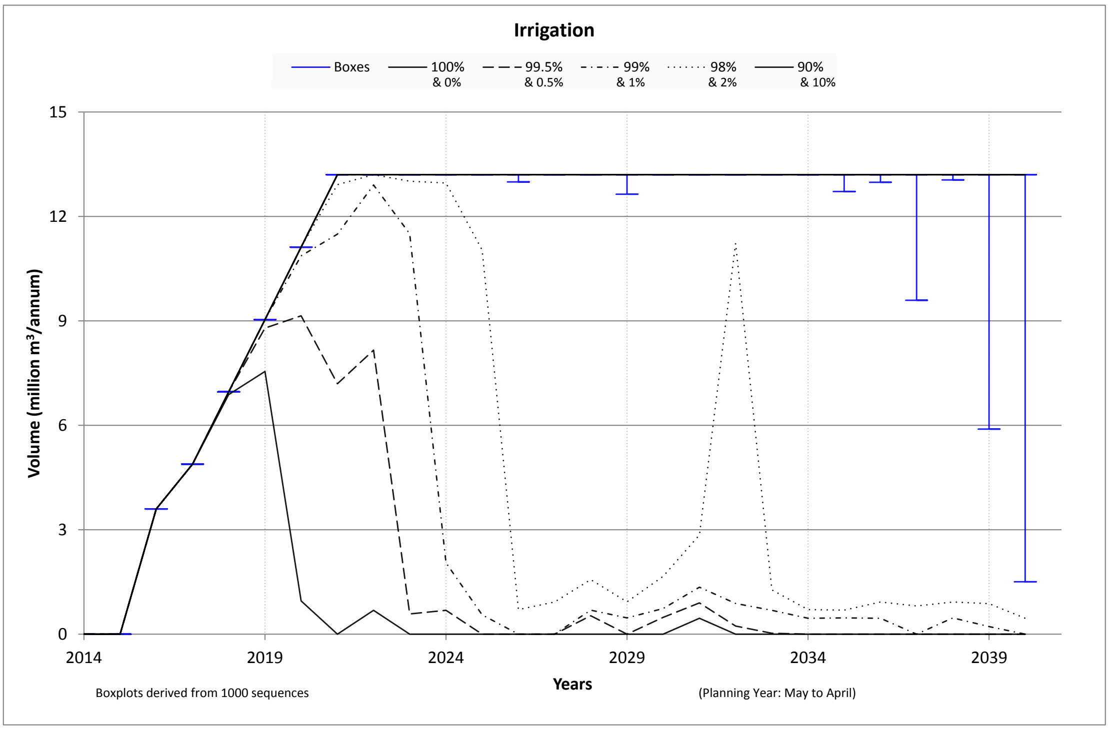

Figure 6-46 : Integrated Nandoni System irrigation supply

6.4 MUTALE RIVER SUB-SYSTEMS

The water services schemes in the Mutale River catchment is currently supplied from groundwater resources and river runoff abstractions. As most of the river runoff abstractions is relative small it is difficult to determine whether these abstractions are supplied at an acceptable level of assurance when using a monthly model.

The intervention options considered for the Mutale system included the following:

- Water conservation and water demand management in urban sector of 0.74 million m^3/a by 2015
- Utilise additional groundwater resources of 2.7 million m^3/a by 2015
- Possible future Rambuda Dam in place by 2024 with 98% (1 in 50 year) assurance yield of 16.7 million m^3/a and 95% (1 in 20 year) if 18.7 million m^3/a

The Rambuda dam site is located in the upper Mutale River. For the purpose of the analysis it was assumed that the support required by the Nandoni system and the Damani RWS as well as for the existing irrigation, will be abstracted directly from Rambuda Dam. Releases from the dam will be made in support of downstream users such as Mutale Town, Mutale Makuya RWS, Luphephe-Nwandezi Main RWS and Masisi RWS. The operating rule used allowed support to the downstream users when the incremental runoff is insufficient to supply these requirements. The first priority water resource to be used by the downstream users is the incremental flows between Rambuda Dam and the downstream users, followed by releases from Rambuda Dam when required.

The storage projection for Rambuda Dam is given in **Figure 6.47**.

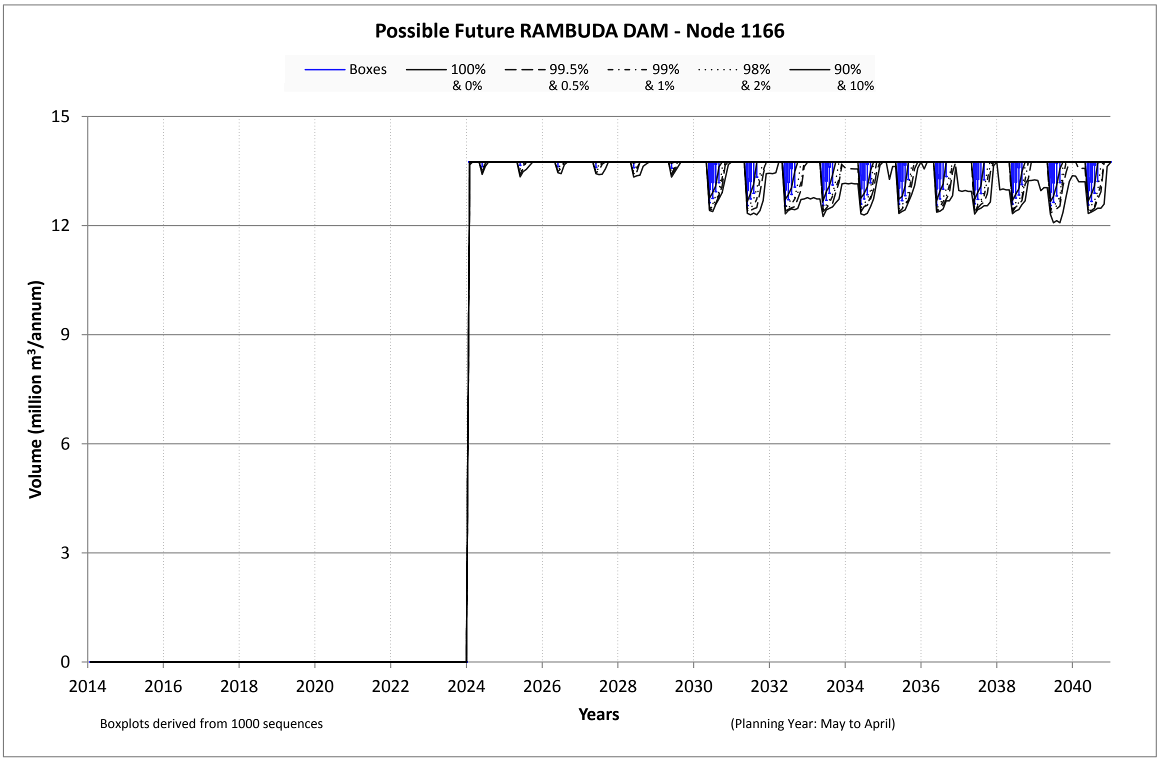

Figure 6-47 : Rambuda Dam storage Projection

The storage projection plot clearly shows that Rambuda Dam is still underutilised for the scenario analysed, although it’s used to support the following set of demands.

- 7 million m^3/a transfer to the Integrated Nandoni system from 2030 onwards
- 5 million m^3/a support to the Damani sub-system from 2030 onwards
- Existing irrigation 2.7 million m^3/a from 2024 onwards.

- Mutale Town 1.97 million in 2024 increasing to 2.8 million m^3/a by 2040
- Mutale Makuya RWS 0.23 million m^3/a in 2024 increasing to 0.35 million m^3/a by 2040
- Luphephe-Nwandezi Main RWS 0.50 million m^3/a in 2024 increasing to 0.88 million m^3/a by 2040
- Masisi RWS and mine 0.59 million m^3/a in 2024 increasing to 0.77 million m^3/a by 2040

Thus although the total demand imposed on the dam is almost equal to the system yield, the dam is still underutilised. This is as result of the high incremental inflows downstream of the dam, while the downstream demands are relative small. On a monthly basis the flows in the river is for most of the time then sufficient to always supply in the required demand without releasing water from Rambuda Dam. The water supply plot is given in **Figure 6.48** and shows a very high assurance of supply.

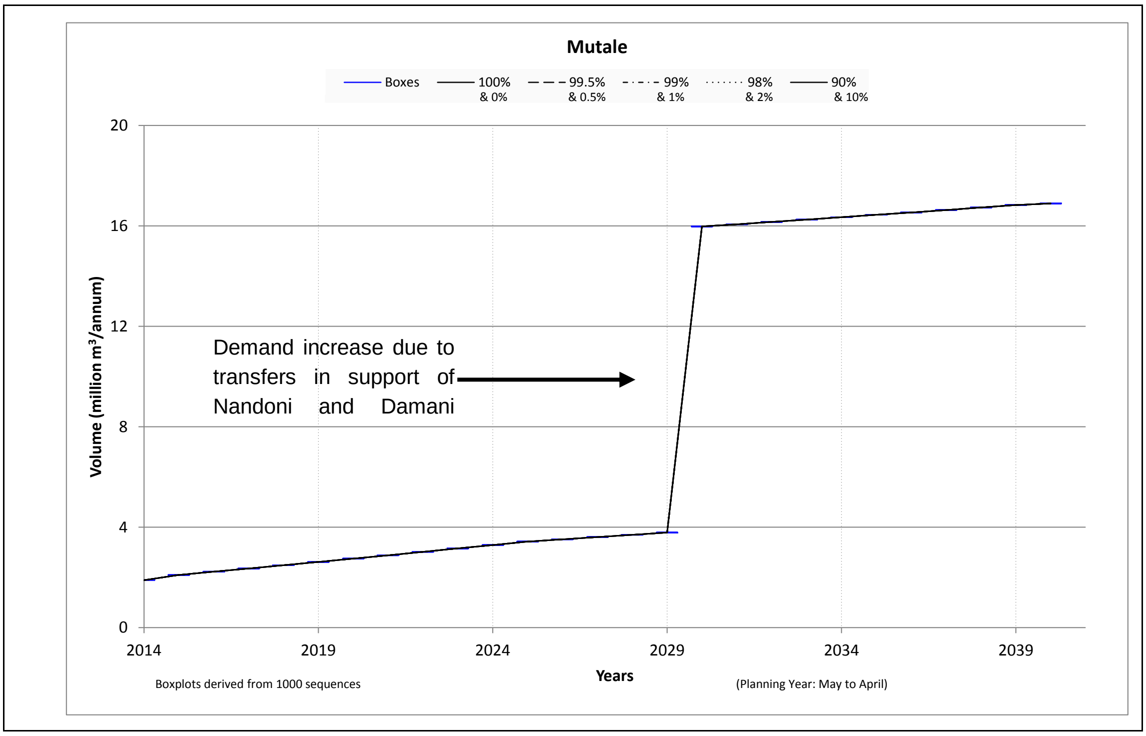

Figure 6-48 : Rambuda Dam System Supply

The demand supply graph for the total system for all the demands domestic and irrigation as well as the transfers to the Nandoni and Damani systems, shows no deficits over the total simulation period even before Rambuda Dam was in place.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 GROOT LETABA RIVER SYSTEM AND SUB-SYSTEMS

- Due to the over utilization of Dap Naudé Dam the assurance of supply from this resource is not very good. This can however be counteracted by means of the higher assurance supply from Ebenezer as well as from the other resources used by Polokwane. It will thus still be beneficial for Polokwane to keep on operating Dap Naudé Dam in this manner as it will increase the total average transfer volume to Polokwane.

- The Groot Letaba Main System was simulated in the WRPM based on the existing operating rules. Short-term stochastic yield characteristics were therefore not used to protect this system against failures. It was found that the operating rule was too conservative and the zero allocation to irrigation from the 15% level and lower was dropped to 5%, to be able to better utilize the storage in the dam. The rule however requires further adjustment as from the final results it was evident that the resources were not sufficiently protected against failures.
- The assurance of supply to the urban/industrial and rural domestic users from the Groot Letaba Main System was in general reasonable but slightly below the target of 98% (1 in 50 year that was set for these users.
- Nwamitwa Dam improved the assurance of supply to the users. It took approximately 5 to 6 years for Nwamitwa Dam to fill and for the storage levels to stabilise before the advantage of Nwamitwa Dam was evident. This is due to the fact that the Groot Letaba Main System is over utilized which is clearly illustrated by the results and the fact the existing operating rule cut the supply to irrigation by 50% when the storage in the dam drops to below 95%.
- The strict restriction rules imposed on the Groot Letaba Main System is clearly demonstrated when examining the supply to irrigation, showing an extremely low assurance supply to 50% of the irrigation demand. The remaining 50% are however supplied at a similar assurance as that evident for urban/industrial requirements, which is higher than what is normally required for irrigation purposes. This also indicates that the existing restriction rules need some refinement to achieve a more optimal use of this resource.
- The water balances prepared from the long-term stochastic yield analysis indicated that a next intervention option is required by 2030 to be able to maintain the required water balance for the Groot Letaba Main System. The WRPM analyses showed that intervention will be required by 2033 to 2034, thus a few years later. The restriction and operating rules as used for the WRPM analysis purposes however do require refinements which will impact on the given dates for the next intervention option.
- The Magoebaskloof Vergelegen Dam Sub-system is currently underutilised, but this depends strongly on when or whether the full irrigation allocation will be taken up again in future. If the full irrigation allocation is taken up again and the growth in the domestic requirements is imposed on this sub-system, deficits in the water supply will start to occur and the supply will then in general be at unacceptable low assurance levels. Over and above this Lepelle Northern Water has submitted a licence application to obtain even more water from this resource, which will decrease the assurance of supply further. The only option to obtain more water for the domestic sector from this sub-system, will be to exchange some of the current unutilised irrigation allocation from the Magoebaskloof Vergelegen sub-system for domestic purposes. In this process of exchange it should be taken into account that irrigation is supplied at a lower assurance than domestic/industrial requirements. In the event of such an exchange of water allocation the process as laid down in the National Water Act must be followed.
- Both Thabina and Thapane dams are currently over utilised and are not able to supply their users at the required assurance levels. From 2020 onwards some of the demand load on these two dams as well as the expected future demand growth were taken of these dams and imposed on the future Nwamitwa Dam. This significantly improved the water supply

assurance from these two dams, to almost adhere to the required 98% assurance. The demands moved onto Nwamitwa Dam were in general well supplied at the required assurance of 98% until 2033/34. This also indicates that some refinements might still be required on the demand split and the operating rules for these two small sub-systems.

- Modjadji Dam is able to supply the growing demand imposed on the dam until 2018, where after the assurance of supply will start to reduce to below the 98% target assurance. The protection of Modjadji Dam against complete failure by means of the short-term stochastic curves was well achieved, although the protection obtained is somewhat on the conservative side. Some refinement can therefore be done on the short-term curves that should also improve the assurance of supply from Modjadji Dam. From 2021 onwards the growth in demand imposed on Modjadji Dam was supplied from the Middle Letaba system, to be able to reduce the load on Modjadji Dam. The Middle Letaba system was able to support this growing demand at the required assurance of 98% until 2033 thereafter the assurance of supply was decreasing towards unacceptable low levels. The demand component to be supplied from Modjadji Dam from 2021 onwards, seems a bit too high and will require some refinement.

7.2 MIDDLE LETABA NSAMI SYSTEM

- The Middle Letaba Nsami system is already over utilised and the recommended intervention options need to be in place as soon as possible, preferably not later than the indicated target dates.
- The short-term stochastic yield characteristics used to protect the resource worked well as indicated by the dam storage projections.
- The development of additional groundwater resources is crucial and a feasibility study to confirm the availability of these resources need to take place as soon as possible.
- The water supply results indicated that another intervention option will be required by about 2034. The water balances that were based on the long-term stochastic yield results as previously prepared however showed that the system should be in balance until 2040, which is 6 years later than the date from the WRPM analysis. This is a typical result when short-term stochastic yield characteristics is used to protect the resource as it produces more conservative results. The short-term yield characteristics is used to protect the resource from total failure (dam being empty) as evident from the storage projection plots. When the long-term yield is determined the maximum possible volume is taken from the resource leading to failures in the process of determining the long-term yield, thus deriving a more optimistic yield result. The WRPM simulates what is happening in reality more closely, and should rather be used as the final result for decision and planning purposes. Further refinements of the operating rules can also assist towards a more optimal use of the resource.

7.3 LUVUVHU RIVER SYSTEM AND SUB-SYSTEMS

- The Albasini Dam sub-system is the most stressed sub-system within the Luvuvhu catchment.

- The combined support from Albasini and Nandoni dams with no irrigation demand imposed on Albasini Dam will be able to maintain the assurance of supply to Makhado RWS, Sinthumele Kutana RWS and the Air Force Base until 2039.
- The irrigation supply from Albasini Dam should be reconsidered once the Validation/Verification study on water use in the catchment have been completed.
- The Damani Dam will not be able to support both the rural domestic and irrigation requirements allocated to this dam.
- Damani Dam with limited support from Nandoni Dam will be able to supply the rural domestic requirements until 2026 where after the sub-system starts to experience difficulties to maintain the rural domestic supply at the 98% assurance.
- By 2030 when support is obtained from a dam in the Mutale River, the storage in Damani Dam recovers significantly. This will then allow to start with the implementation of the irrigation developments allocated to Damani Dam.
- The Integrated Nandoni System is the only system in the Luvuvhu River catchment which is currently not yet fully utilised. Volumes for future use were however already allocated to various users, mainly for domestic water use purposes but also for irrigation downstream of Nandoni Dam.
- These allocations were included as demands imposed on the Integrated Nandoni System at assumed dates, due to the lack of proper planning dates. When all these allocated and existing demands and related growth projections are imposed on the system, it is clear that the Integrated Nandoni system is already over allocated and will require further intervention options from 2025 onwards, depending on the timing when the different demand centres are phased in, including the possible future irrigation developments.
- The EWR imposed on Nandoni Dam was obtained from a desk top estimate and can be significantly different from the reserve, still to be determined. This can result in quite a different water balance than that obtained from the current WRPM analysis.
- Increasing the storage capacities of the weirs downstream of Nandoni Dam can due to the large incremental inflows, significantly increase the system yield and should be investigated in comparison with appropriate operating rules.
- The future link from Nandoni Dam to the Damani Dam supply area will not be worth wile for the scenario when a future dam in the Mutale River is considered, as the Damani RWS is largely located within the Mutale River basin and reasonably close to the possible Mutale River Dam sites.
- Refinement of the operating rules within the Integrated Nandoni System are in general required and should result in improved water balances.
- In all the sub-systems where short-term stochastic yield results were used as part of the operating rule, a very simple priority classification was used. All urban and rural domestic requirements were allocated to a 98% (1 in 50 year) assurance and irrigation requirements to a 90% (1 in 10 year) assurance. These assurances need to be clarified with the users as some of the Urban/ domestic can be supplied at a higher assurance and some at a lower assurance than the 98% used in all the analysis carried out for this study. The same also apply to the irrigation sector. Applying a more detailed user priority classification to the model will also impact on the water supply situation and implementation dates of future intervention options.

7.4 MUTALE RIVER SYSTEM

- Although the total demand imposed on the possible future Rambuda Dam slightly exceeded the long-term yield, the Rambuda storage projection plot Cleary showed that the dam was not fully utilized. This is due to incremental flows generated downstream of the possible Rambuda Dam which is partly used to supply the downstream requirements.
- More detailed and refined analysis will be required for the Mutale River system:
    - once more information of the actual location of all abstraction points are available
    - the proposed layout and required infrastructure of the future supply system is known
- Based on the WRPM analysis with Rambuda Dam in place it seems that sufficient water will be available to supply all the projected future demands. It is possible that the transfer volume to the integrated Nandoni System can be increased to improve the water supply in the Nandoni System from 2035 onwards.

8 REFERENCES

DWA, 2013. **Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System: Literature Review Report, P WMA 02/B810/00/1412/2.** Prepared by WRP Consulting Engineers (Pty) Ltd in association with DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting

DWA, 2014. **Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System: Hydrology Report, P WMA 02/B810/00/1412/5.** Prepared by WRP Consulting Engineers (Pty) Ltd in association with DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting

DWA, 2014b. **Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System: Yield Analysis Report, P WMA 02/B810/00/1412/12.** Prepared by WRP Consulting Engineers (Pty) Ltd in association with DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting

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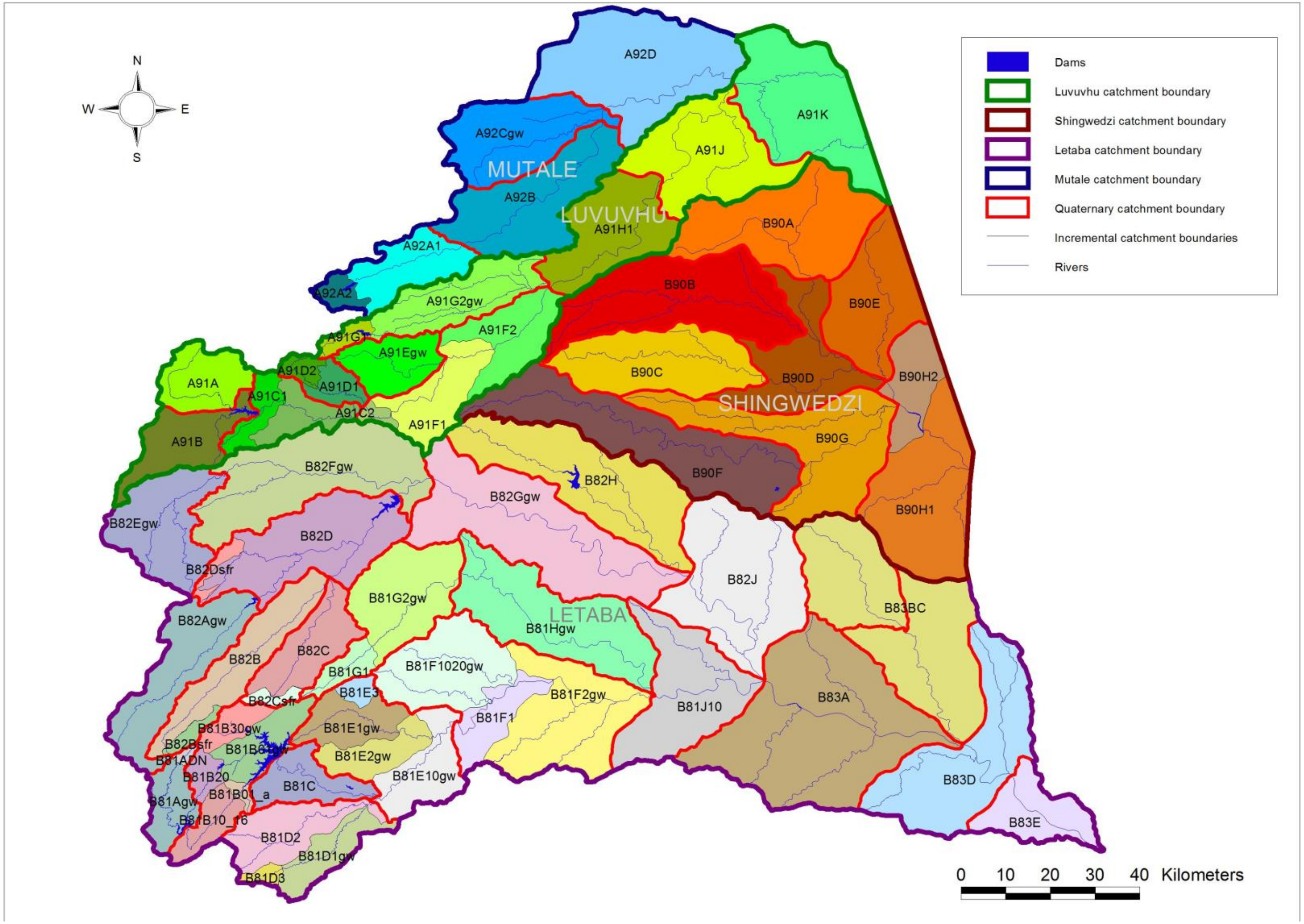
DWA, 2014d. **Development of a Reconciliation Strategy for the Luvuvhu and Letaba Water Supply System: Water Requirements and Return Flow Report, P WMA 02/B810/00/1412/3**. Prepared by WRP Consulting Engineers (Pty) Ltd in association with DMM Development Consultants, Golder Associates Africa, Worley Parsons, Kyamandi, Hydrosol and Zitholele Consulting

Appendix A

Figures



N
W
E
S
Dams
Luvuvhu catchment boundary
Shingwedzi catchment boundary
Letaba catchment boundary
Mutale catchment boundary
Quaternary catchment boundary
Incremental catchment boundaries
Rivers
MUTALE
LUVUVHU
SHINGWEDZI
LETABA
A92D
A92Cgw
A92B
A92A1
A91K
A91J
A91H1
A91G2gw
A91F2
A91Egw
A91A
A91C1
A91D2
A91D1
A91C2
A91F1
A91B
B90A
B90B
B90E
B90C
B90D
B90H2
B90G
B90F
B90H1
B82Fgw
B82H
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B82Egw
B82D
B82Dsfr
B82J
B81G2gw
B82Agw
B81Hgw
B83BC
B82B
B82C
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B81D1gw
B81D3
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B81Agw
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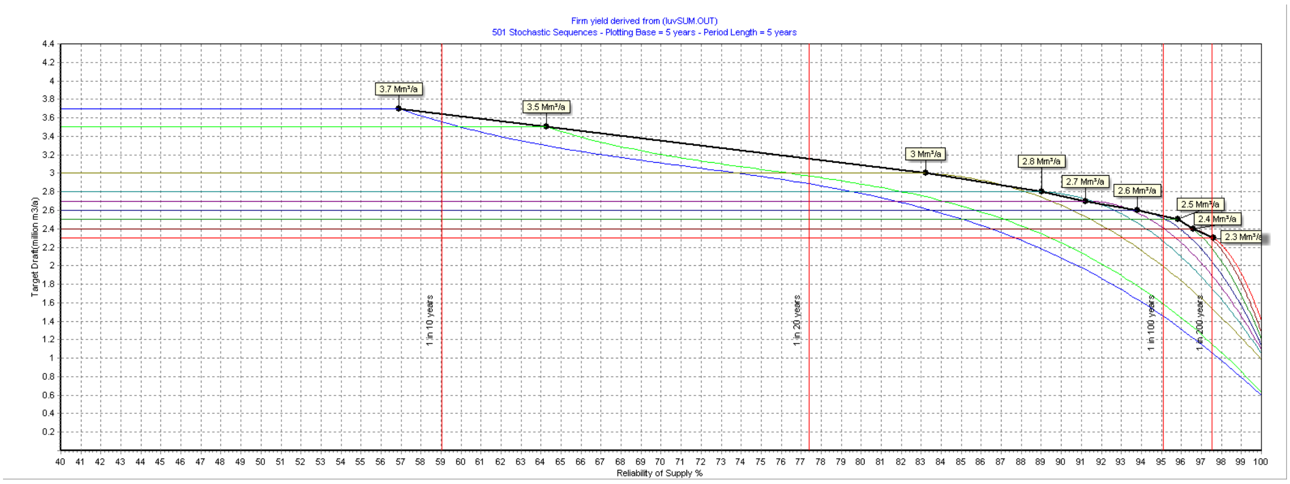
10
20
30
40
Kilometers

Appendix B

Short Term Curve Plots

Dap Naude

100%



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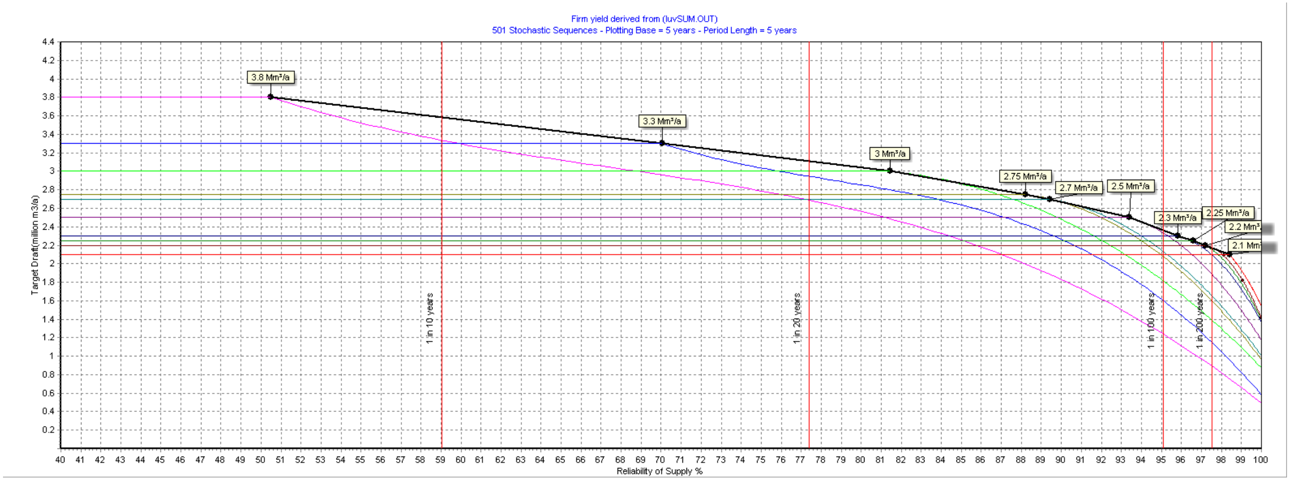

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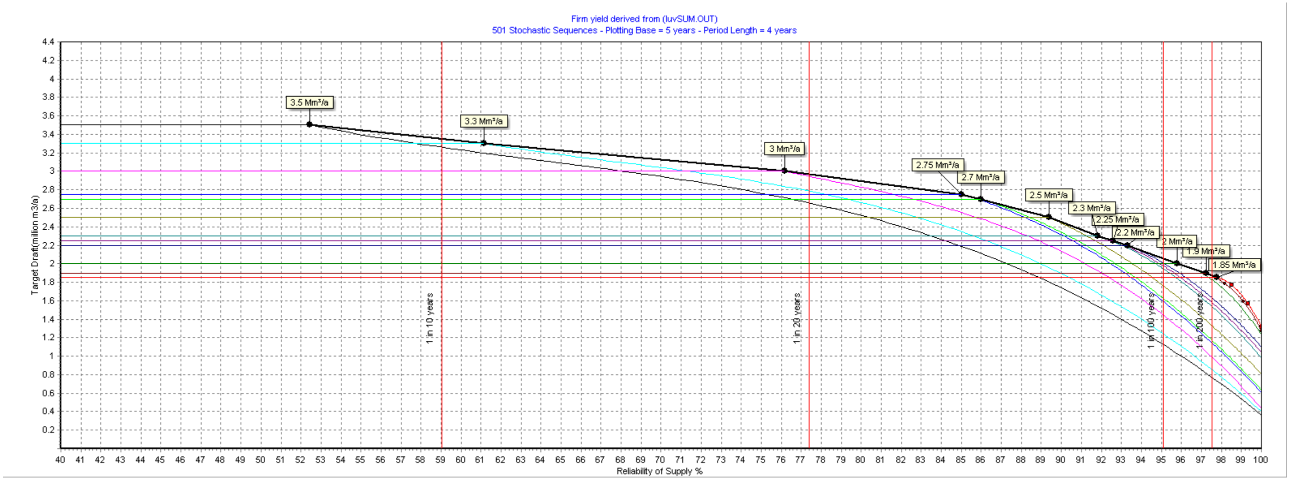

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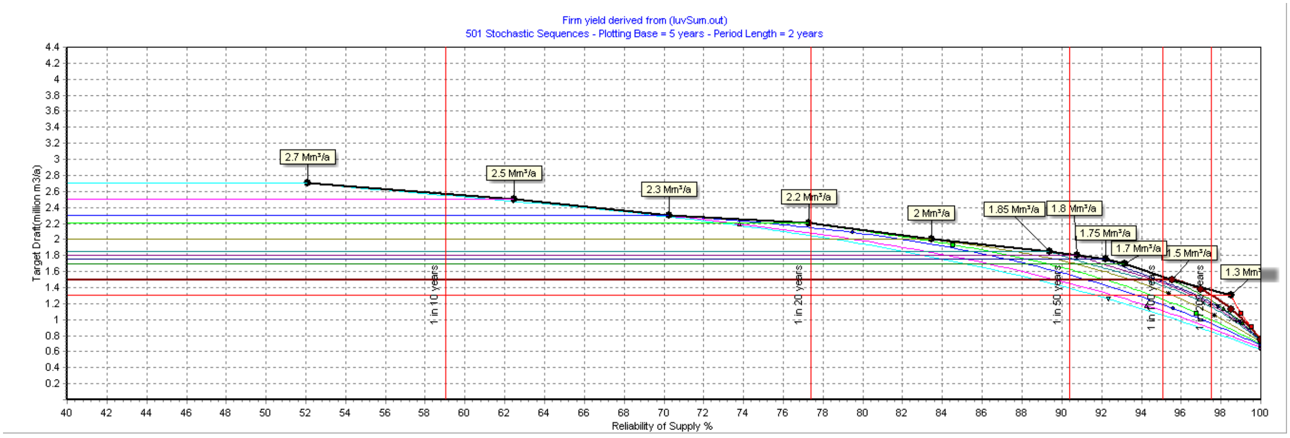
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Target Draft(million m3/a)
Reliability of Supply %

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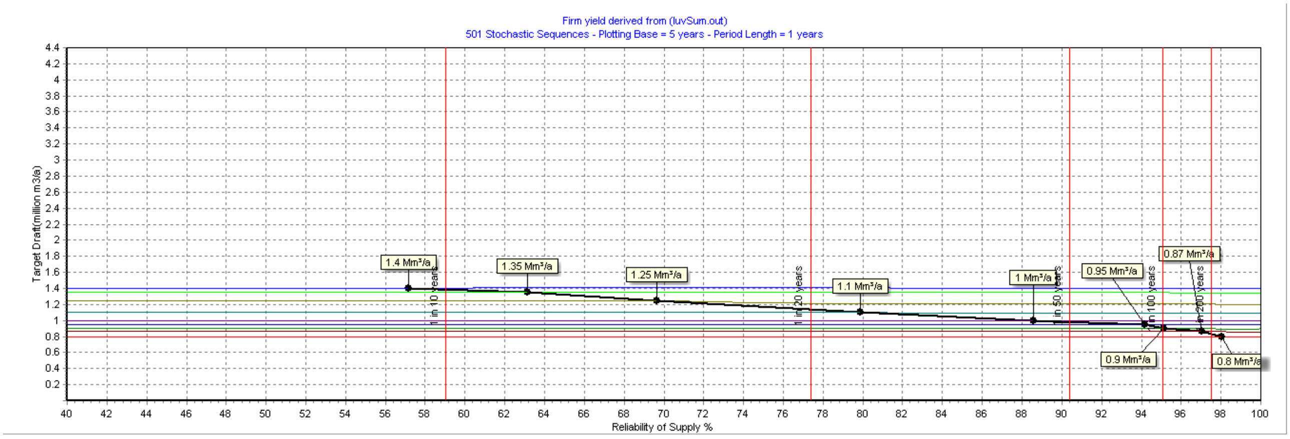
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Reliability of Supply %

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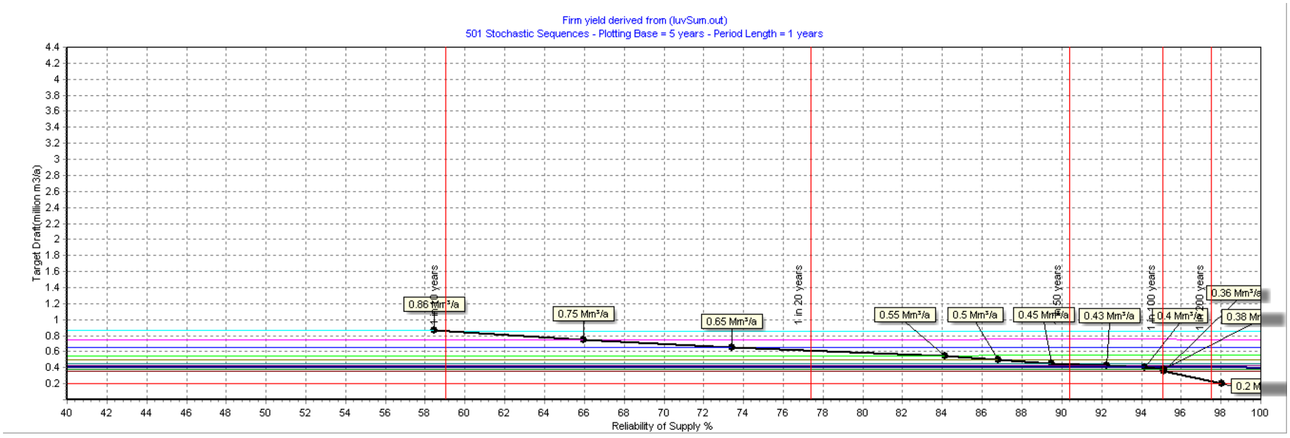
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Dap Naude and Ebenezer Dams

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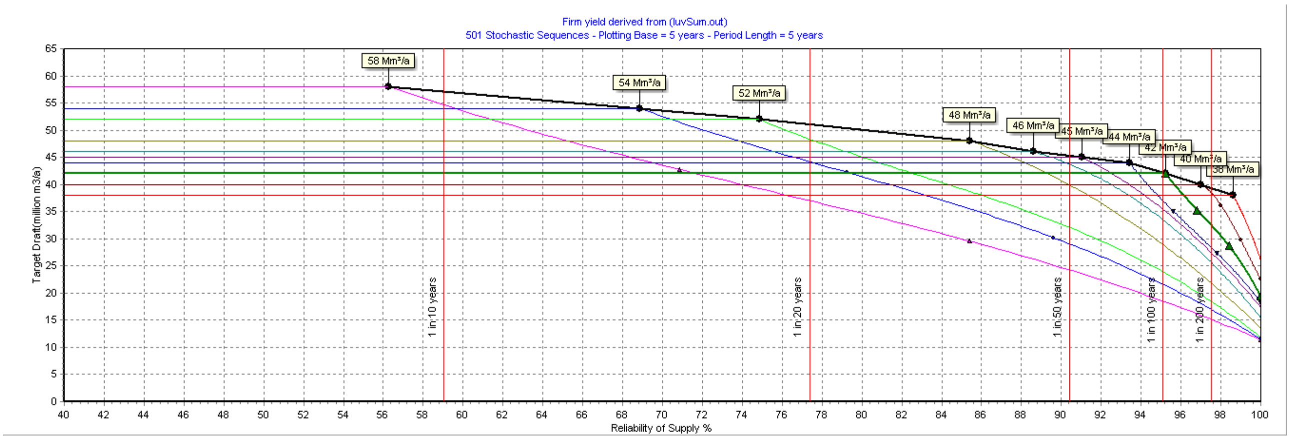

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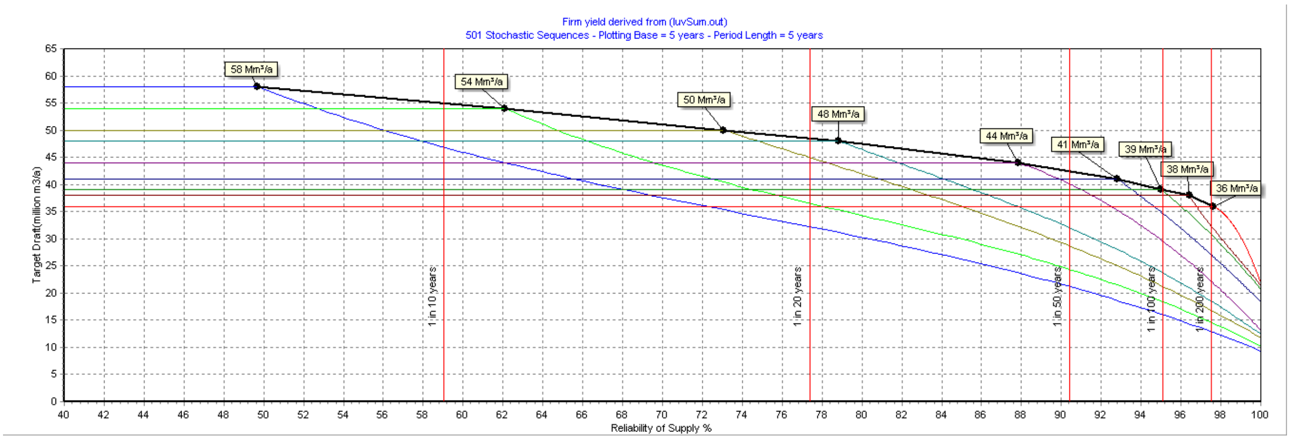

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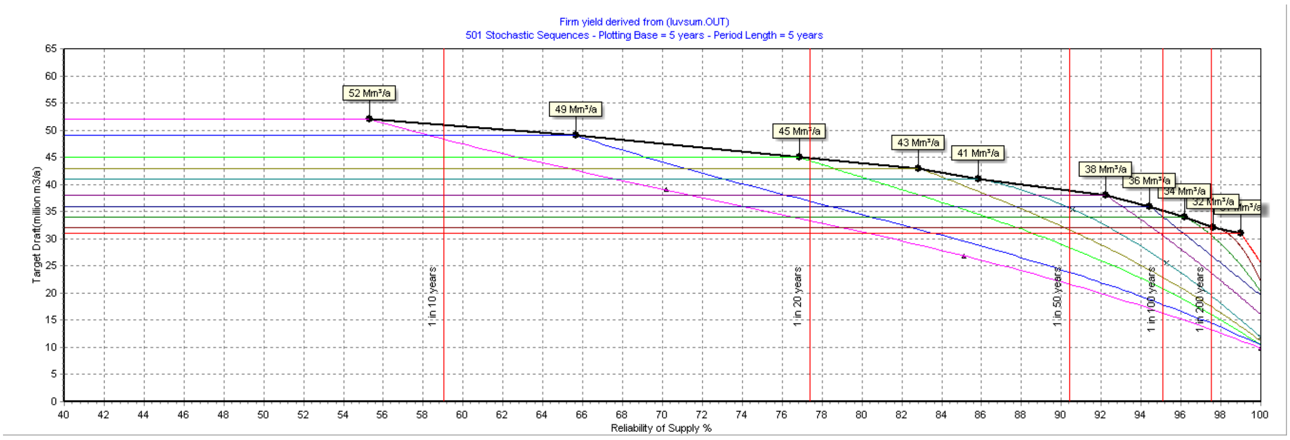

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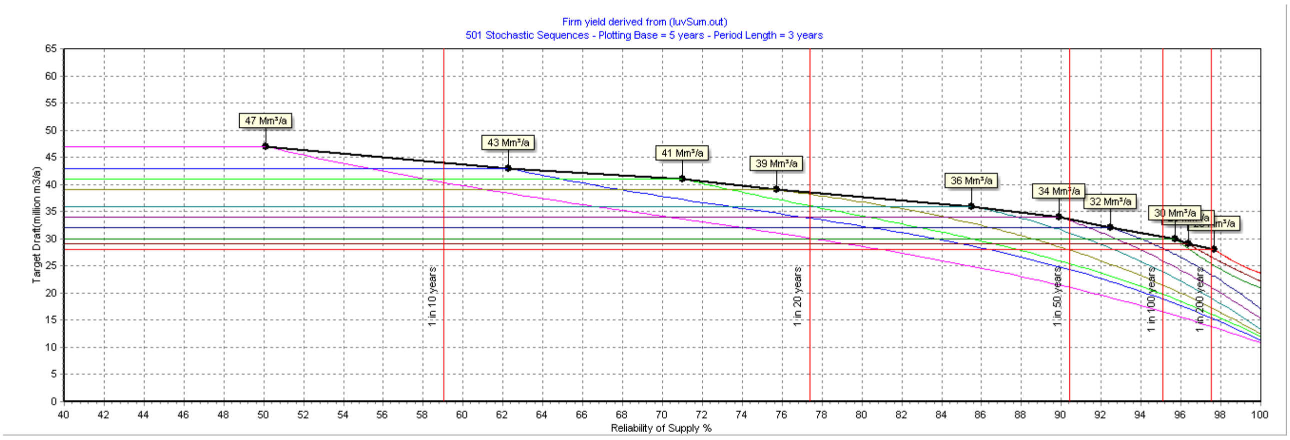

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Target Draft(million m3/a)
Reliability of Supply %
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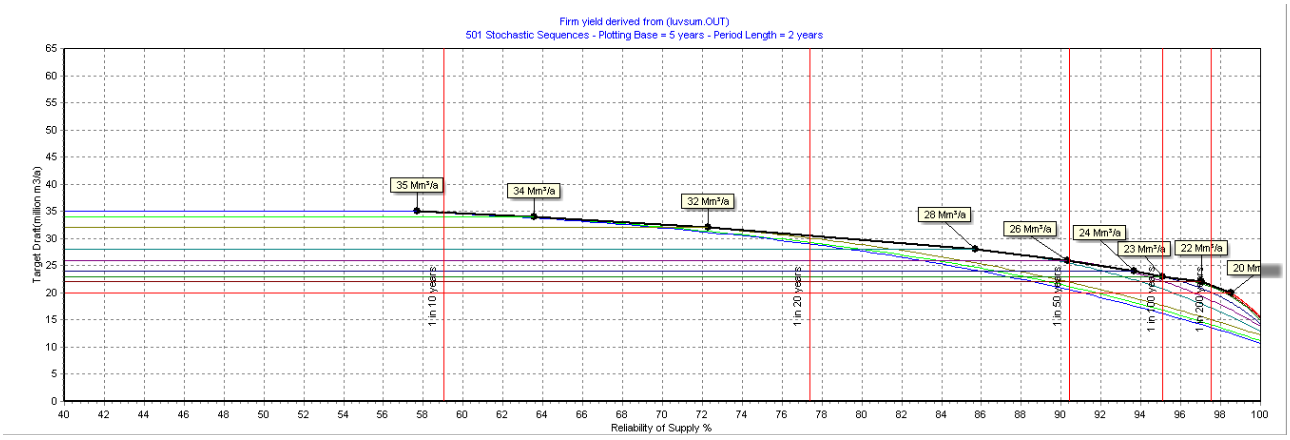
43 Mm³/a
41 Mm³/a
39 Mm³/a
36 Mm³/a
34 Mm³/a
32 Mm³/a
30 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

20%



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Target Draft(million m3/a)
Reliability of Supply %
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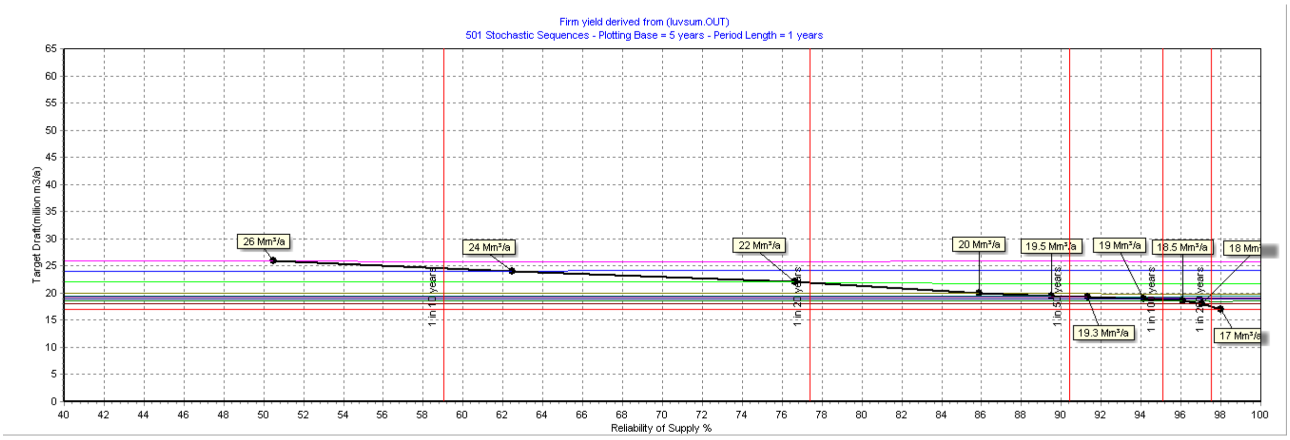
34 Mm³/a
32 Mm³/a
28 Mm³/a
26 Mm³/a
24 Mm³/a
23 Mm³/a
22 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

10%



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Target Draft(million m3/a)
Reliability of Supply %
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24 Mm³/a
22 Mm³/a
20 Mm³/a
19.5 Mm³/a
19 Mm³/a
18.5 Mm³/a
19.3 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

Middel Letaba and Nsami Dams

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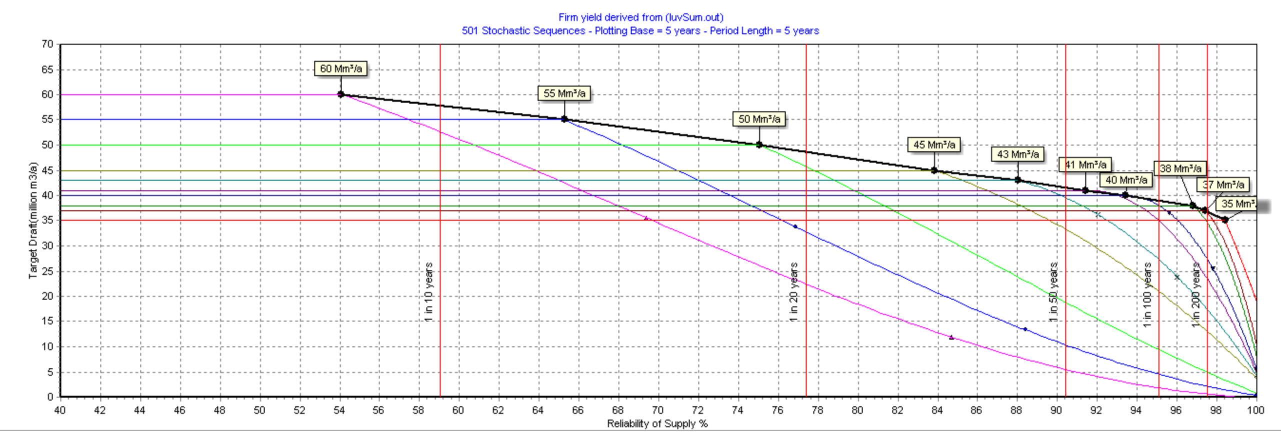

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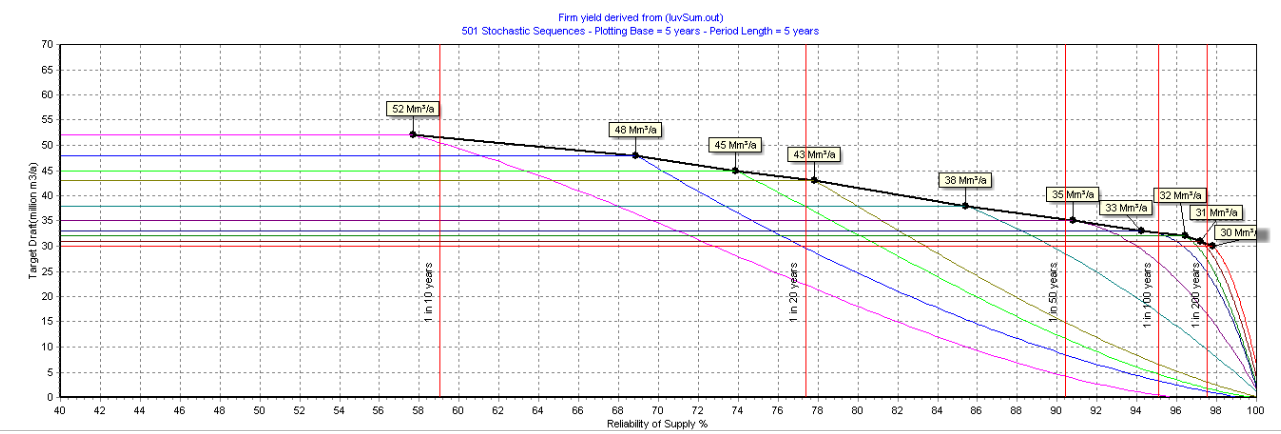

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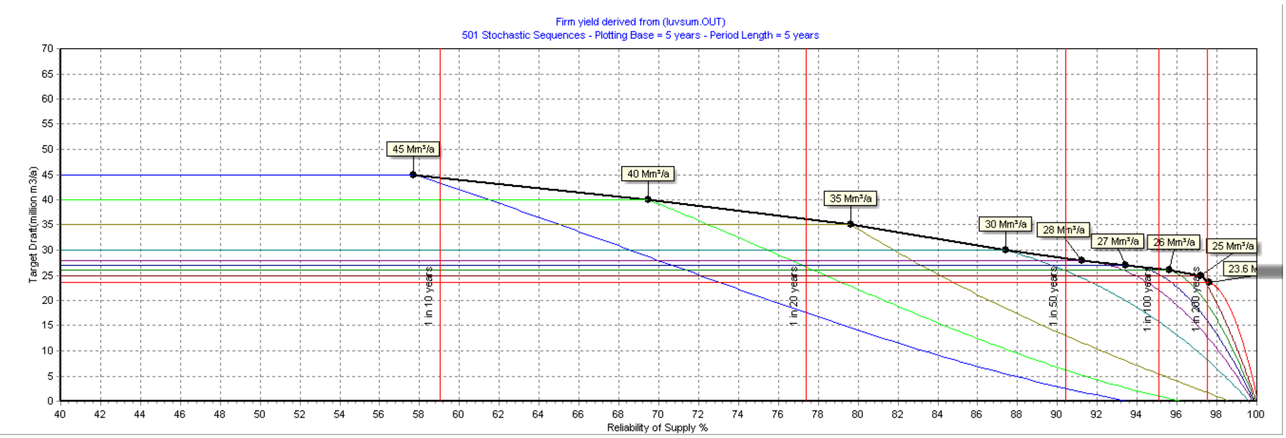

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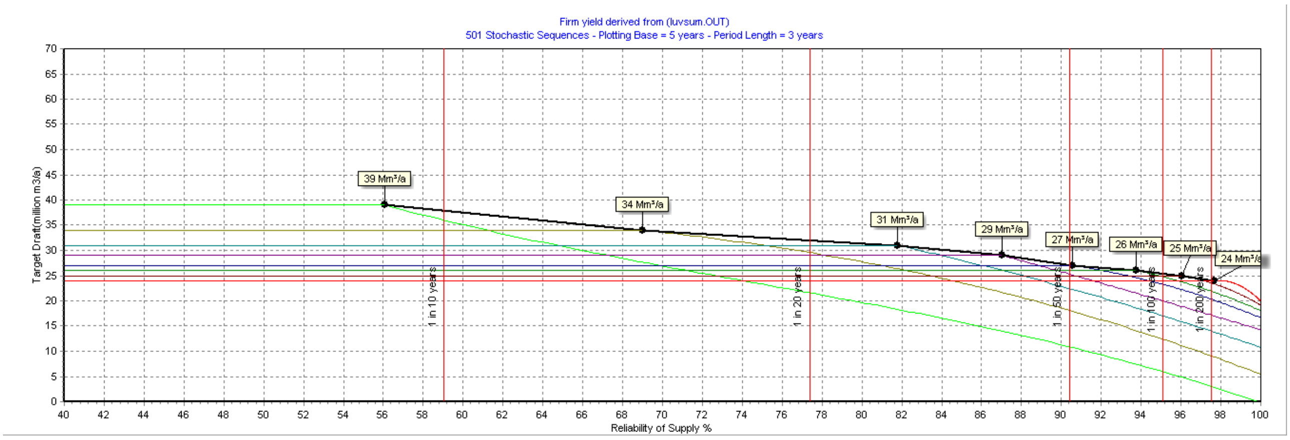
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Target Draft(million m3/a)
Reliability of Supply %
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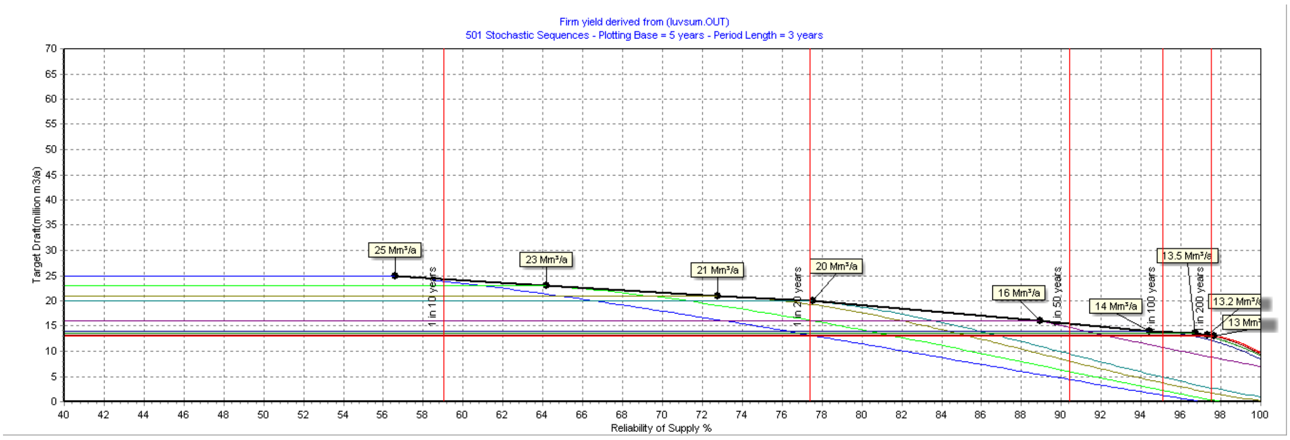
34 Mm³/a
31 Mm³/a
29 Mm³/a
27 Mm³/a
26 Mm³/a
25 Mm³/a
24 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

20%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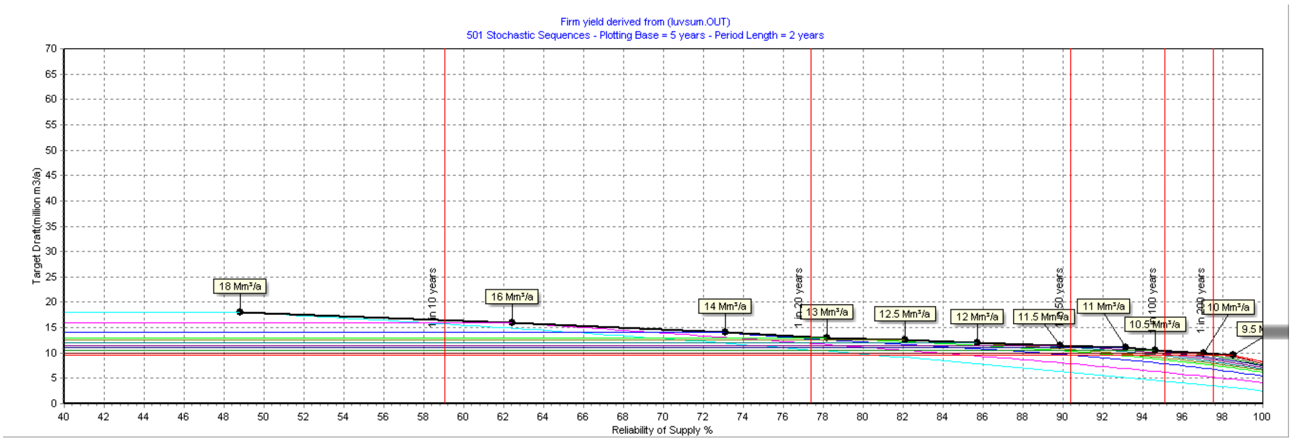
Target Draft(million m3/a)
Reliability of Supply %
25 Mm³/a
23 Mm³/a
21 Mm³/a
20 Mm³/a
16 Mm³/a
14 Mm³/a
13.5 Mm³/a
13.2 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

10%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Target Draft(million m3/a)
Reliability of Supply %
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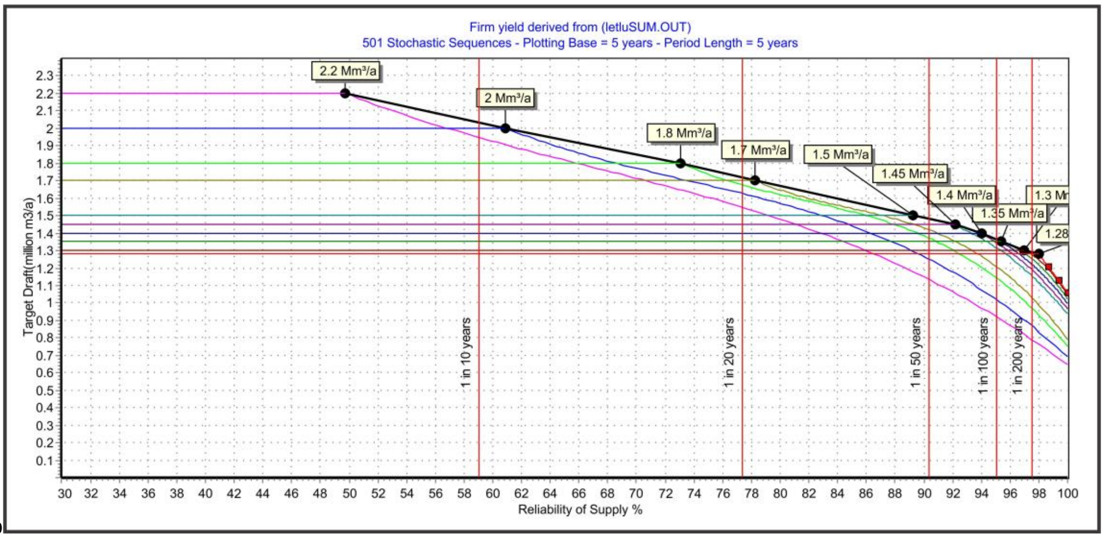
16 Mm³/a
14 Mm³/a
13 Mm³/a
12.5 Mm³/a
12 Mm³/a
11.5 Mm³/a
11 Mm³/a
10.5 Mm³/a
10 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

Thapane Dam



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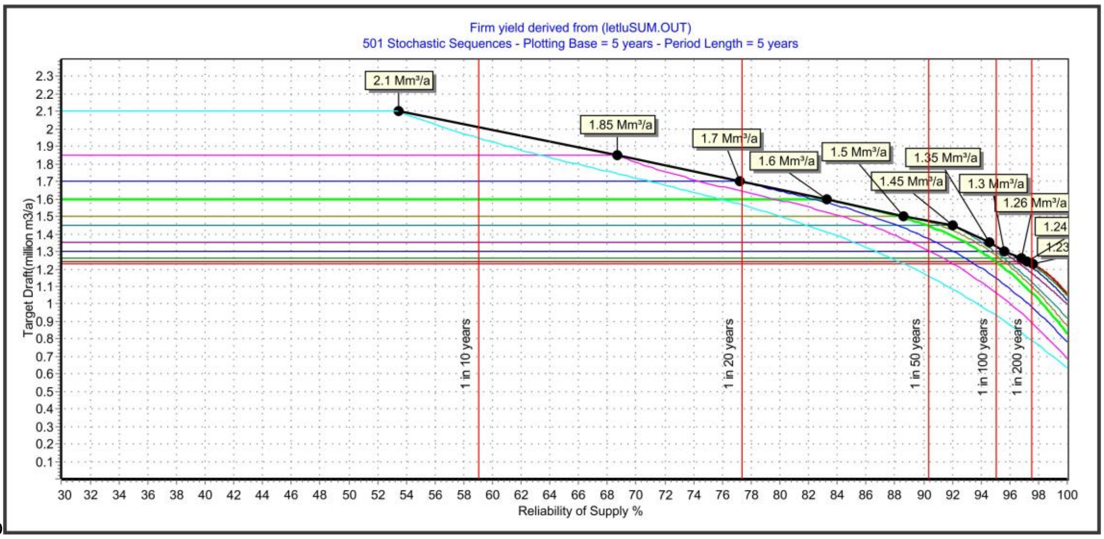

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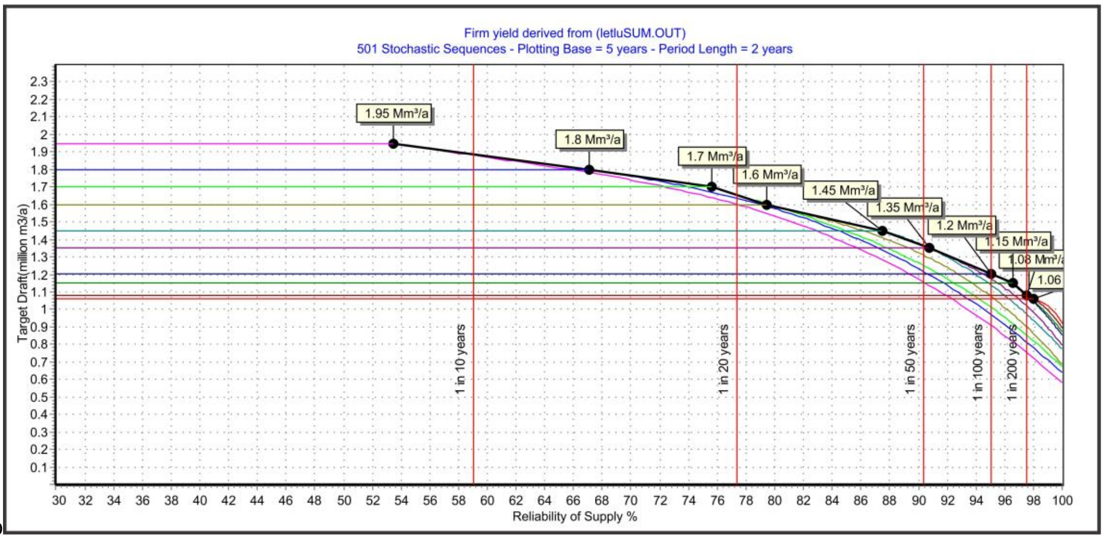

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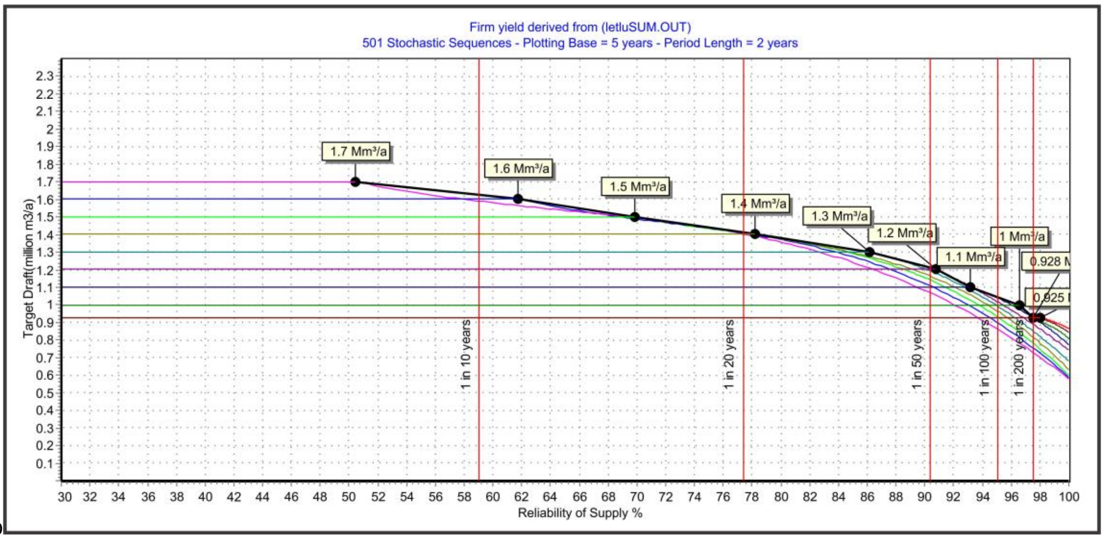

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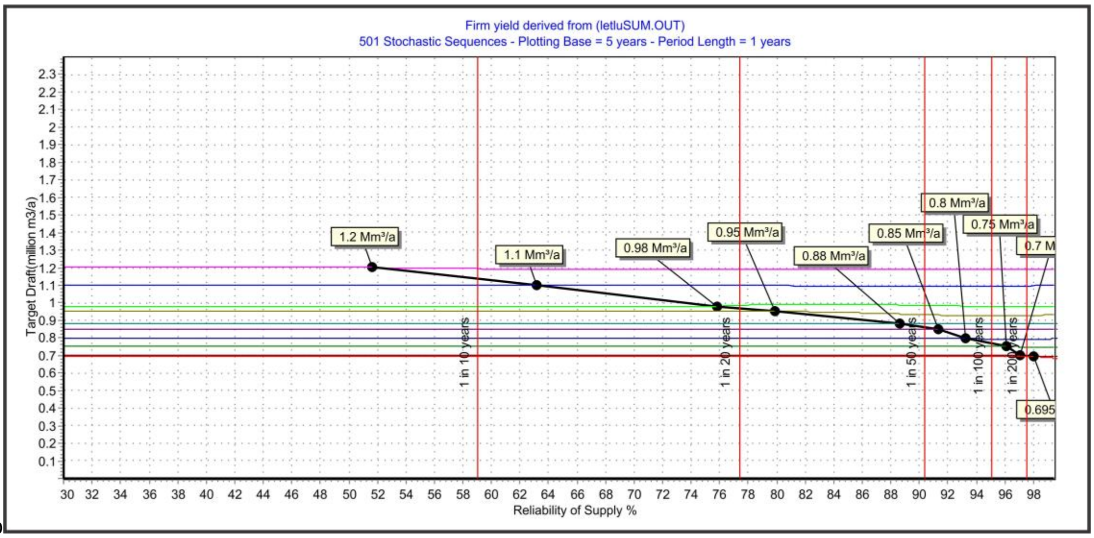
Target Draft(million m3/a)
Reliability of Supply %
1.7 Mm³/a
1.6 Mm³/a
1.5 Mm³/a
1.4 Mm³/a
1.3 Mm³/a
1.2 Mm³/a
1.1 Mm³/a
1 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

40%



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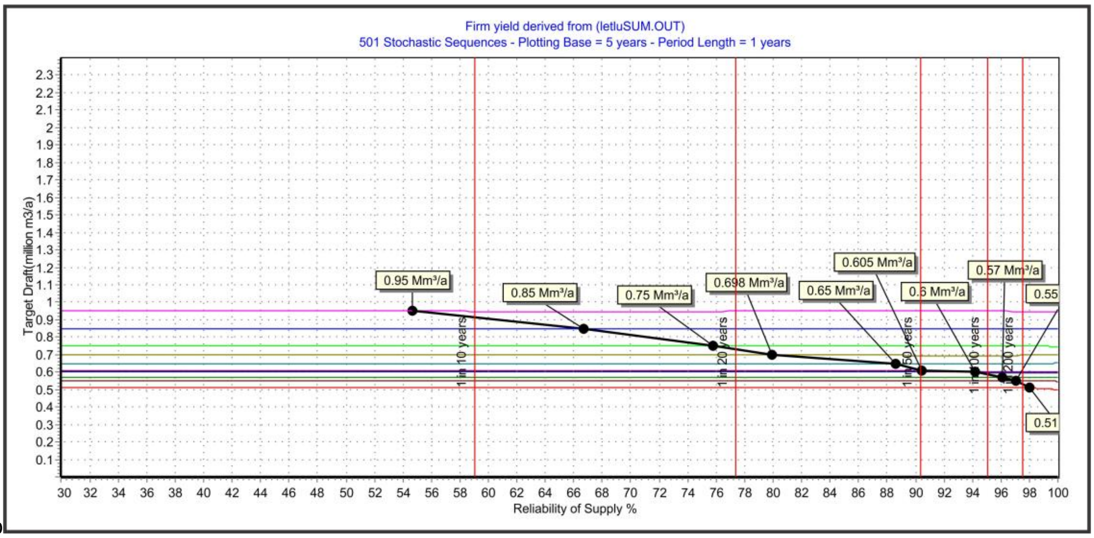
Target Draft(million m3/a)
Reliability of Supply %
1.2 Mm³/a
1.1 Mm³/a
0.98 Mm³/a
0.95 Mm³/a
0.88 Mm³/a
0.85 Mm³/a
0.8 Mm³/a
0.75 Mm³/a
1 in 10 years
1 in 20 years

20%



Firm yield derived from (letluSUM.OUT)
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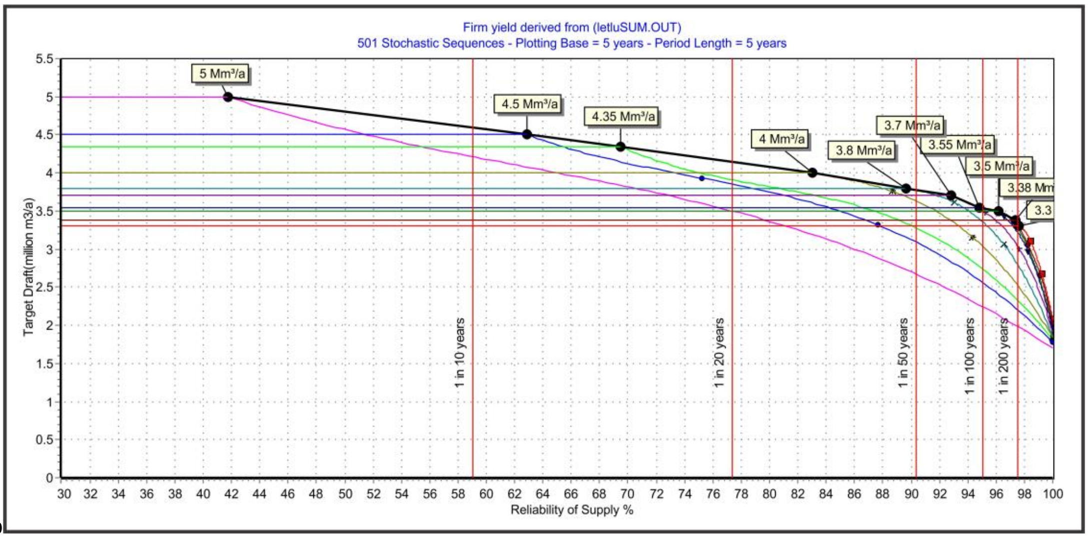
Target Draft(million m3/a)
Reliability of Supply %
0.95 Mm³/a
0.85 Mm³/a
0.75 Mm³/a
0.698 Mm³/a
0.65 Mm³/a
0.605 Mm³/a
0.6 Mm³/a
0.57 Mm³/a
1 in 10 years

10%

Thabina



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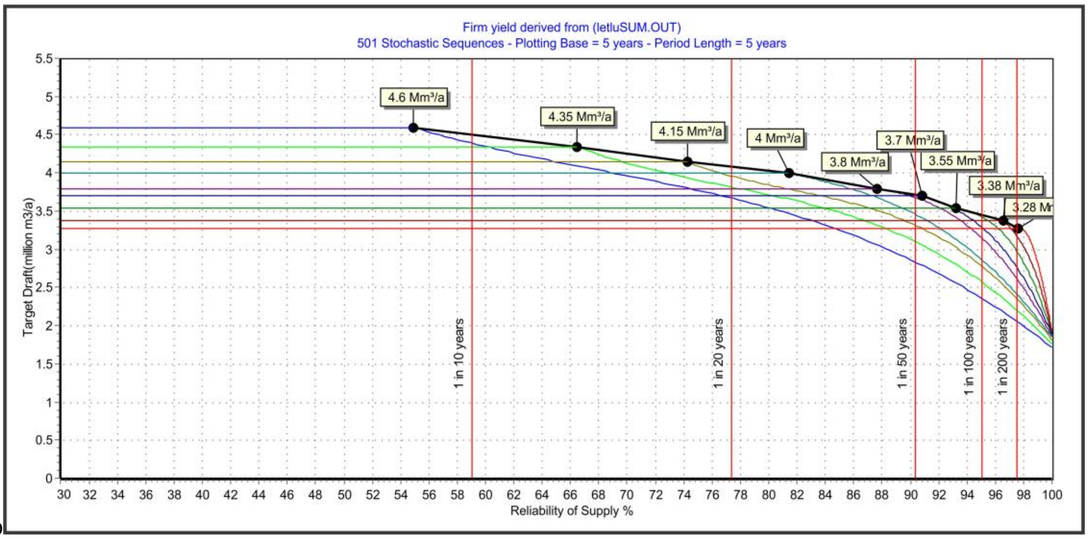

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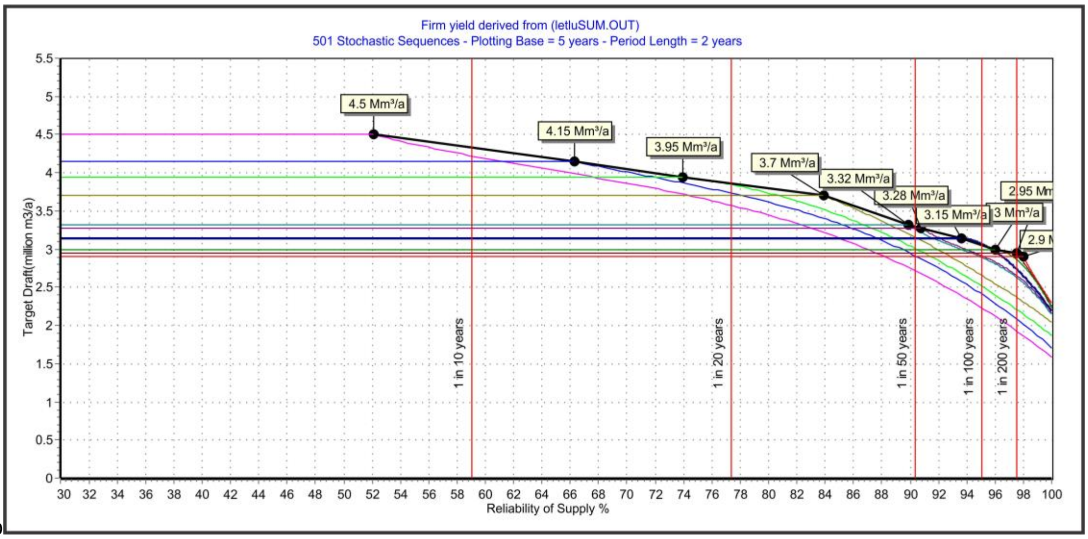

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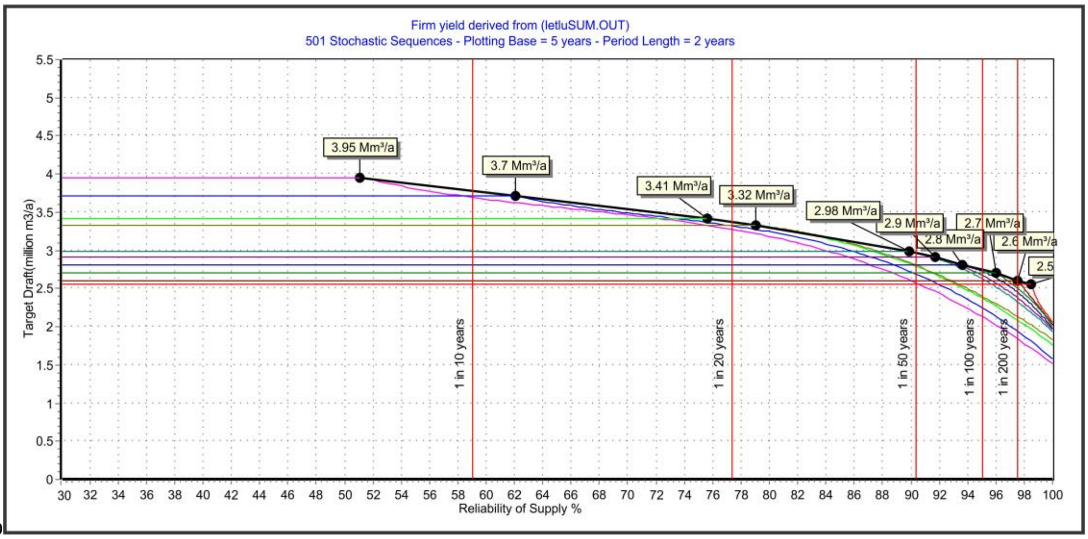
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Reliability of Supply %
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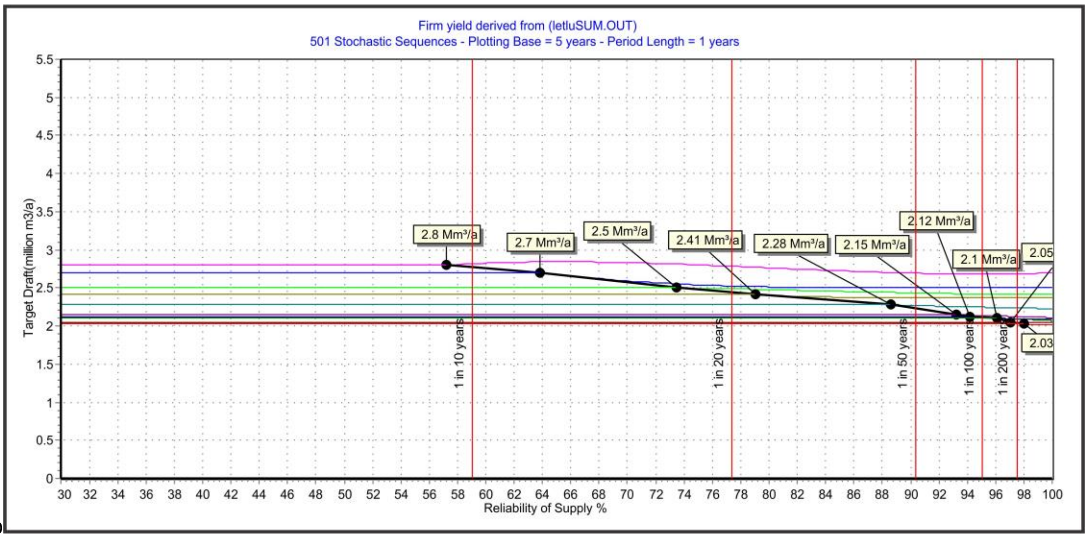
3.7 Mm³/a
3.41 Mm³/a
3.32 Mm³/a
2.98 Mm³/a
2.9 Mm³/a
2.8 Mm³/a
2.7 Mm³/a
2.6 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

40%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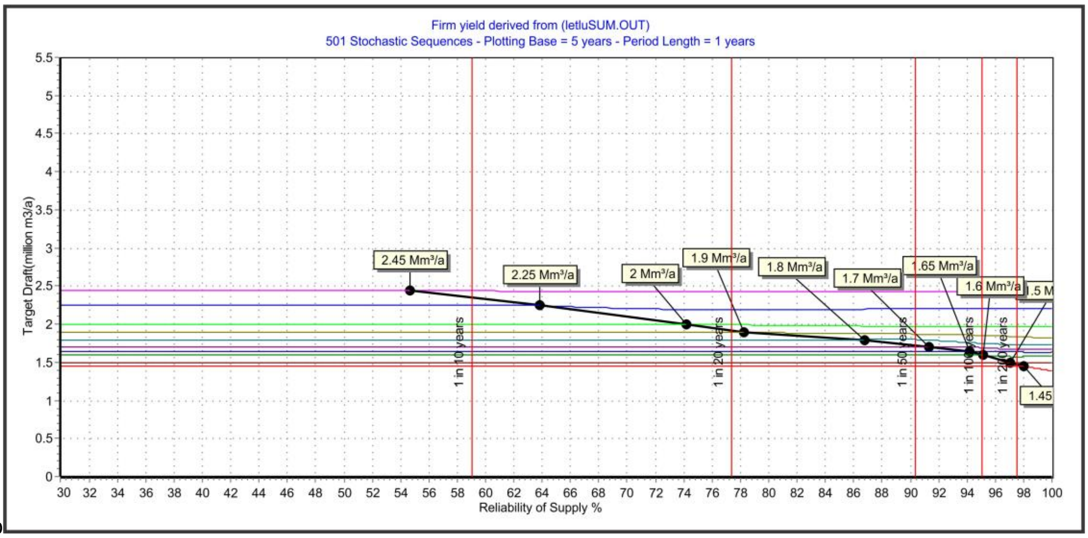
Target Draft(million m3/a)
Reliability of Supply %
2.8 Mm³/a
2.7 Mm³/a
2.5 Mm³/a
2.41 Mm³/a
2.28 Mm³/a
2.15 Mm³/a
2.12 Mm³/a
2.1 Mm³/a
2.05
2.03
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years

20%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Target Draft(million m3/a)
Reliability of Supply %
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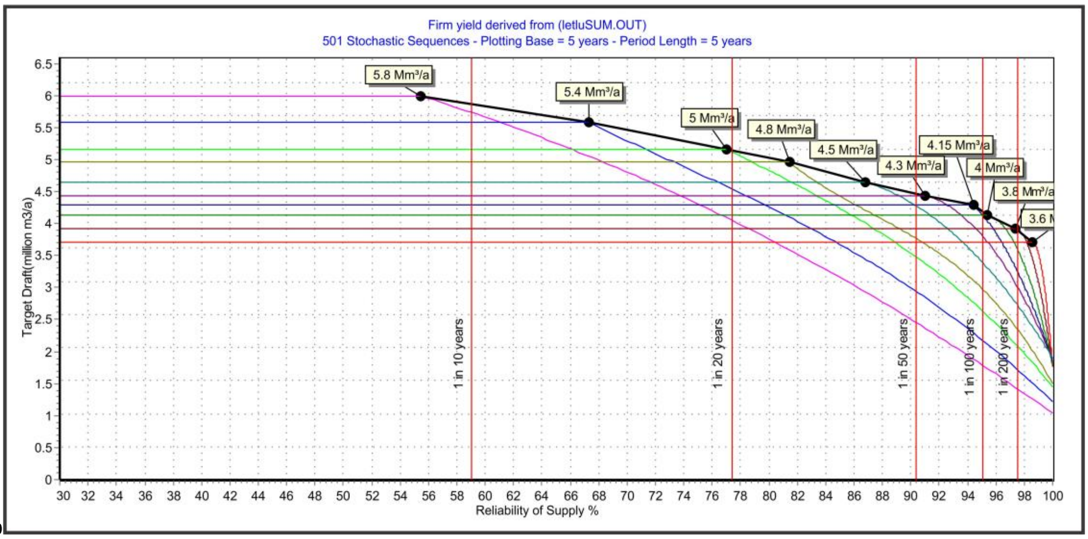
2.25 Mm³/a
2 Mm³/a
1.9 Mm³/a
1.8 Mm³/a
1.7 Mm³/a
1.65 Mm³/a
1.6 Mm³/a
1.45
1 in 10 years

10%

Modjadji



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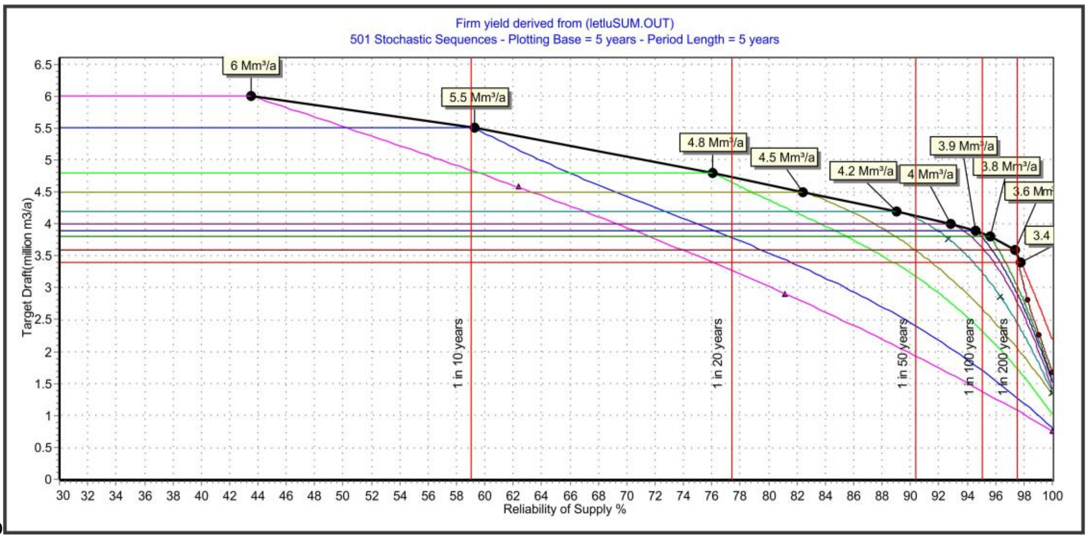

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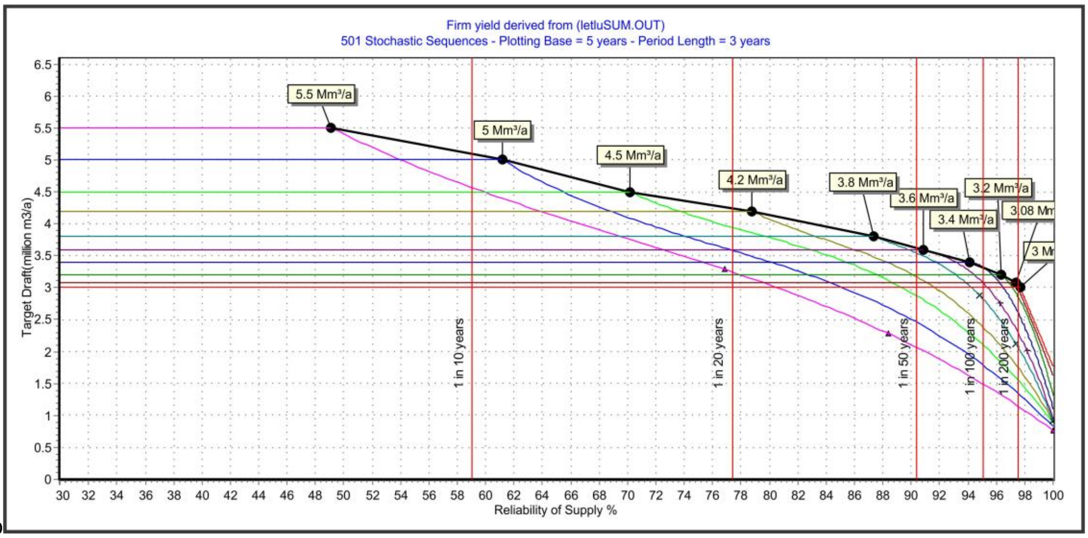

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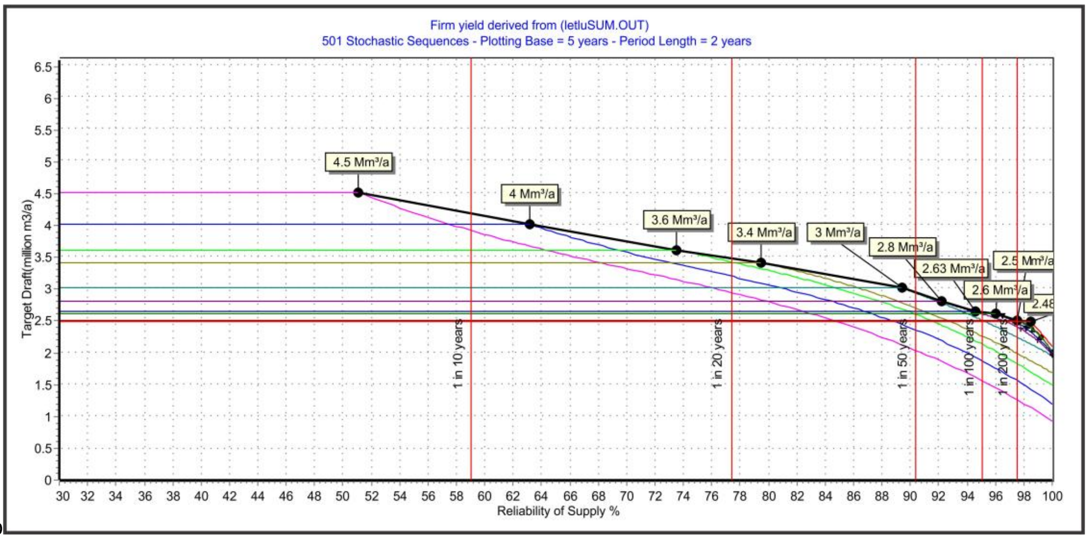

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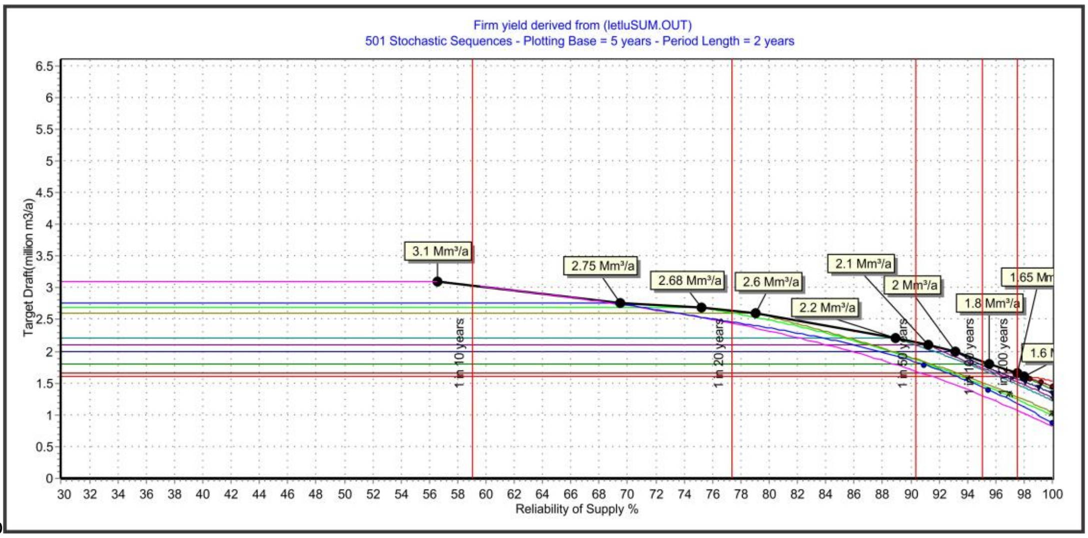

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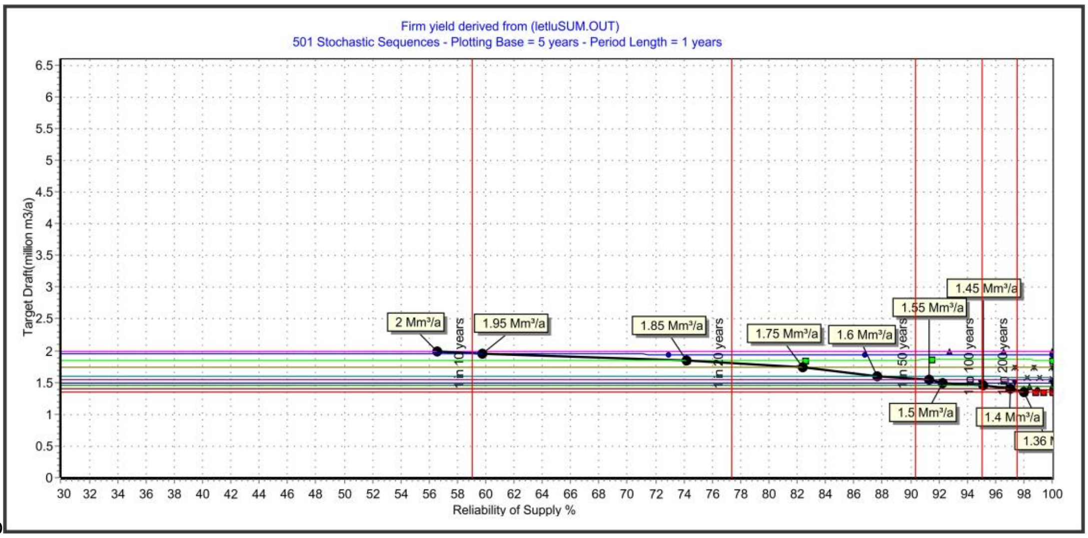

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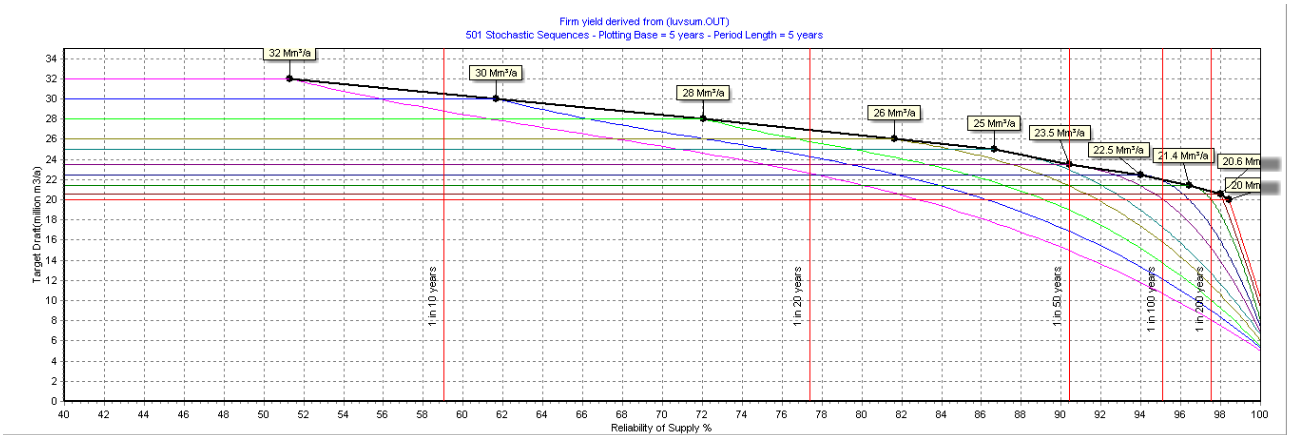
PhiphidiVondo

100%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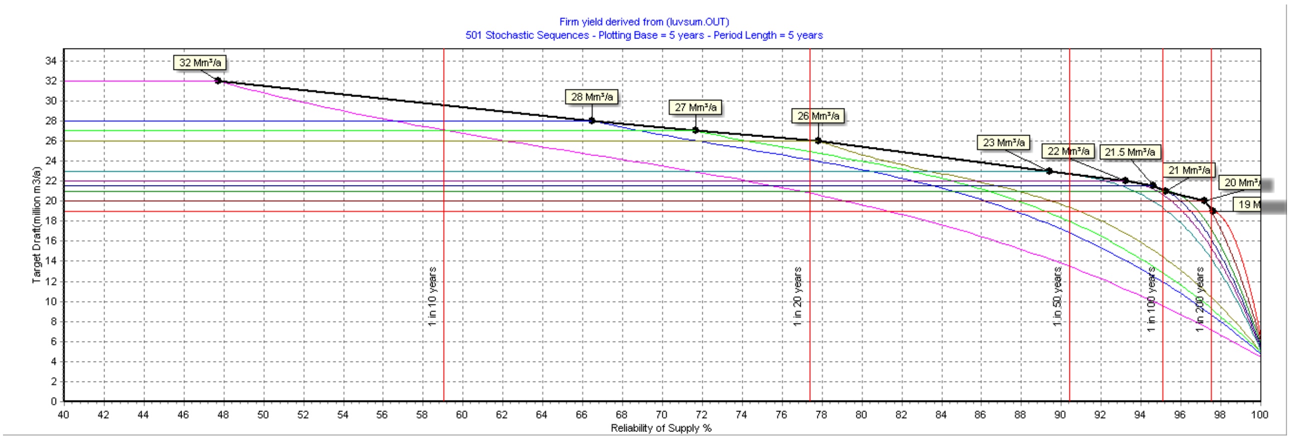
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
32 Mm³/a
30 Mm³/a
28 Mm³/a
26 Mm³/a
25 Mm³/a
23.5 Mm³/a
22.5 Mm³/a
21.4 Mm³/a

80%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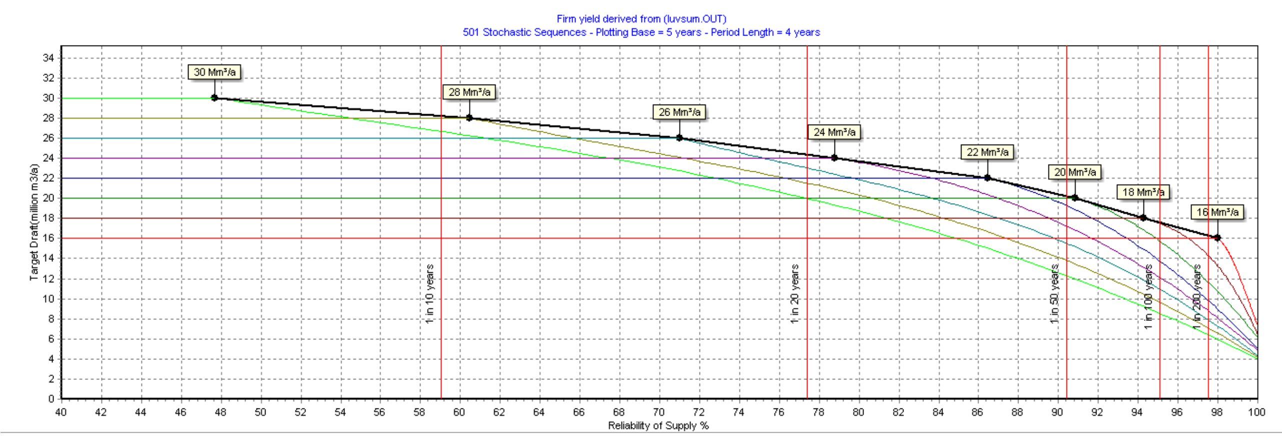
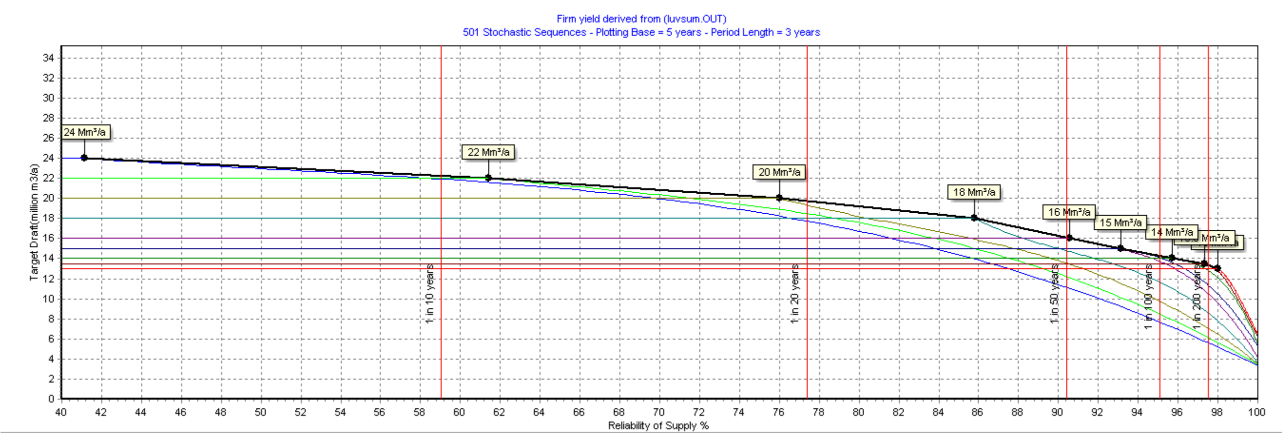
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
32 Mm³/a
28 Mm³/a
27 Mm³/a
26 Mm³/a
23 Mm³/a
22 Mm³/a
21.5 Mm³/a
21 Mm³/a

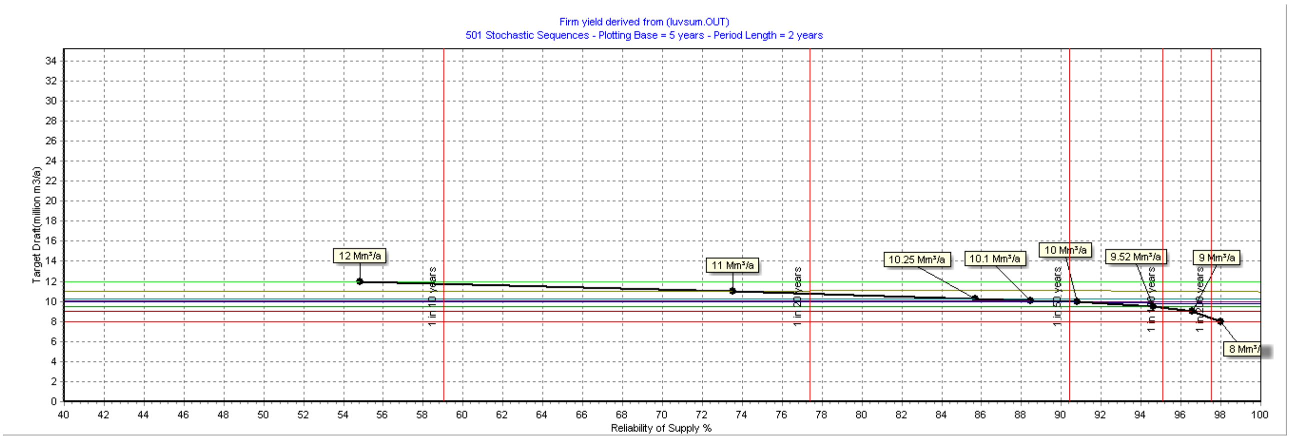
60%


Firm yield derived from (luvsum.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 4 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
30 Mm³/a
28 Mm³/a
26 Mm³/a
24 Mm³/a
22 Mm³/a
20 Mm³/a
18 Mm³/a
16 Mm³/a

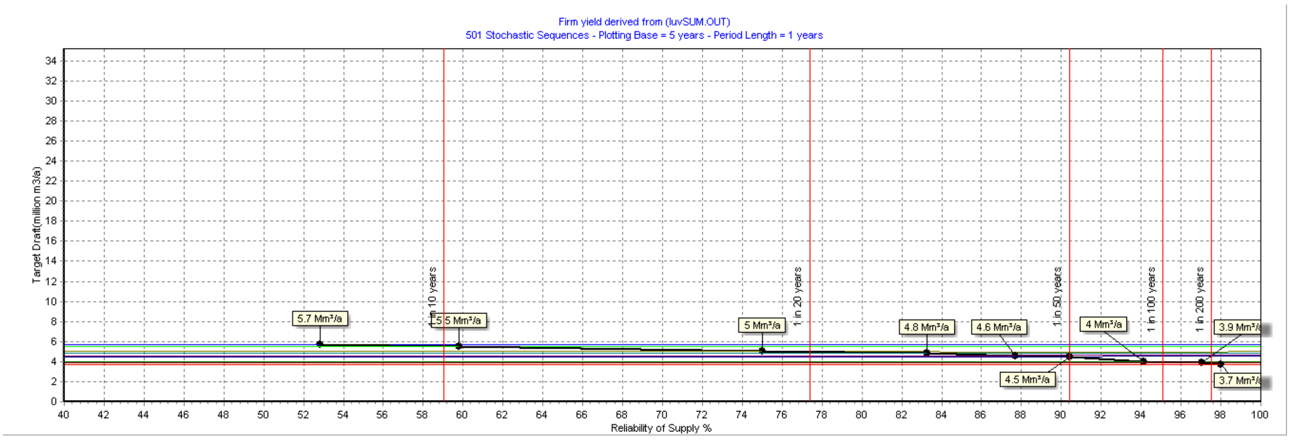
40%


Firm yield derived from (luvsum.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 3 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
24 Mm³/a
22 Mm³/a
20 Mm³/a
18 Mm³/a
16 Mm³/a
15 Mm³/a
14 Mm³/a

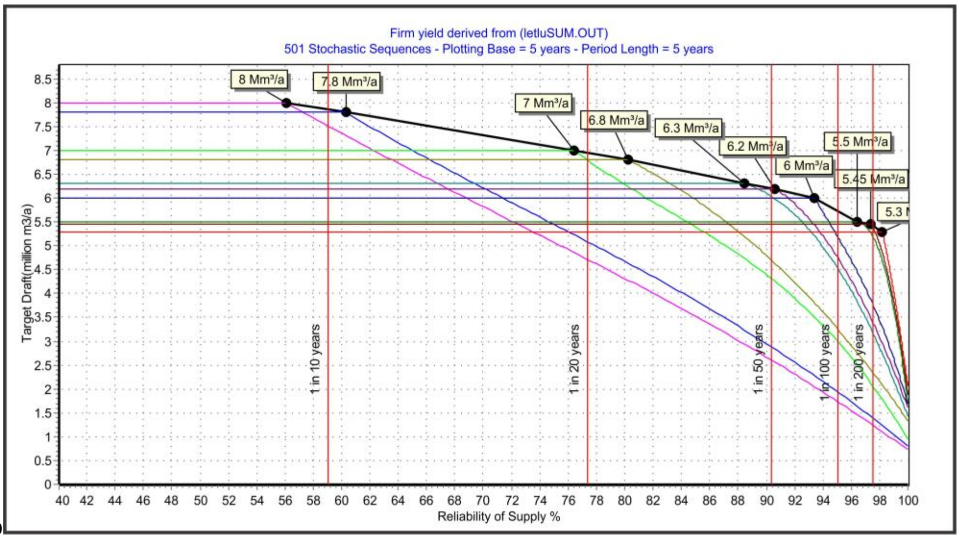
20%



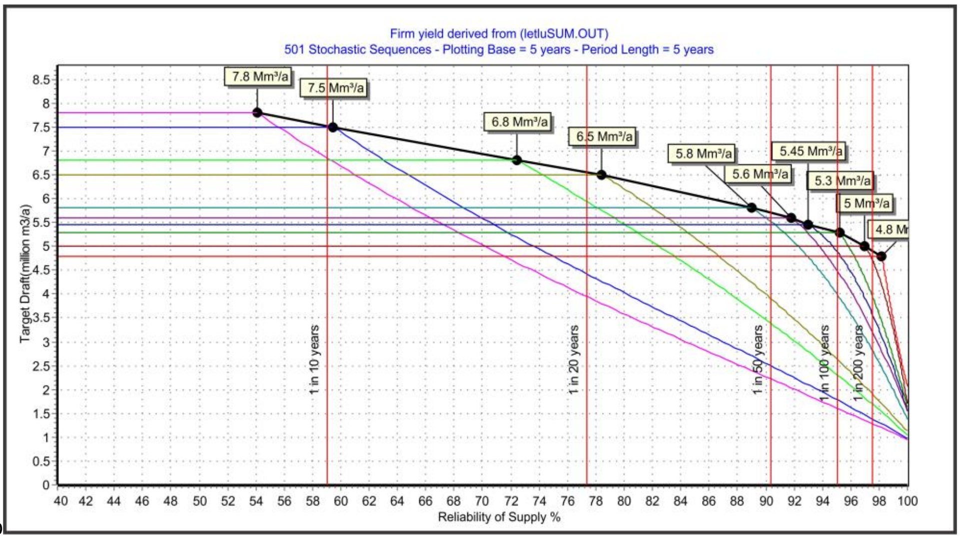
10%



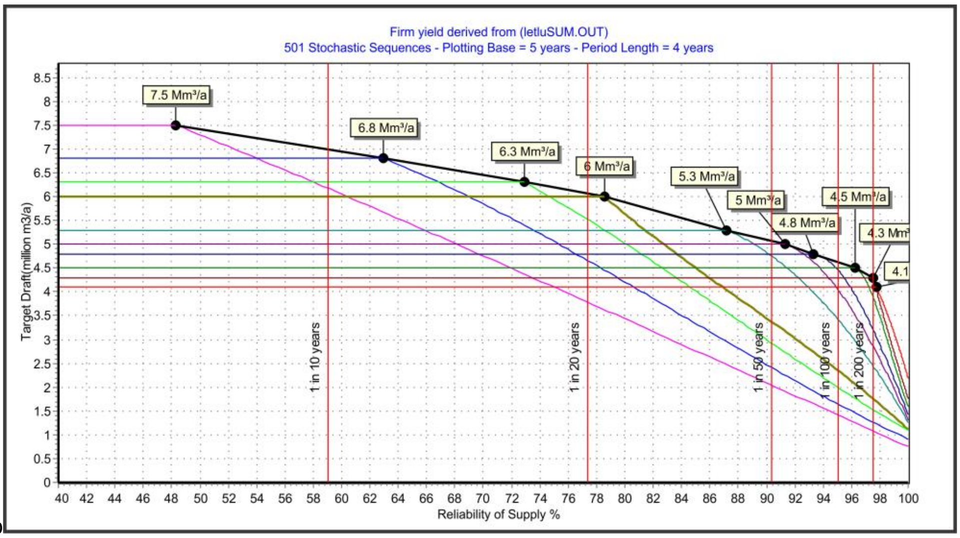
Damani



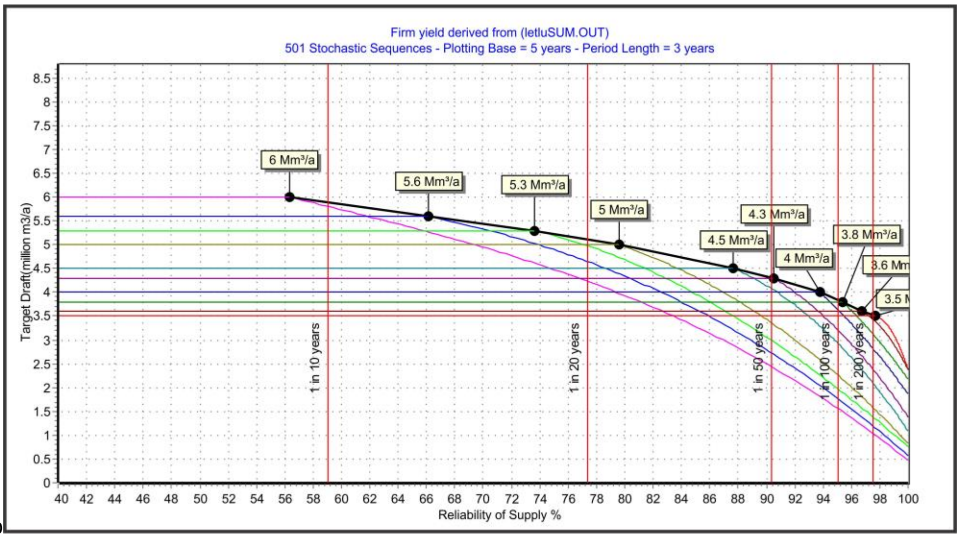
100%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 5 years
7.8 Mm³/a
7.5 Mm³/a
6.8 Mm³/a
6.5 Mm³/a
5.8 Mm³/a
5.6 Mm³/a
5.45 Mm³/a
5.3 Mm³/a
5 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
Target Draft(million m3/a)
Reliability of Supply %

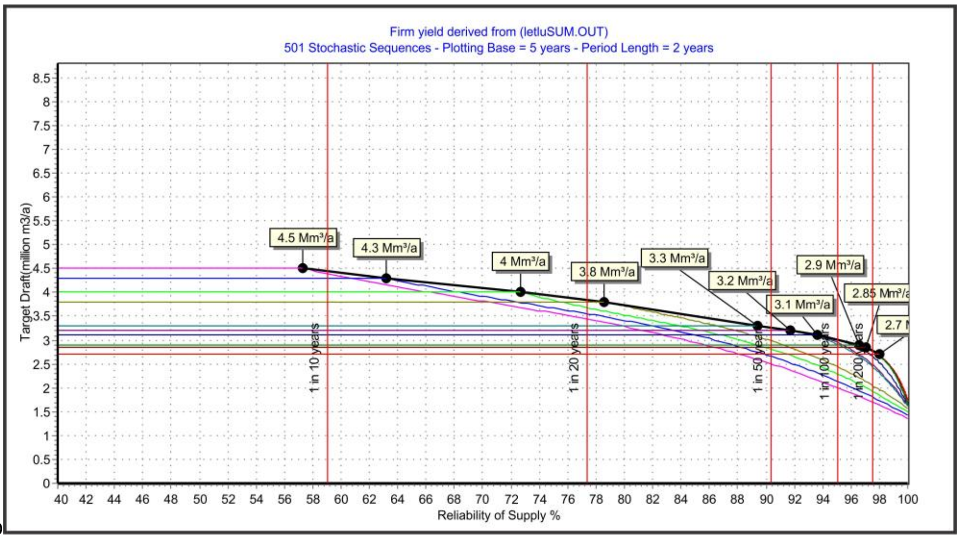
80%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 4 years
7.5 Mm³/a
6.8 Mm³/a
6.3 Mm³/a
6 Mm³/a
5.3 Mm³/a
5 Mm³/a
4.8 Mm³/a
4.5 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
Target Draft(million m3/a)
Reliability of Supply %

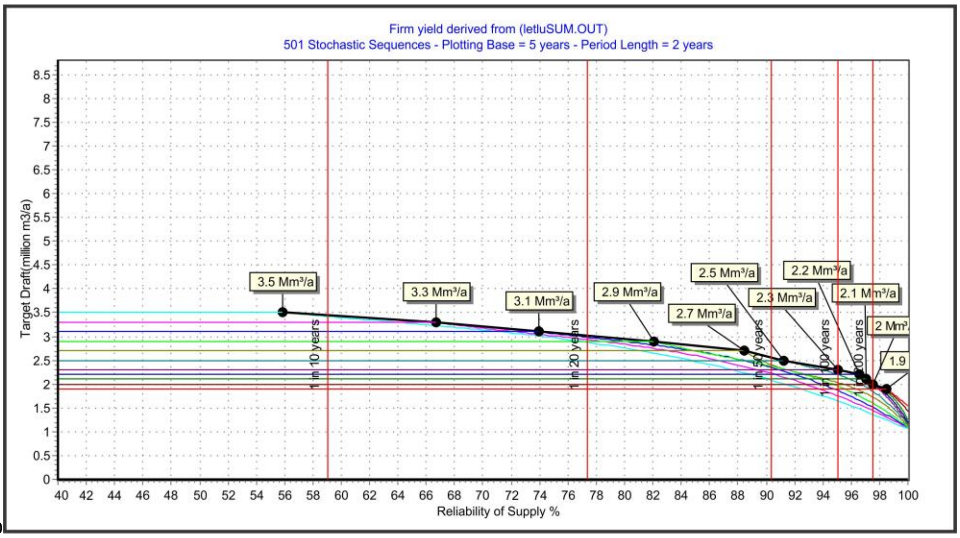
60%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 3 years
6 Mm³/a
5.6 Mm³/a
5.3 Mm³/a
5 Mm³/a
4.5 Mm³/a
4.3 Mm³/a
4 Mm³/a
3.8 Mm³/a
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
Target Draft(million m3/a)
Reliability of Supply %

40%

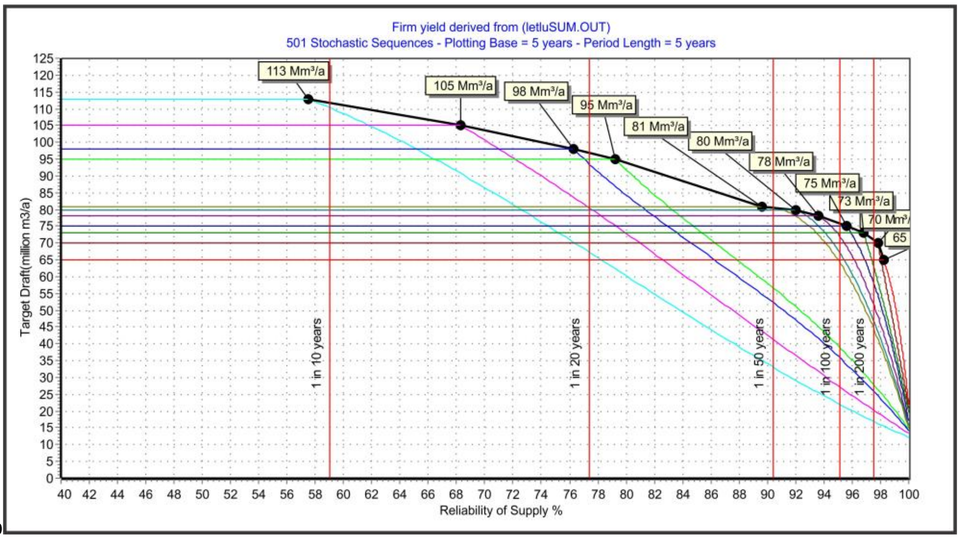


20%



10%

Nandoni



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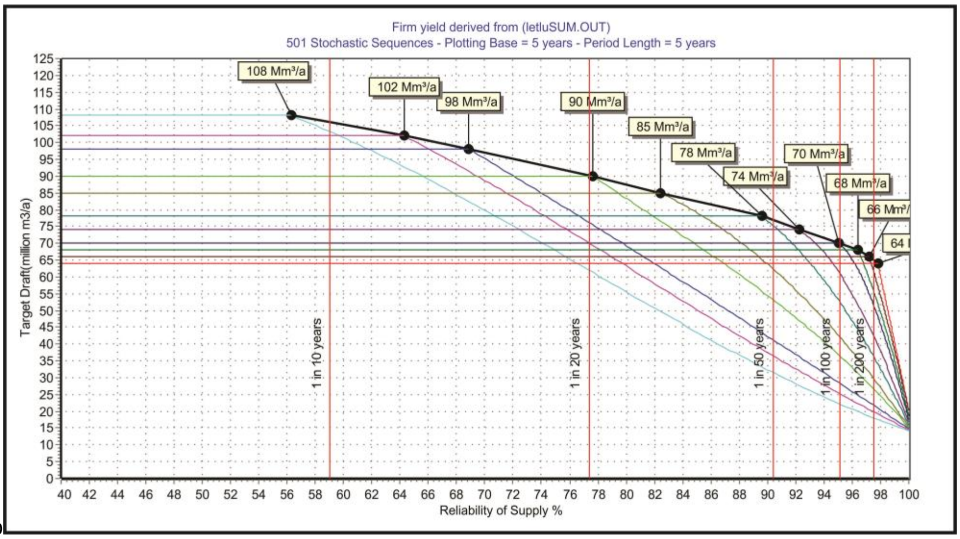
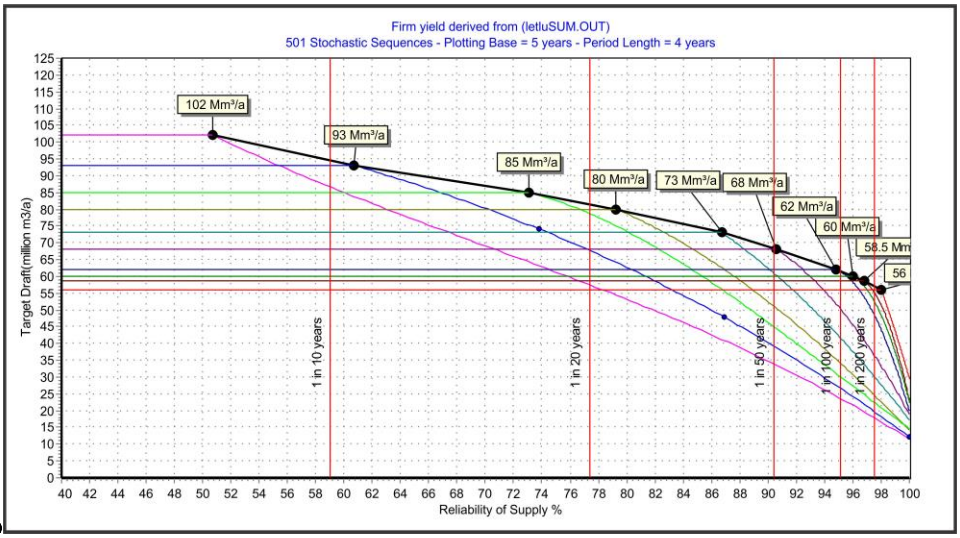
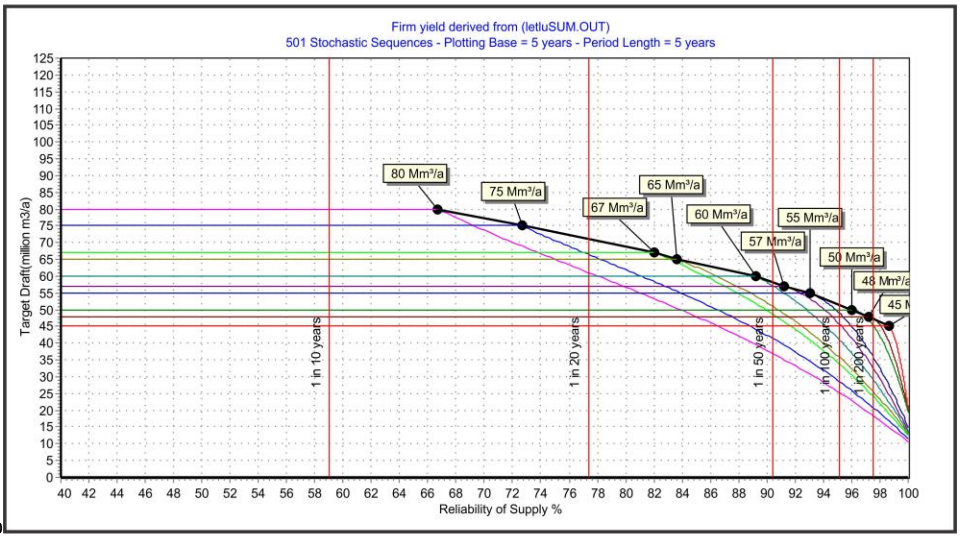

Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 5 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
108 Mm³/a
102 Mm³/a
98 Mm³/a
90 Mm³/a
85 Mm³/a
78 Mm³/a
74 Mm³/a
70 Mm³/a
68 Mm³/a

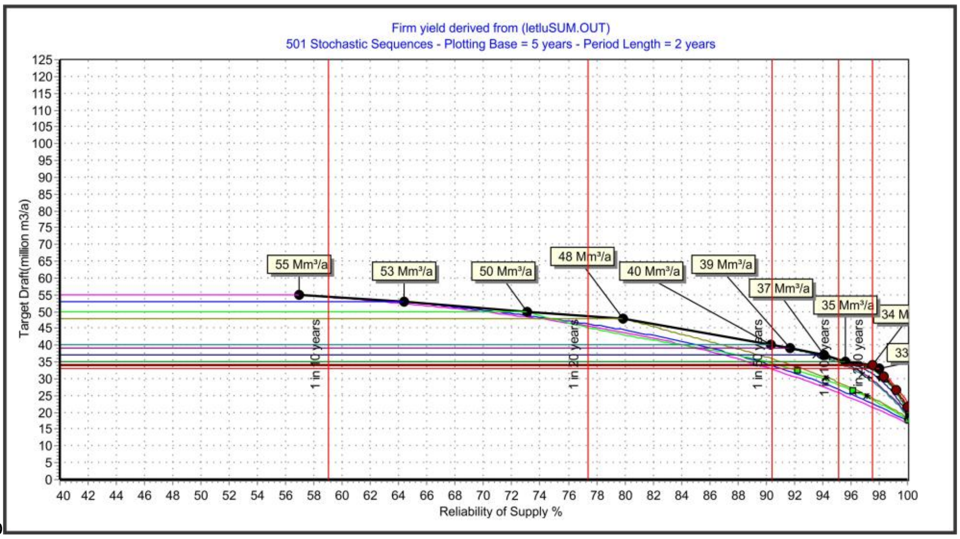
80%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 4 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
102 Mm³/a
93 Mm³/a
85 Mm³/a
80 Mm³/a
73 Mm³/a
68 Mm³/a
62 Mm³/a
60 Mm³/a

60%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 5 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
80 Mm³/a
75 Mm³/a
67 Mm³/a
65 Mm³/a
60 Mm³/a
57 Mm³/a
55 Mm³/a
50 Mm³/a

40%



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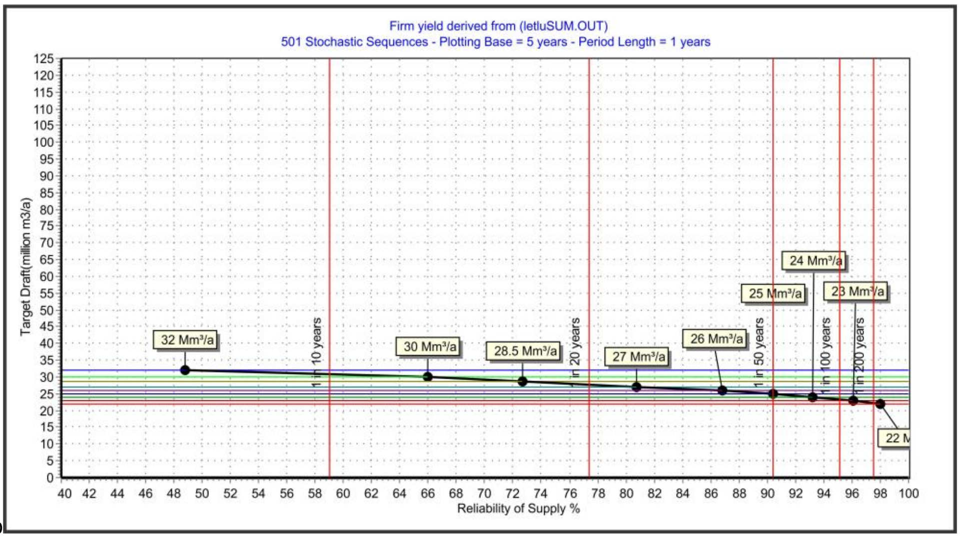
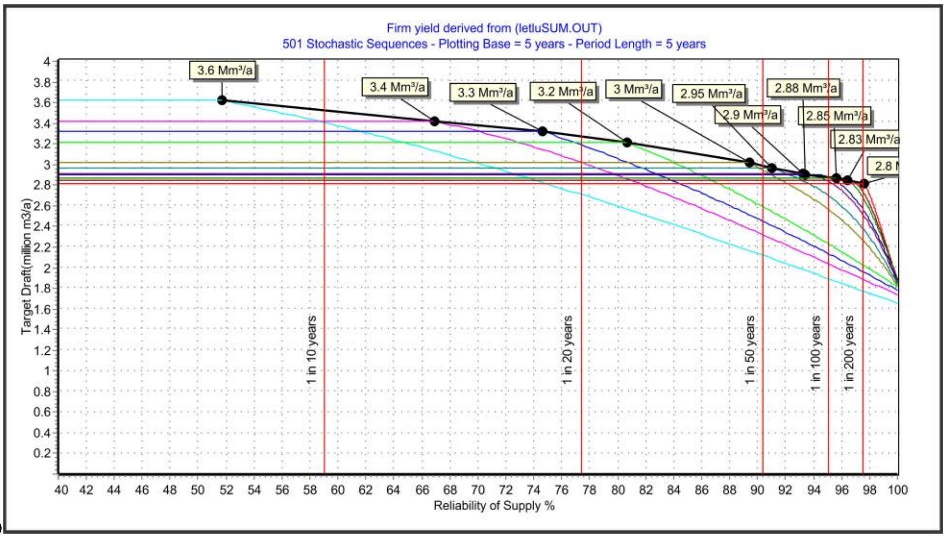
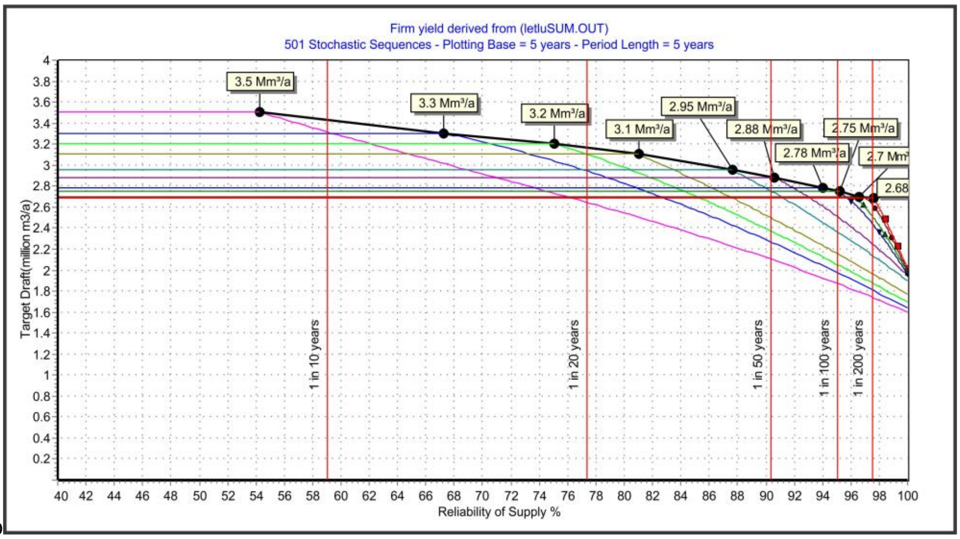


10%

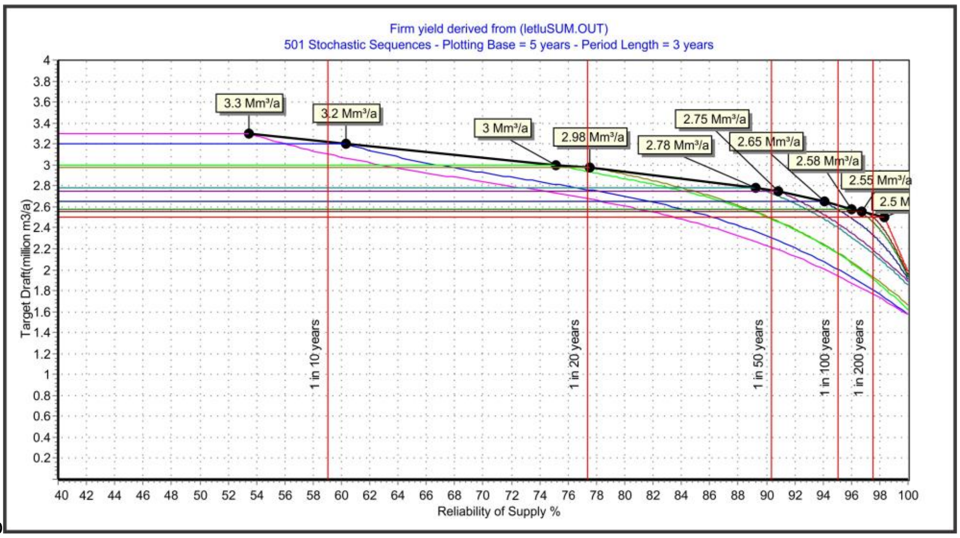
Tshakhuma



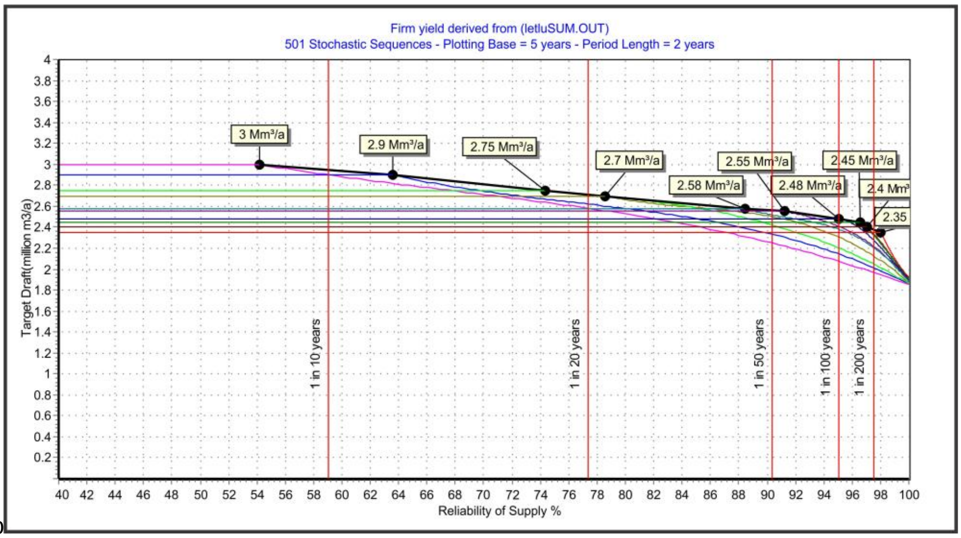
100%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 5 years
3.5 Mm³/a
3.3 Mm³/a
3.2 Mm³/a
3.1 Mm³/a
2.95 Mm³/a
2.88 Mm³/a
2.78 Mm³/a
2.75 Mm³/a
2.7 Mm³
2.68
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
Target Draft(million m3/a)
Reliability of Supply %

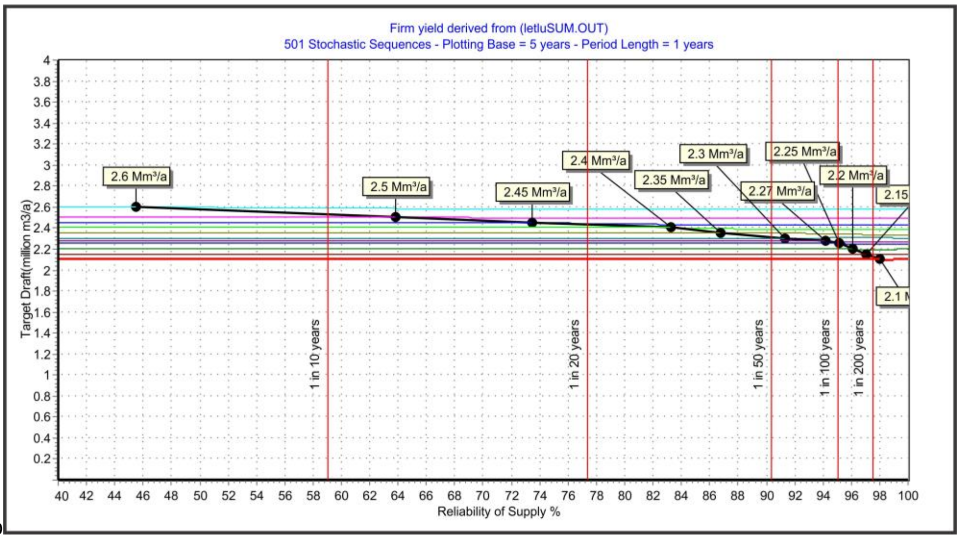
80%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 3 years
3.3 Mm³/a
3.2 Mm³/a
3 Mm³/a
2.98 Mm³/a
2.78 Mm³/a
2.75 Mm³/a
2.65 Mm³/a
2.58 Mm³/a
2.55 Mm³/a
2.5 M
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
Target Draft(million m3/a)
Reliability of Supply %

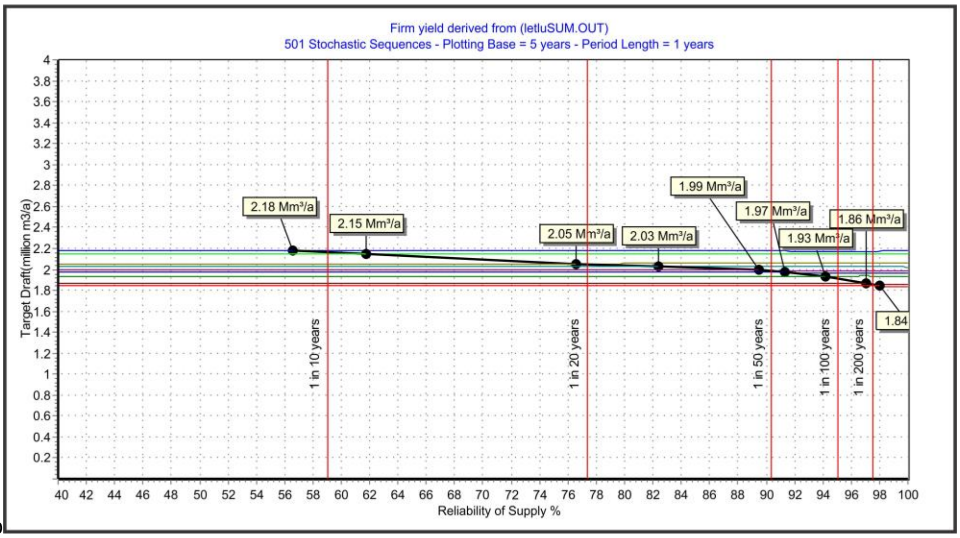
60%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 2 years
3 Mm³/a
2.9 Mm³/a
2.75 Mm³/a
2.7 Mm³/a
2.58 Mm³/a
2.55 Mm³/a
2.48 Mm³/a
2.45 Mm³/a
2.4 Mm³
2.35
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
Target Draft(million m3/a)
Reliability of Supply %

40%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 1 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
2.6 Mm³/a
2.5 Mm³/a
2.45 Mm³/a
2.4 Mm³/a
2.35 Mm³/a
2.3 Mm³/a
2.27 Mm³/a
2.25 Mm³/a
2.2 Mm³/a

20%


Firm yield derived from (letluSUM.OUT)
501 Stochastic Sequences - Plotting Base = 5 years - Period Length = 1 years
Target Draft(million m3/a)
Reliability of Supply %
1 in 10 years
1 in 20 years
1 in 50 years
1 in 100 years
1 in 200 years
2.18 Mm³/a
2.15 Mm³/a
2.05 Mm³/a
2.03 Mm³/a
1.99 Mm³/a
1.97 Mm³/a
1.93 Mm³/a
1.86 Mm³/a

10%

Appendix C
Short Term Coefficients

Dap Naude

1.00					
2.300000	0.383742	-0.603237	0.201690	0.017805	0.023952
2.400000	0.471207	-0.933618	0.549784	-0.087373	0.033932
2.500000	0.568828	-1.405125	1.519590	-0.683293	0.041916
2.600000	0.621304	-1.710763	1.940414	-0.850956	0.061876
2.700000	0.674101	-2.080510	2.575288	-1.168879	0.087824
2.800000	0.721376	-2.298372	3.014939	-1.437943	0.109780
3.000000	0.763143	-2.357001	3.027139	-1.433282	0.167665
3.500000	0.820341	-2.377194	2.995880	-1.439028	0.357285
3.700000	0.839243	-2.364560	3.064146	-1.538829	0.431138
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
2.100000	0.477240	-1.826500	2.747377	-1.398117	0.015968
2.200000	0.357084	-0.636895	0.253493	0.026318	0.027944
2.250000	0.436764	-1.219781	1.458506	-0.675489	0.033932
2.300000	0.450275	-1.176580	1.314301	-0.587997	0.041916
2.500000	0.589711	-1.517133	1.760020	-0.832598	0.065868
2.700000	0.701910	-1.952155	2.370570	-1.120325	0.105788
2.750000	0.726252	-2.052357	2.502489	-1.176384	0.117764
3.000000	0.777937	-2.149026	2.530442	-1.159352	0.185629
3.300000	0.825268	-2.322539	2.806409	-1.309138	0.299401
3.800000	0.871479	-2.259758	2.830783	-1.442504	0.495010
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
1.850000	0.285810	-0.505584	0.195872	0.023903	0.022404
1.900000	0.327575	-0.615892	0.388864	-0.100548	0.027369
2.000000	0.497824	-1.780215	2.675232	-1.392840	0.042234
2.200000	0.546645	-1.217756	1.302788	-0.631677	0.066905
2.250000	0.585813	-1.311199	1.391151	-0.665765	0.074281
2.300000	0.623213	-1.407660	1.479447	-0.695000	0.081646
2.500000	0.734928	-1.571888	1.665795	-0.828835	0.106109
2.700000	0.804503	-1.633444	1.431884	-0.602943	0.140132
2.750000	0.818593	-1.679406	1.474951	-0.614137	0.149805
3.000000	0.854925	-1.962760	1.721514	-0.613679	0.238212
3.300000	0.878300	-2.303229	2.378625	-0.953696	0.388567
3.500000	0.895983	-2.373451	2.653549	-1.176080	0.475444
0.40					
1.300000	0.417891	-0.365759	0.077508	-0.129640	0.014903
1.500000	0.503388	-0.931780	0.537039	-0.108646	0.044307
1.700000	0.565194	-1.029514	0.701474	-0.237154	0.068403
1.750000	0.579966	-1.125533	1.023587	-0.478020	0.077938
1.800000	0.595230	-1.182413	1.046112	-0.458929	0.092131
1.850000	0.608249	-1.241088	1.169562	-0.536723	0.106192

2.000000	0.643867	-1.356741	1.043610	-0.330736	0.165607
2.200000	0.687789	-1.404702	1.105981	-0.389069	0.226871
2.300000	0.707548	-1.528980	1.152253	-0.330821	0.297528
2.500000	0.740508	-1.560907	1.308099	-0.487701	0.375509
2.700000	0.768807	-1.684074	1.458789	-0.543522	0.478957
0.20					
0.800000	0.001417	-0.001412	0.006288	-0.006292	0.019801
0.870000	0.014136	-0.000117	0.003000	-0.017019	0.029584
0.900000	0.004779	0.026211	-0.076256	0.045266	0.048914
0.950000	0.006197	0.008942	-0.046894	0.031755	0.058463
1.000000	0.001313	0.022048	-0.017508	-0.005853	0.114159
1.100000	0.008153	-0.008685	0.037729	-0.037197	0.201106
1.250000	0.042395	-0.086989	0.232216	-0.187622	0.303789
1.350000	0.007480	-0.044825	0.066445	-0.029100	0.368472
1.400000	-0.000768	0.022231	-0.101899	0.080436	0.428256
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
0.200000	-0.001919	0.081620	-0.221312	0.141611	0.019801
0.360000	0.007282	-0.007905	0.035084	-0.034461	0.048914
0.380000	0.004247	-0.004390	0.019346	-0.019202	0.048914
0.400000	0.008137	-0.016509	0.044822	-0.036451	0.058463
0.430000	0.008954	-0.009328	0.041023	-0.040649	0.077331
0.450000	0.006266	-0.005698	0.026498	-0.027066	0.105064
0.500000	0.006488	-0.006748	0.030013	-0.029753	0.132127
0.550000	-0.005714	0.005500	-0.025288	0.025502	0.158531
0.650000	0.000263	-0.000254	0.001147	-0.001155	0.265628
0.750000	0.004617	-0.101037	0.261879	-0.165459	0.340346
0.860000	0.010206	-0.000176	0.003212	-0.013243	0.415380

Dap Naude Ebenezer

1.00					
38.000000	0.297949	-0.190655	-0.427329	0.320036	0.013972
40.000000	0.436314	-0.518186	-0.129949	0.211820	0.029940
42.000000	0.537885	-0.822762	0.579433	-0.294556	0.047904
44.000000	0.584073	-0.720396	0.394546	-0.258223	0.065868
45.000000	0.552310	-0.245216	-1.144286	0.837192	0.089820
46.000000	0.650032	-0.968651	0.163889	0.154730	0.113772
48.000000	0.784601	-1.797659	2.017330	-1.004272	0.145709
52.000000	0.773824	-1.424910	1.282167	-0.631082	0.251497
54.000000	0.784757	-1.326917	1.060634	-0.518474	0.311377
58.000000	0.802984	-1.183516	0.915921	-0.535390	0.437126
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
36.000000	0.534393	-1.976785	3.043494	-1.601103	0.023952

38.000000	0.435264	-0.428488	0.085269	-0.092045	0.035928
39.000000	0.425988	-0.139468	-0.841525	0.555006	0.049900
41.000000	0.561033	-0.744970	0.326033	-0.142096	0.071856
44.000000	0.752335	-1.643855	1.679264	-0.787743	0.121756
48.000000	0.767226	-1.442138	1.342441	-0.667530	0.211577
50.000000	0.766891	-1.166027	0.683597	-0.284461	0.269461
54.000000	0.810756	-1.326344	1.356906	-0.841317	0.379242
58.000000	0.838446	-1.286047	1.292718	-0.845116	0.502994
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
31.000000	0.335507	-1.046860	1.251812	-0.540459	0.009980
32.000000	0.401221	-1.431540	2.024080	-0.993761	0.023952
34.000000	0.390699	-0.467404	-0.070094	0.146798	0.037924
36.000000	0.514402	-1.042939	1.288198	-0.759661	0.055888
38.000000	0.619820	-1.093410	1.055493	-0.581902	0.077844
41.000000	0.710382	-1.132559	0.369251	0.052926	0.141717
43.000000	0.813329	-1.878488	2.314422	-1.249263	0.171657
45.000000	0.765952	-1.221691	0.757822	-0.302083	0.231537
49.000000	0.786371	-1.172075	0.826197	-0.440493	0.343313
52.000000	0.810653	-1.233694	0.921809	-0.498768	0.447106
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
28.000000	0.102333	0.278008	-0.765973	0.385633	0.023178
29.000000	0.243795	-0.286472	0.139665	-0.096988	0.036325
30.000000	0.310170	-0.267906	0.049085	-0.091349	0.042872
32.000000	0.430838	-0.316046	-0.554723	0.439931	0.075337
34.000000	0.584065	-1.076272	0.946410	-0.454203	0.100985
36.000000	0.655080	-1.274506	1.027003	-0.407577	0.145172
39.000000	0.697528	-1.483385	1.254766	-0.468909	0.242795
41.000000	0.710580	-1.306015	1.092498	-0.497063	0.289816
43.000000	0.737621	-1.554049	1.612394	-0.795966	0.377452
47.000000	0.769538	-1.359055	1.339074	-0.749557	0.498831
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
20.000000	0.220834	-0.262224	0.031178	0.010212	0.014903
22.000000	0.304314	-0.477321	0.184094	-0.011087	0.029672
23.000000	0.351536	-0.834421	0.717450	-0.234565	0.049156
24.000000	0.406216	-0.846096	0.654765	-0.214885	0.063613
26.000000	0.494144	-1.048234	0.883396	-0.329307	0.096832
28.000000	0.562477	-1.210825	1.024221	-0.375873	0.143045
32.000000	0.618990	-1.051211	0.518427	-0.086206	0.277168
34.000000	0.672479	-1.361718	1.005408	-0.316169	0.364162
35.000000	0.692659	-1.456107	1.056706	-0.293258	0.423272
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
17.000000	-0.000210	0.000234	-0.001059	0.001035	0.019801
18.000000	0.000523	-0.000537	0.002387	-0.002373	0.029584
18.500000	0.000495	0.001094	0.000768	-0.002357	0.039288
19.000000	0.006348	-0.006420	0.028830	-0.028758	0.058463
19.300000	0.011601	-0.005827	0.028923	-0.034697	0.086651
19.500000	0.006444	-0.024503	0.102290	-0.084231	0.105064
20.000000	0.006708	-0.000081	0.001759	-0.008385	0.141001
22.000000	0.011814	-0.001178	0.008684	-0.019320	0.233911
24.000000	-0.004575	0.003697	-0.051269	0.052147	0.375352
26.000000	0.011925	-0.066629	0.184221	-0.129517	0.495085
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Middle Letaba & Nsami Dams

1.00					
35.000000	0.647409	-1.662637	1.873382	-0.858154	0.015968
37.000000	0.726940	-1.255236	0.631107	-0.102811	0.025948
38.000000	0.812789	-1.522728	1.004683	-0.294744	0.031936
40.000000	0.861366	-1.854858	1.126877	-0.133385	0.065868
41.000000	0.999615	-3.112233	3.853596	-1.740978	0.085828
43.000000	0.901186	-1.657178	0.925263	-0.169271	0.119760
45.000000	0.964668	-1.945162	1.759110	-0.778615	0.161677
50.000000	0.983660	-0.784404	-0.508325	0.309070	0.249501
55.000000	0.993299	-0.375233	-1.181460	0.563393	0.347305
60.000000	1.002014	-0.132143	-1.675194	0.805323	0.459082
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
30.000000	0.773112	-1.154986	0.173549	0.208325	0.021956
31.000000	0.911220	-1.814135	1.370678	-0.467763	0.027944
32.000000	0.917783	-1.473082	0.424072	0.131227	0.035928
33.000000	0.943505	-2.323119	1.837810	-0.458197	0.057884
35.000000	1.075862	-3.113328	3.840408	-1.802943	0.091816
38.000000	1.027371	-1.984398	1.850967	-0.893940	0.145709
43.000000	0.996650	-0.528337	-0.709515	0.241202	0.221557
45.000000	1.006014	-0.387232	-1.088617	0.469835	0.261477
48.000000	1.011990	-0.403432	-0.710175	0.101617	0.311377
52.000000	1.019285	-0.003267	-2.189906	1.173887	0.423154
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
23.600000	0.943915	-1.755306	0.810840	0.000551	0.023952
25.000000	1.009496	-1.320061	0.318431	-0.007866	0.027944
26.000000	1.030068	-1.702792	0.488467	0.184257	0.043912
27.000000	1.042960	-2.072279	1.014200	0.015118	0.065868
28.000000	1.049899	-2.117887	1.177477	-0.109489	0.087824

30.000000	1.055313	-1.858563	1.041065	-0.237815	0.125749
35.000000	1.057574	-0.853398	-0.050499	-0.153676	0.203593
40.000000	1.060411	-0.335274	-1.295084	0.569948	0.305389
45.000000	1.069093	-0.245708	-1.520044	0.696658	0.423154
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
24.000000	0.300125	-1.383895	2.191513	-1.107743	0.023178
25.000000	0.249717	-0.499397	0.416575	-0.166895	0.039601
26.000000	0.332439	-0.671979	0.668963	-0.329424	0.062404
27.000000	0.397869	-0.702059	0.475708	-0.171517	0.094600
29.000000	0.546695	-0.922997	0.899746	-0.523445	0.129494
31.000000	0.658364	-0.839586	0.255188	-0.073967	0.182335
34.000000	0.841564	-1.399692	0.651590	-0.093461	0.310007
39.000000	1.005429	-1.545278	1.267832	-0.727983	0.439457
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
13.000000	0.258373	-0.429229	0.171620	-0.000764	0.023178
13.200000	0.409567	-1.420057	2.125508	-1.115018	0.026472
13.500000	0.386684	-0.998129	1.222007	-0.610562	0.033045
14.000000	0.408080	-0.856691	0.564458	-0.115847	0.055911
16.000000	0.651532	-1.393730	1.911720	-1.169522	0.110529
20.000000	0.922915	-0.393455	-1.715171	1.185711	0.224852
21.000000	0.990710	-0.707501	-1.388805	1.105596	0.272325
23.000000	1.063589	-1.104780	-0.524923	0.566114	0.358068
25.000000	1.072300	-1.052654	-0.385938	0.366293	0.434169
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
9.500000	0.217792	-0.340609	-0.114298	0.237115	0.014903
10.000000	0.309812	-1.009727	1.399707	-0.699792	0.029672
10.500000	0.307558	-0.727272	0.726397	-0.306683	0.053990
11.000000	0.363770	-0.830650	1.000477	-0.533597	0.068403
11.500000	0.401699	-0.795532	0.685394	-0.291561	0.101519
12.000000	0.442044	-0.847227	0.546331	-0.141149	0.143045
12.500000	0.501505	-1.108798	1.074967	-0.467674	0.178972
13.000000	0.542505	-1.211339	1.249454	-0.580620	0.218291
14.000000	0.624011	-1.248720	1.297818	-0.673109	0.268926
16.000000	0.739206	-1.009405	0.465739	-0.195540	0.375509
18.000000	0.860236	-1.150951	0.302939	-0.012224	0.512050

Thapane

1.00					
1.280000	0.184409	-0.341544	0.472385	-0.315249	0.019960
1.300000	0.197383	-0.210722	-0.133030	0.146370	0.029940
1.350000	0.250593	-0.480292	0.335125	-0.105425	0.045908
1.400000	0.306453	-0.655592	0.627008	-0.277869	0.059880
1.450000	0.353790	-0.764128	0.706678	-0.296341	0.077844
1.600000	0.482535	-1.297681	1.514854	-0.699707	0.157685
1.700000	0.538144	-1.455730	1.762717	-0.845131	0.217565
1.800000	0.583872	-1.483442	1.758287	-0.858717	0.269461
2.000000	0.655388	-1.497729	1.666561	-0.824219	0.391218
2.200000	0.706966	-1.405847	1.425894	-0.727013	0.502994
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
1.230000	0.187492	-0.643096	1.004244	-0.548641	0.023952
1.260000	0.208839	-0.606369	0.874786	-0.477256	0.031936
1.300000	0.246513	-0.629752	0.792646	-0.409408	0.043912
1.400000	0.348190	-0.720732	0.854861	-0.482320	0.063872
1.500000	0.437615	-0.958816	0.742267	-0.221067	0.113772
1.700000	0.571974	-1.546521	1.853566	-0.879018	0.227545
1.850000	0.628863	-1.545815	1.752490	-0.835538	0.313373
2.100000	0.698227	-1.502674	1.602358	-0.797911	0.465070
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
1.060000	0.131026	-0.269465	0.196596	-0.058157	0.019841
1.080000	0.170598	-0.267521	0.096421	0.000502	0.024764
1.150000	0.241622	-0.340631	0.163304	-0.064295	0.034565
1.200000	0.289384	-0.460123	0.157952	0.012787	0.049156
1.350000	0.412675	-0.760473	0.535821	-0.188024	0.092131
1.450000	0.442039	-0.514845	-0.217994	0.290800	0.124735
1.600000	0.574735	-1.264167	1.091281	-0.401848	0.205313
1.700000	0.605963	-1.150756	0.844712	-0.299919	0.243863
1.800000	0.645826	-1.378298	1.046120	-0.313647	0.329382
1.950000	0.701305	-1.750766	1.720548	-0.671087	0.465353
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
0.925000	0.064486	-0.082734	-0.003320	0.021569	0.019841
0.928000	0.089856	-0.142628	0.030594	0.022177	0.024764
1.000000	0.194003	-0.288519	0.334063	-0.239547	0.034565
1.100000	0.238564	0.089667	-0.971809	0.643579	0.068403
1.200000	0.373274	-0.412306	-0.042981	0.082013	0.092131
1.300000	0.477903	-0.802851	0.370159	-0.045211	0.138489
1.400000	0.548758	-1.285580	1.144447	-0.407625	0.218291
1.500000	0.601320	-1.627705	1.777480	-0.751095	0.301559

1.600000	0.632879	-1.750571	2.038309	-0.920617	0.383006
1.700000	0.659595	-1.885812	2.294048	-1.067831	0.495666
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
0.695000	0.011842	0.000712	-0.004875	-0.007680	0.019801
0.700000	0.009463	-0.024163	0.056563	-0.041863	0.029584
0.750000	0.005590	0.017970	-0.060148	0.036588	0.039288
0.800000	0.004189	0.023096	-0.007876	-0.019409	0.067935
0.850000	0.000855	0.022589	-0.071386	0.047941	0.086651
0.880000	0.000039	-0.000040	0.000178	-0.000177	0.114159
0.950000	0.017172	0.081030	-0.220408	0.122207	0.201106
0.980000	0.000402	0.034523	-0.177479	0.142555	0.241941
1.100000	0.000218	0.049757	-0.126292	0.076316	0.368472
1.200000	0.008093	-0.007877	0.035621	-0.035837	0.483424
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
0.510000	0.011842	0.000712	-0.004875	-0.007680	0.019801
0.550000	0.009525	-0.075166	0.124170	-0.058530	0.029584
0.570000	0.001316	-0.001389	0.005894	-0.005821	0.039288
0.600000	0.007954	-0.000220	0.003174	-0.010907	0.058463
0.605000	0.003831	-0.013790	0.061220	-0.051261	0.095895
0.650000	-0.001516	0.055265	-0.100820	0.047071	0.114159
0.698000	-0.004205	0.078532	-0.169989	0.095662	0.201106
0.750000	0.004300	-0.019068	0.034591	-0.019823	0.241941
0.850000	0.000765	-0.000012	0.000230	-0.000983	0.333161
0.950000	0.004691	-0.035686	0.092647	-0.061652	0.453329
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Thabina

1.00					
3.300000	0.365143	-0.606683	0.152723	0.088817	0.023952
3.380000	0.400033	-0.706968	0.519405	-0.212470	0.025948
3.500000	0.484387	-1.348090	1.560448	-0.696746	0.037924
3.550000	0.450359	-1.163300	1.008146	-0.295205	0.051896
3.700000	0.482222	-1.245779	1.217027	-0.453469	0.071856
3.800000	0.512287	-1.295746	1.145811	-0.362351	0.103792
4.000000	0.540588	-1.346984	1.208030	-0.401634	0.169661
4.350000	0.583357	-1.627188	2.103128	-1.059297	0.305389
4.500000	0.604797	-1.537070	1.824357	-0.892084	0.371257
5.000000	0.659593	-1.405464	1.544210	-0.798339	0.582834
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
3.280000	0.412533	-0.807227	0.333290	0.061404	0.023952
3.380000	0.436646	-0.897179	0.690298	-0.229765	0.033932
3.550000	0.465344	-1.168549	1.029133	-0.325928	0.067864

3.700000	0.490626	-1.103076	0.878351	-0.265901	0.091816
3.800000	0.509588	-1.167619	0.895920	-0.237889	0.123752
4.000000	0.538461	-1.195429	0.964462	-0.307494	0.185629
4.150000	0.563186	-1.534636	1.832625	-0.861175	0.257485
4.350000	0.595233	-1.518313	1.806736	-0.883656	0.335329
4.600000	0.626489	-1.434731	1.533601	-0.725360	0.451098
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
2.900000	0.209800	-0.200034	0.022479	-0.032245	0.019841
2.950000	0.234769	-0.266309	0.031371	0.000168	0.024764
3.000000	0.259349	-0.477287	0.212566	0.005373	0.039443
3.150000	0.305209	-0.533538	0.203192	0.025137	0.063613
3.280000	0.341310	-0.757657	0.838346	-0.421999	0.092131
3.320000	0.354008	-0.786743	0.883418	-0.450683	0.101519
3.700000	0.491500	-1.041338	1.158378	-0.608540	0.161124
3.950000	0.529640	-0.983804	0.553063	-0.098899	0.260628
4.150000	0.587453	-1.315647	1.185795	-0.457601	0.337207
4.500000	0.646670	-1.545437	1.645734	-0.746968	0.478957
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
2.550000	0.196719	-0.176440	0.123399	-0.143677	0.014903
2.600000	0.222355	-0.231523	0.009112	0.000055	0.024764
2.700000	0.260425	-0.408222	0.230252	-0.082455	0.039443
2.800000	0.297503	-0.554934	0.319986	-0.062554	0.063613
2.900000	0.325898	-0.558675	0.275681	-0.042904	0.082684
2.980000	0.418476	-1.245667	1.677534	-0.850343	0.101519
3.320000	0.448961	-0.804064	0.382640	-0.027537	0.209653
3.410000	0.503562	-1.214182	1.167392	-0.456772	0.243863
3.700000	0.573485	-1.590215	1.836291	-0.819560	0.379265
3.950000	0.617998	-1.748096	2.185633	-1.055535	0.489022
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
2.030000	0.005774	-0.002631	0.013499	-0.016642	0.019801
2.050000	0.004026	0.016627	-0.050589	0.029937	0.029584
2.100000	0.016261	-0.047109	0.088689	-0.057841	0.039288
2.120000	0.014213	-0.024314	0.059220	-0.049119	0.058463
2.150000	0.019815	-0.039947	0.062479	-0.042347	0.067935
2.280000	0.023533	-0.024243	0.014555	-0.013846	0.114159
2.410000	0.017397	-0.029064	0.084924	-0.073257	0.209411
2.500000	0.035117	0.000282	-0.079146	0.043747	0.265628
2.700000	0.073241	-0.023240	0.128143	-0.178144	0.361533
2.800000	0.036639	0.099301	-0.480756	0.344816	0.428256
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					

1.450000	0.023685	0.001425	-0.009750	-0.015360	0.019801
1.500000	0.005064	-0.005405	0.023001	-0.022660	0.029584
1.600000	0.012802	-0.013120	0.057477	-0.057159	0.048914
1.650000	0.007134	0.014471	-0.051456	0.029850	0.058463
1.700000	0.010745	0.086144	-0.278569	0.181680	0.086651
1.800000	0.035438	0.056498	-0.290549	0.198613	0.132127
1.900000	0.043918	-0.129904	0.178536	-0.092549	0.217646
2.000000	0.013775	0.021643	-0.073889	0.038471	0.257799
2.250000	0.020117	-0.032631	0.151733	-0.139219	0.361533
2.450000	0.006446	-0.003420	0.029696	-0.032723	0.453329
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Modjadji

1.00					
3.600000	0.535128	-1.089195	0.639573	-0.085506	0.013972
3.800000	0.544244	-1.012290	0.397123	0.070924	0.025948
4.000000	0.596964	-1.424732	1.264029	-0.436261	0.045908
4.150000	0.618481	-1.388813	1.457585	-0.687252	0.055888
4.300000	0.570332	-1.005422	0.390031	0.045059	0.089820
4.500000	0.619964	-1.347072	1.201751	-0.474643	0.131737
4.800000	0.697988	-1.479235	1.540141	-0.758894	0.185629
5.000000	0.733109	-1.384504	1.176467	-0.525072	0.229541
5.400000	0.782894	-1.264114	0.799829	-0.318609	0.327345
5.800000	0.826911	-1.180301	0.394498	-0.041108	0.445110
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
3.400000	0.362404	-0.430411	0.128982	-0.060976	0.021956
3.600000	0.535271	-0.514159	0.232773	-0.253884	0.025948
3.800000	0.483759	0.217523	-2.019824	1.318542	0.043912
3.900000	0.532871	-0.149871	-1.374279	0.991279	0.053892
4.000000	0.601257	-0.731333	-0.420697	0.550773	0.071856
4.200000	0.673875	-1.297538	0.736806	-0.113142	0.109780
4.500000	0.759482	-1.831008	2.006032	-0.934506	0.175649
4.800000	0.788420	-1.583358	1.395913	-0.600975	0.239521
5.500000	0.853019	-1.497229	1.312953	-0.668743	0.407186
6.000000	0.872962	-1.232062	0.536894	-0.177794	0.564870
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
3.000000	0.413773	-0.472524	0.189475	-0.130723	0.023178
3.080000	0.391566	0.167261	-1.352904	0.794077	0.026472
3.200000	0.507472	-0.261732	-1.086874	0.841134	0.036325
3.400000	0.686908	-1.460404	0.950789	-0.177294	0.059160
3.600000	0.739443	-1.752277	1.442736	-0.429902	0.091401
3.800000	0.756720	-1.854015	1.721616	-0.624321	0.126344
4.200000	0.818001	-2.320849	2.940278	-1.437431	0.212797

4.500000	0.804027	-1.981975	2.219682	-1.041734	0.298498
5.000000	0.834864	-1.755224	2.038869	-1.118508	0.388422
5.500000	0.861093	-1.496715	1.440781	-0.805159	0.508885
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
2.480000	0.123901	-0.051278	-0.054333	-0.018290	0.014903
2.500000	0.201848	-0.384196	0.239099	-0.056751	0.024764
2.600000	0.235584	-0.589666	0.614021	-0.259939	0.039443
2.630000	0.246177	-0.547588	0.364478	-0.063066	0.053990
2.800000	0.297161	-0.676995	0.731759	-0.351924	0.077938
3.000000	0.393506	-0.841210	0.972490	-0.524785	0.106192
3.400000	0.531290	-1.032735	0.892813	-0.391368	0.205313
3.600000	0.589514	-1.105237	0.805768	-0.290045	0.264784
4.000000	0.702350	-1.445538	1.493124	-0.749936	0.367958
4.500000	0.794258	-1.539555	1.673628	-0.928332	0.489022
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
1.600000	0.099987	-0.154338	0.047325	0.007026	0.019841
1.650000	0.166400	-0.235449	0.149798	-0.080749	0.024764
1.800000	0.271622	-0.403159	0.150799	-0.019263	0.044307
2.000000	0.376343	-0.496622	0.167961	-0.047682	0.068403
2.100000	0.441541	-0.713678	0.606563	-0.334426	0.087415
2.200000	0.504558	-0.795109	0.624416	-0.333864	0.110849
2.600000	0.610963	-1.105664	0.697197	-0.202495	0.209653
2.680000	0.654515	-1.182830	0.578113	-0.049797	0.248075
2.750000	0.701319	-1.449555	0.957935	-0.209698	0.305575
3.100000	0.762713	-1.828708	1.808667	-0.742672	0.433972
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
1.360000	0.006232	-0.022758	0.044700	-0.028174	0.019801
1.400000	0.003646	-0.002486	0.015937	-0.017098	0.029584
1.450000	0.001365	-0.003111	0.007789	-0.006043	0.048914
1.500000	0.004643	-0.001032	0.016084	-0.019695	0.077331
1.550000	0.006053	-0.006343	0.026842	-0.026552	0.086651
1.600000	0.017129	-0.058796	0.065822	-0.024156	0.123180
1.750000	0.002168	-0.004969	0.026531	-0.023730	0.175774
1.850000	-0.002533	-0.049743	0.156385	-0.104109	0.257799
1.950000	0.009829	0.001486	-0.039625	0.028310	0.402272
2.000000	0.004781	-0.000085	0.001539	-0.006236	0.434609
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Phiphidi & Vondo dams

1.00					
20.000000	0.550896	-1.062663	1.213236	-0.701469	0.015968
20.600000	0.518959	-0.346929	-0.474932	0.302902	0.019960

21.400000	0.623060	-1.129349	0.380656	0.125633	0.035928
22.500000	0.671067	-1.398478	0.843006	-0.115596	0.059880
23.500000	0.706675	-1.693374	1.384527	-0.397828	0.095808
25.000000	0.733489	-1.450965	0.857203	-0.139727	0.133733
26.000000	0.766666	-1.738357	1.395135	-0.423444	0.183633
28.000000	0.804948	-2.033825	2.153227	-0.924350	0.279441
30.000000	0.823364	-2.036484	2.242218	-1.029098	0.383234
32.000000	0.842475	-1.949872	2.125282	-1.017885	0.487026
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
19.000000	0.725253	-1.909029	1.984895	-0.801119	0.023952
20.000000	0.825560	-2.194684	2.904829	-1.535705	0.027944
21.000000	0.727796	-1.351242	0.528478	0.094968	0.047904
21.500000	0.746428	-1.366106	0.600649	0.019028	0.053892
22.000000	0.761044	-1.566919	0.896310	-0.090435	0.067864
23.000000	0.780007	-2.158760	2.116758	-0.738005	0.105788
26.000000	0.808586	-2.134102	2.475385	-1.149870	0.221557
27.000000	0.817468	-2.018367	2.024727	-0.823828	0.283433
28.000000	0.830697	-2.041668	2.114583	-0.903612	0.335329
32.000000	0.860894	-1.883911	2.086381	-1.063364	0.522954
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
16.000000	0.545503	-0.662924	-0.122805	0.240227	0.019920
18.000000	0.642689	-1.433171	1.127617	-0.337134	0.057052
20.000000	0.724405	-1.461541	1.189955	-0.452819	0.091447
22.000000	0.814609	-1.742682	1.575055	-0.646982	0.135288
24.000000	0.842302	-1.980678	1.967593	-0.829217	0.212132
26.000000	0.834500	-1.752853	1.578236	-0.659883	0.289835
28.000000	0.851429	-1.751134	1.522574	-0.622869	0.395343
30.000000	0.867096	-1.758469	1.450654	-0.559281	0.523237
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
13.000000	0.503246	-0.599598	-0.093325	0.189677	0.019880
13.500000	0.535871	-0.701683	-0.166119	0.331931	0.026472
14.000000	0.601212	-1.512860	1.294122	-0.382474	0.042872
15.000000	0.650231	-1.522662	1.236274	-0.363843	0.068880
16.000000	0.739883	-2.002370	2.065431	-0.802944	0.094600
18.000000	0.797433	-1.942899	2.301763	-1.156297	0.142046
20.000000	0.822511	-1.871657	1.902578	-0.853432	0.239816
22.000000	0.844672	-2.018647	1.847423	-0.673447	0.385687
24.000000	0.862523	-2.392284	2.536554	-1.006793	0.588677
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

0.20					
8.000000	0.001169	0.005626	-0.014889	0.008094	0.019841
9.000000	0.003356	-0.002292	0.008119	-0.009183	0.034565
9.520000	0.005855	-0.006644	0.028604	-0.027815	0.053990
10.000000	0.021390	-0.001086	0.013960	-0.034264	0.092131
10.100000	0.014169	-0.027119	0.076406	-0.063456	0.115492
10.250000	0.000279	-0.000373	0.001638	-0.001545	0.143045
11.000000	0.004141	-0.039733	0.025010	0.010582	0.264784
12.000000	0.003758	0.008884	-0.022977	0.010335	0.451538
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
3.700000	0.001855	-0.001951	0.008611	-0.008515	0.019801
3.900000	0.000645	0.006942	-0.002384	-0.005203	0.029584
4.000000	0.009143	0.036924	-0.143623	0.097557	0.058463
4.500000	-0.002088	0.002139	-0.009528	0.009477	0.095895
4.600000	-0.010796	0.010808	-0.046308	0.046296	0.123180
4.800000	-0.008205	0.008853	-0.037685	0.037038	0.167188
5.000000	-0.000317	0.072431	-0.158079	0.085966	0.249904
5.500000	0.000769	0.004868	-0.019403	0.013766	0.402272
5.700000	0.001152	0.019031	-0.074067	0.053884	0.471549
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Damani

1.00					
5.300000	0.692311	-1.265984	0.981921	-0.408249	0.017964
5.450000	0.663719	-1.173407	0.626800	-0.117111	0.025948
5.500000	0.694725	-1.606680	1.145381	-0.233425	0.035928
6.000000	0.720908	-1.163965	0.721116	-0.278058	0.065868
6.200000	0.708617	-0.892097	-0.227530	0.411010	0.093812
6.300000	0.755488	-1.257153	0.288361	0.213304	0.115768
6.800000	0.857629	-1.842581	1.869047	-0.884095	0.197605
7.000000	0.864263	-1.679912	1.521912	-0.706263	0.235529
7.800000	0.896535	-1.248171	0.700366	-0.348730	0.397206
8.000000	0.909172	-1.182075	0.566451	-0.293548	0.439122
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.80					
4.800000	0.481899	0.199278	-1.353218	0.672040	0.017964
5.000000	0.531458	0.103518	-2.095657	1.460681	0.029940
5.300000	0.742254	-1.523510	1.451355	-0.670099	0.047904
5.450000	0.763432	-1.755932	1.703763	-0.711262	0.069860
5.600000	0.792495	-1.833207	2.033202	-0.992490	0.081836
5.800000	0.783659	-1.432854	0.973372	-0.324177	0.109780

6.500000	0.840983	-1.233243	0.645456	-0.253197	0.215569
6.800000	0.845736	-1.088022	0.330505	-0.088219	0.275449
7.500000	0.869764	-0.911422	0.305706	-0.264048	0.405190
7.800000	0.877281	-0.786754	0.122973	-0.213500	0.459082
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
4.100000	0.368701	0.256668	-1.595748	0.970379	0.022404
4.300000	0.516853	0.063166	-1.274330	0.694311	0.024888
4.500000	0.649266	-0.680254	-0.478610	0.509597	0.037284
4.800000	0.702135	-1.075998	0.105403	0.268460	0.066905
5.000000	0.738112	-1.191609	0.352313	0.101184	0.086549
5.300000	0.788014	-1.536497	1.178387	-0.429904	0.128011
6.000000	0.829147	-1.136291	0.789309	-0.482166	0.214510
6.300000	0.822611	-0.685404	-0.430707	0.293500	0.271147
6.800000	0.866111	-0.754011	-0.448675	0.336575	0.370424
7.500000	0.900186	-0.922842	-0.023281	0.045937	0.516774
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
3.500000	0.414127	-1.322506	1.703219	-0.794840	0.023178
3.600000	0.412949	-1.177116	1.507641	-0.743473	0.033045
3.800000	0.463924	-0.846033	0.804462	-0.422353	0.046138
4.000000	0.520067	-0.516962	-0.169885	0.166781	0.062404
4.300000	0.666423	-0.847087	0.042303	0.138361	0.094600
4.500000	0.759315	-1.231433	0.553643	-0.081525	0.123190
5.000000	0.839892	-1.364997	0.659725	-0.134620	0.203707
5.300000	0.857184	-1.294897	0.360660	0.077052	0.263515
5.600000	0.897916	-1.577817	0.834644	-0.154742	0.338446
6.000000	0.921936	-1.743751	1.250788	-0.428972	0.436815
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
2.700000	0.354615	-0.670353	0.524778	-0.209040	0.019841
2.850000	0.407431	-0.963542	0.916209	-0.360098	0.029672
2.900000	0.431584	-1.067282	1.019919	-0.384220	0.034565
3.100000	0.473643	-1.291924	1.334367	-0.516086	0.063613
3.200000	0.493908	-1.143672	0.911374	-0.261610	0.082684
3.300000	0.513664	-1.370260	1.353618	-0.497022	0.106192
3.800000	0.587485	-1.206731	1.026940	-0.407695	0.213979
4.000000	0.627162	-1.319571	1.297899	-0.605491	0.273054
4.300000	0.669096	-1.412059	1.378166	-0.635203	0.367958
4.500000	0.698844	-1.386325	1.290084	-0.602604	0.426852
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
1.900000	0.091223	0.082473	-0.030983	-0.142713	0.014903
2.000000	0.201367	0.143331	-1.045713	0.701015	0.024764
2.100000	0.406758	-0.870306	0.778584	-0.315036	0.029672

2.200000	0.456419	-0.827441	0.582241	-0.211219	0.034565
2.300000	0.480687	-0.853620	0.273442	0.099490	0.049156
2.500000	0.540170	-1.321468	1.336482	-0.555184	0.087415
2.700000	0.585642	-1.410256	1.906812	-1.082198	0.115492
2.900000	0.621166	-1.438659	1.536774	-0.719281	0.178972
3.100000	0.658383	-1.681824	1.744620	-0.721179	0.260628
3.300000	0.675883	-1.624198	1.629837	-0.681523	0.333301
3.500000	0.698418	-1.654963	1.554393	-0.597848	0.441038

Nandoni

1.00					
65.000000	0.661701	-1.106138	0.512197	-0.067760	0.017964
70.000000	1.036195	-3.635397	6.012297	-3.413095	0.021956
73.000000	0.800376	-1.526286	1.523551	-0.797641	0.031936
75.000000	0.735881	-0.897899	-0.243282	0.405300	0.043912
78.000000	0.792649	-1.407444	0.602308	0.012486	0.063872
80.000000	0.823732	-1.679603	1.177209	-0.321339	0.079840
81.000000	0.817086	-1.799547	1.143630	-0.161169	0.103792
95.000000	0.845302	-1.278853	0.920923	-0.487372	0.207585
98.000000	0.854654	-1.230306	0.854910	-0.479258	0.237525
105.000000	0.872004	-0.824500	-0.234253	0.186749	0.317365
113.000000	0.891985	-0.689430	-0.684925	0.482370	0.425150
0.80					
64.000000	0.838274	-2.105872	3.029630	-1.762032	0.021956
66.000000	0.725454	-1.074227	0.676101	-0.327329	0.027944
68.000000	0.708631	-0.751291	-0.189221	0.231881	0.035928
70.000000	0.748012	-1.101443	0.164335	0.189096	0.049900
74.000000	0.774272	-1.202775	0.344004	0.084500	0.077844
78.000000	0.810790	-1.351757	0.787008	-0.246040	0.103792
85.000000	0.804463	-1.102621	0.115661	0.182497	0.175649
90.000000	0.830908	-1.209062	0.637425	-0.259271	0.223553
98.000000	0.847993	-0.875566	0.001026	0.026547	0.311377
102.000000	0.857858	-0.722236	-0.360584	0.224962	0.357285
108.000000	0.868817	-0.582895	-0.784053	0.498132	0.437126
0.60					
56.000000	0.493573	-0.662547	0.311893	-0.142919	0.019920
58.500000	0.535674	-0.422045	-0.929054	0.815425	0.032329
60.000000	0.617495	-0.995043	0.244992	0.132557	0.039760
62.000000	0.703495	-1.461971	1.057916	-0.299440	0.052118
68.000000	0.800922	-1.882111	2.168756	-1.087567	0.093894
73.000000	0.776619	-1.129635	0.530530	-0.177514	0.132864
80.000000	0.815306	-1.031709	0.030850	0.185553	0.207372
85.000000	0.828542	-0.983735	-0.169814	0.325007	0.268804
93.000000	0.869136	-1.317622	0.538685	-0.090199	0.393086
102.000000	0.887464	-1.284190	0.883148	-0.486422	0.492929

1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
45.000000	0.545348	-0.922692	0.293214	0.084130	0.013972
48.000000	0.638569	-1.591629	1.491988	-0.538929	0.027944
50.000000	0.694878	-1.965785	2.251186	-0.980278	0.039920
55.000000	0.738565	-1.377583	0.814876	-0.175858	0.069860
57.000000	0.778354	-1.533570	1.039022	-0.283807	0.087824
60.000000	0.778444	-1.286174	0.651113	-0.143384	0.107784
65.000000	0.801051	-1.403542	0.811328	-0.208837	0.163673
67.000000	0.816289	-1.377694	0.808465	-0.247060	0.179641
75.000000	0.847682	-1.463134	1.090591	-0.475139	0.273453
80.000000	0.868402	-1.405769	1.043642	-0.506274	0.333333
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
33.000000	0.097094	1.170527	-2.984904	1.717283	0.019841
34.000000	0.361402	-0.442833	0.053289	0.028142	0.024764
35.000000	0.419647	-1.023491	0.822822	-0.218978	0.044307
37.000000	0.472916	-1.154273	1.110444	-0.429087	0.058809
39.000000	0.510799	-1.164208	0.955987	-0.302578	0.082684
40.000000	0.528003	-1.256920	1.132817	-0.403900	0.096832
48.000000	0.617076	-1.086769	0.859420	-0.389727	0.200958
50.000000	0.643552	-1.409984	1.625167	-0.858735	0.268926
53.000000	0.671343	-1.448324	1.199833	-0.422851	0.356529
55.000000	0.697234	-1.606440	1.411693	-0.502487	0.430419
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.10					
22.000000	0.005595	-0.012450	0.032447	-0.025592	0.019801
23.000000	0.004030	-0.004739	0.020230	-0.019521	0.039288
24.000000	-0.000302	0.000337	-0.001460	0.001425	0.067935
25.000000	0.003749	-0.000056	0.001074	-0.004767	0.095895
26.000000	-0.000198	0.000202	-0.000909	0.000905	0.132127
27.000000	0.003272	0.005714	-0.030189	0.021203	0.192732
28.500000	-0.000091	0.000091	-0.000410	0.000410	0.273391
30.000000	0.000554	-0.012124	0.060947	-0.049377	0.340346
32.000000	0.002130	0.016762	-0.052030	0.033138	0.512180
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Tshakhuma

1.00					
2.800000	0.328357	-0.311338	-0.167917	0.150898	0.023952
2.830000	0.339394	-0.494250	-0.076763	0.231619	0.035928
2.850000	0.347302	-0.613185	0.110153	0.155730	0.043912
2.880000	0.359752	-0.859778	0.574374	-0.074348	0.065868
2.900000	0.368732	-0.835572	0.601013	-0.134173	0.067864

2.950000	0.381760	-0.838644	0.688069	-0.231185	0.089820
3.000000	0.395912	-0.755985	0.602309	-0.242236	0.105788
3.200000	0.438676	-0.556970	0.147662	-0.029369	0.193613
3.300000	0.466236	-0.598146	0.158866	-0.026957	0.253493
3.400000	0.491928	-0.586141	-0.037672	0.131885	0.331337
3.600000	0.543166	-0.653612	0.027751	0.082695	0.483034
0.80					
2.680000	0.246349	-0.253558	-0.047566	0.054774	0.023952
2.700000	0.261679	-0.334184	-0.118096	0.190601	0.033932
2.750000	0.280621	-0.394757	-0.035821	0.149957	0.047904
2.780000	0.294934	-0.449557	0.021830	0.132793	0.059880
2.880000	0.354530	-0.744949	0.829998	-0.439578	0.093812
2.950000	0.371978	-0.583221	0.425259	-0.214016	0.123752
3.100000	0.423788	-0.424975	-0.099711	0.100898	0.189621
3.200000	0.465614	-0.516890	-0.083407	0.134683	0.249501
3.300000	0.503888	-0.695738	0.151613	0.040237	0.327345
3.500000	0.543556	-0.760603	0.415925	-0.198878	0.457086
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.60					
2.500000	0.208098	-0.211846	0.003747	0.000002	0.016578
2.550000	0.235995	-0.397231	0.091430	0.069806	0.033045
2.580000	0.252087	-0.450814	0.200219	-0.001493	0.039601
2.650000	0.280650	-0.516974	0.373542	-0.137218	0.059160
2.750000	0.333378	-0.647044	0.589563	-0.275896	0.091401
2.780000	0.346358	-0.641632	0.473458	-0.178185	0.107352
2.980000	0.454926	-1.036440	0.989524	-0.408010	0.224852
3.000000	0.460669	-1.083234	1.029340	-0.406775	0.248738
3.200000	0.507976	-1.248351	1.448260	-0.707885	0.396598
3.300000	0.524569	-1.209980	1.430116	-0.744705	0.465598
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.40					
2.350000	0.180434	-0.100379	-0.111668	0.031613	0.019841
2.400000	0.201570	-0.174475	-0.119487	0.092393	0.029672
2.450000	0.222825	-0.229498	-0.062707	0.069380	0.034565
2.480000	0.234861	-0.307415	-0.057754	0.130308	0.049156
2.550000	0.260616	-0.581578	0.472083	-0.151121	0.087415
2.580000	0.272961	-0.777771	0.927673	-0.422862	0.115492
2.700000	0.323465	-1.119797	1.595031	-0.798699	0.213979
2.750000	0.322675	-0.760386	0.665303	-0.227593	0.256458
2.900000	0.357930	-0.844912	1.000393	-0.513411	0.364162
3.000000	0.383465	-0.772471	0.735312	-0.346306	0.458472
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.20					
2.100000	0.000242	-0.004405	0.022092	-0.017928	0.019801
2.150000	0.003134	0.001922	-0.009528	0.004471	0.029584

2.200000	0.002702	-0.008978	0.053920	-0.047644	0.039288
2.250000	0.003485	-0.000037	0.000891	-0.004339	0.048914
2.270000	0.002798	-0.011885	0.048046	-0.038959	0.058463
2.300000	0.002646	-0.036403	0.074526	-0.040768	0.086651
2.350000	0.006896	0.011128	-0.059206	0.041181	0.132127
2.400000	0.007720	-0.000078	0.001914	-0.009556	0.167188
2.450000	0.009082	-0.002513	0.014690	-0.021259	0.265628
2.500000	0.003959	-0.000059	0.001179	-0.005079	0.361533
2.600000	0.009395	0.000616	-0.000249	-0.009763	0.544980
0.10					
1.840000	0.003042	-0.005647	0.015029	-0.012424	0.019801
1.860000	0.004308	-0.004708	0.019622	-0.019222	0.029584
1.930000	-0.002631	0.002880	-0.012329	0.012080	0.058463
1.970000	0.003535	-0.002760	0.015168	-0.015943	0.086651
1.990000	0.002643	-0.002530	0.011579	-0.011692	0.105064
2.030000	0.004458	-0.022353	0.038376	-0.020481	0.175774
2.050000	-0.003112	0.002734	-0.013406	0.013785	0.233911
2.150000	0.002399	-0.000162	0.001341	-0.003578	0.382171
2.180000	0.003394	0.001158	-0.004766	0.000214	0.434609
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
1.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Appendix D

Water Requirements Spreadsheet

Table A-1: Letaba Luvuvhu water requirements projection

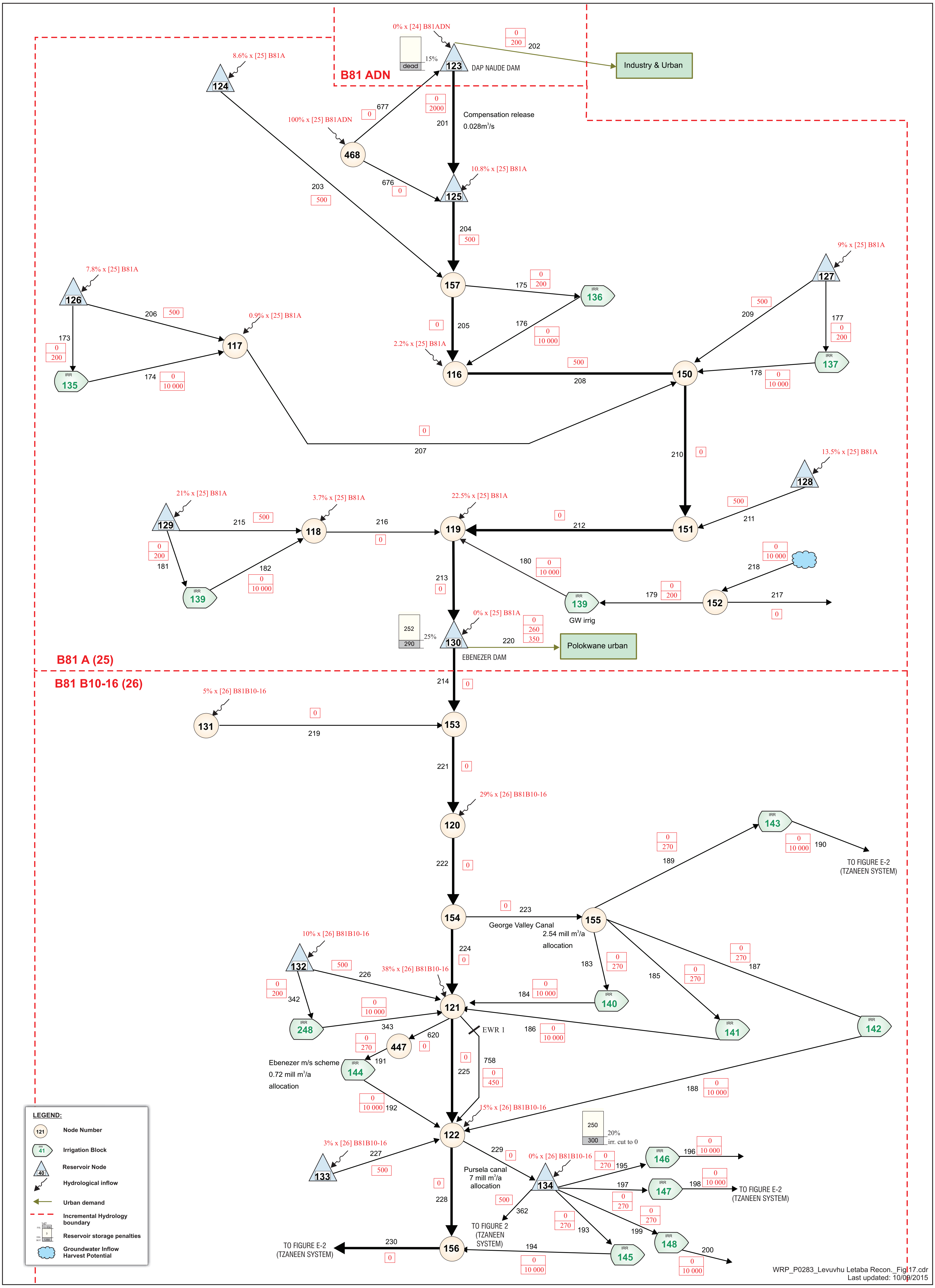
SUB-SYSTEM	Resource	WRPM CHANNEL NO.	Channel Sub-component	DESCRIPTION	Water Services Scheme nr	DEMAND TYPE	WRPM TYPE	Nadoni allocation	Irrigation Block No.	WRPM Base Demand	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants and groundwater		877a	Vondo Central RWS excl Thoyandou & Tshisahulu	14	Urban Rural	sub component			4.41	5.507	6.053	6.600	7.146	7.769	8.392	9.015	9.638	10.260	10.962	11.66	12.36	13.07	13.77	14.04	14.31	14.58	14.86	15.13	15.41	15.69	15.97	16.25	16.53	16.83	17.13	17.43	17.74	18.04
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants and groundwater		877b	Vondo Central RWS Thoyandou only	14	Urban Rural	sub component			9.17	9.512	9.683	9.854	10.026	10.201	10.376	10.551	10.726	10.901	11.080	11.260	11.440	11.620	11.799	11.873	11.947	12.021	12.095	12.169	12.244	12.318	12.393	12.467	12.542	12.620	12.698	12.775	12.853	12.931
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants and groundwater		877c	Vondo Central RWS Tshisahulu only	14	Urban Rural	sub component			0.64	0.78	0.85	0.92	0.99	1.06	1.13	1.20	1.28	1.35	1.42	1.50	1.57	1.65	1.72	1.74	1.76	1.77	1.79	1.80	1.82	1.84	1.85	1.87	1.89	1.91	1.92	1.94	1.96	1.98
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants and groundwater		877d	Vondo East RWS	15	Urban Rural	sub component			0.40	0.43	0.45	0.46	0.48	0.50	0.51	0.53	0.54	0.56	0.58	0.59	0.61	0.63	0.65	0.66	0.67	0.68	0.70	0.71	0.72	0.74	0.75	0.76	0.78	0.79	0.80	0.82	0.83	0.85
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants and groundwater		877e	Vondo North Rural RWS	11	Urban Rural	sub component			0.10	0.113	0.117	0.122	0.127	0.132	0.137	0.142	0.147	0.152	0.157	0.163	0.168	0.174	0.179	0.183	0.187	0.190	0.194	0.198	0.201	0.205	0.209	0.213	0.217	0.221	0.225	0.229	0.233	0.237
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants and groundwater		877f	Vondo South RWS	31	Urban Rural	sub component			1.24	1.430	1.524	1.619	1.714	1.816	1.919	2.021	2.123	2.226	2.336	2.447	2.557	2.668	2.778	2.816	2.854	2.892	2.930	2.968	3.006	3.045	3.084	3.123	3.161	3.202	3.243	3.284	3.325	3.366
Greater Thohoyandou	Middle Letaba & Groundwater & Nandoni		877g	Malamulele West RWS (Was previously supplied from Middle Letaba)	21	Urban Rural	sub component			1.03	1.08	1.100	1.123	1.146	1.184	1.221	1.259	1.297	1.335	1.374	1.414	1.454	1.494	1.534	1.559	1.584	1.609	1.634	1.659	1.685	1.710	1.736	1.762	1.788	1.815	1.842	1.869	1.896	1.924
Greater Thohoyandou	Groundwater		877h	Malamulele West RWS (Was previously supplied from Middle Letaba)	21	Urban Rural	sub component			0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Middle Letaba Nsami system	Middle Letaba & Nsami dams			Malamulele West RWS (Was previously supplied from Middle Letaba)	21	Urban Rural	sub component			0.82	0.87	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greater Thohoyandou	Nandoni Dam			Malamulele West RWS (Was previously supplied from Middle Letaba)	21	Urban Rural	sub component	2.128		1.15	0.00	0.00	0.91	0.94	0.97	1.01	1.05	1.09	1.12	1.16	1.20	1.24	1.28	1.32	1.35	1.37	1.40	1.42	1.45	1.47	1.50	1.53	1.55	1.58	1.60	1.63	1.66	1.69	1.71
GW - Thohoyandou	Groundwater		877h	GREATER THOYANDOU Groundwater		Urban Rural	sub component			0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.44
Greater Thohoyandou	Vondo & Phiphidi dams, Dzingae & Dzindi package plants	877		Greater Thoyandou surface water		Urban Rural	Master Control Channel			15.74	17.14	17.80	19.45	20.17	21.20	22.23	23.26	24.29	25.32	26.45	27.58	28.71	29.84	30.97	31.41	31.85	32.30	32.74	33.18	33.63	34.09	34.54	34.99	35.44	35.93	36.41	36.89	37.38	37.86
Greater Thohoyandou	Vondo Dam	1098		Vondo Irrigation no wc/wdm applicable		Irrigation	Master Control Channel			14.20	0.00	0.000	0.000	0.000	0.500	1.000	1.500	2.000	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800
Greater Thohoyandou	Tshakuma Dam & Groundwater		1132a	Tshakhuma RWS	22	Urban Rural	sub component			1.58	1.675	1.723	1.770	1.818	1.868	1.917	1.967	2.017	2.067	2.119	2.172	2.224	2.276	2.329	2.368	2.408	2.447	2.486	2.526	2.566	2.607	2.647	2.688	2.728	2.771	2.814	2.857	2.900	2.942
Greater Thohoyandou	Groundwater - Tshakuma		1132b		22	Urban Rural	sub component			0.17	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
Greater Thohoyandou	Tsakuma Dam	1132		Tsakuma Dam urban	22	Urban Rural	Master Control Channel			1.41	1.467	1.495	1.524	1.552	1.602	1.652	1.701	1.751	1.801	1.853	1.906	1.958	2.011	2.063	2.102	2.142	2.181	2.221	2.260	2.300	2.341	2.381	2.422	2.462	2.505	2.548	2.591	2.634	2.677
Greater Thohoyandou	Damani Dam & Groundwater		1198a	Damani RWS	9	Urban Rural	sub component			2.20	2.863	3.195	3.527	3.858	4.218	4.578	4.938	5.298	5.658	6.047	6.435	6.824	7.212	7.601	7.705	7.809	7.913	8.017	8.121	8.226	8.332	8.438	8.544	8.650	8.762	8.874	8.986	9.099	9.211
Greater Thohoyandou	Groundwater - Damani		1198b	Damani RWS	9	Urban Rural	sub component			0.35	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350	0.350
Greater Thohoyandou	Damani Dam	896		Damani Irrigation no wc/wdm applicable		Irrigation	Master Control Channel			0.40	0.000	0.000	0.000	0.000	0.792	1.584	2.376	3.168	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960	3.960
Greater Thohoyandou	Damani Dam	1198		Damani RWS	9	Urban Rural	Master Control Channel	0.57		3.40	2.436	2.729	3.022	3.315	3.675	4.035	4.395	4.755	5.115	5.504	5.892	6.281	6.669	7.058	7.162	7.266	7.370	7.474	7.578	7.684	7.789	7.895	8.001	8.107	8.219	8.331	8.443	8.556	8.668
Greater Thohoyandou	Damani Dam	2004		Groundwater development			Master Control Channel			1.90			0.000	0.000	0.000	0.000	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900	1.900
Nandoni	Nandoni Dam and downstream incremental flow		1105a	Lambani RWS	17	Urban Rural	sub component			0.21	0.234	0.246	0.258	0.271	0.284	0.297	0.311	0.324	0.337	0.352	0.367	0.381	0.396	0.411	0.420	0.430	0.439	0.449	0.458	0.468	0.478	0.488	0.498	0.508	0.519	0.529	0.540	0.551	0.561
Nandoni	Nandoni Dam and downstream incremental flow		1105b	North Malamulele East RWS	19	Urban Rural	sub component			3.06	3.638	3.929	4.220	4.511	4.824	5.136	5.449	5.761	6.074	6.408	6.742	7.076	7.410	7.745	7.845	7.945	8.045	8.145	8.245	8.347	8.448	8.550	8.652	8.754	8.861	8.968	9.075	9.182	9.289
Nandoni	Groundwater		1105c	North Malamulele East RWS	19	Urban Rural	sub component			0.16	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.160
Nandoni	Nandoni Dam and downstream incremental flow		1105d	Tshifudi RWS	16	Urban Rural	sub component			1.13	1.200	1.234	1.269	1.304	1.340	1.377	1.414	1.450	1.487	1.525	1.564	1.603	1.642	1.680	1.709	1.739	1.768	1.797	1.826	1.856	1.886	1.916	1.947	1.977	2.009	2.041	2.073	2.105	2.136
Nandoni	Groundwater		1105e	Tshifudi RWS	16	Urban Rural	sub component			0.27	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270	0.270
Nandoni	Nandoni Dam & Xikundu Weir	1105		Xikundu		Urban Rural	Master Control Channel			4.90	3.79	4.07	4.34	4.62	4.98	5.35	5.71	6.07	6.43	6.82	7.21	7.60	7.98	8.37	8.51	8.65	8.79	8.93	9.07	9.21	9.35	9.49	9.63	9.77	9.92	10.07	10.22	10.37	10.52
Nandoni	Nandoni Dam & Mhinga Weir	1106		Mhinga: no wc/wdm applicable		Urban Rural	Master Control Channel			0.73	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730
Nandoni	Nandoni Dam & Xikundu Weir	2001		Irrigation to be developed		Urban Rural	Master Control Channel			5.2	0.00	0.000	0.000	0.000	1.550	1.940	2.730	3.520	4.160	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200
Nandoni	Nandoni Dam & Mhinga Weir	2002		Irrigation to be developed		Urban Rural	Master Control Channel			5.2	0.00	0.000	0.000	0.000	1.550	1.940	2.730	3.520	4.160	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200	5.200
Nandoni	Nandoni Dam & Mhinga Weir	2007		Groundwater development			Master Control Channel			5.4														5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400	5.400
Nandoni	Nandoni Dam and downstream incremental flow & GW		1107a	South Malamulele East RWS excl Malamulele	20	Urban Rural	sub component			2.48	3.063	3.353	3.643	3.933	4.248	4.563	4.878	5.193	5.508	5.848	6.189	6.529	6.870	7.210	7.312	7.413	7.515	7.617	7.718	7.822	7.925	8.029	8.133	8.236	8.346	8.456	8.565	8.675	8.785
Nandoni	Nandoni Dam and downstream incremental flow & GW		1107b	South Malamulele East RWS Malamulele Town only	20	Urban Rural	sub component			1.13	1.162	1.178	1.194	1.209	1.225	1.241	1.257	1.273	1.288	1.304	1.320	1.337	1.353	1.369	1.383	1.398	1.412	1.427	1.441	1.456	1.470	1.485	1.499	1.514	1.529	1.545	1.560	1.576	1.591
Nandoni	Groundwater		1107c	South Malamulele East RWS Malamulele Town only	20	Urban Rural	sub component			0.11	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Nandoni	Nandoni Dam & Malamule Weir	1107		Malamule	20	Urban Rural	Master Control Cha	6.6		5.30	4.01	4.27	4.52	4.78	5.11	5.44	5.77	6.10	6.43	6.79	7.14	7.50	7.86	8.21	8.33	8.44	8.56	8.68	8.79	8.91	9.03	9.15	9.26	9.38	9.51	9.63	9.76	9.88	10.01
Nandoni	Nandoni Dam	889		Support to Giyani no wc/wdm applicable		Urban Rural	Master Control Cha	5		5.00	0.000	0.000	0.000	0.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Outside WMA Sinthumele system	Nandoni Dam & Groundwater		874a	SINTHUMELE Total demand	27	Urban Rural	sub component			3.38	3.584	3.687	3.789	3.891	3.998	4.105	4.213	4.320	4.427	4.540	4.653	4.766	4.879	4.992	5.074	5.157	5.240	5.323	5.405	5.490	5.576	5.661	5.746	5.831	5.921	6.011	6.101	6.191	6.282
Outside WMA Sinthumele system	Groundwater		874b	SINTHUMELE Groundwater supply	27	Urban Rural	sub component			0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
Nandoni	Nandoni Dam	874		SinthumeleSurface water: no wc/wdm applicable	27	Urban Rural	Master Control Cha	3.882		3.88	0.00	0.00	0.00	0.00	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	1.30	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88	3.88
Outside WMA Airforce Base	Nandoni Dam & Groundwater		875a	AIRFORCE Total Demand	28	Urban Industrial	sub component				0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58
Outside WMA Airforce Base	Groundwater		875b	AIRFORCE Groundwater supply	28	Urban Industrial	sub component				0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28
Nandoni	Nandoni Dam	875		Airforce Surface water: checked no wc/wdm applicable	28	Urban Industrial	Master Control Cha	0.482		0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Nandoni	Nandoni Dam & Groundwater		803a	Valdezia RWS	24	Urban Rural	sub component			0.31	0.33	0.34	0.35	0.36	0.37	0.38	0.39	0.40	0.41	0.42	0.43	0.44	0.45	0.46	0.46	0.47	0.48	0.49	0.50	0.50	0.51	0.52	0.53	0.54	0.55	0.55	0.56	0.57	0.58
Groundwater Nandoni	Groundwater		803b	Valdezia RWS	24	Urban Rural	sub component			0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Nandoni	Nandoni Dam	803		Valdezia RWS	24	Urban Rural	Master Control Cha	0.126		0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.10	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.17	0.18	0.19	0.19	0.20	0.21	0.22
Albasini & Nandoni	Albasini & Nandoni dams & Groundwater		1161a	Makhado RWS excl Makhado & Tshikota	25	Urban	sub component			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Albasini & Nandoni	Albasini & Nandoni dams & Groundwater		1161b	Makhado RWS Makhado only	25	Urban	sub component			2.71	2.78	2.81	2.85	2.88	2.91	2.95	2.98	3.02	3.05	3.08	3.12	3.15	3.19	3.22	3.25	3.27	3.30	3.32	3.35	3.37	3.40	3.42	3.45	3.47	3.50	3.52	3.55	3.58	3.60
Albasini & Nandoni	Albasini & Nandoni dams & Groundwater		1161c	Makhado RWS Tshikota only	25	Urban	sub component			0.89	0.93	0.95	0.98	1.00	1.02	1.04	1.06	1.08	1.11	1.13	1.15	1.17	1.20	1.22	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.30	1.32	1.33	1.34	1.35	1.36	1.37	1.38
Albasini & Nandoni	Albasini & Nandoni dams & Groundwater		1161d & 893a	Makhado Total	25	Urban	sub component			3.60	3.71	3.77	3.82	3.88	3.93	3.99	4.05	4.10	4.16	4.22	4.27	4.33	4.39	4.44	4.48	4.52	4.55	4.59	4.62	4.66	4.70	4.73	4.77	4.80	4.84	4.88	4.91	4.95	4.99
GW - Makhado	Groundwater - Makhado		1161e & 893b	MAKHADO FROM Groundwater	25	Urban	sub component			1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20	1.20
Albasini & Nandoni	Albasini & Nandoni dams		1161f & 893c	Makhado from Surface Water	25	Urban	sub component			2.40	2.20	2.10	2.00	1.90	1.96	2.01	2.07	2.13	2.18	2.24	2.30	2.35	2.41	2.47	2.50	2.54	2.58	2.61	2.65	2.68	2.72	2.76	2.79	2.83	2.86	2.90	2.94	2.98	3.01
Albasini	Albasini Dam	1161		Makhado from Albasini no wc/wdm applicable	25	Urban	Master Control Channel			2.50	2.20	2.10	2.00	1.90	1.96	2.01	2.07	2.13	2.18	2.24	2.30	2.35	2.41	2.47	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Nandoni	Nandoni Dam	893		Makhado from Nandoni	25	Urban	Master Control Cha	3.819		0.50	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.036	0.072	0.108	0.144	0.180	0.216	0.251	0.287	0.323	0.360	0.397	0.434	0.471	0.508
Albasini	Albasini Dam & Groundwater		1088a	Albasini Irrigation Total		Irrigation	sub component			7.30	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300	7.300
GW - Albasini	Groundwater - Albasini		1088b	Albasini Irrigation Groundwater		Irrigation	sub component			2.42	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418	2.418
Albasini	Albasini Dam	1088		Albasini Irrigation Surface Water Irrigation		Irrigation	Irrigation Block		1117	4.88	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882	4.882
Albasini	Levubu weir	1086		Albasini Irrigation Surface Water Irrigation		Irrigation	Irrigation Block		1116	2.70	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700	2.700
	Latonyanda canal	1046		Latonyanda canal		Irrigation	Irrigation Block		1096	2.54	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538
	Latonyanda canal	1080		Latonyanda canal		Irrigation	Irrigation Block		1113	2.54	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538	2.538
	Barotta canal	1044		Barotta canal		Irrigation	Irrigation Block		1095	1.02	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025	1.025
Nandoni	Nandoni Dam & Groundwater		894a	Levubu CBD WS	23	Urban	sub component			0.08	0.098	0.107	0.117	0.126	0.129	0.132	0.136	0.139	0.143	0.146	0.150	0.153	0.157	0.160	0.164	0.168	0.172	0.176	0.180	0.184	0.188	0.192	0.197	0.201	0.205	0.210	0.214	0.219	0.223
Nandoni	Groundwater		894b	Levubu CBD WS	23	Urban	sub component			0.07	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.070
Nandoni	Nandoni Dam	894		Levubu CBD WS	23	Urban	Master Control Cha	0.15		0.01	0.026	0.034	0.042	0.050	0.054	0.057	0.060	0.064	0.067	0.071	0.074	0.078	0.081	0.085	0.089	0.093	0.097	0.101	0.105	0.109	0.113	0.117	0.121	0.125	0.130	0.134	0.139	0.143	0.148

SUB-SYSTEM	Resource	WRPM CHANNEL NO.	Channel Sub-componen	DESCRIPTION	Water Services Scheme n	DEMAND TYPE	WRPM TYPE	Nadoni allocation	Irrigation Block No.	WRPM Base Demand	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Middle Letaba Nsami system	Nandoni Dam & Groundwater		898a	Tshitale RWS (Located in Klein Letaba catchment)	39	Urban Rural	sub component			0.83	0.886	0.912	0.939	0.965	0.997	1.029	1.061	1.093	1.124	1.158	1.192	1.225	1.259	1.293	1.314	1.336	1.358	1.379	1.401	1.423	1.445	1.468	1.490	1.512	1.535	1.559	1.582	1.606	1.629
Middle Letaba Nsami system	Groundwater		898b	Tshitale RWS (Located in Klein Letaba catchment)	39	Urban Rural	sub component			0.44	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
Middle Letaba Nsami system	No support from Middle Letaba Dam		898c	Tshitale RWS (Located in Klein Letaba catchment)	39	Urban Rural	sub component			0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nandoni Dam	Nandoni Dam		898d	Tshitale RWS (Located in Klein Letaba catchment)	39	Urban Rural	sub component	1.336		0.39	0.000	0.000	0.000	0.000	0.000	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.336	0.853	0.874	0.896	0.918	0.939	0.961	0.983	1.005	1.028	1.050	1.072	1.095	1.119	1.142	1.166	1.189
Middle Letaba Nsami system	Middle Letaba & Groundwater & Nandoni		898e	Total Elim / Vleifontein RWS	29	Urban Rural	sub component			2.28	2.478	2.576	2.675	2.774	2.912	3.050	3.188	3.326	3.464	3.613	3.762	3.910	4.059	4.208	4.274	4.339	4.405	4.470	4.536	4.603	4.670	4.737	4.804	4.871	4.943	5.014	5.085	5.156	5.228
Middle Letaba Nsami system	Groundwater		898f	GW - Elim / Vleifontein RWS	29	Urban Rural	sub component			0.48	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
Middle Letaba Nsami system	Middle Letaba & Nsami dams		898g	Total Elim / Vleifontein RWS	29	Urban Rural	sub component			1.80	1.998	2.096	2.195	2.294	2.432	0.573	0.711	0.849	0.987	1.136	1.285	1.433	1.582	0.887	0.953	1.018	1.084	1.149	1.215	1.282	1.349	1.416	1.483	1.550	1.622	1.693	1.764	1.835	1.907
Nandoni Dam	Nandoni Dam		898h	Total Elim / Vleifontein RWS	29	Urban Rural	sub component	2.577		1.80	0.000	0.000	0.000	0.000	0.000	1.997	1.997	1.997	1.997	1.997	1.997	1.997	1.997	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841
Middle Letaba Nsami system	Middle Letaba & Groundwater & Nandoni		898i	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component			0.69	0.736	0.758	0.781	0.804	0.846	0.887	0.929	0.971	1.013	1.058	1.103	1.148	1.193	1.238	1.258	1.278	1.297	1.317	1.337	1.357	1.378	1.398	1.418	1.439	1.460	1.482	1.503	1.525	1.546
Middle Letaba Nsami system	Groundwater		898j	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component			0.40	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
Middle Letaba Nsami system	Middle Letaba & Nsami dams		898k	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component			0.29	0.336	0.358	0.381	0.404	0.446	0.487	0.529	0.571	0.613	0.658	0.703	0.748	0.793	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Nandoni Dam	Nandoni Dam		898l	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component	1.49		0.29	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.838	0.858	0.878	0.897	0.917	0.937	0.957	0.978	0.998	1.018	1.039	1.060	1.082	1.103	1.125	1.146
Middle Letaba Nsami system	Middle Letaba & Groundwater & Nandoni		898m	Middle Letaba RWS : Majosi	38	Urban Rural	sub component			1.97	2.099	2.164	2.229	2.294	2.413	2.532	2.652	2.771	2.890	3.018	3.147	3.275	3.404	3.532	3.589	3.646	3.702	3.759	3.815	3.873	3.931	3.989	4.047	4.105	4.167	4.228	4.290	4.351	4.413
Middle Letaba Nsami system	Groundwater		898n	Middle Letaba RWS : Majosi	38	Urban Rural	sub component			0.88	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
Middle Letaba Nsami system	Middle Letaba & Nsami dams		898o	Middle Letaba RWS : Majosi	38	Urban Rural	sub component			1.09	1.219	1.284	1.349	1.414	1.533	1.652	1.772	1.891	2.010	2.138	2.267	2.395	2.524	0.152	0.209	0.266	0.322	0.379	0.435	0.493	0.551	0.609	0.667	0.725	0.787	0.848	0.910	0.971	1.033
Nandoni Dam	Nandoni Dam		898p	Middle Letaba RWS : Majosi	38	Urban Rural	sub component	2.5		1.09	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
Nandoni	**Nandoni Dam**	**898**		**Support to Middle Letaba RWSs: wc/wdm in sub components**		**Urban Rural**	**Master Control Cha**	**7.90**		**3.57**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.33**	**2.33**	**2.33**	**2.33**	**2.33**	**2.33**	**2.33**	**2.33**	**7.03**	**7.07**	**7.11**	**7.16**	**7.20**	**7.24**	**7.28**	**7.32**	**7.37**	**7.41**	**7.45**	**7.50**	**7.54**	**7.59**	**7.63**	**7.68**
Matoks system outside WMA	Future groundwater development		899a	Botlokwa GWS	41	Urban Rural	sub component	4.66		1.824	2.250	2.463	2.677	2.890	3.125	3.359	3.594	3.829	4.064	4.321	4.579	4.836	5.093	5.350	5.435	5.520	5.604	5.689	5.774	5.861	5.947	6.034	6.121	6.208	6.300	6.393	6.485	6.577	6.670
Matoks system outside WMA	of 4.62 million m^3/a possible		899b	Nthabiseng GWS	43	Urban Rural	sub component	0		0.277	0.300	0.312	0.323	0.335	0.347	0.360	0.372	0.384	0.397	0.410	0.423	0.436	0.449	0.462	0.468	0.474	0.480	0.486	0.493	0.499	0.505	0.511	0.517	0.523	0.530	0.536	0.543	0.550	0.556
Matoks system outside WMA	-		899c	Ramakgopa GWS	42	Urban Rural	sub component	0		0.967	1.042	1.080	1.118	1.155	1.195	1.234	1.274	1.313	1.353	1.394	1.436	1.478	1.519	1.561	1.583	1.605	1.628	1.650	1.672	1.695	1.718	1.740	1.763	1.786	1.809	1.833	1.857	1.881	1.905
Matoks system outside WMA	Groundwater		899d				sub component			0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830	0.830
Nandoni	**Nandoni Dam**	**899**		**Support Matoks area**		**Urban Rural**	**Master Control Cha**	**4.66**		**2.238**	**2.675**	**2.894**	**3.112**	**3.331**	**3.617**	**3.904**	**4.191**	**4.478**	**4.765**	**5.077**	**5.389**	**5.701**	**6.013**	**6.325**	**6.438**	**6.551**	**6.664**	**6.777**	**6.890**	**7.005**	**7.121**	**7.237**	**7.352**	**7.468**	**7.591**	**7.713**	**7.836**	**7.959**	**8.082**
Mukumbani Scheme	**Tshirovha River**	**1036**		**Mukumbani Tea Estates no wc/wdm applicable**		**Irrigation**	**Master Control Cha**	**3.300**		**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**	**3.300**
Rambuda possible scheme	Mutale River & Groundwater		1005a	Mutale Town	7	Urban Rural	sub component			2.20	2.333	2.399	2.200	2.532	2.601	2.671	2.740	2.810	2.879	2.952	3.025	3.099	3.172	3.245	3.296	3.347	3.398	3.449	3.500	3.552	3.604	3.657	3.709	3.761	3.817	3.872	3.928	3.983	4.000
Rambuda possible scheme	Groundwater		1005b	Mutale Town	7	Urban Rural	sub component			0.70	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700	0.700
Rambuda possible scheme	**Mutale River**	**1005**		**Mutale Town**	**7**	**Urban Rural**	**Master Control Channel**			**2.20**	**1.430**	**1.395**	**1.360**	**1.326**	**1.395**	**1.464**	**1.534**	**1.603**	**1.673**	**1.746**	**1.819**	**1.892**	**1.965**	**2.038**	**2.089**	**2.140**	**2.191**	**2.242**	**2.293**	**2.346**	**2.398**	**2.450**	**2.503**	**2.555**	**2.610**	**2.666**	**2.721**	**2.776**	**2.794**
Rambuda possible scheme	**Mutale River**	**1035**		**Tshiombo Irrigation scheme no wc/wdm applicable**		**Irrigation**	**Master Control Channel**			**2.70**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**
Rambuda possible scheme	Mutale River & Groundwater		1039a	Mutale Mukuya RWS	8	Urban Rural	sub component			0.29	0.303	0.311	0.287	0.327	0.336	0.344	0.353	0.361	0.369	0.378	0.387	0.396	0.405	0.414	0.420	0.427	0.434	0.440	0.447	0.454	0.461	0.468	0.474	0.481	0.489	0.496	0.503	0.510	0.517
Rambuda possible scheme	Groundwater		1039b	Mutale Mukuya RWS	8	Urban Rural	sub component			0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Rambuda possible scheme	**Mutale River**	**1039**		**Mutale Mukuya RWS**	**8**	**Urban Rural**	**Master Control Channel**			**0.177**	**0.167**	**0.162**	**0.125**	**0.152**	**0.160**	**0.169**	**0.177**	**0.186**	**0.194**	**0.203**	**0.212**	**0.221**	**0.229**	**0.238**	**0.245**	**0.252**	**0.258**	**0.265**	**0.272**	**0.278**	**0.285**	**0.292**	**0.299**	**0.306**	**0.313**	**0.320**	**0.328**	**0.335**	**0.342**
Tswere future demand	**Mutale River**	**881**		**Tswere future demand**			**Master Control Channel**			**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rambuda possible scheme	Mutale & Mbodi River & Groundwater		1041a	Luphephe / Nwanedzi Main RWS	3	Urban Rural	sub component			0.770	0.839	0.873	0.773	0.939	0.974	1.010	1.045	1.080	1.116	1.153	1.191	1.229	1.267	1.304	1.326	1.348	1.370	1.392	1.414	1.436	1.459	1.482	1.504	1.527	1.551	1.575	1.599	1.623	1.650
Rambuda possible scheme	Groundwater		1041b	Luphephe / Nwanedzi Main RWS	3	Urban Rural	sub component			0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770	0.770
Rambuda possible scheme	**Mutale & Mbodi River**	**1041**		**Luphephe / Nwanedzi Main RWS**	**3**	**Urban Rural**	**Master Control Channel**			**0.100**	**0.069**	**0.103**	**0.003**	**0.169**	**0.204**	**0.240**	**0.275**	**0.310**	**0.346**	**0.383**	**0.421**	**0.459**	**0.497**	**0.534**	**0.556**	**0.578**	**0.600**	**0.622**	**0.644**	**0.666**	**0.689**	**0.712**	**0.734**	**0.757**	**0.781**	**0.805**	**0.829**	**0.853**	**0.880**
Rambuda possible scheme	Mutale lower & Groundwater		1048a	Masisi RWS	2	Urban Rural & Mine	sub component			0.50	0.529	0.544	0.499	0.573	0.589	0.604	0.620	0.636	0.651	0.668	0.684	0.700	0.717	0.733	0.744	0.754	0.765	0.775	0.786	0.797	0.807	0.818	0.829	0.840	0.851	0.862	0.874	0.885	0.895
Rambuda possible scheme	Groundwater		1048b	Masisi RWS	2	Urban Rural & Mi	sub component			0.50	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Rambuda possible scheme	Groundwater		1048c	Tshikondeni Coal mine	4	Mining	sub component			0.06	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.060
Rambuda possible scheme	Mutale Lower		1048d	Tshikondeni Coal mine	4	Mining	sub component			0.55	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550	0.550
Rambuda possible scheme	**Mutale River**	**1048**		**Masisi RWS & Mining**	**2**	**Urban Rural & Mine**	**Master Control Channel**			**0.49**	**0.473**	**0.465**	**0.397**	**0.449**	**0.464**	**0.480**	**0.495**	**0.511**	**0.526**	**0.543**	**0.559**	**0.576**	**0.592**	**0.608**	**0.619**	**0.629**	**0.640**	**0.651**	**0.661**	**0.672**	**0.683**	**0.693**	**0.704**	**0.715**	**0.726**	**0.738**	**0.749**	**0.761**	**0.770**
Rambuda possible scheme	**Mutale River**	**1049**		**Irrigation Revitalise no wc/wdm applicable**		**Irrigation**	**Master Control Channel**			**0.10**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Rambuda possible scheme	**Mutale River**	**2006**		**Groundwater development**			**master Control Channel**			**2.70**				**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**	**2.700**
Middle Letaba Nsami scheme	**Middle Letaba Dam (Middle Letaba WTW)**	**2003**		**Groundwater development**			**Master Control Channel**			**12.90**							**0.000**	**0.000**	**0.000**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.900**	**12.000**	**12.900**	**12.900**
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		615a	Middle Letaba RWS : Babangu	36	Urban Rural	sub component			1.560	1.663	1.714	1.416	1.817	1.912	2.006	2.101	2.195	2.290	2.391	2.493	2.595	2.697	2.799	2.843	2.888	2.933	2.978	3.023	3.069	3.115	3.161	3.206	3.252	3.301	3.350	3.399	3.447	3.301
Middle Letaba Nsami scheme	Groundwater		615b	Middle Letaba RWS : Babangu	36	Urban Rural	sub component			0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510
Middle Letaba Nsami scheme	Middle Letaba Dam		615c	Middle Letaba RWS : Babangu	36	Urban Rural	sub component			1.050	1.153	1.204	0.906	1.307	1.402	1.496	1.591	1.685	1.780	1.881	1.983	2.085	2.187	2.289	2.333	2.378	2.423	2.468	2.513	2.559	2.605	2.651	2.696	2.742	2.791	2.840	2.889	2.937	2.791
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		615d	Middle Letaba RWS : Bolobedu NW	45	Urban Rural	sub component			0.996	1.062	1.095	0.904	1.160	1.221	1.281	1.341	1.402	1.462	1.527	1.592	1.657	1.722	1.787	1.815	1.844	1.873	1.901	1.930	1.959	1.989	2.018	2.047	2.076	2.108	2.139	2.170	2.201	2.108
Middle Letaba Nsami scheme	Groundwater		615e	Middle Letaba RWS : Bolobedu NW	45	Urban Rural	sub component			0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440	0.440
Middle Letaba Nsami scheme	Middle Letaba Dam		615f	Middle Letaba RWS : Bolobedu NW	45	Urban Rural	sub component			0.556	0.622	0.655	0.464	0.720	0.781	0.841	0.901	0.962	1.022	1.087	1.152	1.217	1.282	1.347	1.375	1.404	1.433	1.461	1.490	1.519	1.549	1.578	1.607	1.636	1.668	1.699	1.730	1.761	1.668
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		615g	Middle Letaba RWS : Magoro	37	Urban Rural	sub component			1.707	1.820	1.876	1.549	1.989	2.092	2.195	2.299	2.402	2.505	2.617	2.728	2.839	2.951	3.062	3.111	3.160	3.210	3.259	3.308	3.358	3.408	3.458	3.509	3.559	3.612	3.666	3.719	3.772	3.612
Middle Letaba Nsami scheme	Groundwater		615h	Middle Letaba RWS : Magoro	37	Urban Rural	sub component			1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050	1.050
Middle Letaba Nsami scheme	Middle Letaba Dam		615i	Middle Letaba RWS : Magoro	37	Urban Rural	sub component			0.657	0.770	0.826	0.499	0.939	1.042	1.145	1.249	1.352	1.455	1.567	1.678	1.789	1.901	2.012	2.061	2.110	2.160	2.209	2.258	2.308	2.358	2.408	2.459	2.509	2.562	2.616	2.669	2.722	2.562
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		615j	Middle Letaba RWS : Majosi	38	Urban Rural	sub component			1.969	2.099	2.164	2.229	2.294	2.413	2.532	2.652	2.771	2.890	3.018	3.147	3.275	3.404	3.532	3.589	3.646	3.702	3.759	3.815	3.873	3.931	3.989	4.047	4.105	4.167	4.228	4.290	4.351	4.413
Middle Letaba Nsami scheme	Groundwater		615k	Middle Letaba RWS : Majosi	38	Urban Rural	sub component			0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880	0.880
Middle Letaba Nsami scheme	Nandoni Dam support		898p	Middle Letaba RWS : Majosi	38	Urban Rural	sub component	2.5		1.089	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
Middle Letaba Nsami scheme	Middle Letaba Dam		615l	Middle Letaba RWS : Majosi	38	Urban Rural	sub component			1.089	1.219	1.284	1.349	1.414	1.533	1.652	1.772	1.891	2.010	2.138	2.267	2.395	2.524	0.152	0.209	0.266	0.322	0.379	0.435	0.493	0.551	0.609	0.667	0.725	0.787	0.848	0.910	0.971	1.033
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		615m	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component			0.690	0.736	0.758	0.781	0.804	0.846	0.887	0.929	0.971	1.013	1.058	1.103	1.148	1.193	1.238	1.258	1.278	1.297	1.317	1.337	1.357	1.378	1.398	1.418	1.439	1.460	1.482	1.503	1.525	1.546
Middle Letaba Nsami scheme	Groundwater		615n	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component			0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
Middle Letaba Nsami scheme	Nandoni Dam support		898l	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component	1.49		0.290	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.838	0.858	0.878	0.897	0.917	0.937	0.957	0.978	0.998	1.018	1.039	1.060	1.082	1.103	1.125	1.146
Middle Letaba Nsami scheme	Middle Letaba Dam		615o	Middle Letaba RWS : Vyeboom Masia	30	Urban Rural	sub component			0.290	0.336	0.358	0.381	0.404	0.446	0.487	0.529	0.571	0.613	0.658	0.703	0.748	0.793	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		615p	Elim / Vleifontein RWS WS Elim/Waterval	29	Urban Rural	sub component			2.280	2.478	2.576	2.163	2.774	2.912	3.050	3.188	3.326	3.464	3.613	3.762	3.910	4.059	4.208	4.274	4.339	4.405	4.470	4.536	4.603	4.670	4.737	4.804	4.871	4.943	5.014	5.085	5.156	4.943
Middle Letaba Nsami scheme	Groundwater		615q	Elim / Vleifontein RWS WS Elim/Waterval	29	Urban Rural	sub component			0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480	0.480
Middle Letaba Nsami scheme	Nandoni Dam support		898h	Elim / Vleifontein RWS WS Elim/Waterval	29	Urban Rural	sub component	2.577		1.800	0.000	0.000	0.000	0.000	0.000	1.997	1.997	1.997	1.997	1.997	1.997	1.997	1.997	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841	2.841
Middle Letaba Nsami scheme	Middle Letaba Dam		615r	Elim / Vleifontein RWS WS Elim/Waterval	29	Urban Rural	sub component			1.800	1.998	2.096	1.683	2.294	2.432	0.573	0.711	0.849	0.987	1.136	1.285	1.433	1.582	0.887	0.953	1.018	1.084	1.149	1.215	1.282	1.349	1.416	1.483	1.550	1.622	1.693	1.764	1.835	1.622
Middle Letaba Nsami scheme	Middle Letaba Dam		886a	Support to Modjaji Scheme		Urban Rural	sub component			0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.123	0.246	0.370	0.493	0.616	0.678	0.740	0.803	0.865	0.927	0.991	1.055	1.118	1.182	1.246	1.313	1.381	1.449	1.516	1.584
Middle Letaba Nsami scheme	**Middle Letaba Dam (Middle Letaba WTW)**	**615**		**Babangu, Bolebedu,Magoro, Majosi, Vyeboom, Elim Vleifontein Waterval: wc/wdm in sub components**		**Urban Rural**	**Master Control Channel**			**5.540**	**6.097**	**6.424**	**5.282**	**7.078**	**7.635**	**6.195**	**6.752**	**7.310**	**7.867**	**8.590**	**9.314**	**10.037**	**10.761**	**7.303**	**7.610**	**7.917**	**8.224**	**8.531**	**8.838**	**9.152**	**9.466**	**9.780**	**10.095**	**10.409**	**10.743**	**11.076**	**11.410**	**11.744**	**11.259**
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		871a	Middle Letaba RWS : Malamulele West	32	Urban Rural	sub component			0.320	0.356	0.374	0.392	0.410	0.429	0.449	0.468	0.487	0.507	0.528	0.548	0.569	0.590	0.611	0.620	0.629	0.639	0.648	0.657	0.666	0.676	0.685	0.695	0.704	0.714	0.724	0.734	0.744	0.755
Middle Letaba Nsami scheme	Groundwater		871b	*Middle Letaba RWS : Malamulele West*	32	Urban Rural	sub component			0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110	0.110
Middle Letaba Nsami scheme	Middle Letaba Dam		871c	*Middle Letaba RWS : Malamulele West*	32	Urban Rural	sub component			0.210	0.246	0.264	0.282	0.300	0.319	0.339	0.358	0.377	0.397	0.418	0.438	0.459	0.480	0.501	0.510	0.519	0.529	0.538	0.547	0.556	0.566	0.575	0.585	0.594	0.604	0.614	0.624	0.634	0.645
Middle Letaba Nsami scheme	Middle Letaba Dam & Groundwater		871d	Mapuve / System N RWS	35	Urban Rural	sub component			0.420	0.498	0.537	0.576	0.615	0.664	0.713	0.762	0.811	0.859	0.912	0.965	1.017	1.070	1.123	1.138	1.154	1.169	1.184	1.200	1.216	1.231	1.247	1.263	1.279	1.295	1.312	1.328	1.345	1.358
Middle Letaba Nsami scheme	Groundwater		871e	Mapuve / System N RWS	35	Urban Rural	sub component			0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170	0.170
Middle Letaba Nsami scheme	Middle Letaba Dam		871f	Mapuve / System N RWS	35	Urban Rural	sub component			0.250	0.328	0.367	0.406	0.445	0.494	0.543	0.592	0.641	0.689	0.742	0.795	0.847	0.900	0.953	0.968	0.984	0.999	1.014	1.030	1.046	1.061	1.077	1.093	1.109	1.125	1.142	1.158	1.175	1.188
Middle Letaba Nsami system	Middle Letaba & Nsami dams		871g	Malamulele West RWS (Only initial years supplied fr	21	Urban Rural	sub component			0.820	0.866	0.890	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Middle Letaba Nsami scheme	**Middle Letaba Dam (Mapuve WTW)**	**871**		**Mapuve, Middle Letaba Malamulele West check mal west with hgm**		**Urban Rural**	**Master Control Channel**			**1.280**	**1.440**	**1.520**	**0.688**	**0.744**	**0.813**	**0.881**	**0.949**	**1.018**	**1.086**	**1.160**	**1.233**	**1.307**	**1.380**	**1.454**	**1.478**	**1.503**	**1.528**	**1.552**	**1.577**	**1.602**	**1.627**	**1.652**	**1.678**	**1.703**	**1.729**	**1.756**	**1.782**	**1.809**	**1.833**
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887a	*Giyani System A/B WS*	49	Urban Rural	sub component			2.390	2.658	2.792	2.926	3.061	3.205	3.350	3.495	3.639	3.784	3.940	4.096	4.252	4.408	4.564	4.632	4.701	4.770	4.839	4.907	4.978	5.048	5.118	5.189	5.259	5.334	5.408	5.483	5.558	5.633
Middle Letaba Nsami scheme	Groundwater		887b	*Giyani System A/B WS*	49	Urban Rural	sub component			0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510	0.510
Middle Letaba Nsami scheme	Middle Letaba & Nsami dam		887c	*Giyani System A/B WS*	49	Urban Rural	sub component			1.880	2.148	2.282	2.416	2.551	2.695	2.840	2.985	3.129	3.274	3.430	3.586	3.742	3.898	4.054	4.122	4.191	4.260	4.329	4.397	4.468	4.538	4.608	4.679	4.749	4.824	4.898	4.973	5.048	5.123
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887d	*Giyani System C/D WS excl Giyani & Kremetart*	48	Urban	sub component			4.875	5.422	5.696	5.969	6.243	6.538	6.833	7.128	7.423	7.718	8.036	8.354	8.672	8.990	9.309	9.449	9.589	9.729	9.869	10.010	10.153	10.296	10.440	10.583	10.727	10.879	11.031	11.184	11.336	11.489
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887e	Giyani System C/D WS Giyani only	48	Urban	sub component			4.212	4.684	4.921	5.157	5.393	5.648	5.903	6.158	6.413	6.668	6.943	7.218	7.493	7.767	8.042	8.163	8.285	8.406	8.527	8.648	8.772	8.896	9.020	9.144	9.267	9.399	9.531	9.663	9.794	9.926
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887f	*Giyani System C/D WS Kremetart only*	48	Urban	sub component			0.243	0.271	0.284	0.298	0.312	0.326	0.341	0.356	0.371	0.385	0.401	0.417	0.433	0.449	0.465	0.472	0.479	0.486	0.493	0.500	0.507	0.514	0.521	0.528	0.536	0.543	0.551	0.558	0.566	0.574
Middle Letaba Nsami scheme	Groundwater		887g	*Giyani System C/D WS*	48	Urban	sub component			1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970	1.970
Middle Letaba Nsami scheme	Middle Letaba & Nsami dam		887h	*Giyani System C/D WS*	48	Urban	sub component			7.360	8.407	8.931	9.454	9.978	10.543	11.107	11.672	12.237	12.802	13.411	14.019	14.628	15.237	15.846	16.114	16.382	16.651	16.919	17.187	17.462	17.736	18.011	18.285	18.560	18.851	19.143	19.435	19.727	20.018
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887i	*Giyani System D : South West WS*	54	Urban Rural	sub component			1.220	1.357	1.425	1.494	1.562	1.636	1.710	1.784	1.858	1.932	2.011	2.091	2.170	2.250	2.330	2.365	2.400	2.435	2.470	2.505	2.541	2.577	2.613	2.649	2.684	2.723	2.761	2.799	2.837	2.875
Middle Letaba Nsami scheme	Groundwater		887j	*Giyani System D : South West WS*	54	Urban Rural	sub component			0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610	0.610
Middle Letaba Nsami scheme	Middle Letaba & Nsami dam		887k	*Giyani System D : South West WS*	54	Urban Rural	sub component			0.610	0.747	0.815	0.884	0.952	1.026	1.100	1.174	1.248	1.322	1.401	1.481	1.560	1.640	1.720	1.755	1.790	1.825	1.860	1.895	1.931	1.967	2.003	2.039	2.074	2.113	2.151	2.189	2.227	2.265
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887l	Giyani System F1 WS	33	Urban Rural	sub component			0.910	1.012	1.063	1.114	1.165	1.220	1.276	1.331	1.386	1.441	1.500	1.560	1.619	1.678	1.738	1.764	1.790	1.816	1.842	1.869	1.895	1.922	1.949	1.976	2.002	2.031	2.059	2.088	2.116	2.145
Middle Letaba Nsami scheme	Groundwater		887m	Giyani System F1 WS	33	Urban Rural	sub component			0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230	0.230
Middle Letaba Nsami scheme	Middle Letaba & Nsami dam		887n	Giyani System F1 WS	33	Urban Rural	sub component			0.680	0.782	0.833	0.884	0.935	0.990	1.046	1.101	1.156	1.211	1.270	1.330	1.389	1.448	1.508	1.534	1.560	1.586	1.612	1.639	1.665	1.692	1.719	1.746	1.772	1.801	1.829	1.858	1.886	1.915
Middle Letaba Nsami scheme	Middle Letaba & Nsami dams & GW		887o	Giyani System F2 WS	34	Urban Rural	sub component			0.42	0.467	0.491	0.514	0.538	0.563	0.589	0.614	0.640	0.665	0.692	0.720	0.747	0.775	0.802	0.814	0.826	0.838	0.850	0.862	0.875	0.887	0.899	0.912	0.924	0.937	0.950	0.964	0.977	0.990
Middle Letaba Nsami scheme	Groundwater		887p	Giyani System F2 WS	34	Urban Rural	sub component			0.28	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280	0.280
Middle Letaba Nsami scheme	Middle Letaba & Nsami dam		887q	Giyani System F2 WS	34	Urban Rural	sub component			0.140	0.187	0.211	0.234	0.258	0.283	0.309	0.334	0.360	0.385	0.412	0.440	0.467	0.495	0.522	0.534	0.546	0.558	0.570	0.582	0.595	0.607	0.619	0.632	0.644	0.657	0.670	0.684	0.697	0.710
Middle Letaba Nsami scheme	**Middle Letaba & Nsami dam (Giyani WTW)**	**887**		**Giyani system**		**Urban Rural**	**Master Control Channel**			**5.670**	**11.538**	**11.972**	**12.405**	**12.839**	**8.703**	**9.567**	**10.431**	**11.295**	**12.159**	**13.090**	**14.021**	**14.952**	**15.883**	**16.814**	**17.224**	**17.635**	**18.045**	**18.456**	**18.866**	**19.286**	**19.706**	**20.125**	**20.545**	**20.965**	**21.411**	**21.857**	**22.304**	**22.750**	**23.196**
Middle Letaba Nsami scheme	**Middle Letaba & Nsami dam**	**618**		**Irrigation from Middle Letaba main canal no wc/wdm applicable**		**Irrigation**	**Master Control Channel**			**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**	**0.634**
Middle Letaba Nsami scheme	**Middle Letaba & Nsami dam**	**872**		**Middle Letaba canal losses no wc/wdm applicable**		**Losses**	**Master Control Channel**			**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**	**4.000**

SUB-SYSTEM	Resource	WRPM CHANNEL NO.	Channel Sub-componen	DESCRIPTION	Water Services Scheme n	DEMAND TYPE	WRPM TYPE	Nandoni allocation	Irrigation Block No.	WRPM Base Demand	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Sekgosese Individual Groundwater Scheme	Groundwater			Sekgosese Individual Groundwater Scheme	44	Urban Rural	sub component			0.230	0.246	0.255	0.263	0.271	0.280	0.288	0.297	0.306	0.314	0.324	0.333	0.342	0.351	0.361	0.366	0.372	0.378	0.384	0.389	0.395	0.401	0.407	0.413	0.419	0.425	0.431	0.438	0.444	0.450
Sekgopo Local GWS	Groundwater			Sekgopo Local GWS	60	Urban Rural	sub component			0.190	0.235	0.258	0.281	0.303	0.328	0.352	0.377	0.401	0.426	0.452	0.478	0.504	0.531	0.557	0.565	0.572	0.580	0.587	0.595	0.602	0.610	0.617	0.625	0.633	0.641	0.649	0.657	0.665	0.673
Dap Naude	Dap Naude Dam	202		Polokwane abstraction from Dap Naude no wc/wdm applicable		Urban Industrial	Master Control Channel			4.00	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000	4.000
Magoebaskloof Vergelegen	Magoebaskloof Dam	900		Tea Plantation (growth uncertain)		Irrigation	Master Control Channel			1.70	1.700	1.700	1.700	1.951	2.202	2.453	2.705	2.956	3.207	3.458	3.709	3.960	4.212	4.463	4.714	4.965	5.216	5.467	5.718	5.970	6.221	6.472	6.723	6.974	7.225	7.477	7.728	7.979	8.230
Magoebaskloof Vergelegen	Magoebaskloof Dam	600		Politsi tea plantation scheme		Irrigation	Master Control Channel		32	2.80	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800	2.800
Magoebaskloof Vergelegen	Magoebaskloof Dam	39		Politsi tea plantation scheme		Irrigation	Irrigation Block		32	3.20	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200	3.200
Magoebaskloof Vergelegen	Vergelegen Dam	167		Politsi, Duiwelskloof, Gakgapane	73	Urban Industrial	Master Control Channel			2.340	2.068	2.023	1.977	1.931	1.978	2.024	2.071	2.117	2.164	2.212	2.261	2.309	2.358	2.406	2.454	2.502	2.550	2.598	2.646	2.695	2.744	2.794	2.843	2.892	2.945	2.998	3.051	3.104	3.157
Hans Merensky System	Hans Merensky Dam	45		Westfalia Estates & other irrigators		Irrigation	Irrigation Block		38	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510	4.510
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	220		Polokwane abstraction from Ebenezer no wc/wdm applicable		Urban Industrial	Min Max			16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170	16.170
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	189		Georges Valley Canal Irrigation supply		Irrigation	Irrigation block		143	0.50	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	187		Georges Valley Canal Irrigation supply		Irrigation	Irrigation block		142	0.42	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420	0.420
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	185		Georges Valley Canal Irrigation supply		Irrigation	Irrigation block		141	1.40	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400	1.400
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	183		Georges Valley Canal Irrigation supply		Irrigation	Irrigation block		140	0.22	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220	0.220
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	195		Pusela Canal irrigation supply		Irrigation	Irrigation block		146	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079	2.079
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	197		Pusela Canal irrigation supply		Irrigation	Irrigation block		147	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190	4.190
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	199		Pusela Canal irrigation supply		Irrigation	Irrigation block		148	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360	0.360
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	193		Pusela Canal irrigation supply		Irrigation	Irrigation block		145	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370	0.370
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	191		Ebenezer M/S Scheme		Irrigation	Irrigation block		144	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720
Ebenezer Tzaneen Nwamitwa	Ebenezer & Tzaneen dams		66a & 68a	Tzaneen / Modjadjiskloof WS Tzaneen	73	Urban Industrial Rural	sub component			3.480	3.523	3.520	3.516	3.513	3.545	3.578	3.610	3.642	3.675	3.707	3.739	3.771	3.803	3.835	3.865	3.896	3.926	3.957	3.987	4.017	4.047	4.077	4.108	4.138	4.169	4.200	4.231	4.262	4.293
Ebenezer Tzaneen Nwamitwa	Ebenezer Dam	66		Tzaneen Town	73	Urban Industrial Rural	Min Max			2.200	2.243	2.240	2.236	2.233	2.265	2.298	2.330	2.362	2.395	2.427	2.459	2.491	2.523	2.555	2.585	2.616	2.646	2.677	2.707	2.737	2.767	2.797	2.828	2.858	2.889	2.920	2.951	2.982	3.013
Ebenezer Tzaneen Nwamitwa	Tzaneen dam	68		Tzaneen Town no wc/wdm applicable	73	Urban Industrial Rural	Min Max			1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280	1.280
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	543 / 995		Ritavi / Letaba RWS	55	Urban Rural	Min Max			2.700	2.635	2.597	2.657	2.717	2.810	2.908	3.005	3.103	3.201	3.299	3.402	3.506	3.610	3.713	3.817	3.882	3.947	4.012	4.076	4.141	4.208	4.275	4.341	4.408	4.474	4.545	4.616	4.686	4.757
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	69		Ritavi II RWS excl Nkowankowa	75	Urban Rural	Min Max			11.000	10.764	9.956	10.341	10.726	11.229	11.776	12.324	12.871	13.419	13.966	14.562	15.158	15.754	16.350	16.945	17.228	17.511	17.794	18.077	18.360	18.651	18.941	19.232	19.523	19.813	20.125	20.437	20.749	21.060
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	686 / 996		Siluwane - Nondweni Extended RWS	50	Urban Rural	Min Max			0.300	0.208	0.217	0.225	0.234	0.256	0.278	0.300	0.323	0.345	0.369	0.393	0.417	0.441	0.465	0.473	0.481	0.489	0.497	0.505	0.513	0.521	0.529	0.537	0.545	0.553	0.562	0.570	0.579	0.587
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	885		Support to Tapane RWS no wc/wdm applicable	56	Urban Rural	Min Max			0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.375	0.439	0.503	0.567	0.630	0.694	0.738	0.782	0.826	0.870	0.913	0.959	1.004	1.049	1.094	1.139	1.187	1.236	1.284	1.332	1.380
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	884		Support to Thabina RWS no wc/wdm applicable	74	Urban Rural	Min Max			0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.968	2.323	2.678	3.033	3.388	3.743	3.876	4.008	4.141	4.273	4.406	4.541	4.676	4.810	4.945	5.080	5.223	5.366	5.509	5.652	5.795
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	674		Industrial no wc/wdm applicable		Industrial	Min Max			4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082	4.082
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	346		Irrigation directly from Tzaneen Dam		Irrigation	Irrigation block		250	0.92	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915	0.915
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	104		Irrigation from River d/s of Tzaneen Dam		Irrigation	Irrigation block		72	2.84	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840	2.840
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	79		Irrigation from River d/s of Tzaneen Dam		Irrigation	Irrigation block		63	2.10	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100	2.100
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	71		Irrigation from River via Noord canal d/s of Tzaneen Dam		Irrigation	Irrigation block		58	4.36	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360	4.360
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	160		Irrigation from River via Noord canal d/s of Tzaneen Dam		Irrigation	Irrigation block		110	2.78	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780	2.780
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	81		Irrigation from River via Noord canal d/s of Tzaneen Dam		Irrigation	Irrigation block		64	12.32	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317	12.317
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	517		Irrigation from River via Noord canal d/s of Tzaneen Dam		Irrigation	Irrigation block		395	9.34	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339	9.339
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	85		Irrigation from River via N&N canal d/s of Tzaneen Dam		Irrigation	Irrigation block		66	3.42	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420	3.420
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	519		Irrigation from River via N&N canal d/s of Tzaneen Dam		Irrigation	Irrigation block		396	9.61	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610	9.610
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	83		Irrigation from River d/s of Tzaneen Dam		Irrigation	Irrigation block		65	0.74	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740	0.740
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	344		Irrigation from River d/s of Tzaneen Dam		Irrigation	Irrigation block		249	0.34	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340	0.340
Ebenezer Tzaneen Nwamitwa	Tzaneen Dam	375		Irrigation from River d/s of Tzaneen Dam		Irrigation	Irrigation block		320	2.22	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	379		Irrigation from River at Nwamitwa Dam		Irrigation	Irrigation block		322	2.22	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220	2.220
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	405		Irrigation from River d/s Nwamitwa Dam		Irrigation	Irrigation block		335	4.75	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750	4.750
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	403		Irrigation from River d/s Nwamitwa Dam		Irrigation	Irrigation block		334	3.09	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090	3.090
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	545		Irrigation from River d/s Nwamitwa Dam		Irrigation	Irrigation block		408	2.23	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230	2.230
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	411		Irrigation from River d/s Nwamitwa Dam		Irrigation	Irrigation block		338	2.18	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180	2.180
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	902		Irrigation from River d/s Nwamitwa Dam no wc/wdm applicable	Resource Poor	Irrigation	Master Control Channel			31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330	31.330
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	425		Irrigation from River d/s Nwamitwa Dam		Irrigation	Irrigation block		345	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	427		Irrigation from River d/s Nwamitwa Dam		Irrigation	Irrigation block		346	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	431		Irrigation from River at Nondweni Weir		Irrigation	Irrigation block		348	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270	3.270
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	433		Irrigation from River d/s Nondweni Weir		Irrigation	Irrigation block		349	0.47	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470	0.470
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	435		Irrigation from River d/s Nondweni Weir		Irrigation	Irrigation block		350	2.57	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570	2.570
Ebenezer Tzaneen Nwamitwa	Tzaneen & Nwamitwa dams	2005		Groundwater development			Master Control Channel			2.50	0.000	0.000	0.000	0.000	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500	2.500
Thabina System	Thabina Dam & Groundwater		67a	Thabina RWS Total (SW & GW)	74	Urban Rural	sub component			4.176	4.779	5.081	5.382	5.684	6.012	6.339	6.667	6.994	7.322	7.677	8.032	8.387	8.742	9.097	9.230	9.362	9.495	9.628	9.760	9.895	10.030	10.165	10.299	10.434	10.577	10.720	10.863	11.006	11.149
Thabina System	Groundwater		67b	Thabina RWS Total (GW)	74	Urban Rural	sub component			1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370	1.370
Thabina System	Thabina Dam	67		Thabina RWS Total (SW)	74	Urban Rural	Master Control Channel			3.700	3.616	3.860	3.785	4.030	4.357	4.685	5.013	5.340	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700	3.700
Thapane System	Thapane Dam & Groundwater		901a	Thapane RWS (SW & GW)	56	Urban Rural	sub component			1.615	1.729	1.785	1.842	1.899	1.959	2.019	2.079	2.139	2.200	2.264	2.328	2.391	2.455	2.519	2.563	2.607	2.651	2.695	2.738	2.784	2.829	2.874	2.919	2.964	3.012	3.061	3.109	3.157	3.205
Thapane System	Groundwater		901b	Thapane RWS (GW)	56	Urban Rural	sub component			0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.300
Thapane System	Thapane Dam	901		Thapane RWS Total (SW)	56	Urban Rural	Master Control Channel			1.400	1.391	1.428	1.466	1.504	1.564	1.624	1.684	1.745	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430	1.430
Modjaji System	Modjaji Dam & Groundwater		544a	Mojadji RWS	57	Urban Rural	sub component			1.497	2.008	2.094	1.836	2.266	2.358	2.450	2.542	2.635	2.727	2.826	2.925	3.024	3.123	3.222	3.272	3.322	3.372	3.422	3.472	3.523	3.574	3.625	3.676	3.728	3.782	3.836	3.891	3.945	3.999
Modjaji System	Groundwater		544b	Mojadji RWS	57	Urban Rural	sub component			0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Modjaji System	Support from Middle Letaba	886		Mojadji RWS no wc/wdm applicable	57	Urban Rural	Master Control Channel			1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.123	0.246	0.370	0.493	0.616	0.678	0.740	0.803	0.865	0.927	0.991	1.055	1.118	1.182	1.246	1.313	1.381	1.449	1.516	1.584
Modjaji System	Modjaji Dam	544		Mojadji RWS	57	Urban Rural	Master Control Channel			3.500	3.019	3.061	2.759	3.145	3.260	3.374	3.489	3.604	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719	3.719
Modjaji System	Modjaji Dam & Groundwater		544c	Worcester / Mothobeki RWS	46	Urban Rural	sub component			0.594	0.650	0.678	0.705	0.733	0.763	0.793	0.823	0.853	0.882	0.914	0.946	0.978	1.010	1.042	1.059	1.075	1.091	1.107	1.123	1.140	1.156	1.173	1.190	1.206	1.224	1.241	1.259	1.277	1.294
Modjaji System	Groundwater		544d	Worcester / Mothobeki RWS	46	Urban Rural	sub component			0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Modjaji System	Modjaji Dam		544e	Worcester / Mothobeki RWS	46	Urban Rural	sub component			0.594	0.614	0.596	0.578	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560	0.560
Modjaji System	Modjaji Dam & Groundwater		544f	Lower Molototsi RWS	47	Urban Rural	sub component			0.450	0.492	0.513	0.534	0.555	0.577	0.600	0.622	0.645	0.668	0.692	0.716	0.740	0.764	0.789	0.801	0.813	0.825	0.838	0.850	0.862	0.875	0.887	0.900	0.912	0.926	0.939	0.952	0.966	0.979
Modjaji System	Groundwater		544g	Lower Molototsi RWS	47	Urban Rural	sub component			0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Modjaji System	Modjaji Dam		544h	Lower Molototsi RWS	47	Urban Rural	sub component			0.45	0.462	0.468	0.474	0.480	0.503	0.525	0.548	0.571	0.593	0.617	0.642	0.666	0.690	0.714	0.727	0.739	0.751	0.763	0.775	0.788	0.801	0.813	0.826	0.838	0.851	0.865	0.878	0.891	0.905
Nandoni	Nandoni Dam	2511		Nandoni growth		Urban Rural	Master Control Channel			5			0	0	0.08	0.58	1.28	1.97	2.66	3.41	4.15	4.89	5.64	6.38	6.64	6.89	7.15	7.40	7.66	7.92	8.18	8.44	8.70	8.96	9.23	9.51	9.78	10.06	10.33
Rambuda possible scheme	Mutale River	2510		Rambuda support to Damani		Urban Rural	Master Control Channel			5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Rambuda possible scheme	Mutale River	2509		Rambuda support to Nandoni		Urban Rural	Master Control Channel			7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Nandoni	Mutale River	2508		Nandoni support from Rambuda		Urban Rural	Master Control Channel			7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Nandoni	Mutale River	2507		Damani support from Rambuda		Urban Rural	Master Control Channel			5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1	5.1
Nandoni	Nandoni Dam	148		Nandoni EWR on curve		Urban Rural	Master Control Channel			12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Nandoni	Nandoni Dam	883		Damani support to Nandoni		Urban Rural	Master Control Channel			0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Nandoni	Damani Dam	2512		Nandoni support from Damani		Urban Rural	Master Control Channel			0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6

Appendix E

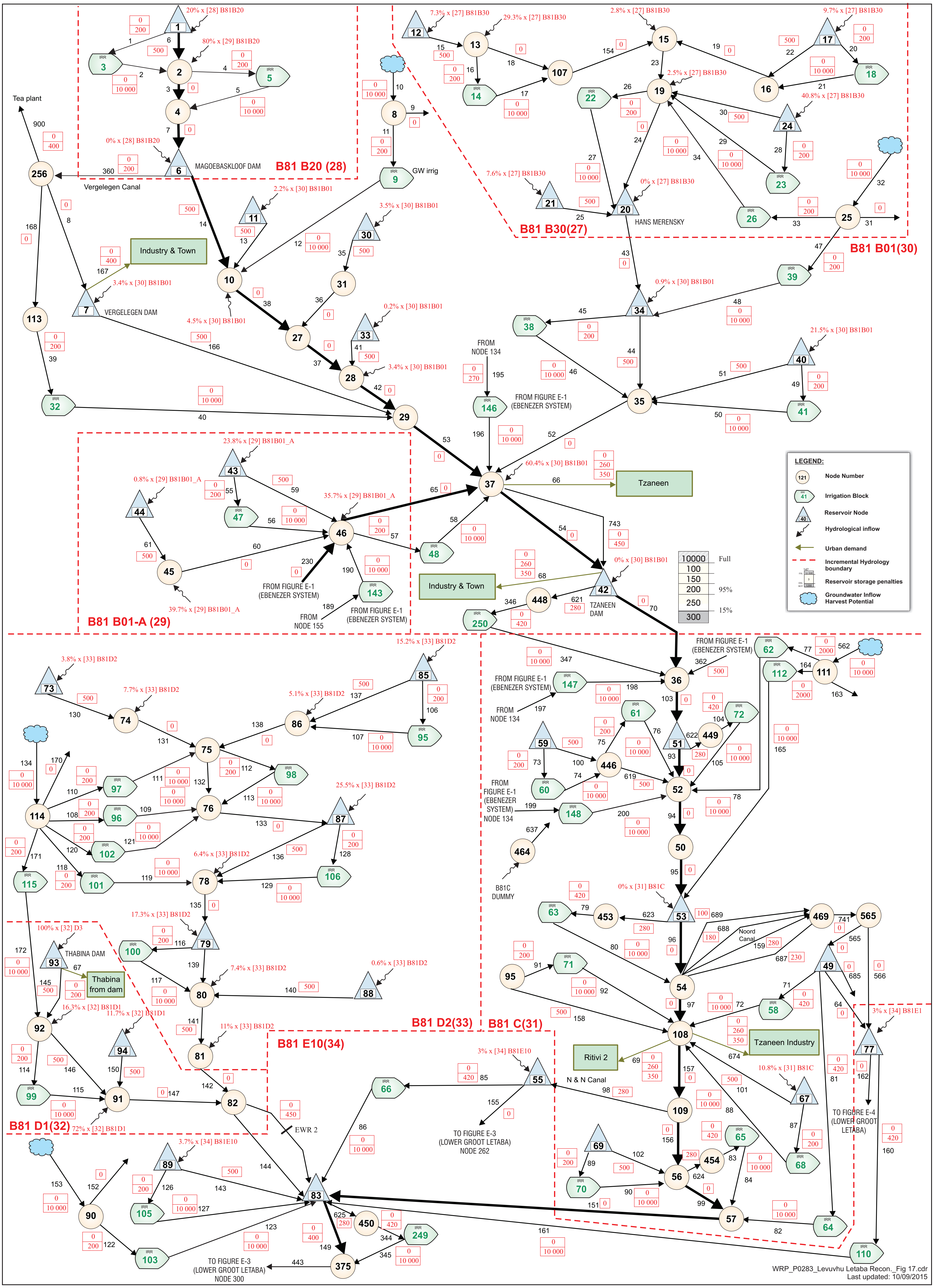
WRPM System Schematics



DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LEVUVHU AND LETABA WATER SUPPLY SYSTEM

WRPM: Ebenezer System

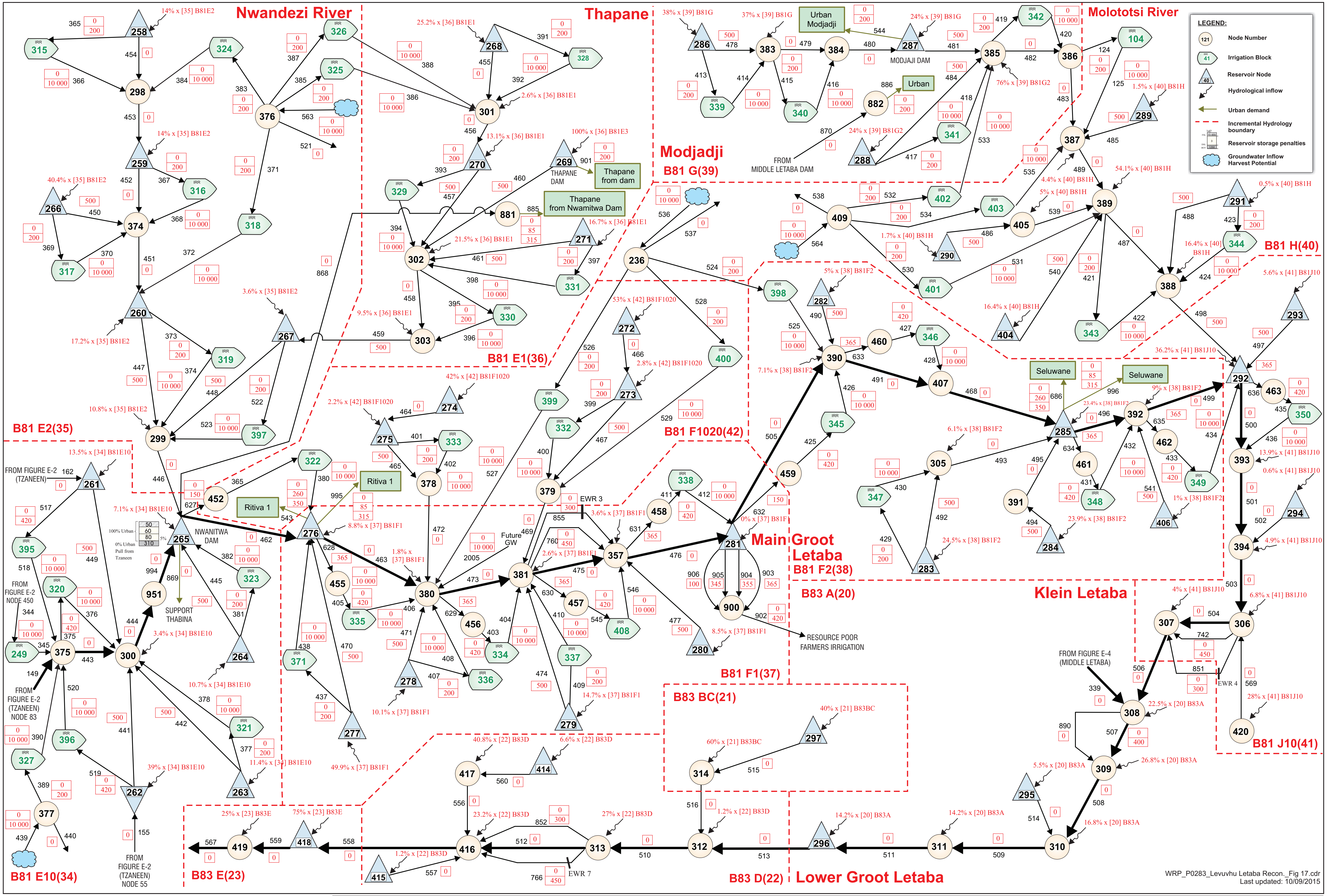
E-1



DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LEVUVHU AND LETABA WATER SUPPLY SYSTEM

WRPM: Tzaneen System

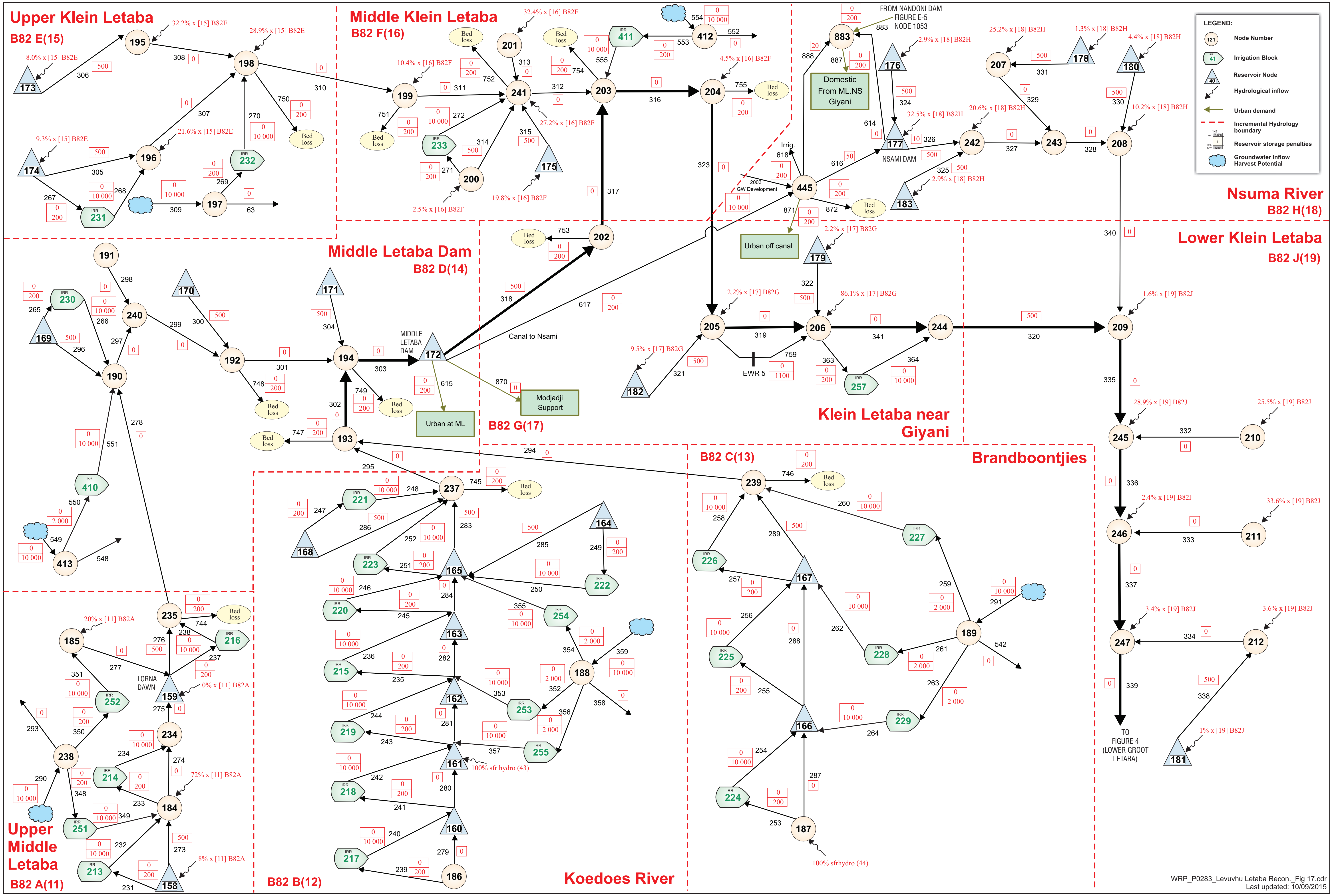
E-2



DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LEVUVHU AND LETABA WATER SUPPLY SYSTEM

WRPM: Lower Groot Letaba

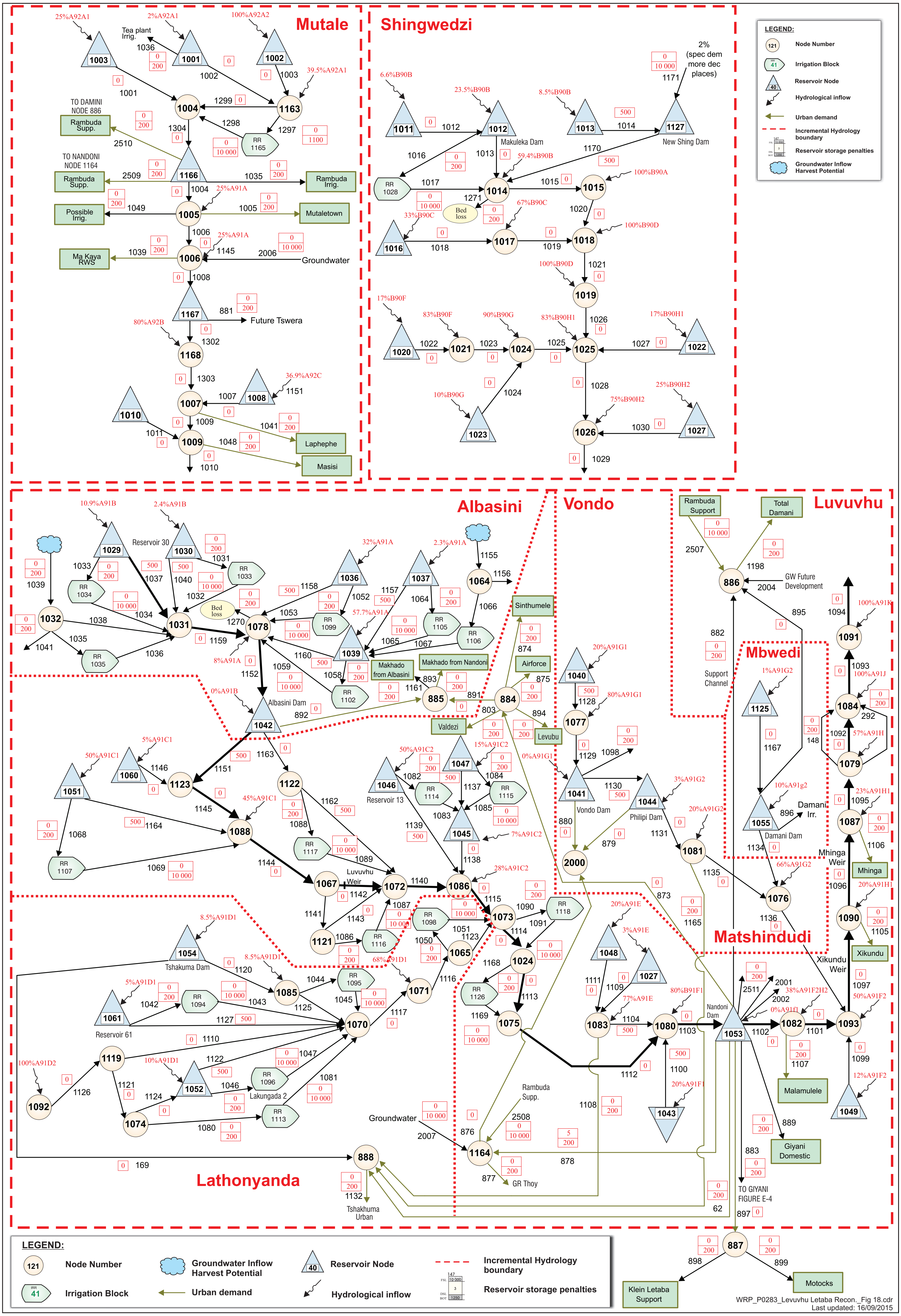
E-3



DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE LEVUVHU AND LETABA WATER SUPPLY SYSTEM

WRPM: Middle Letaba

E-4



DEVELOPMENT OF A RECONCILIATION STRATEGY
FOR THE LEVUVHU AND LETABA WATER SUPPLY SYSTEM

WRPM: Luvuvhu System

E-5