DWS report number: P WMA 03/X22/00/6718/7

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

CONTINUATION OF WATER REQUIREMENTS AND AVAILABILITY RECONCILIATION STRATEGY STUDY FOR THE MBOMBELA MUNICIPAL AREA

Updated Reconciliation Strategy

FINAL
March 2021

FC/02687.cdr

P WMA 03/X22/00/6718/7

water & sanitation

Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

CONTINUATION OF WATER REQUIREMENTS AND AVAILABILITY RECONCILIATION STRATEGY FOR THE MBOMBELA MUNICIPAL AREA

UPDATED RECONCILIATION STRATEGY

(FINAL)

FEBRUARY 2021

COMPILED FOR:	COMPILED BY:
Department of Water and Sanitation Contact person: K Mandaza Private Bag X313, Pretoria 0001 South Africa Telephone: +27(0) 12 336 7670 Email: MandazaK@dws.gov.za	**BJ/iX/WRP Joint Venture** Contact person: C Seago Block 5, Green Park Estate, 27 George Storrar Drive, Pretoria Telephone: +27(0) 12 346 3496 Email: caryns@wrp.co.za

CONTINUATION OF WATER REQUIREMENTS AND AVAILABILITY RECONCILIATION STRATEGY FOR THE MBOMBELA MUNICIPAL AREA

UPDATED RECONCILIATION STRATEGY

(FINAL)

FEBRUARY 2021

This report is to be referred to in bibliographies as:

Department of Water and Sanitation, South Africa, February 2021. CONTINUATION OF WATER REQUIREMENTS AND AVAILABILITY RECONCILIATION STRATEGY FOR THE MBOMBELA MUNICIPAL AREA: WATER RECONCILIATION STRATEGY

LIST OF STUDY REPORTS

Report Name	Report Number	DWS Report Number
Inception	1	P WMA 03/X22/00/6718
Economic Growth and Demographic Analysis	2	P WMA 03/X22/00/6818
Water Requirements and Return Flows	3	P WMA 03/X22/00/6918
Water Conservation and Water Demand Management	4	P WMA 03/X22/00/6718/4
Water Resources Analysis	5	P WMA 03/X22/00/6718/5
Infrastructure and Cost Assessment	6	P WMA 03/X22/00/6718/6
Updated Reconciliation Strategy	**7**	**P WMA 03/X22/00/6718/7**
Executive Summary: Updated Reconciliation Strategy	8	

Title:	**Updated Reconciliation Strategy**
Authors:	**Study Team**
Project Name:	**Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area**
DWS Report No:	**P WMA 03/X22/00/6718/7**
Status of Report:	**Final Report**
First Issue:	**August 2020**
Final Issue:	**October 2020**

Consultants: **BJE/iX/WRP Joint Venture**

Approved for the Consultants by:

....

C Seago

Study Leader

DEPARTMENT OF WATER AND SANITATION

Directorate National Water Resource Planning

Approved for the Department of Water and Sanitation by:

....

K Mandaza

Project Manager: National Water Resource Planning (East)

....

P Mlilo

Director: National Water Resource Planning

TABLE OF CONTENTS

APPENDICES

APPENDIX A: Simplified Water Resources and Supply Area Diagram

APPENDIX B: Water balance details

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

BJE	Black Jills Engineers Pty Ltd.
CoM	City of Mbombela
DARDLEA	Department of Agriculture, Rural Development, Land & Environmental Affairs
DM	District Municipality
DWA	Department of Water Affairs (now DWS)
DWAF	Department of Water Affairs and Forestry (now DWS)
DWS	Department of Water and Sanitation
EWR	Ecological Water Requirement
FSC	Full Supply Capacity
GRA	Groundwater Resource Assessment
GRIP	Groundwater Resource Information Project
HFY	Historic Firm Yield
IAPs	Invasive Alien Plants
IB	Irrigation Board
IIMA	Tripartite Interim Agreement Between The Republic of Mozambique and The Republic Of South Africa and The Kingdom Of Swaziland for Co-Operation on The Protection and Sustainable Utilisation of The Water Resources of the Incomati And Maputo Watercourses (IIMA)
ISDP	Internal Strategic Development Plan
IUCMA	Inkomati-Usuthu Catchment Management Agency
IWAAS	Inkomati Water Availability Assessment Study
iX	iX Engineers Pty Ltd.
JV	Joint Venture
KLP	Klipkopje, Longmere, Primkop Dams
LM	Local Municipality
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MEA	Mean Annual Evaporation
NGIS	National Groundwater Monitoring Network
NGS	National Groundwater Strategies
NWRP	National Water Resource Planning
PSP	Professional Services Provider
SDIP	Service Delivery Implementation Plan
S-Pan	Simons Pan
StraSC	Strategy Steering Committee
TSG	Technical Support Group
V&V	Validation and Verification
WAP	Water Allocation Plan
WfW	Working for Water
WReMP	Water Resources Modelling Platform
WRP	WRP Consulting Engineers Pty Ltd.

WRPM	Water Resources Planning Model
WRSM	Water Resources Simulation Model
WRYM	Water Resources Yield Model
WSA	Water Service Authority
WSDP	Water Services Development Plan
WSP	Water Services Provider
WSS	Water Supply Scheme
WTW	Water Treatment Works
WWTW	Waste Water Treatment Works
WUA	Water User Association

LIST OF UNITS AND SYMBOLS

ha	Hectare
l/c/d	Litres per Capita per Day
km^2	Square Kilometres
Mℓ/d	Mega Litres per Day
m^3/a	Cubic Metres per Annum
mcm/a	Million Cubic Metres per Annum
$m^3/ha/a$	Cubic Metres per Hectare per Annum
$m^3/km^2/a$	Cubic Metres per Square Kliometre per Annum
million m^3/a	Million Cubic Metre per Annum
m^3/s	Cubic Metres per Second
%	Percentage

EXECUTIVE SUMMARY

Introduction

The Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area (this Study) followed on the *Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area (DWA, 2014)*. The overall objective of this Study was to systematically update, improve, and extend the Water Resource Reconciliation Strategy to cover the entire Crocodile (East) and Sabie Sub-Catchments, in order for the Strategy to remain relevant, technically sound, economically viable, socially acceptable and sustainable. This report is the updated Reconciliation Strategy and is preceded by a number of supporting technical reports.

Overview of Study Area

The Study Area includes both the Crocodile (East) and the Sabie Sub-Catchments, which form part of the Ehlanzeni District Municipality (DM). The focus of this study was on the City of Mbombela Local Municipality (CoM LM) (centre of the Study Area), former Umjindi LM (South), which was recently amalgamated with the CoM LM, and Bushbuckridge LM (North). The remainder of the Study Area incorporates parts of the Emakhazeni LM (West), Thaba Chweu LM (North-West) and Nkomazi LM (South-East), which are situated and form part of the Crocodile (East) and Sabie Sub- Catchments.

The confluence of the Crocodile (East) River and Sabie River, which are the main rivers in the Study Area, is in neighbouring Mozambique. These two rivers are both trans-boundary waterways and are therefore governed by an international treaty stating the minimum flows that are required to flow into the neighbouring country Mozambique.

The two largest dams in the Study Area are the Inyaka Dam in Bushbuckridge LM and Kwena Dam in the Thaba Chweu LM There are also smaller dams in the CoM LM such as Witklip Dam, Longmere Dam, Klipkopjes Dam, Primkop Dam and Da Gama Dam. The resources serve a total population of about 1 330 000 people with current urban water requirements of about 129 million m^3/annum. The irrigation sector is the main user with the Crocodile Irrigation Board having an allocation of 304 million m^3/annum. The National Water Act requires that environmental flows be specified and accommodated in all river systems in South Africa. The Kruger National Park is located at the downstream end of both the Sabie and the Crocodile catchments, and is an important ecological area for which environmental flows need to be supplied.

Background and Approach

This report provides the final updated Water Reconciliation Strategy prepared as a result of this Study. The original Strategy (DWA, 2014) was used as a basis for the update. However, the original Strategy covered only the CoM LM area. As part of the enhancement, the Strategy has been extended to cover all the Municipal areas falling within the Crocodile (East) and Sabie sub-catchments. Previous All Towns Strategies as well as the Sabie Reconciliation Strategy (DWS, 2016) have been assessed and updated.

In addition to the update of the Strategy, part of the Study has included the monitoring of progress of implementation of the original Strategy interventions. This has been undertaken in the form of Strategy Steering Committee Meetings whereby responsible Institutions have provided feedback on progress.

At the time of undertaking this Reconciliation Strategy update, the Inkomati Usuthu Catchment Management Agency (IUCMA) were in the process of preparing a Catchment Management Strategy (CMS). One of the legal requirements of a CMA is to develop a CMS. The CMS is established to guide the management of Water Resources over the next five years. The CMS incorporates aspects (eg. setting tariffs) wider than those considered in the Reconciliation Strategy which is focussed on development planning over the long term. The IUCMA have been involved with the development of this Reconciliation Strategy and therefore alignment between the two processes has taken place.

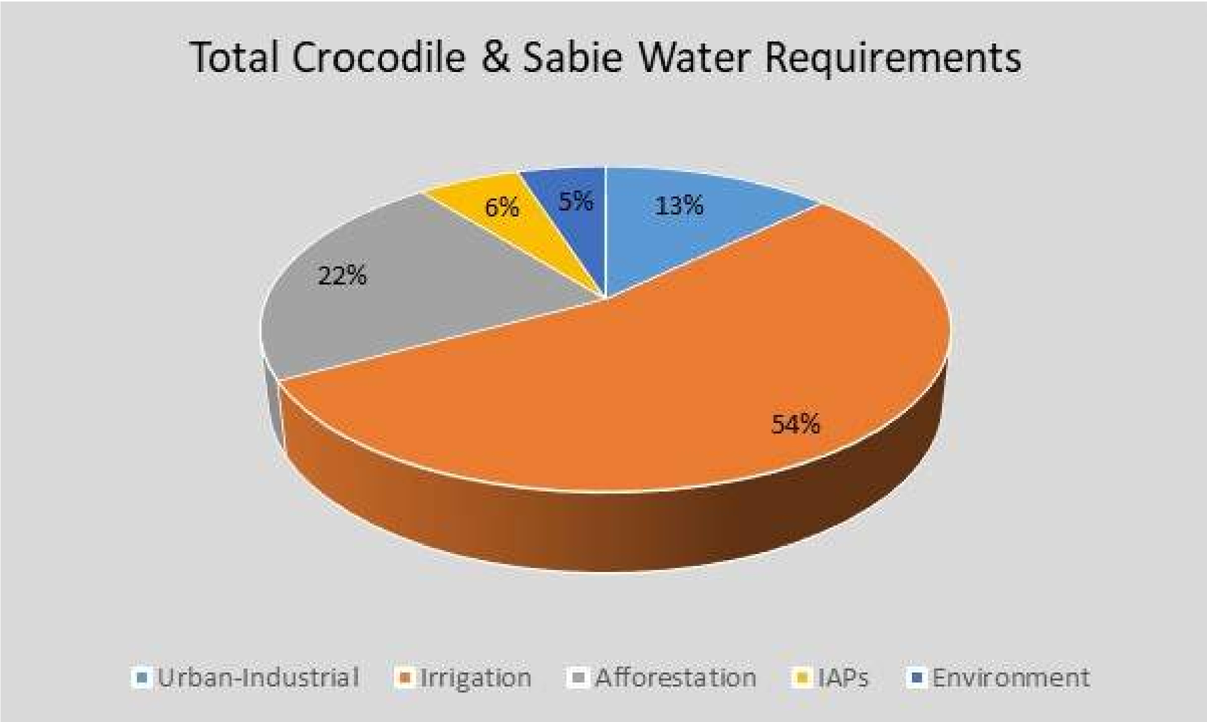
Aspects Supporting Strategy Formulation

A number of detailed assessments have been undertaken as part of this Study in order to obtain the required information to update the Reconciliation Strategy. These Tasks have been documented in separate supporting reports covering:

- Demographic and Socio Economic
- Water Requirements
- Water Conservation and Water Demand Management
- Water Resources
- Infrastructure and Cost Assessment

The demographic assessment gathered information from various sources relating to current population estimates and future population growth. The growth considered aspects such as migration due to future job opportunities etc. Over the projection period (up till 2040) the realistic population growth estimates for the CoM LM were determined to be approximately 1.2% on an annual average, and for the Bushbuckridge LM approximately 0.3% on an annual average.

Current water requirements for the various water user sectors were obtained and used as a basis to develop future water requirement projections. The results from the demographic assessment were used for the urban sector water requirement projections. Existing allocations were used for the irrigation sector, and no growth in these requirements were assumed. Landuse impacts resulting from afforestation and alien vegetation were obtained and included. The Environmental Flow Requirements developed as part of the Classification Study (DWS, 2014a) were also included. The following figure presents a breakdown of the water requirements per user sector.



A detailed water conservation and water demand management assessment was undertaken, focusing on the urban sector The results indicated that, on implementing a suitable plan including institutional, financial, social and technical components, the CoM could achieve a 10% saving on water losses and the Bushbuckridge LM could aim for a 15% saving.

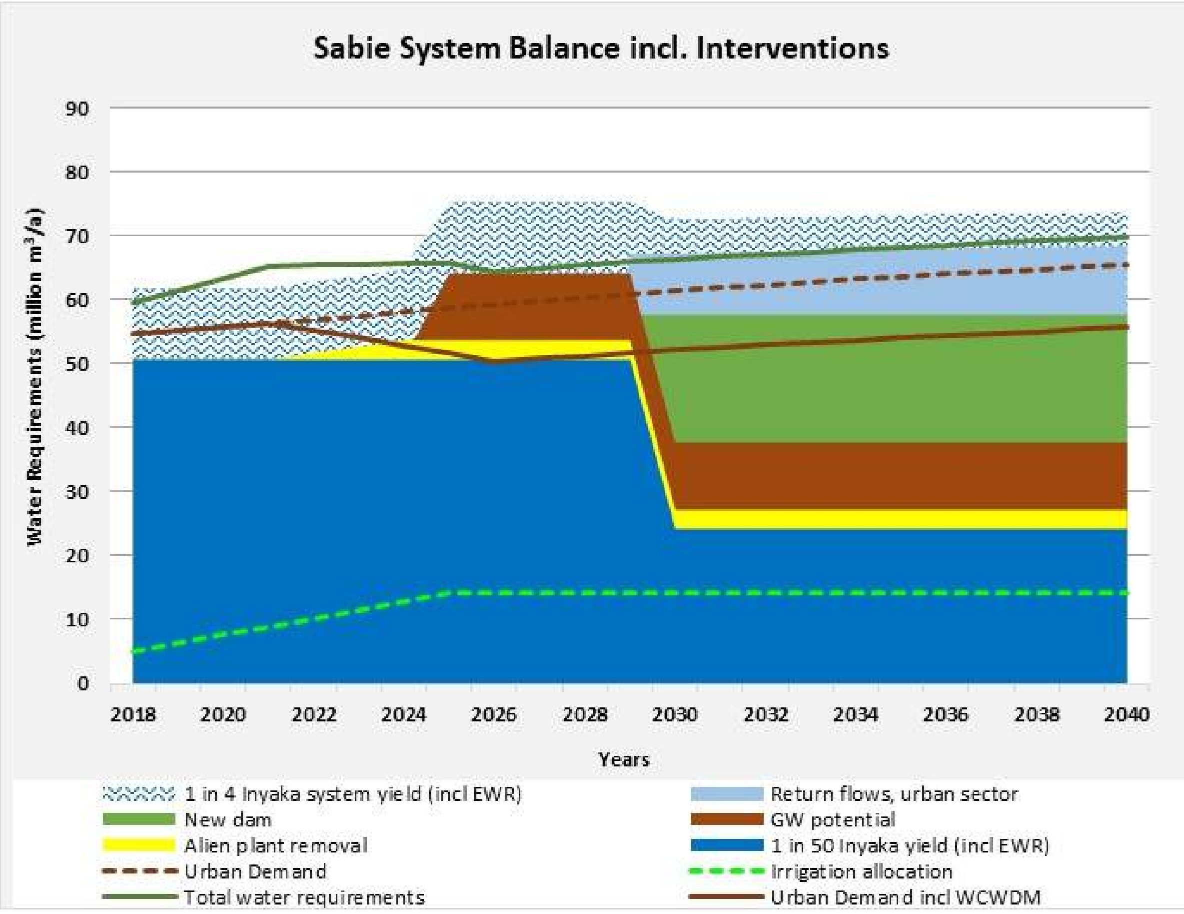
The water resources assessment included updating the DWS water resources simulation models with all the latest available information. Yield and scenario planning analyses were then undertaken. The results indicate that the water resources of both the Crocodile and Sabie sub-catchments are not sufficient to provide the users with their water at the required level of assurance.

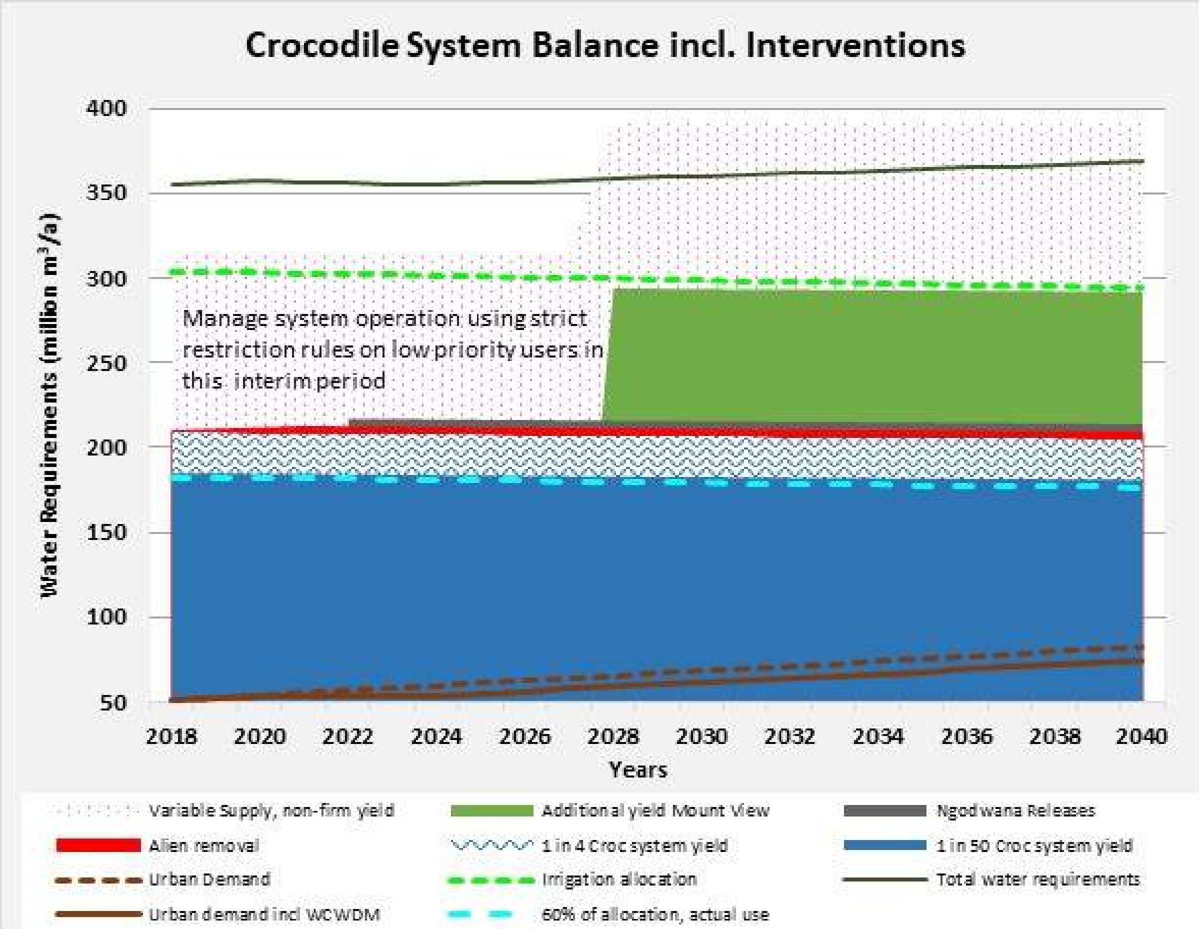
The infrastructure assessment determined that the Mountain View dam is the more suitable option for augmentation of the Crocodile catchment. The decision of whether Dingleydale or New Forest Dam should be developed in the Sand catchment to augment supply to

Bushbuckridge and support the environmental reserve should be made after a pre-feasibility Study is undertaken.

Water Balances

Individual water balances have been prepared for eleven different systems and sub-systems. The decision on differentiating between water balance areas involved grouping of users sharing similar water resources. The Strategy presents the current water balances for each of the systems, as well as future projected balances including intervention options. The current water balance for both the Sabie and Crocodile systems indicates severe deficits. A number of interventions are required in order to obtain a positive water balance. The water balances for the two main systems are presented in the following figures.





Strategy Actions and Implementation Plan

As a result of the existing in-balance between water resources and water requirements, many of the intervention options presented in the Strategy are set at a high priority and urgent level. The success of strategy implementation relies of various institutions fulfilling their assigned responsibilities in terms of intervention actions, These institutions include, but are not limited to, the IUCMA, DWS National Office and Local Municipalities.

The following table provides a summary of the intervention options.

Intervention	Primary Responsibility	Target Date (priority)
WCWDM	Local Municipalities: City of Mbombela LM, Bushbuckridge LM, Emakhazeni LM, Thaba Chweu LM Nkomazi LM	High priority, implementation to continue/start immediately CoM: 10% savings, reduction in growth by 2023 Bushbuckridge: 15% savings, reduction in growth by 2023
Reduce canal losses	City of Mbombela LM	Medium priority level, as and when funds available

Intervention	Primary Responsibility	Target Date (priority)
Remove alien vegetation	Department of Environmental Affairs, WWF, Sanparks & IUCMA	High priority, implementation to continue/start immediately
Water use entitlement exchange from irrigation to urban	Department of Water and Sanitation: Directorate to be confirmed City of Mbombela, IUCMA	High priority, implementation to continue/start immediately 2021 for existing applications Ongoing for additional applications
Eliminating unlawful uses	IUCMA	High priority, implementation to continue/start immediately Target date: 2022
Compulsory licensing	IUCMA	Target date: 2025 if required
Water Reuse	Bushbuckridge LM	Medium priority level, when new dam constructed
Interim Restriction Rule to Benefit Priority (Primary) Users	DWS: Directorate Water Resources Planning Systems, IUCMA	Immediate and ongoing
Efficient system operation	IUCMA and users	Immediate and ongoing
Groundwater Development	IUCMA, Local Municipalities,	Ongoing
New Dam Construction & Existing Dam Raising	DWS: Options Analyses (large dams, CoM (Primkop) DWS: NWRP for Wtiklip (part of future Recon update)	Urgent and requires fast tracking. Construction to be complete by 2030.
Water releases from Ngodwana Dam	DWS: NWRP CoMLM, Sappi	Medium priority level

1 INTRODUCTION

1.1 Background and Objectives

The Department of Water and Sanitation (DWS) commissioned a study on the development of a Water Reconciliation Strategy for Mbombela Municipal Area (2013-2015) to inform the planning and implementation of water resource management interventions necessary to reconcile future water requirements and water use patterns up to a period of thirty years.

For the Reconciliation Strategy of the Mbombela Municipal Area, referred to as the Strategy hereafter, to be implemented, and for the Strategy to remain relevant to properly fulfil its purpose into the future it has to be dynamic. Hence, the water balance has to be continuously monitored and the developed Strategy has to be regularly updated and maintained. This would ensure that planned intervention options identified for implementation will also be revised where necessary to consider any changes that may have potential impacts on the projected water balance.

The DWS commissioned the Implementation and Continuation of the Water Reconciliation Strategy for the Mbombela Municipal Area, referred to as this Study, to facilitate a process to maintain the relevance of the Strategy. The overall objective of the Study was to systematically expand, update and improve the Strategy in order for the Strategy to remain technically sound, economically feasible, as well as socially and environmentally acceptable and sustainable.

1.2 Water Reconciliation Strategy

Whilst this Study focusses on the update of the Mbombela Strategy (DWA, 2014), the footprint of the Study Area has been expanded to include the full Crocodile (East) and Sabie Sub-catchments and their associated water users. For this reason, the Strategies developed for these other areas have also been incorporated and updated as part of this Study. These include the Sabie-Sand Strategy (DWS, 2016) as well as various All Towns Strategies focussing on smaller urban areas.

The Mbombela Strategy (DWA, 2014) excluded some of the water source areas and focussed specifically on the area inside the Municipal boundary. Water Resources were included as water allocated to specific users rather than yields and water available from the catchment as a whole. Only the urban sector was considered in the water balances. This Study enhances the previous Strategy as it deals with the catchment as a whole, an integrated system with various resources and users groups.

1.3 Study Area

The Study Area included both the Crocodile (East) and the Sabie Sub-Catchments, which form part of the Ehlanzeni District Municipality (DM) as illustrated in the Study Area map in **Figure 1-1**. The focus of this study was on the City of Mbombela (CoM) Local Municipality (LM) (centre of the Study Area), former Umjindi LM (South), which was recently amalgamated with the CoM LM, and Bushbuckridge LM (North). The remainder of the Study Area incorporated parts of the Emakhazeni LM (West), Thaba Chweu LM (North-West) and Nkomazi LM (South-East), which are situated and form part of the Crocodile (East) and Sabie Sub- Catchments.

Two major water courses traverse the two Sub- Catchments in the Study Area, which are the Crocodile (East) River and the Sabie River. The Crocodile (East) River, originates at Dullstroom and joins the Lunsklip River before entering the Kwena Dam from which it flows through the Schoemanskloof Mountains. The Crocodile (East) River joins with a major tributary, the Elands River, which originates at Machadodorp and flows through Waterval Boven before its confluence with Ngodwana River. The Crocodile and Elands rivers have their confluence at Montrose. The river meanders through the catchment from West to East, where it joins with smaller tributaries such as the Nels River, Wit River, Kaap River and Nsikazi River. The Crocodile River finally merges with the Komati River close to Komatipoort, where it becomes the Inkomati River.

A major tributary of the Sabie River is the Sand River, which has its origin on the border of Thaba Chweu LM and Bushbuckridge LM and the Marite River, which is regulated by releases from the Inyaka Dam. The Sabie River impounds the Corumana Dam in Mozambique, which is upstream of the confluence with the Sabie River and the Inkomati River (Xivane) within Mozambique, where it discharges into the Indian Ocean as the Inkomati River to the north of the City of Maputo, Mozambique.

There are two major dams in the Study Area, which are the Inyaka Dam in Bushbuckridge LM, Kwena Dam in the Thaba Chweu LM, as well as smaller dams in the CoM LM such as Witklip Dam, Longmere Dam, Klipkopje Dam, Primkop Dam and Da Gama Dam.

The Sappi Ngodwana Mill is a major industrial water user in the Crocodile (East) Sub-catchment, which abstracts water from the Ngodwana Dam, on the Ngodwana River, and obtains additional water supply from former irrigation licenses. Other major industrial water users are the TSB Malelane sugar mill in Nkomazi LM in the Lower Crocodile (East) Tertiary Catchment and smaller mining operations in the former Umjindi LM.

The largest water user in the Crocodile (East) Sub-Catchment is the irrigation sector (467 million m^3/annum), followed by commercial afforestation (158 million m^3/annum). The shared watercourses with Mozambique are regulated by an international water sharing agreement (IIMA, 2002).

There are water transfers from the neighbouring Lomati Catchment to support the towns of Barberton and Shiyalongubo. There is also a transfer from the Sabie Sub- Catchment to the Crocodile (East) Sub-Catchment to support the Nsikazi North demand centre.

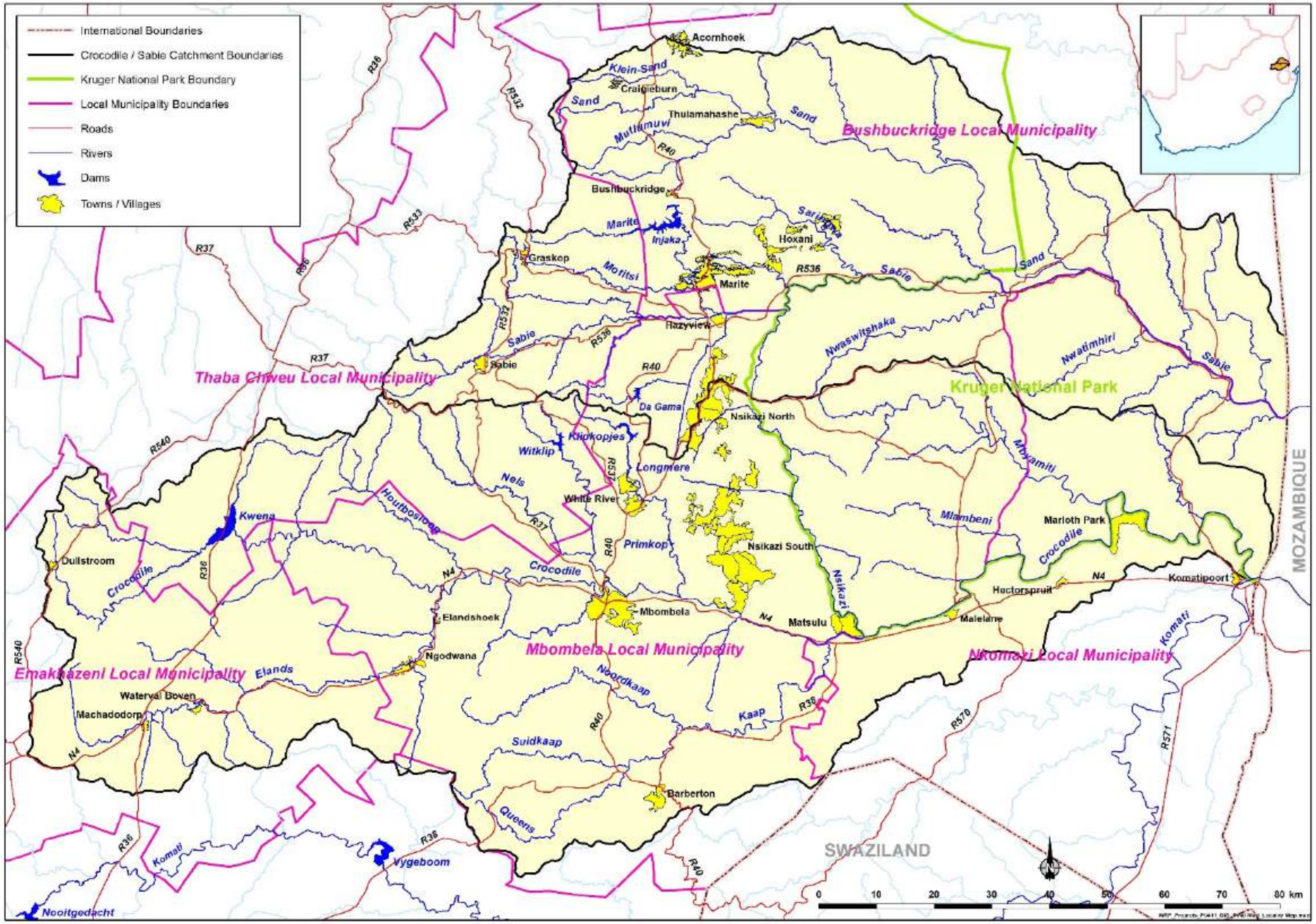


Figure 1-1: Map of the Study Area

1.4 Purpose and Structure of this Report

This report presents the updated water reconciliation strategy for the Crocodile (East) and Sabie-Sand catchments. The purpose of this report was to:

- Summarise the information obtained and assessed as part of preceding detailed Technical Reports produced as part of this Study.
- Present the current water balance status in terms of existing resources and water requirements.
- Determine future intervention options in order to augment the existing water resources.
- Present water balances comparing future water requirement projections with intervention options implemented on a timeline.
- Assign responsibility for implementation of actions to various applicable institutions.

The report is structured as follows:

- **Section 1** provides a formal overview of the Study Area, this strategy and the purpose and structure of this report.
- **Section 2** presents an overview of the current water use and projected water requirements.
- **Section 3** provides a summary of the Water Conservation and Water Demand Management assessment undertaken.
- **Section 4** presents the water resources availability from the catchments included in the Study Area.
- **Section 5** provides the current water balances included existing water resources only.
- **Section 6** provides an overview of the various options to increase water supply or decrease water requirements available to the Study Area.
- **Section 7** presents a reconciliation of water requirements and intervention options in the form of water balance plots.
- **Section 8** provides and implementation action plan including the assignment of responsibility to various Institutions.
- **Section 9** presents recommendations for further work relating specifically to the future update and enhancement of the Strategy.
- **Section 10** indicates the study references.

2 CURRENT WATER USE AND PROJECTED WATER REQUIREMENTS

2.1 Demographics and Population Projections

A detailed demographic assessment was done and is documented in DWS, 2018a, one of the preceding technical reports to this Strategy.

The City of Mbombela LM is divided by the N4 highway which runs from west to east, and the R40 which divides the City of Mbombela LM from north to south. The main town of the City of Mbombela LM is Mbombela which functions as the main administrative and service delivery node within the City of Mbombela LM. Mbombela is also the administrative capital of the Mpumalanga Province and houses various provincial departments within its borders. Other nodes of importance are White River, which functions as a secondary node to Mbombela, Rocky Drift which functions as a regional industrial node and Hazyview, which is a local service delivery and tourism node within the City of Mbombela LM.

Unemployment and poverty are core challenges in the Bushbuckridge LM. Furthermore, the Bushbuckridge LM is characterized with a vast number of protected areas, including the KNP and various nature reserves covering approximately 815 000 Ha, which equates to about 80% of the Bushbuckridge LM's land area.

The Bushbuckridge LM is renowned for its agricultural and tourism attractions. The Bushbuckridge LM Area provides a link to economically viable centres in the Lowveld, particularly Hazyview, Hoedspruit, Pilgrim Rest and Graskop. The R40 provincial road passes through the Bushbuckridge LM starting from Marite to Acornhoek.

In order to project population changes relevant information pertaining to the City of Mbombela and Bushbuckridge LMs was gathered from previous studies undertaken by the Department of Water and Sanitation (DWS), desktop research and further information gathering as well as discussions with relevant stakeholders and role-players.

Discussions revolved around the dynamics and development patterns of the municipalities. These included discussions on municipal plans, current commercial, industrial and residential developments, housing projects, and proposed future developments.

The base population data was refined and growth scenarios up to 2040 were developed. The model used to project future growth produced realistic and high growth scenario results. These growth scenarios are based on detailed local information relating to structural economic changes, policy changes, income groups, strategic development projects, social dynamics, proposed housing developments, infrastructure developments, urbanisation and migration trends, as well as historical growth patterns.

Modelling was undertaken according to Water Supply Schemes (WSSs), which are each characterised by unique attributes and circumstances. Each individual geographic region or WSS can be viewed as an area on its own, which interrelates with the various other regions identified within the City of Mbombela and Bushbuckridge LMs. Each region had a specific growth forecast, based on information obtained from the plans and discussions with the LM role-players in the City of Mbombela and Bushbuckridge LMs, which determines the rate of population growth as well as the development of residential, commercial and industrial developments. The modelling process focused on population growth, of individuals (and households) and the distribution of these individuals within the City of Mbombela and Bushbuckridge LMs.

The resultant projected population at local municipal level at 5 year intervals from 2010 to 2040 for the realistic and high growth scenarios are given in **Table 2.1** below.

Table 2.1: Municipal projected population per 5 years per growth scenario, 2010 to 2040

Municipality	Scenario	2010	2015	2020	2025	2030	2035	2040
Mbombela LM (former) excl. rural	Realistic	570 446	611 228	647 312	681 604	716 484	750 755	784 628
	High	570 958	625 675	682 826	733 699	783 528	831 715	882 311
Umjindi LM (former) excl. rural	Realistic	62 779	69 517	73 565	77 617	81 866	86 304	90 922
	High	62 778	72 397	79 961	85 420	91 072	96 842	102 925
Bushbuckridge LM excl. rural	Realistic	528 388	538 801	546 244	553 638	561 102	568 632	576 233
	High	528 388	548 854	569 644	590 126	610 294	630 120	649 579

Subsequent to the completion of the demographic assessment, the Bushbuckridge LM provided additional information based on house counts undertaken by the municipality. The information suggested that the actual 2020 population is approximately 705 476 people, based on the house count of 174 369 houses, and four people per household. This higher population was considered as a water requirement scenario in the water balances.

2.2 Urban and Industrial Water Requirements (DWS, 2018b)

Five Local Municipalities are either partially or fully located in the Study area. These are Mbombela LM, Nkomazi LM, Thaba Chweu LM, Emakhazeni LM and Bushbuckridge LM. The main towns and urban centres are as follows: Mbombela, Nsikazi North and South, White River, Karino, Matsulu, Malelane, Hactorspruit, Dullstroom, Machadodorp, Waterval Boven, Barberton, Acornhoek, Thulamahashe, Hoxane, Marite, Hazyview, Graskop and Sabie. The

Municipalities and town locations are shown **Figure 2-1**. A simplified schematic layout of the Study area, urban water resources and locations is provided in **Appendix A**.

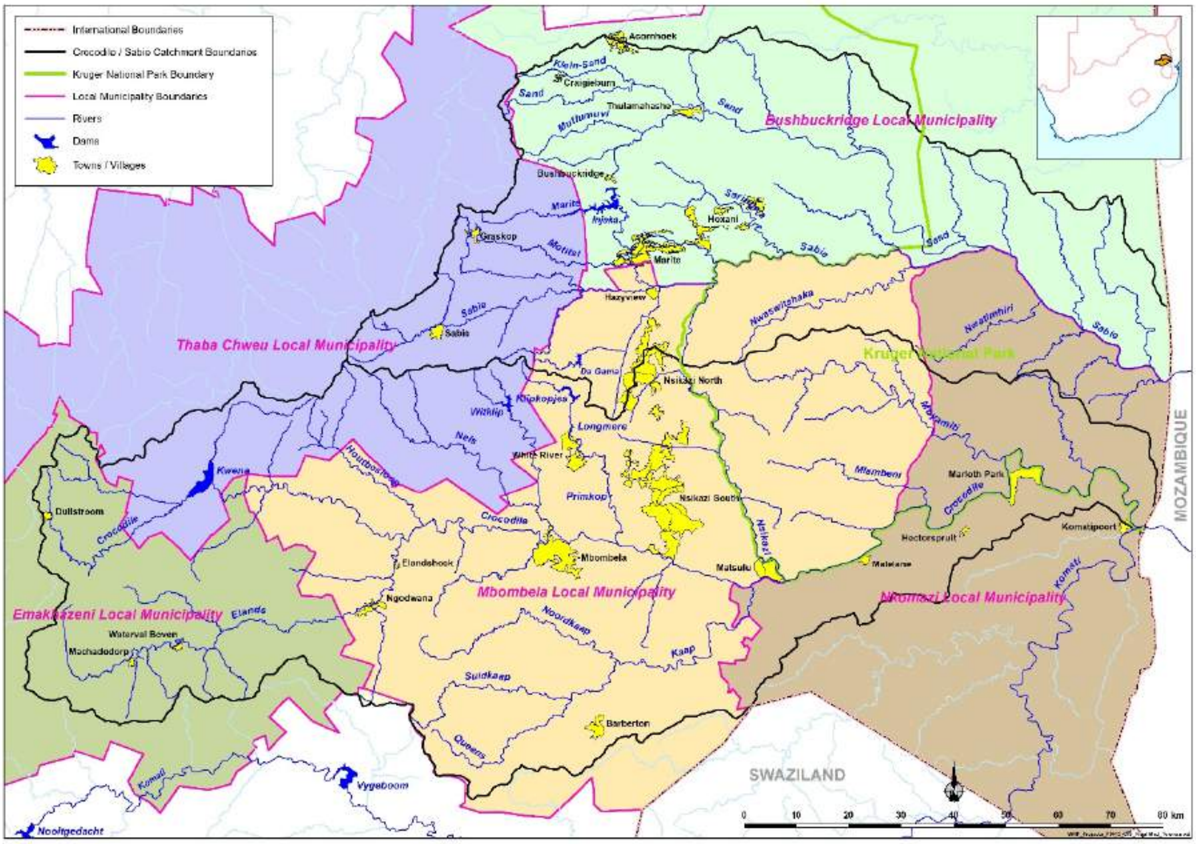


Figure 2-1: Locations of Municipalities and urban areas with Study area

Population growth estimations and the related economic growth characteristics within the study area formed the basis for the calculation of the urban/industrial and domestic water requirement calculations. An increase in service levels over time was introduced resulting in an increase in the per capita water uses, specifically in those areas with currently low service levels.

Table 2.2 provides a summary of the domestic and industrial requirements of users located in the study area. It should be noted that these projected requirements may exceed the conditions of the existing allocations, as it is important to plan for future growth without the limitation of the allocation.

Table 2.2: Urban and industrial projected water requirements per year indicated

Demand Centre	Requirement (million m^3/annum)				
	2018	2025	2030	2035	2040
Dullstroom	0.85	1.10	1.20	1.30	1.40
Machadodorp	0.95	1.20	1.40	1.50	1.60
Watervalboven	0.95	1.10	1.20	1.30	1.40

Demand Centre	Requirement (million m^3/annum)				
	2018	2025	2030	2035	2040
Sappi Ngodwana domestic	0.75	0.96	1.14	1.35	1.59
Sappi industrial	14.00	14.00	14.00	14.00	14.00
Elandshoek	0.11	0.14	0.16	0.17	0.19
Barberton, Umjindi	5.39	6.05	6.56	7.02	7.51
Sub-total (Crocodile tributaries)	23.00	24.55	25.66	26.64	27.69
CoM: Nelspruit WTW, part to Rocky drift	17.00	22.28	26.26	30.24	34.22
Karino, Tekwane West	0.92	1.10	1.23	1.35	1.48
Emoyeni, Tekwane North	0.30	0.46	0.58	0.70	0.82
Nsikazi South	25.00	27.97	30.11	32.26	34.40
Shiba Siding	0.11	0.15	0.18	0.19	0.21
Matsulu	6.49	7.50	8.25	8.98	9.76
Malelane	0.73	0.82	0.90	0.90	0.99
Marloth Park	0.92	1.04	1.12	1.19	1.26
Hectorspruit	0.25	0.25	0.28	0.40	0.42
Sub-total (Crocodile main)	51.72	61.57	68.91	76.21	83.56
White River from Witklip Dam	0.28	0.40	0.48	0.56	0.64
White River from Longmere Dam	1.60	2.10	2.51	2.91	3.32
Sub-total (White River)	1.88	2.5	2.99	3.47	3.96
Sabie	1.78	1.78	1.78	1.79	1.79
Graskop	0.83	0.91	0.97	1.04	1.10
Sub-total (Sabie groundwater)	2.61	2.69	2.75	2.83	2.89
Nsikazi North	10.44	11.63	12.51	13.13	13.75
Hazyview	1.61	2.09	2.47	2.70	2.84
Hoxani	14.20	16.00	17.20	18.20	19.20
Marite	3.40	3.90	4.30	4.60	4.80
Acornhoek (own resources)	5.15	7.15	7.85	9.95	10.95
Thulamahashe (own resources)	3.45	4.65	5.45	6.05	6.65
Bushbuckridge Transfer pipeline to Acornhoek and Thulamahashe	25.0	25.0	25.0	25.0	25.0
Sub-total (Inyaka Dam)	63.25	70.42	74.78	79.63	83.19

2.3 Irrigation Water Requirements

Irrigation is a significant user of water in the study area, particularly in the Crocodile catchment. Sugarcane is the most commonly found crop grown in the Crocodile catchment, followed by vegetables and citrus, mainly in the Sabie catchment. Various irrigation Boards are located along the river, all sharing the water resources of the Kwena Dam. The locations thereof are presented in **Figure 2-2**. The figure indicates the Irrigation Board and Government Water

Control Area boundaries, as well as highlights the locations of the irrigation activities within those boundaries.

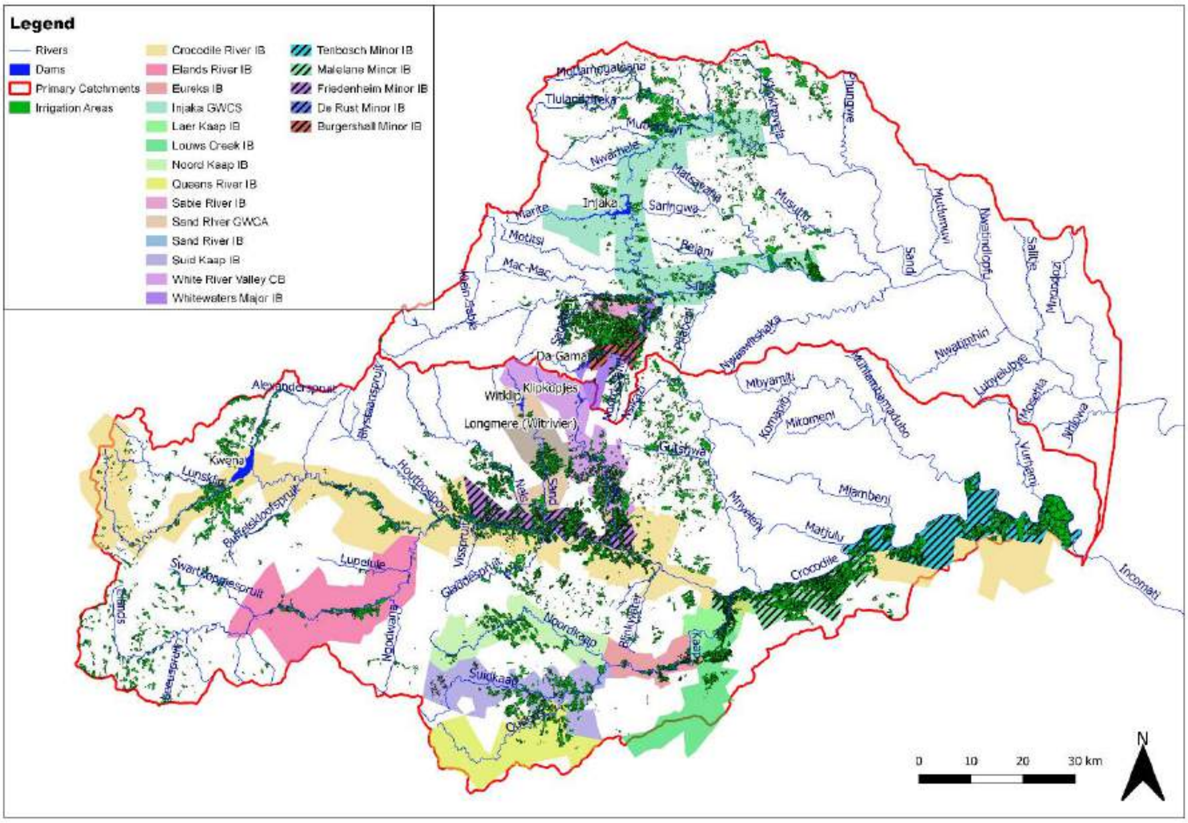


Figure 2-2: Irrigated areas within the Crocodile and Sabie catchments

In most of the sub-catchments within the study area, the water resources are already over allocated with very little if any scope for an increase in irrigation activities. No growth was therefore in general assumed for irrigation over the planning period.

There is an irrigation allocation of 14.1 million m^3/annum from Inyaka Dam in the Sabie catchment. However, much of these previously irrigated areas are lying dormant and processes are underway to revitalize the farming activities. For the purposes of this Strategy, it has been assumed that this revitalization process will be completed by 2025 by which time all the irrigation allocations will again be fully utilized.

The process of validation and verification of irrigation activities is still underway in the Sabie and Crocodile catchments. Accurate information regarding the extent of lawful irrigation allocations will only be available after the completion of this process, which is currently estimated as being 60% complete. The irrigation requirements as determined in the IWAAS have therefore been used in this Strategy, as this is currently still the most accurate source of information.

Table 2.3: Summary of Irrigation: Sabie/Sand catchment

Type	Area (km^2)	Volume (million m^3/annum)
Sabie Irrigation Board	20.63	10.9
White Waters Irrigation Board	27.84	15.6
Diffuse(1) (Sabie)	79.1	63.1
Diffuse (Sand)	24.65	17.06
Total	152.2	106.7

Note (1): Irrigation taking place outside a formal irrigation board, normally on tributaries, is referred to as diffuse irrigation

Table 2.4: Summary of Irrigation: Crocodile catchment

<table>
<tr><th>Type</th><th>Area (km²)</th><th>Volume (million m³/annum)</th></tr>
<tr><td>Elands Irrigation Board</td><td>42.21</td><td>28.7</td></tr>
<tr><td>Upper Croc diffuse</td><td>9.1</td><td>4.3</td></tr>
<tr><td>Upper Croc diffuse</td><td>3.5</td><td>1.5</td></tr>
<tr><td>Crocodile Irrigation Board</td><td>282.86</td><td>304</td></tr>
<tr><td>Sand River IB Avalon & Gradely Farms</td><td rowspan="3">59.3</td><td>10.8</td></tr>
<tr><td>White River IB, Ranch Karino & Curlews</td><td>8.4</td></tr>
<tr><td>Manchester & Good Hope IBs</td><td>4.0</td></tr>
<tr><td>Middle Croc diffuse</td><td>33.72</td><td>20.2</td></tr>
<tr><td>Middle Croc diffuse</td><td>8.2</td><td>4.93</td></tr>
<tr><td>Kaap Upper & Lower IBs</td><td>54.2</td><td>36.1</td></tr>
<tr><td>Kaap Diffuse</td><td>43.8</td><td>55.6</td></tr>
<tr><td>Total</td><td>536.9</td><td>478.5</td></tr>
</table>

2.4 Environmental Water Requirements and International Obligations

The National Water Act (Act 36 of 1998) (NWA) requires that sufficient water must be left in rivers in order to sustain their ecological functioning. This water is referred to in the NWA as the Ecological Reserve. The Ecological and the Basic Human Needs Reserves are the only water uses with the right to water, and as such must be given the highest priority of water supply. The ecological water requirements (EWR) of the Reserve must thus be determined and taken into account as part of any process to reconcile water requirements with the available water resource.

The EWR of both the Crocodile and Sabie River catchments have been determined and Gazetted as part of the Classification process (DWS, 2014a). EWR structures are based on the cumulative natural flow that occurs from the catchments upstream of the EWR site. There are seven EWR sites in the Crocodile River, as presented in **Table 2.5** and eight on the Sabie/Sand as presented in **Table 2.6**. Their locations are provided in **Figure 2-3**.

Table 2.5: Crocodile EWRs

EWR	Site Name	Category	MAR upstream of EWR site (million m^3/annum)	Ecological Reserve (% of NMAR)
EWR1	Valyspruit	A/B	15.6	24.3
EWR2	Goedehoop	B	76.1	30.9
EWR3	Poplar Creek	B/C	194.1	37.2
EWR4	KaNyamazane	C	819.3	26.1
EWR5	Malelane	C	1089.2	22.3
EWR6	Nkongoma	C	1137.5	12.5
EWR7	Honeybird	C	179.3	16.4

Table 2.6: Sabie EWRs

EWR	Site Name	Category	MAR upstream of EWR site (million m^3/annum)	Ecological Reserve (% of NMAR)
EWR1	Upper Sabie	B/C	132.0	35.8
EWR2	Aan de Vliet	C	261.7	27.3
EWR3	Kidney	A/B	493.7	30.8
EWR4	Mac Mac	B	65.8	45.4
EWR5	Marite	B/C	156.4	21.7
EWR6	Mutlumuvi	C	45.0	26.0
EWR7	Upper Sand	C	28.9	20.4
EWR8	Lower Sand	B	133.6	18.5

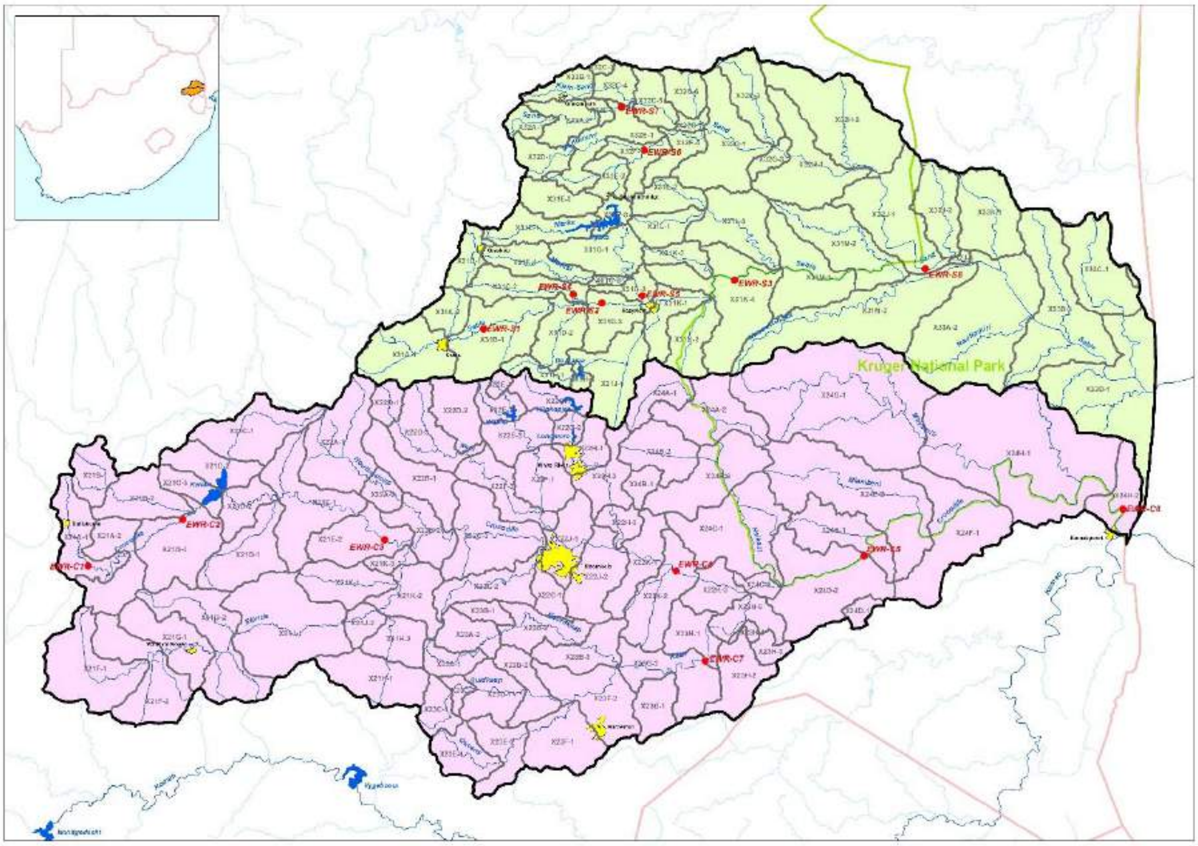


Figure 2-3: Crocodile and Sabie EWR site locations

Further to the EWRs, International Obligations exist for the Crocodile and Sabie Rivers. The requirements are stipulated in the Interim IncoMaputo Water Use Agreement (TPTC 2002), and states that a minimum flow of 2.6 m^3/s is required at Ressano Garcia for environmental purposes. This is assumed to be split 55 % and 45 % between the Komati and Crocodile Rivers respectively (DWAF, 2009). This results in a minimum requirement of 37 million m^3/annum (1.17 m^3/s) to cross the border into Mozambique. If the EWR requirement at EWR Site 6 is more than the international requirement, then it is assumed that the requirement is met. Furthermore 0.6 m^3/s is the required minimum flow from the Sabie River to cross the border.

2.5 Streamflow Reduction Activities

There are large areas of forestry within both the Crocodile and Sabie River catchments including exotic plantations such as Pine, Eucalyptus and Wattle which reduce the amount of water that would otherwise flow in the rivers in the catchments where the plantations are located.

The information available for the afforestation and the alien vegetation streamflow reduction is sourced from the IWAAS (DWAF, 2009). **Table 2.7** presents the area and associated volumetric use by the two activities. The locations of the activities are presented in **Figure 2-4** and **Figure 2-5** as sourced from the IWAAS (DWAF, 2009) and SANBI (website, 2014) for afforestation and alien vegetation respectively.

Table 2.7: Streamflow Reduction in the Study Area

	Afforestation		Alien vegetation	
Tertiary	**Area (km^2)**	**Streamflow reduction (million m^3/a)**	**Area (km^2)**	**Streamflow reduction (million m^3/a)**
X21	587	51.6	89.1	10.1
X22	900	65.8	122.1	17.1
X23	443	39.7	69	4.4
X24	11	0.4	14.9	0.4
X31	797	85.8	182.6	29.9
X32	56	3.9	33.1	1.7
X33	0	0	0	0.0
Total	**2794**	**247.11**	**510.8**	**63.63**

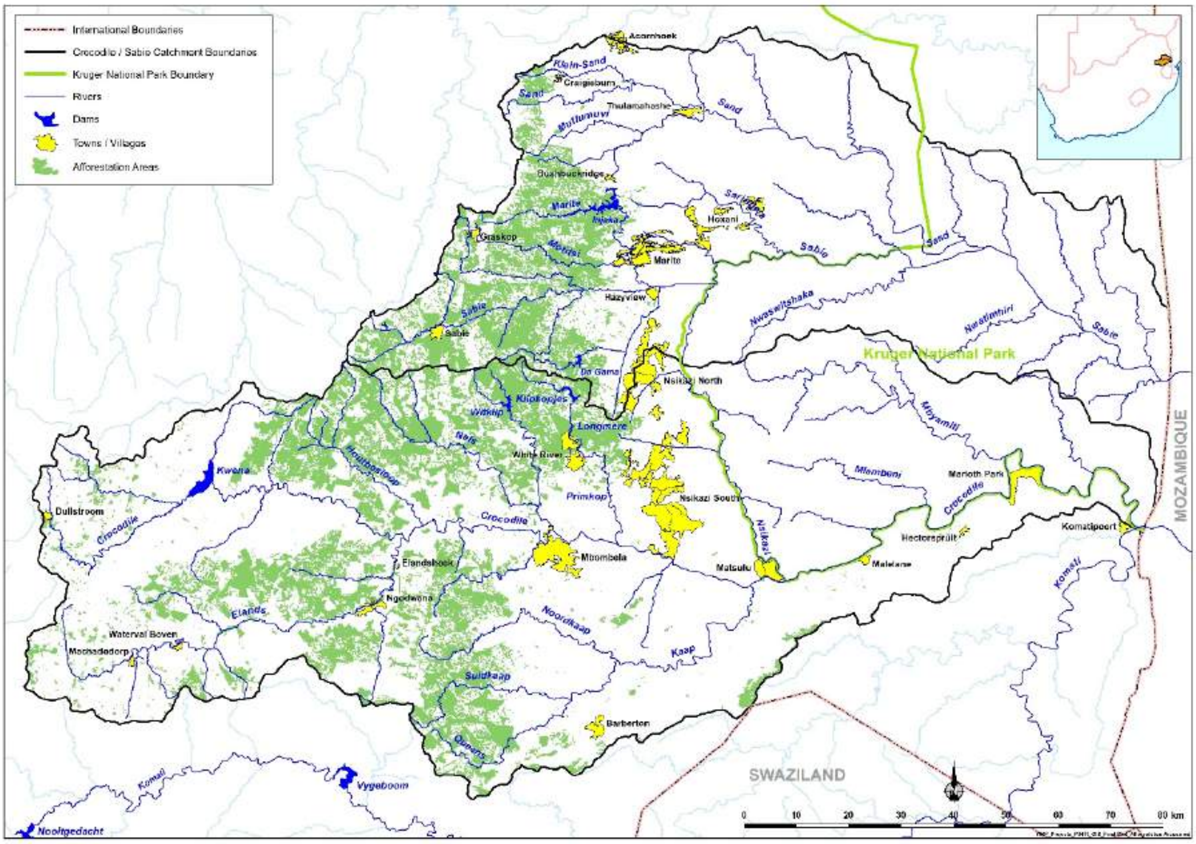


Figure 2-4: Location of afforested areas

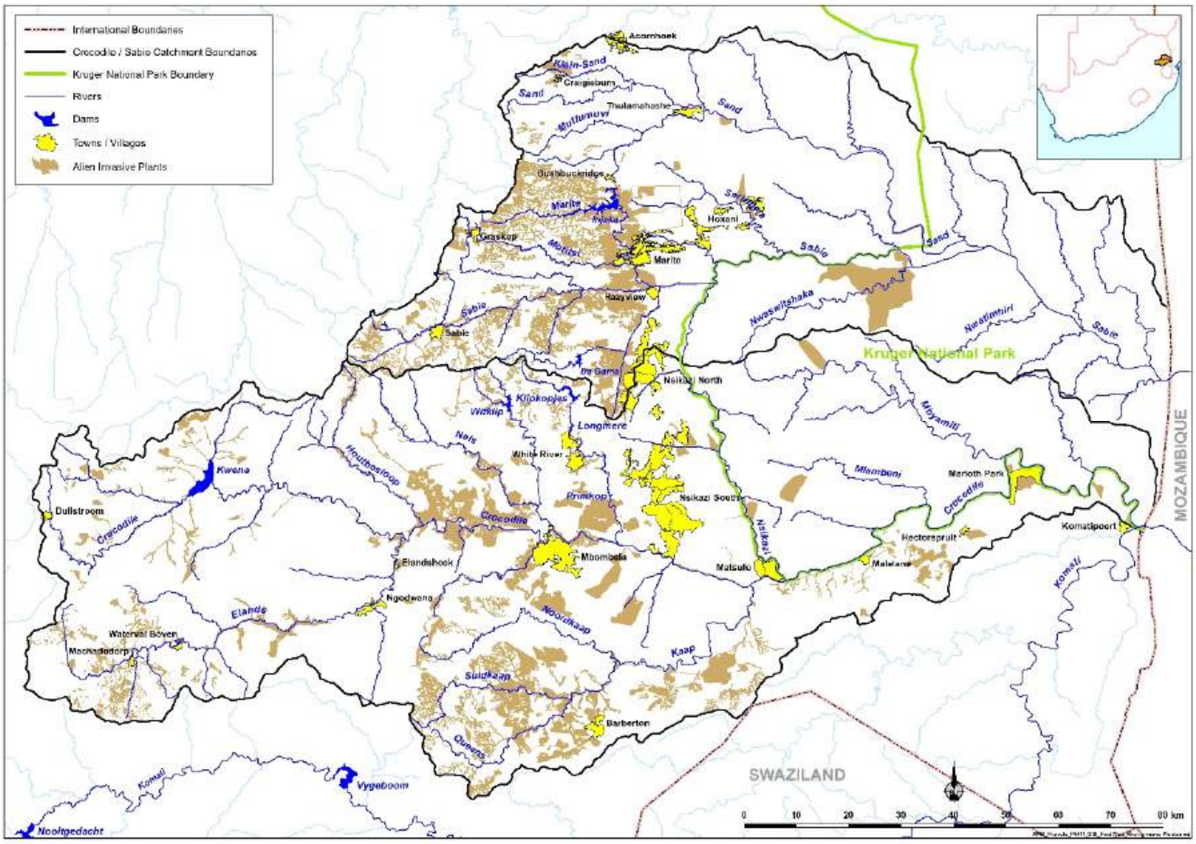


Figure 2-5: Locations of Alien Invasive Plants (WFW, 2014)

2.6 Inter-catchment transfers

An inter-catchment transfer occurs when water is transferred across a catchment divide from one catchment to a user in a neighbouring catchment. Some inter-catchment transfers occur within the Study area and some from catchments outside the study area. These are summarized as follows:

- Transfer from Inyaka Dam (Sabie catchment) to users (Acornhoek and Bushbuckridge) located in the northern Sand catchment, maximum transfer capacity 25 million m^3/annum.
- Transfer from Sabie River (Hoxane WTW) to Nsikazi North (Crocodile catchment), Mbombela portion of Hoxane WTW capacity is 36 Ml/d (13 million m^3/annum)
- Transfer from neighbouring Inkomati Catchment (Lomati Dam) to Barberton-Umjindi, approximately 4 million m^3/annum.
- Transfer from neighbouring Inkomati Catchment (Shiyalongubu Dam) to Louws Creek Irrigation Board, approximately 4.6 million m^3/annum.

2.7 Water use per sector summary

The total 2018 requirements that are imposed on the study area is 1099 million m^3/annum of which 334 million m^3/annum is supplied from the Sabie catchment and 765 million m^3/annum from the Crocodile catchment. The distribution per user group sector is depicted in **Figure 2-6**.

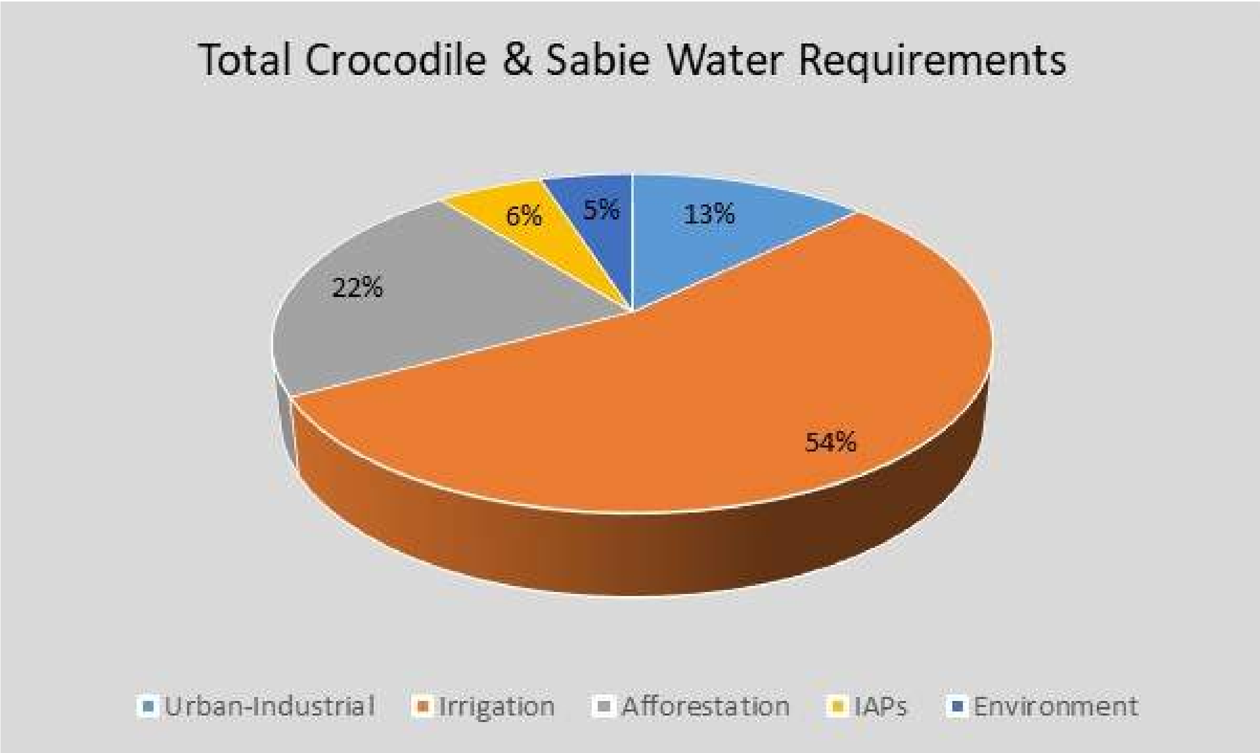


Figure 2-6: Total Crocodile and Sabie water requirements

3 WATER CONSERVATION AND WATER DEMAND MANAGEMENT

A detailed Water Conservation Water Demand Management assessment was done and is documented in DWS, 2019, one of the preceding technical reports to this Strategy.

3.1 Background and Approach

The WCWDM assessment was undertaken in the stepped approach:

- **Status quo assessment:** Review the status quo of the municipalities concerning their institutional, financial, legal, social and technical pillars. The assessments were undertaken to gain a complete understanding of the existing municipal water business, their operations and current key challenges.
- **Assessment Overview of Individual Demand Centres**: To allow for the concise assessment of the water situation, the individual demand centres the individual LM's were assessed and visited to gather information and to gain a better understanding of the status quo. The WCWDM key performance indicators (KPI's) were assessed for each demand centre.
- **Strategy**: Based on the results of the assessments a WCWDM strategy was developed, which was broken down into institutional, financial, social and technical strategy components.
- **Business Plan**: A business plan (targets and budgets) was developed for both the CoM and Bushbuckridge LM and the assumptions were documented.

3.2 Water Loss and NRW Reduction Targets for Participating Municipalities

3.2.1 City of Mbombela

The realistic and optimistic targets for CoM are summarised in **Table 3.1.** The realistic target aims to reduce the system input volume, non-revenue water and water loss by 10%. The optimistic target aims to reduce the input volume, non-revenue water and water loss by 20%.

The realistic target should be achievable if the municipality implements a comprehensive WCWDM programme with limited political support. The optimistic target should be achievable if the necessary political support could be gained to develop institutional capacity, enforce metering, billing and cost recovery and the implementation of cost effective water tariffs.

Both targets will bring the municipality's water loss key performance indicators in line with international standards although there is still significant scope for further improvement.

Table 3.1: CoM Realistic and optimistic targets

Indicator	Current Value	Realistic Target value 10% Reduction	Optimistic Target Value 20% Reduction
System Input volume (million m^3/a)	65,48	55,93	51,09
System Input volume (Mℓ / day)	179,27	153,14	139,88
Billed Authorised Consumption (million m^3/a)	31,64	30,89	32,80
Unbilled Authorised Consumption (million m^3/a)	6,59	5,68	4,66
Water Losses (million m^3/a)	27,25	19,36	13,64
Non-revenue Water (million m^3/a)	33,84	25,04	18,30
% Non-revenue water	52%	45%	36%
% Water Losses	42%	35%	27%
Input Volume (litres / capita / day)	251	214	196
Input Volume (m^3 / household / month)	26	22	20
Authorised Consumption (litres / capita / day)	146	140	143
Authorised Consumption (m^3 / household / month)	15	14	15

If the above targets could be achieved, the future realistic water balance for the municipality is presented in **Figure 3-1** (units are in million m^3/annum).

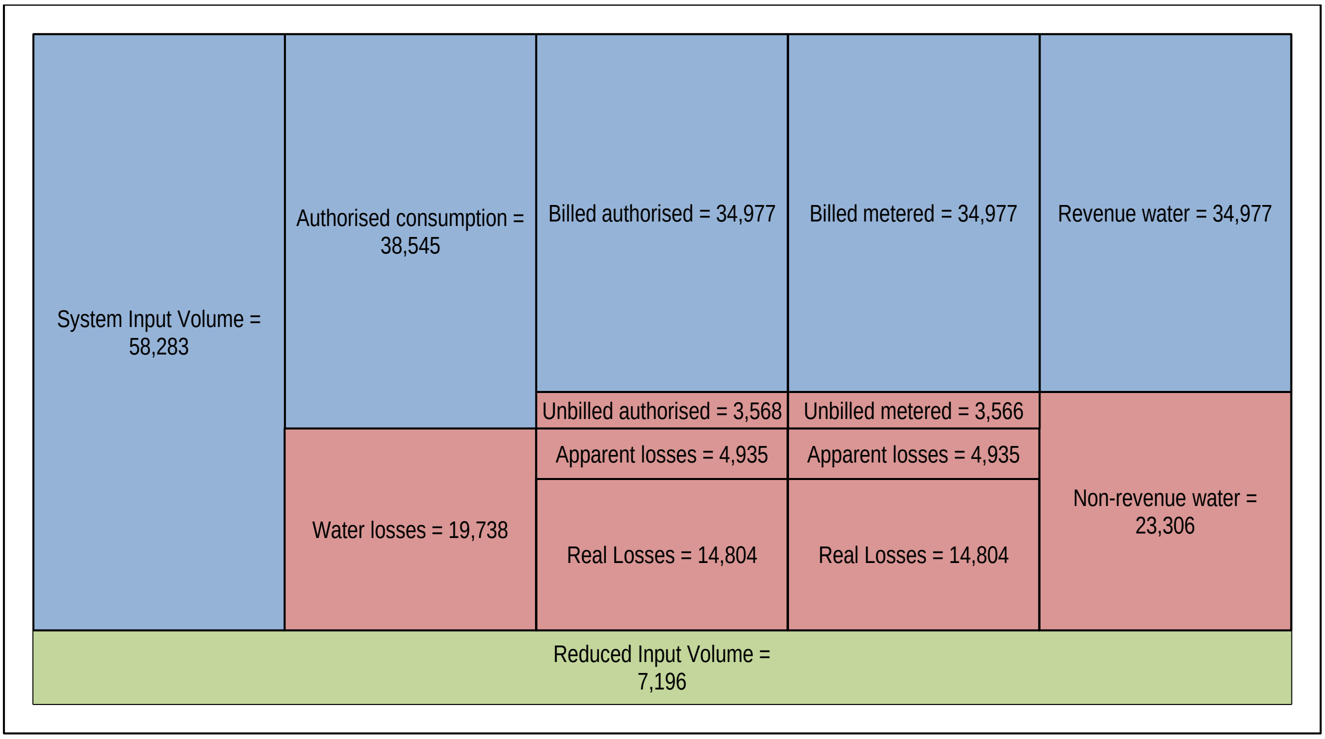


Figure 3-1: CoM target realistic water balance

The recommendations for WCWDM measures are based on the findings of the various analyses undertaken. The assessments include recommendations on interventions, estimated costs, and priorities for the period of five years and a summary of the budget requirements is presented in **Table 3.2**.

Table 3.2: CoM WCWDM budget summary

Interventions	Type	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Institutional	Capex	100 000	300 000	0	0	0	400 000
	Opex	150 000	150 000	150 000	150 000	150 000	750 000
	Sub Total	**250 000**	**450 000**	**150 000**	**150 000**	**150 000**	**1 150 000**
Financial	Capex	200 000	200 000	0	0	0	400 000
	Opex	45 590 380	45 590 380	45 590 380	45 590 380	45 590 380	227 951 900
	Sub Total	**45 790 380**	**45 790 3804**	**45 590 380**	**45 590 380**	**45 590 380**	**228 351 900**
Social	Capex	6 453 496	6 453 496	4 973 496	4 973 496	4 973 496	27 827 480
	Opex	12 809 740	12 809 740	12 809 740	12 809 740	12 809 740	64 048 700
	Sub Total	**19 263 236**	**19 263 236**	**17 783 236**	**17 783 236**	**17 783 236**	**91 876 180**
Technical	Capex	35 760 810	43 225 150	33 375 150	32 937 650	32 937 650	178 236 410
	Opex	21 534 430	21 534 430	21 534 430	21 534 430	21 534 430	107 672 150
	Sub Total	**57 295 240**	**64 759 580**	**54 909 580**	**54 472 080**	**54 472 080**	**285 908 560**
Total		**122 598 856**	**130 263 196**	**118 433 196**	**117 995 696**	**117 995 696**	**607 286 640**

The budget shows that approximately R 120 million per annum is required over the next five years to address WCWDM.

3.2.2 Bushbuckridge LM

The realistic and optimistic targets for Bushbuckridge LM are summarised in **Table 3.3.** The realistic target aims to reduce the system input volume, non-revenue water and water loss by 15%. The optimistic target aims to reduce the input volume, non-revenue water and water loss by 20%.

The realistic target should be achievable if the municipality implements a comprehensive WCWDM programme with limited political support. The optimistic target should be achievable if the necessary political support could be gained to develop institutional capacity, enforce metering, billing and cost recovery and the implementation of cost effective water tariffs.

Both targets will bring the municipality's water loss key performance indicators in line with international standards although there is still significant scope for further improvement.

Table 3.3: Bushbuckridge realistic and optimistic targets

Indicator	Current Value	Realistic Target value 15% Reduction	Optimistic Target Value 20% Reduction
System Input volume (million m^3/a)	49,68	42,23	39,74
System Input volume (Mℓ / day)	136,02	115,61	108,81
Billed Authorised Consumption (million m^3/a)	14,90	16,89	19,87
Unbilled Authorised Consumption (million m^3/a)	0,00	4,22	7,95
Water Losses (million m^3/a)	34,78	21,11	11,92
Non-revenue Water (million m^3/a)	34,78	25,34	19,87
% Non-revenue water	70%	60%	50%
% Water Losses	70%	50%	30%
Input Volume (litres / capita / day)	252	214	201
Input Volume (m^3 / household / month)	38	32	30
Authorised Consumption (litres / capita / day)	76	107	141
Authorised Consumption (m^3 / household / month)	11	16	21

If the above target is achieved the realistic target water balance for the municipality is shown in **Figure 3-2** (units are in million m^3/annum).

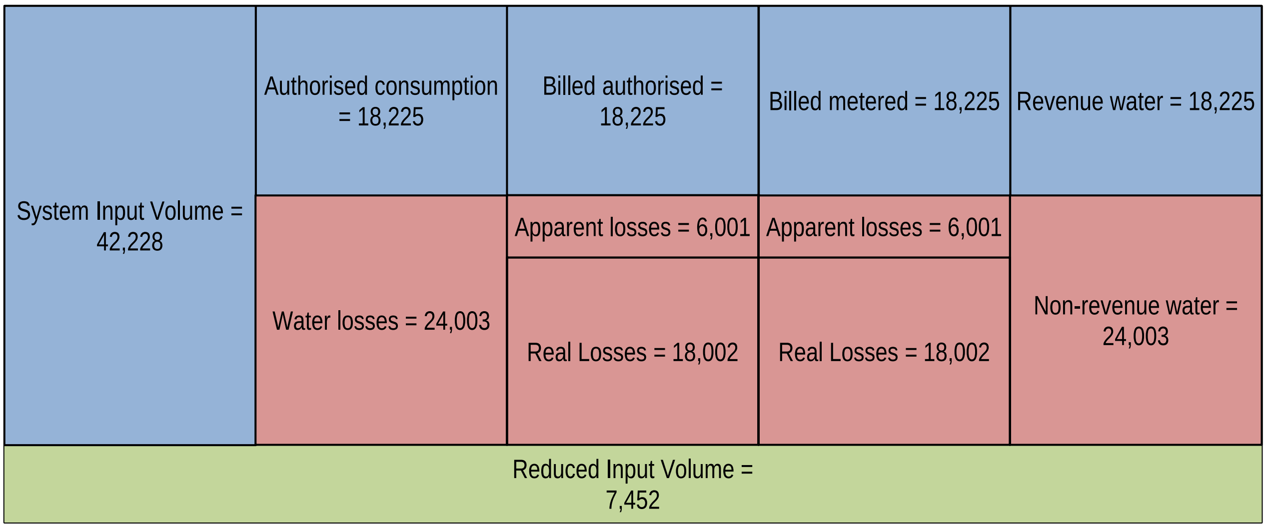


Figure 3-2: Realistic target balance

The five year estimated budget requirements for implementing WCWDM in the Bushbuckridge LM is summarised in **Table 3.4**. The results indicate that approximately R 60 million is required per annum for the next 5 years to address WCWDM.

Table 3.4: WCWDM budget summary

Interventions	Type	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Institutional	Capex	100 000	300 000	0	0	0	400 000
	Opex	375 000	375 000	375 000	375 000	375 000	1 875 000
	Sub Total	**475 000**	**675 000**	**375 000**	**375 000**	**375 000**	**2 275 000**
Financial	Capex	200 000	200 000	0	0	0	400 000
	Opex	22 605 660	22 605 660	22 605 660	22 605 660	22 605 660	113 028 300
	Sub Total	**22 805 660**	**22 805 660**	**22 605 660**	**22 605 660**	**22 605 660**	**113 428 300**
Social	Capex	3 334 088	3 334 088	2 534 088	2 534 088	2 534 088	14 270 440
	Opex	6 575 220	6 575 220	6 575 220	6 575 220	6 575 220	32 876 100
	Sub Total	**9 909 308**	**9 909 308**	**9 109 308**	**9 909 308**	**9 909 308**	**47 146 540**
Technical	Capex	18 800 440	23 355 530	17735 530	17 073 030	17 073 030	94 037 560
	Opex	11 876 205	11 876 205	11 876 205	11 876 205	11 876 205	59 381 025
	Sub Total	**30 676 645**	**35 231 735**	**29 611 735**	**28 949 235**	**28 949 235**	**153 418 585**
Total		**63 866 613**	**68 621 703**	**61 701 703**	**61 039 203**	**61 039 203**	**316 268 425**

3.3 Unit Reference Values

3.3.1 City of Mbombela

Unit reference values for City of Mbombela are summarised in **Table 3.5.** Unit reference values were discounted over 45 years at 6%; 8% and 10%. The costs include capital and operational expenses and the savings include the savings from reduced production costs and increased revenue water.

Table 3.5: Unit Reference Values

Discount rate	Total discounted cost (R)	Total realistic discounted saving (m^3)	URV Rand / m^3	Total optimistic discounted saving (m^3)	URV Rand / m^3
6%	R 1 333 761 763	137 776 487	R 9.68	230 514 555	R 5.79
8%	R 1 044 889 603	103 646 313	R 10.08	173 411 184	R 6.03
10%	R 851 094 264	81 180 876	R 10.48	135 824 144	R 6.27

3.3.2 Bushbuckridge LM

The unit reference values for Bushbuckridge are summarised in **Table 3.6.** Unit reference values were discounted over 45 years at 6%; 8% and 10%. The costs include capital and operational expenses and the savings include the savings from reduced production costs and increased revenue water.

Table 3.6: Unit Reference Values

Discount rate	Total discounted cost (R)	Total realistic discounted saving (m^3)	URV Rand / m^3	Total optimistic discounted saving (m^3)	URV Rand / m^3
6%	R 980 000 576	168 612 040	R 5.81	214 677 346	R 4.56
8%	R 768 335 830	126 843 241	R 6.06	161 497 189	R 4.76
10%	R 626 304 668	99 349 848	R 6.30	126 492 520	R 4.95

3.4 Conclusion and Recommendations (WCWDM)

Based on the findings of the municipal water sector, it is clear that there is significant scope for WCWDM in the study area. WCWDM will result in both a reduction of NRW and the total system input volume. A serious concern however, is the pervasive limitation in institutional capacity and technical skills to embark on WCWDM programmes in the municipalities.

WCWDM interventions should focus on the following interventions:

- Reduce the high water losses and inefficiencies with set targets and timelines;
- Municipalities should improve service delivery, as this will minimise informal and unauthorised connections in some areas;
- Develop and implement an operation and maintenance plan, if an existing plan is not in place;
- Install bulk meters to measure supply from the zones and districts;
- Maintain satisfactory operating pressures and install control valves in areas experiencing high pressures to ensure that operating pressures do not exceed the DWS regulation of 9 bar;
- Properly investigate the status of the service level for drinking water and sanitation in order to assess the situation and formulate recommendations for future improvements of servicing the entire area;
- Investigate the situation of water supply infrastructure on the base of new data in order to assess properly which investments in the refurbishment of the system are required;
- Provide training technical staff and for meter readers and perform monthly audits to eliminate estimates and other inaccuracies; and
- Embark on community awareness programmes that promote the value of water wise gardening.

4 WATER RESOURCE AVAILABILITY

4.1 Surface Water Hydrology

Surface water runoff contributes to water resources availability, however, runoff should not be confused with the yield of a catchment. Runoff represents the amount of water that could potentially be captured in water storage infrastructure and then converted into yield. Runoff varies on an annual basis and is dependent on rainfall, which is highly variable. It can therefore not be translated into the amount of water available for users required at a high level of assurance.

Surface water runoff is the main source of water for users within the Crocodile and Sabie catchments. The total surface water runoff under natural conditions for the tertiary catchments is summarised in **Table 4.1**. The quinary catchment delineations were maintained since the original IWAAS hydrology subdivisions. **Figure 4-1** presents a map of the catchments and sub-catchment delineations. In total, there are 140 sub-catchments. The Mean Annual Runoffs provided in the Table are as per the IWAAS Maintenance Study (DWA, 2012) and cover the time period 1920 to 2004.

Table 4.1: Surface water runoff per tertiary catchment

Major River	Tertiary Catchment	IWAAS (maint.) MAR (million m^3/annum)
Sand	X32	135.96
Sabie	X31	526.68
Sabie	X33	12.51
Kaap	X23	204.22
Crocodile	X21	467.24
Crocodile	X22	359.38
Crocodile	X24	106.62

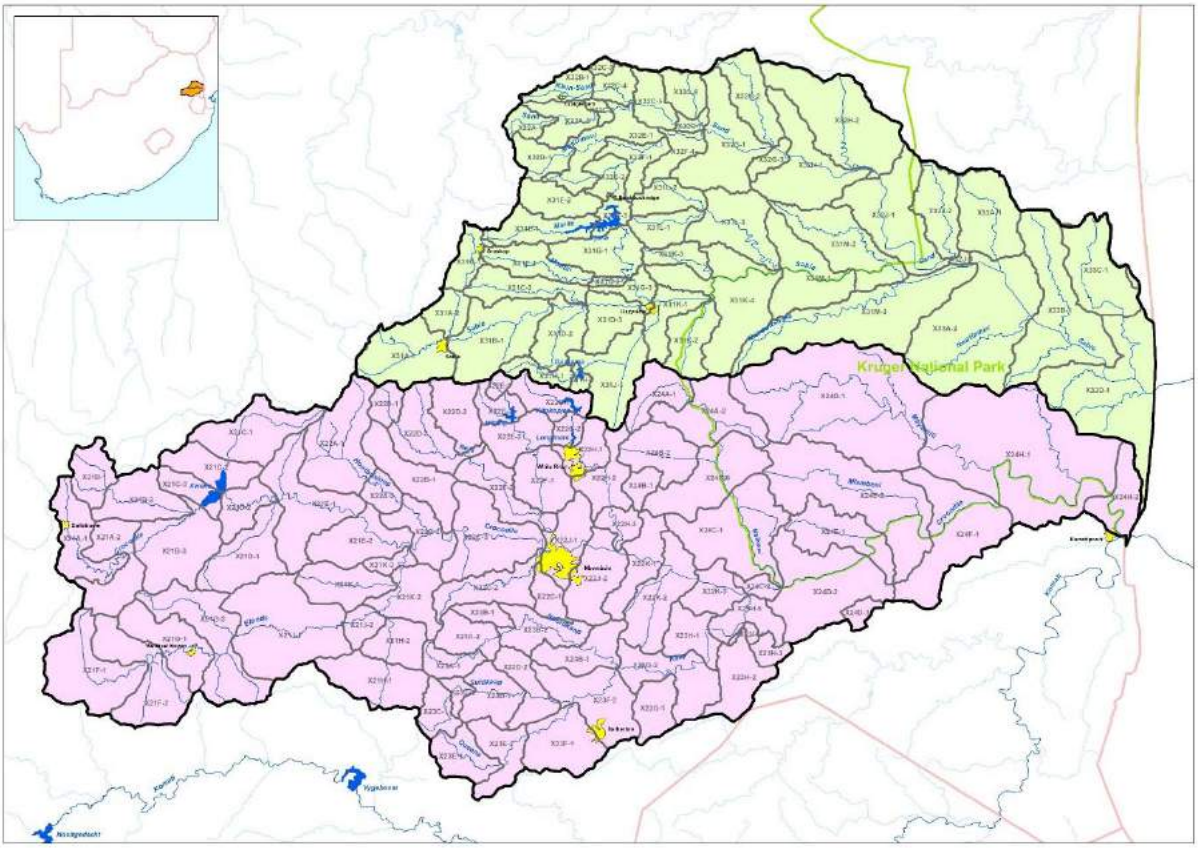


Figure 4-1: Sub-catchment boundary delineation

4.2 Regulating Storage Structures

Two major Dams, Kwena in the Crocodile catchment and Inyaka in the Sabie catchment support water users in the Study area. In addition, there are also several smaller dams as indicated in **Table 4.2**.

Table 4.2: Large Reservoirs located in the Study Area

Major River	Quaternary Catchment	Reservoir	Full Supply Capacity (million m^3)	Users Supplied
Sabie	X31E	Maritsane Dam	2.0	Domestic
Sabie	X31E	Inyaka Dam	125.0	Domestic
Sabie	X31H	Da Gama Dam	13.6	Irrigation
Sand	X32C	Acornhoek Dam	0.1	Irrigation/ Domestic
Sand	X32C	Edinburgh Dam	3.3	Irrigation/ Domestic
Sand	X32F	Orinoco Dam	1.9	Irrigation
Croc	X21C	Kwena Dam	158.9	Irrigation/ Domestic/ Industrial
Croc	X21H	Ngodwana Dam	10.0	Irrigation/ Domestic/ Industrial
Croc	X22E	Witklip Dam	12.7	Irrigation/ Domestic
Croc	X22G	Klipkopje Dam	11.9	Domestic
Croc	X22G	Longmere Dam	4.3	Irrigation/ Domestic

Major River	Quaternary Catchment	Reservoir	Full Supply Capacity (million m^3)	Users Supplied
Croc	X22H	Primkop Dam	2.0	Irrigation/ Domestic
Croc	X23H	Manders Dam	1.0	Irrigation
Croc	X24D	Spago Dam	2.3	Irrigation/ Domestic

Numerous smaller dams are scattered over the study area, most of which supply water for irrigation. The total storage of these small dams adds up to a significant volume of 85 million m^3. Run of river abstractions are common in the higher rainfall areas and along perennial rivers. These diffuse water requirements and impoundments are all accounted for in the WRYM setup and the impacts of these abstractions and small dams are therefore included in the yield analyses and related water balances.

4.3 Water Availability (Yield)

The details of the yield analyses have been documented in the water resources supporting report (DWS, 2020a). The Study area was divided into smaller sub-systems for the purpose of water availability determination. This was done by assessing the individual catchment characteristics and current approach to operation, and resulted in varying yield analyses methodologies being utilized for the various sub-systems. These are described in the following sub-sections. The Water Resources Yield Model (WRYM) developed by the DWS and applied countrywide was applied to carry out long term historical and stochastic yield analysis as well as short term analysis to determine the yield available for a range of initial dam storages. A brief description of what the terminology relating to the yield analyses is as follows:

- Historic Firm Yield: The maximum volume of water that can be abstracted from a resource over the historical observed time period (1920-2004) such that the resource is able to provide the abstracted volume in full each and every year.
- Long Term Yield at various Recurrence Intervals: 201 natural hydrological time series' (known as stochastic sequences) of 85 year record length are analysed in order to determine the system behavior under different hydrological conditions. The analyses allow for some sequences to fail (not supply the abstraction in full) and the results are quoted in assurance of supply depending on how many sequences fail.
- Short Term Yield at various Recurrence Intervals: 501 natural hydrological time series' (known as stochastic sequences) of 5 year record length are analysed in order to determine the system behavior under different hydrological conditions. In this case the resource's starting storage condition is considered

as additional yield is available when the storage volume is high compared with when it volume in storage is lower.

The following sub-sections presenting the yield analyses results include a comparison of the available yield at various assurance of supply levels with the required demands on the systems. The typical approach in South Africa is to provide urban/domestic users at a 98% assurance of supply level (1 in 50 year risk of failure) and irrigators at a 90% assurance of supply level (1 in 10 year risk of failure). In severely stressed systems, it is sometimes not possible to supply users at these criteria, and a 75% assurance of supply level (1 in 4 year risk of failure) is sometimes used for irrigators.

4.3.1 White River Sub-System

The White River system consists of the Witklip, Klipkopje, Longmere and Primkop Dams. The relevant quinary catchments contributing to the White River resources include X22 E1, E2, E3, F1, G1, G2, H1, H2 and H3 as presented in locality **Figure 4-2**.

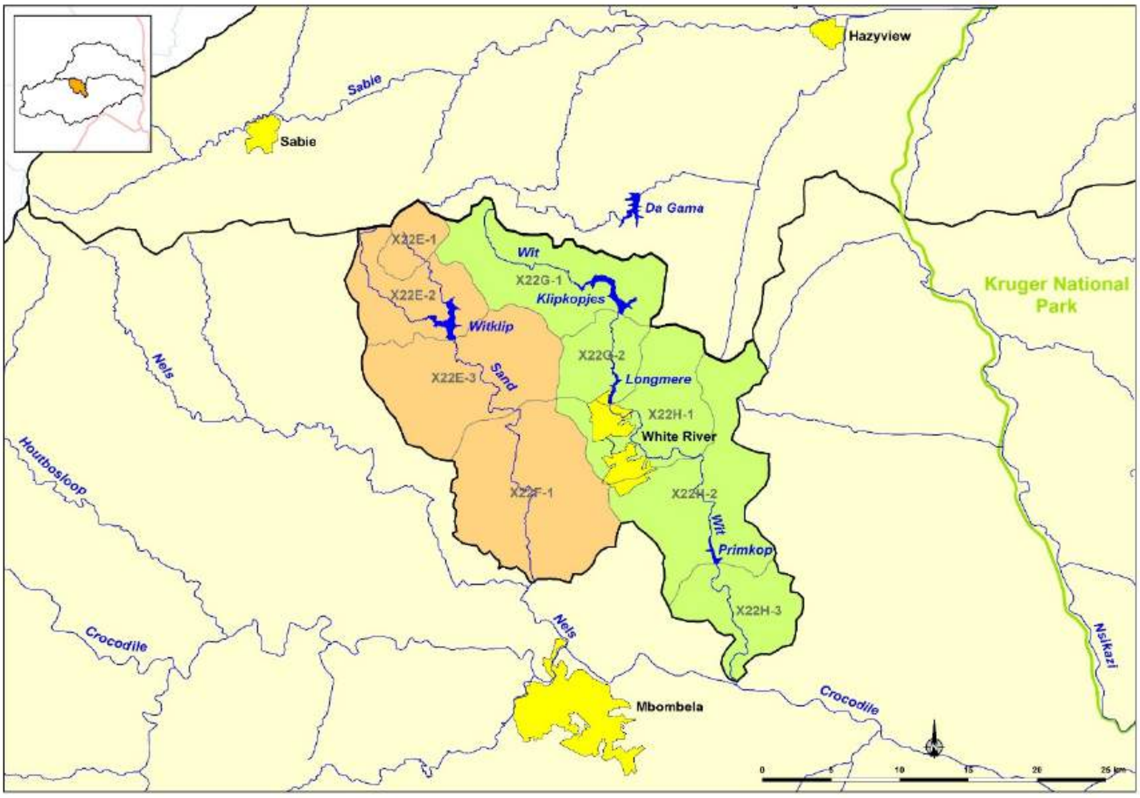


Figure 4-2: Locality of the White River system

For the purposes of the yield analyses of the White River System, the system was further subdivided into two sub-systems, namely, the Witklip Dam and the combination of the

Klipkopje, Longmere and Primkop (KLP) Dams. The WRYM was used to determine the yields of the two sub-systems, with the results obtained as presented in **Table 4.3**.

Table 4.3: White River system yields

Resource	HFY	1 in 4 (75%)	1 in 10 (90%)	1 in 20 (95%)	1 in 50 (98%)	1 in 100 (99%)
	(million m^3/annum)					
Witklip Dam	8.1	9.4	9.3	9.1	8.6	8.0
Klipkopje, Longmere, Primkop Dams	14.0	17.9	17.6	17.2	16	15.2
Total	22.1	27.3	26.9	26.3	24.6	23.2

4.3.2 Crocodile River System

The Crocodile system contains just one major dam, Kwena Dam, which is located in the upper reaches of the catchment. The system provides water to a number of users distributed along a lengthy stretch of river downstream of the Dam. **Figure 4-3** presents a locality of the main users along the Crocodile River.

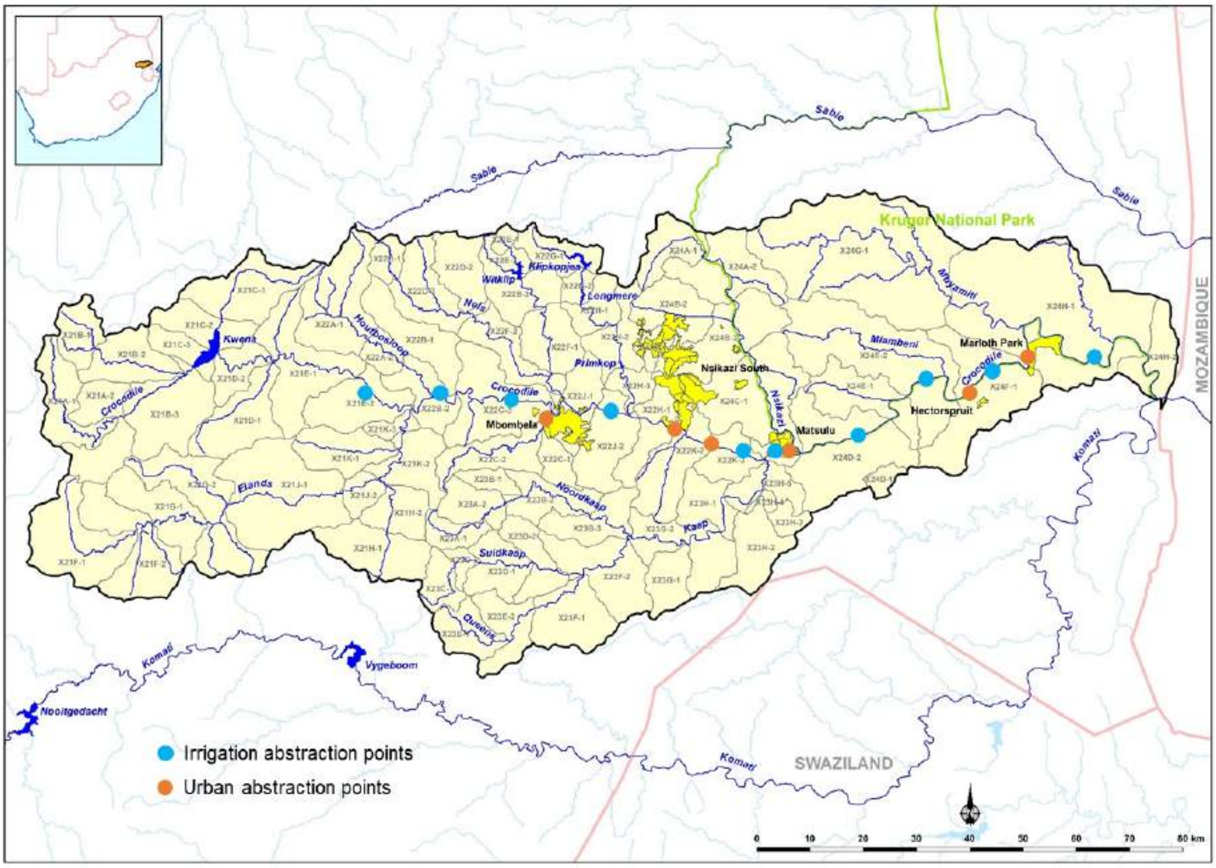


Figure 4-3: Locations of abstraction points along the Crocodile River

The yield of the Crocodile River System is directly influenced by the size of abstraction and location of the users in the system as mentioned in the opening paragraph of this Chapter. The dynamics of the incremental runoff that adds to the water availability of the users were considered when assessing the system capabilities.

It is clear that the yield of Kwena Dam of 49.5 million m^3/annum is far lower than the demands on the dam of 364.9 million m^3/annum. A system yield (historic firm) was therefore determined using the following approach:

- A representative yield node was configured into the model;
- All the user requirements were abstracted from their physical locations and were joined to the yield node;
- The yield channel was placed on the yield node;
- The HFY of 22.2 million m^3 was abstracted (removed) from the White River Resources, and these were not added to the yield node;
- The abstractions were scaled downwards based on the current operation of the system (irrigators restricted prior to domestic users) until the point that the Kwena Dam just fails once in the historic time period.

The result was obtained at a level of 90% domestic demand supplied and 45% irrigation demand supplied which equates to a HFY of the Crocodile system of 186.7 million m^3/annum. Comparing that with the yield of Kwena Dam alone implies that the flows from incremental runoff provide an additional 137.2 million m^3/a to the system yield.

Table 4.4: Crocodile Yield Results

Resource	HFY	1 in 4 (75%)	1 in 10 (90%)	1 in 20 (95%)	1 in 50 (98%)	1 in 100 (99%)
	(million m^3/annum)					
Kwena Dam	49.5	67.6	66.3	64.2	57.8	53.8
Croc system (incl Kwena Dam)	186.7	208.7	206.2	202.3	184.8	179.1

4.3.3 Sabie/Sand River

The Inyaka Dam is the main water resource infrastructure in the Sabie River, and supplies users both in the Sabie catchment as well as the Sand catchment through the Bushbuckridge Transfer Pipeline. Figure 4-4 provides a locality map of the Sabie and Sand River catchments indicating the location of Inyaka Dam.

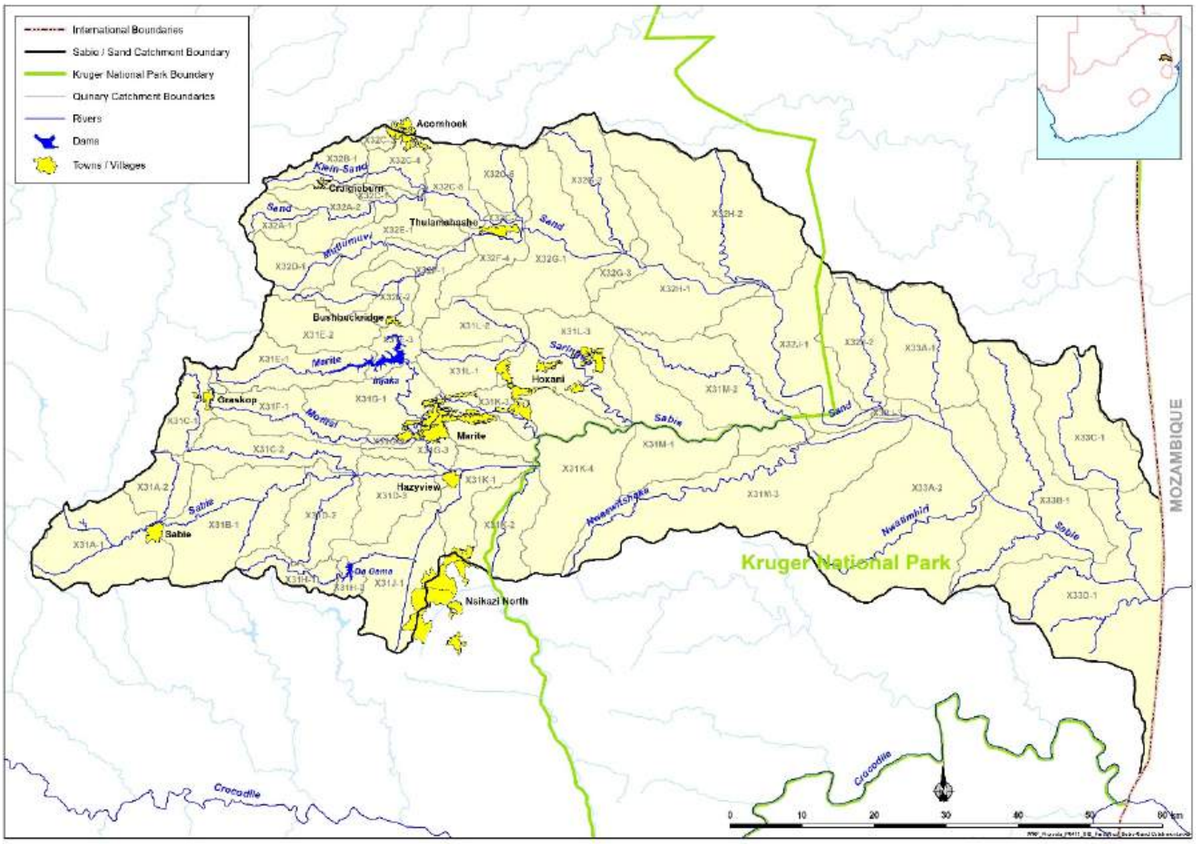


Figure 4-4: Sabie and Sand river catchments

Table 4.5: Sabie Yield Results

Resource	HFY	1 in 4 (75%)	1 in 10 (90%)	1 in 20 (95%)	1 in 50 (98%)	1 in 100 (99%)
	(million m^3/annum)					
Inyaka Dam	21.3	29.5	28.8	27.6	24.2	22.0

4.3.4 Minor Dams in Study Area

The HFYs for smaller dams falling within the Study Area are presented in **Table 4.6.** A locality map of these dams is provided in **Figure 4-5**.

Table 4.6: HFYs of minor dams within the Study Area

Dam	System	User	HFY (million m^3/annum)
Ngodwana	Crocodile (Elandspruit)	Sappi & Irrigation	21.0
Da Gama	Sabie (Whitewaters)	Whitewaters Irrigation Board	10.3
Edinburgh	Sand	Thulamahashe & irrigation	2.29

Dam	System	User	HFY (million m^3/annum)
Orinoco	Sand	Irrigation	0.34
Acornhoek	Sand	Acornhoek (domestic)	0.33

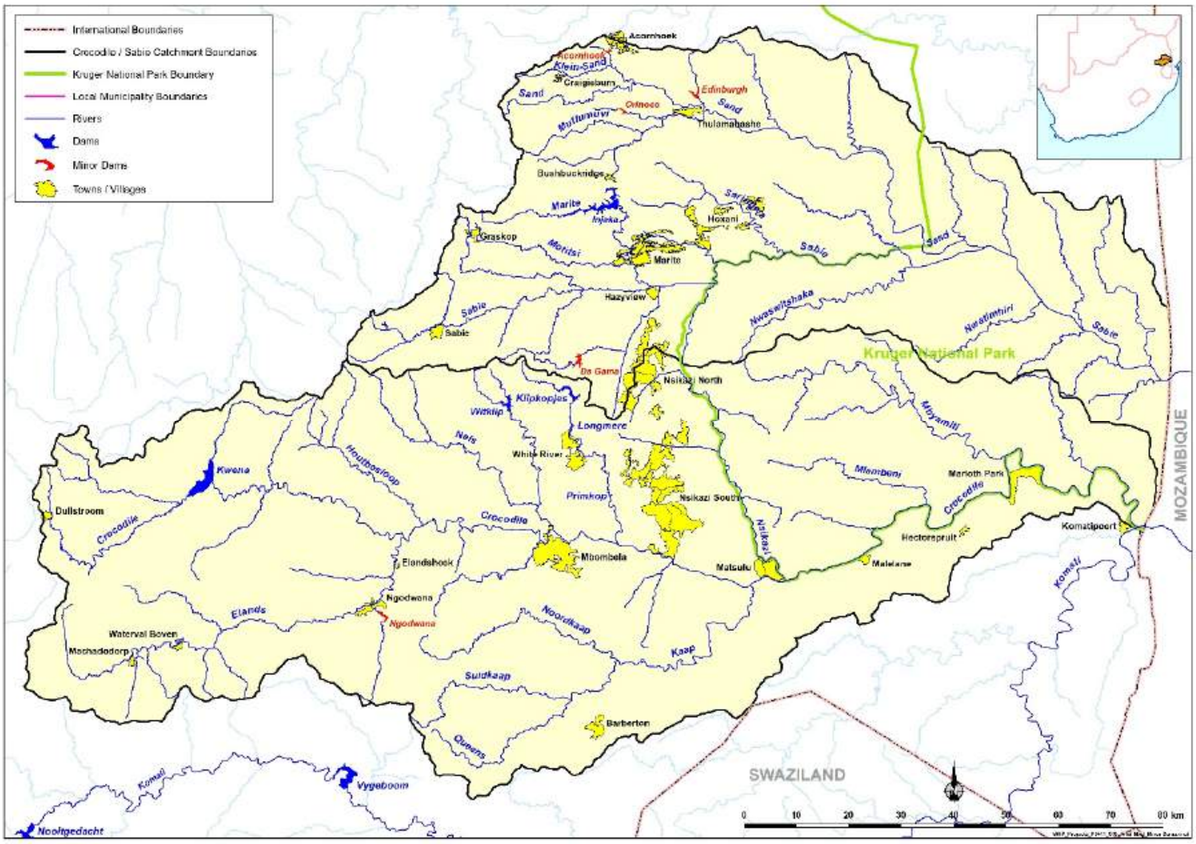


Figure 4-5: Locations of minor dams in the Study Area

4.4 Groundwater Availability

While some localized use of groundwater exists within the catchments, it is generally accepted that groundwater abstraction on a large scale is not a viable option in the Middle Crocodile, City of Mbombela (Nelspruit) and White River, due to high river flow reductions and drawdown during drought conditions (Musa et al., 2015). Some potential exists in the Kaap and Lower Crocodile, however, this is not where the large domestic demands are located.

Borehole data was received from the Bushbuckridge and CoM LM with labels, indicating if the boreholes are operational (in-use) or not- operational, as well as if the boreholes are blocked, dry-dilled, destroyed, unused, already tested or still to be tested. This data is shown as maps in **Figure 4-6** and **Figure 4-7** respectively. There are many boreholes in Bushbuckridge LM which are unused, destroyed, not working and blocked. These boreholes could be rehabilitated to supplement the local water supply infrastructure. In CoM LM there are many boreholes which are non-operational. The cause of the non-operational boreholes should be investigated, and their rehabilitation could assist in supporting the local water supply infrastructure.

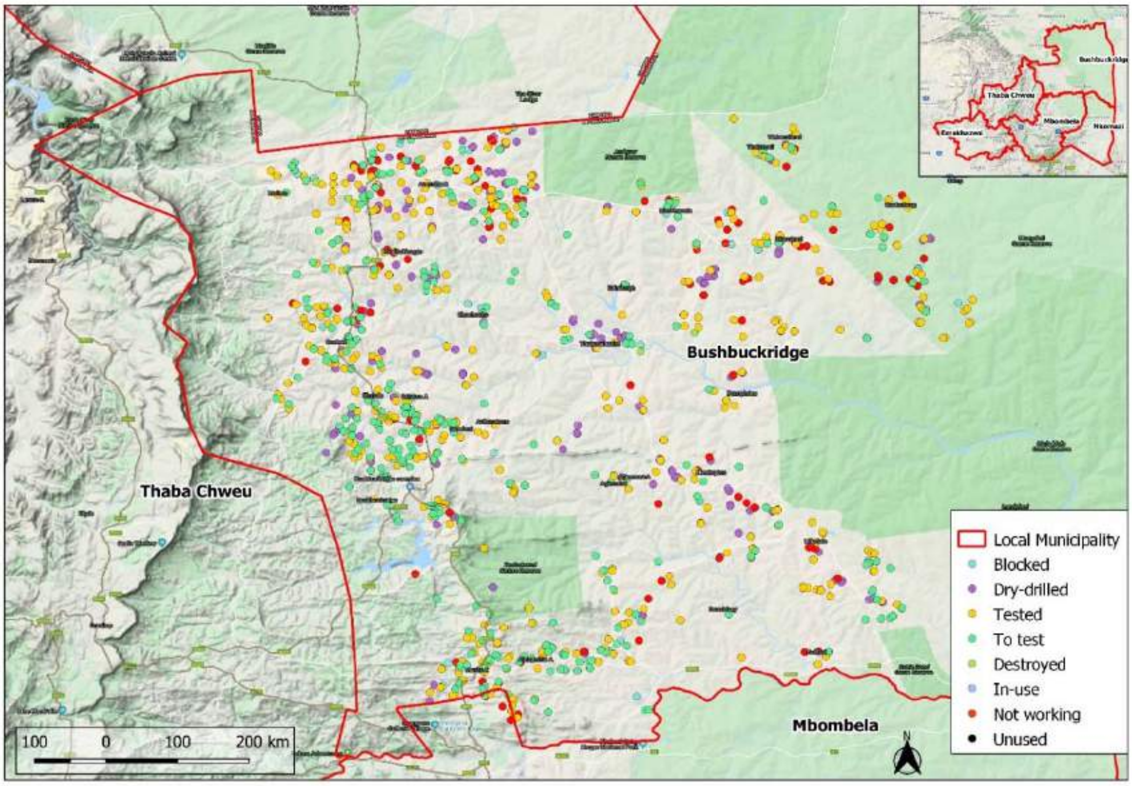


Figure 4-6: Borehole information for Bushbuckridge LM

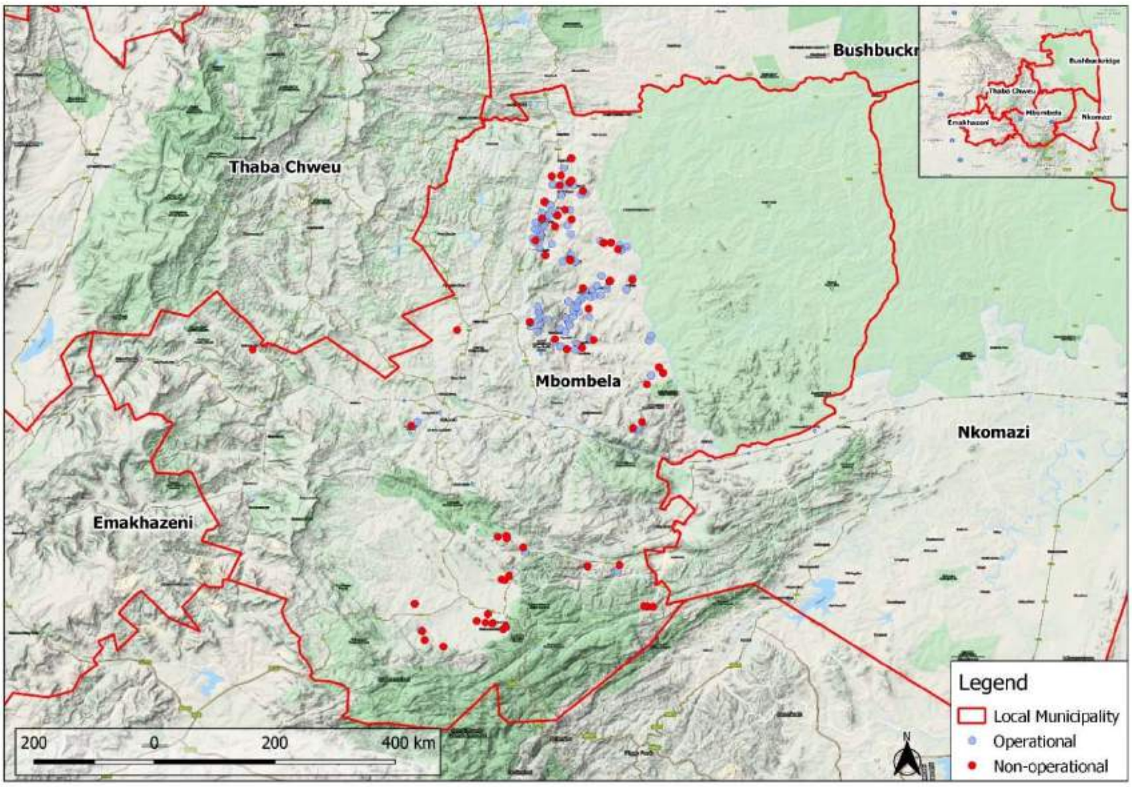


Figure 4-7: Borehole information for Mbombela LM

In addition to the All Towns and IWAAS reports, the five year reliable water and sanitation service delivery implementation plan (SDIP) was reviewed to determine the potential borehole yields at different sites throughout the Local Municipalities. Bushbuckridge LM is shown in **Figure 4-8**, City of Mbombela and former Umjindi in **Figure 4-9**, Thaba Chweu in **Figure 4-10** and Nkomazi in **Figure 4-11**. There are a significant number of borehole sites which do not have any yield attributes, indicated as white dots with black borders. The maps further show dry boreholes as grey dots and boreholes with different yields ranging from very low to very high indicated as red, orange, green and blue dots, respectively. The data is further summarized in small bar charts, however, the green dot (3-5 l/s) on the map legend is indicated as a yellow bar chart. The boreholes which were classified in terms of their yield are either very low or low yielding boreholes, with only a few boreholes indicating promising yields. Groundwater use is indicated with a light blue color.

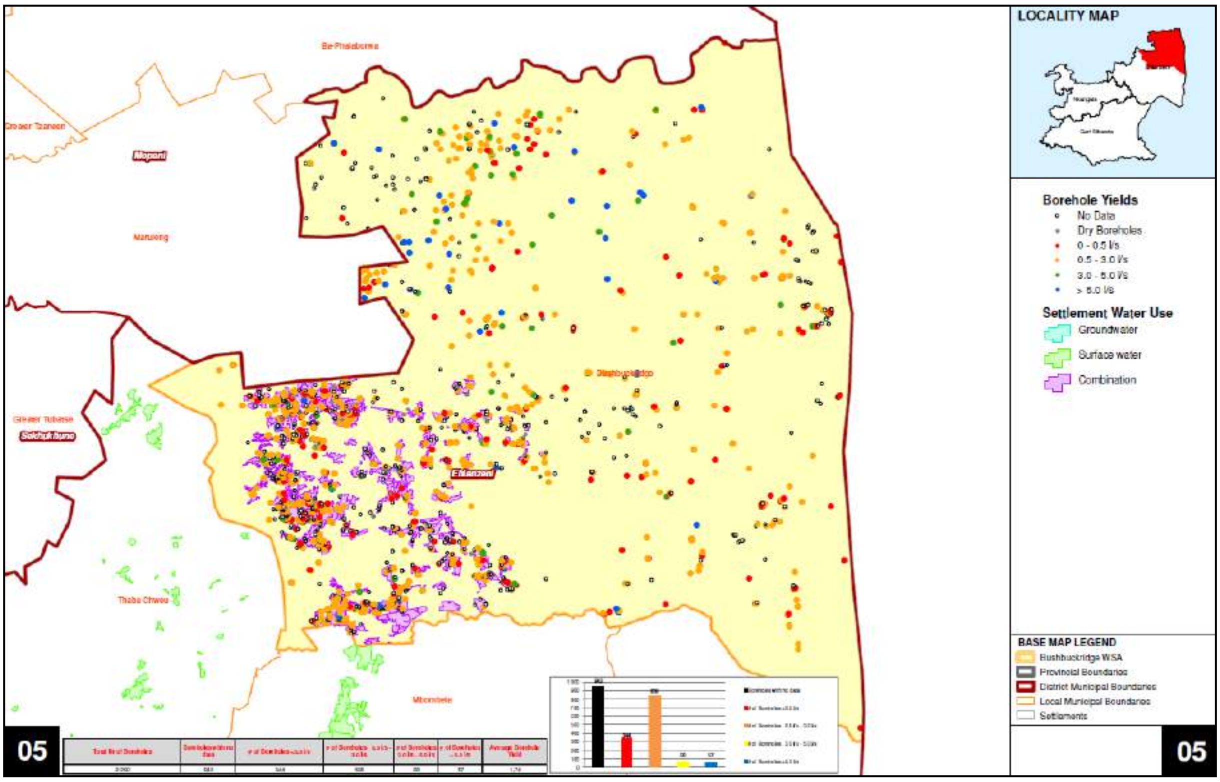


Figure 4-8: Borehole yields for the Bushbuckridge LM (ISDP) (MISA, 2017)

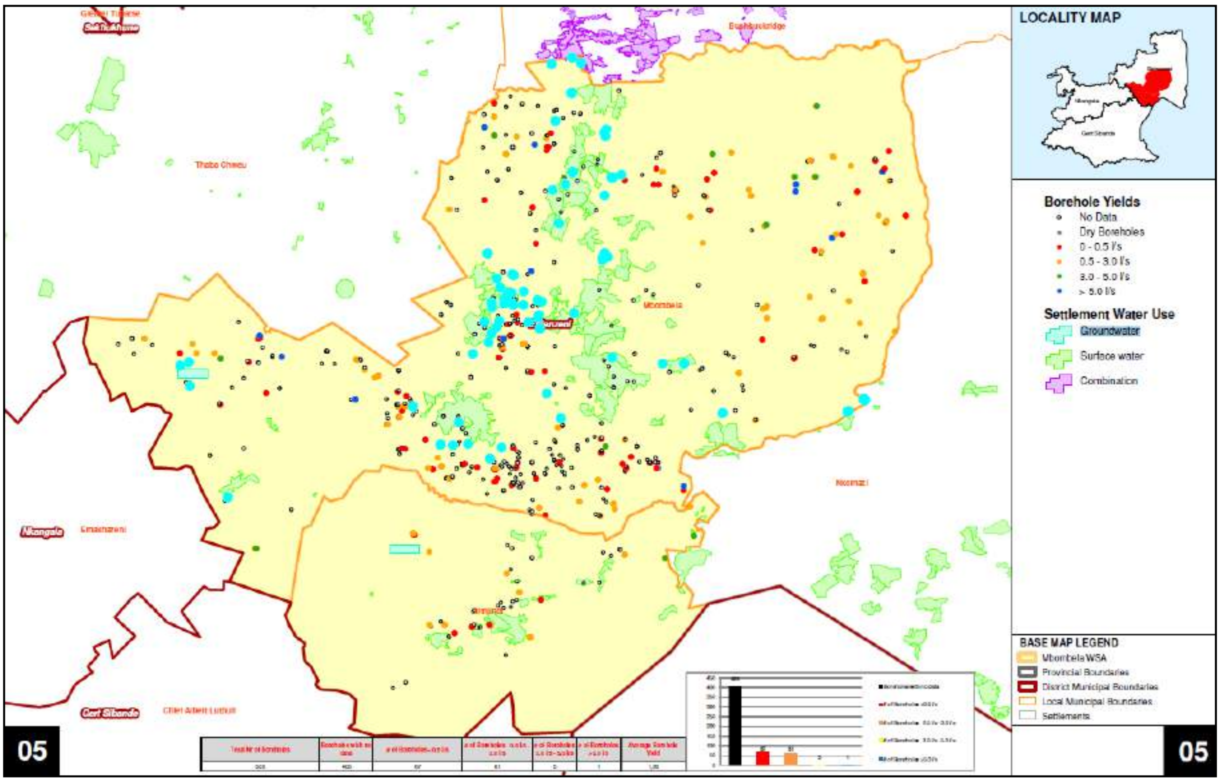


Figure 4-9: Borehole yields for the City of Mbombela LM (ISDP) (MISA, 2016)

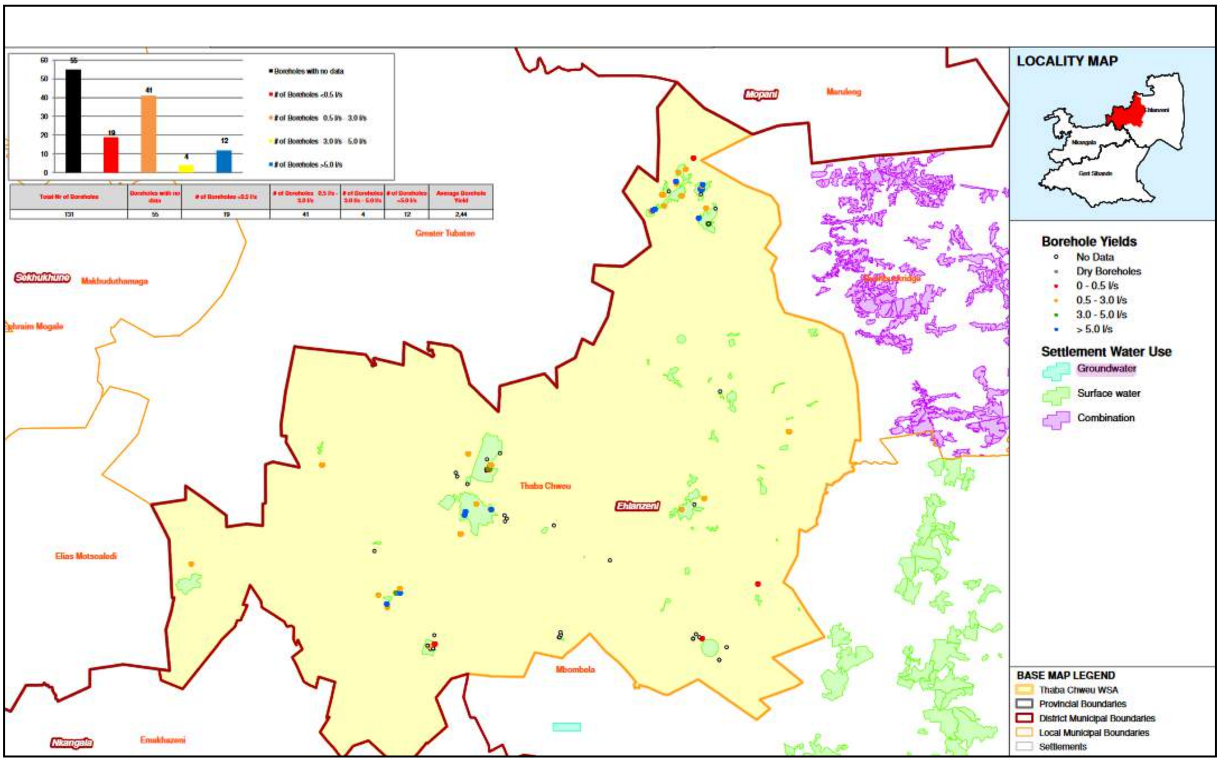


Figure 4-10: Borehole yields for the Thaba Chweu LM (ISDP) (MISA, 2016b)

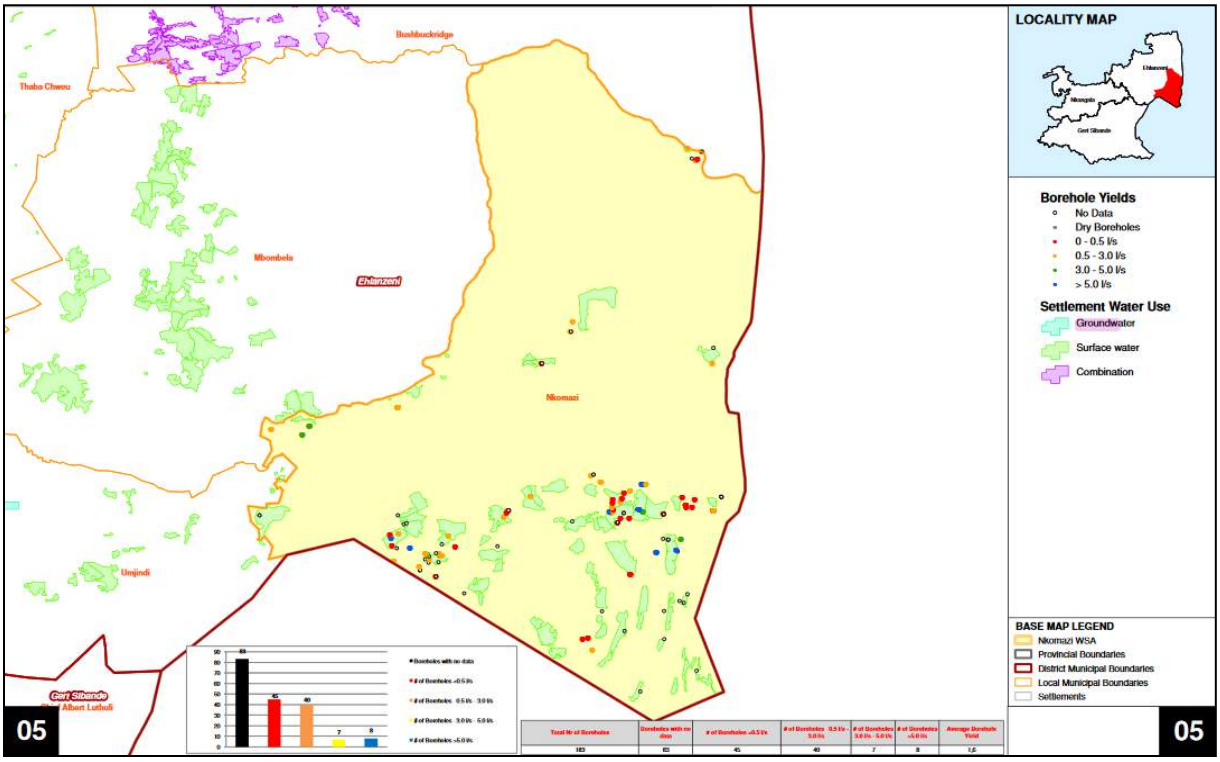


Figure 4-11: Borehole yields for the Nkomazi LM (ISDP) (MISA, 2016c)

5 CURRENT WATER BALANCE STATUS

The Study area covers the Crocodile and Sabie systems and the systems have been subdivided into smaller sub-systems and supply systems for the purpose of preparing water balances. The differentiation considers users that share a common water resource, locality of the storage structures as well as abstraction points. **Figure 5-1** provides an overview of the locations of the various users and resources and how they are arranged (grouped) to compile each water balance. It should be noted that the system is assessed in an integrated manner, and upstream users' water balances are considered when preparing downstream water balances on which they have an impact.

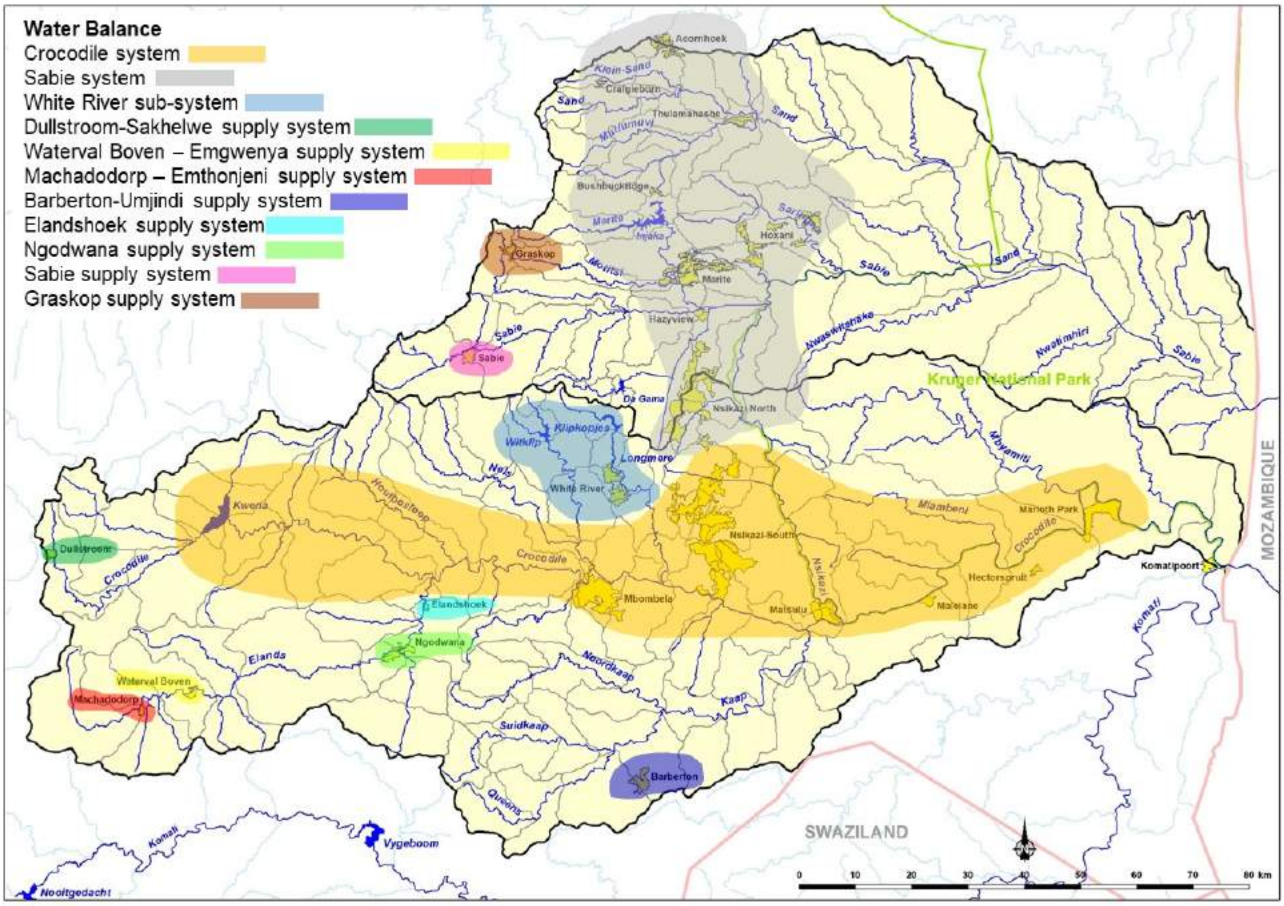


Figure 5-1: Differentiation of system water balances

The water balances take into account the assurance of supply as required by different water use sectors. Water supply to urban/Industrial and rural domestic users is always provided at a higher assurance than water supply to irrigation. For the purpose of the water balances, a 98% assurance was assumed to be applicable to the urban/Industrial and rural domestic sector and a 75% assurance to the irrigation sector. The 98% assurance relates to shortages in supply that will on average be experienced once in 50 years (1 in 50 year) and the 75% assurance for irrigation, to shortages experienced on average once in 4 years (1 in 4 year).

In most irrigation schemes in the study area, the actual supply to irrigation is well below the 75% assurance due to overutilization of the water resources. In this case, the irrigators were able to adapt to the low assurances, in which case the lower assurance of supply to irrigation was accepted for the purpose of the water balance. This approach was followed as there were insufficient water resources to improve the assurance of supply to irrigation in those areas.

The raw data used to create the water balances are presented in **Appendix B**. In addition, a table presenting available information of yields and allocations for various subsystems has been included.

5.1 Crocodile River System

The Crocodile system water balance (**Figure 5.2**) is produced for users along the Crocodile River that have access to releases from Kwena Dam. These users also make use of river runoff entering the Crocodile River from tributaries. The water users included in the Crocodile catchment water balance are as follows:

- City of Mbombela LM (Nelspruit WTW supplying Nelspruit and Rocky Drift, Karino, Nsikazi South, Matsulu),
- Nkomazi LM (Malelane; Marloth Park; Hectorspruit) and
- Crocodile Main Irrigation Board.

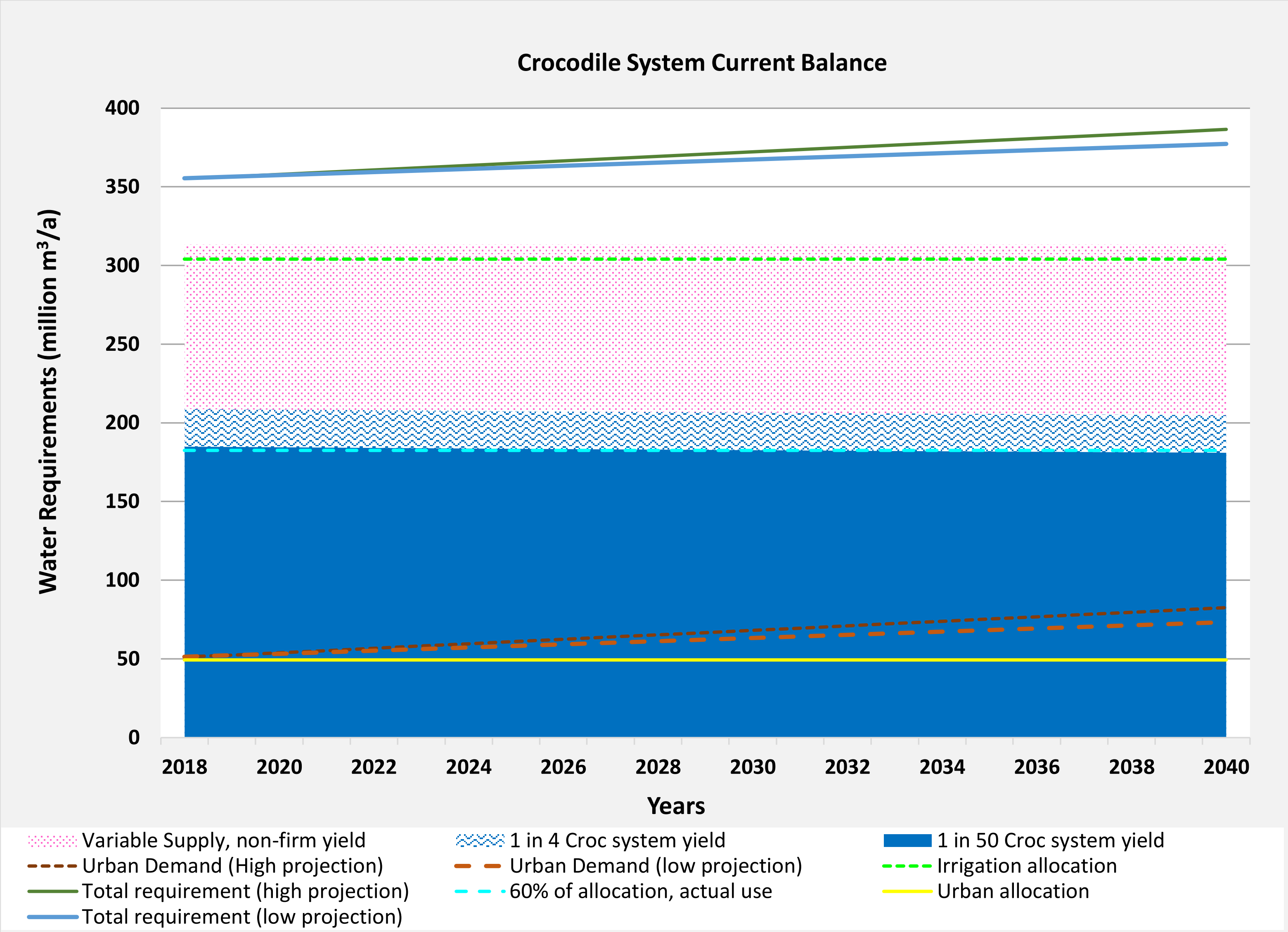


Figure 5-2: Current Water Balance, Crocodile System

Though not prominent from the plot, the yield available decreases slightly over the years due to an increase in water requirements by the upstream domestic users of Elandshoek, Machadodorp, Waterval Boven, Barberton and Dullstroom. The yield decrease equates to approximately 4 million m^3/a by year 2040.

The current water balance plot shows that the 98% assurance yield is sufficient to provide the current water requirements and future growth of the urban sector at the required level of supply. However, it is evident that, when adding the water requirements of the irrigators, the 75% assurance yield is insufficient to provide the system requirements. Modelling results showed that the irrigators were able to get an average supply greater than the 75% assurance yield. This variable supply is a non-firm yield, and can only be achieved if system operation is such that irrigators take river runoff when it is available. Irrigators are currently using approximately 60% of their allocation and this volume is indicated on the graph.

5.2 White River Sub-System

The White River sub-system water balance (**Figure 5-3**) is produced for users within the White River catchment that have access to the Kleinkopje, Longmere and Primkop Dams as well as the Witklip Dam in the Sand catchment. The water users included in the White River sub-system water balance are as follows:

- City of Mbombela LM (White River, Emoyeni, Tekwane) and
- Irrigation Boards (Sand River, Avalon and Gradely Farms, White River IB, Ranch Karino and Curlews, Manchester, Good Hope)

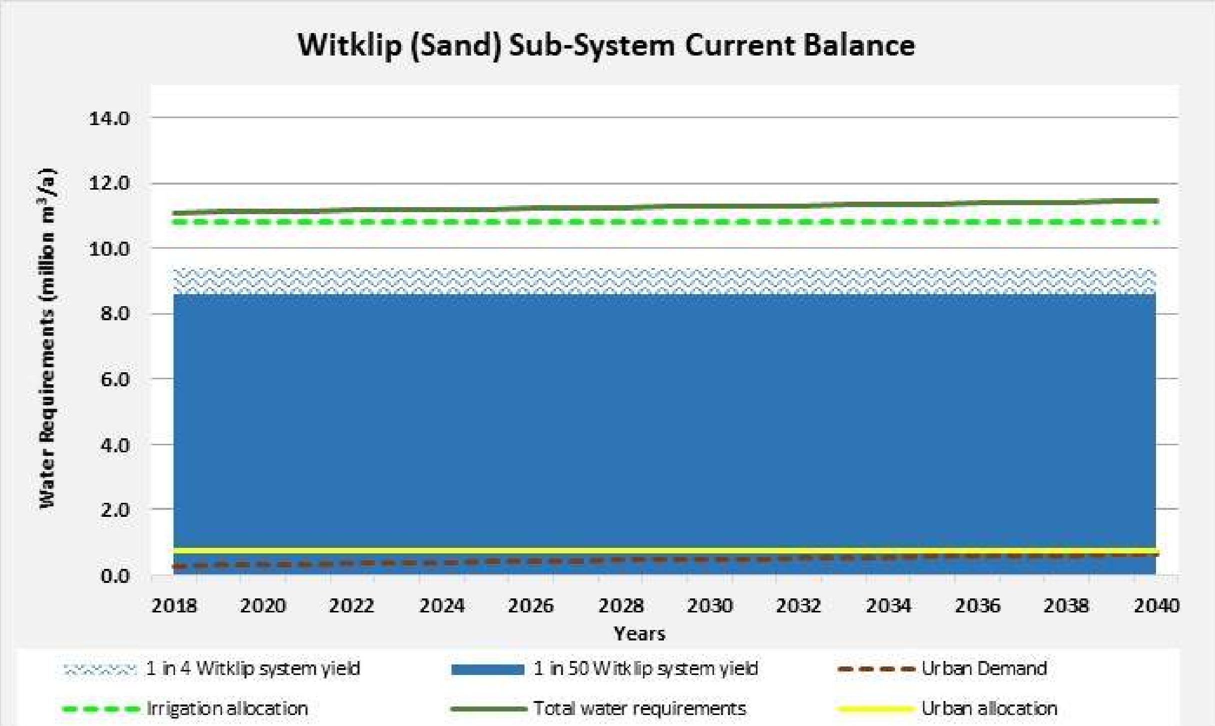


Figure 5-3: Current Water Balance, Witklip Dam / Sand River Sub-System

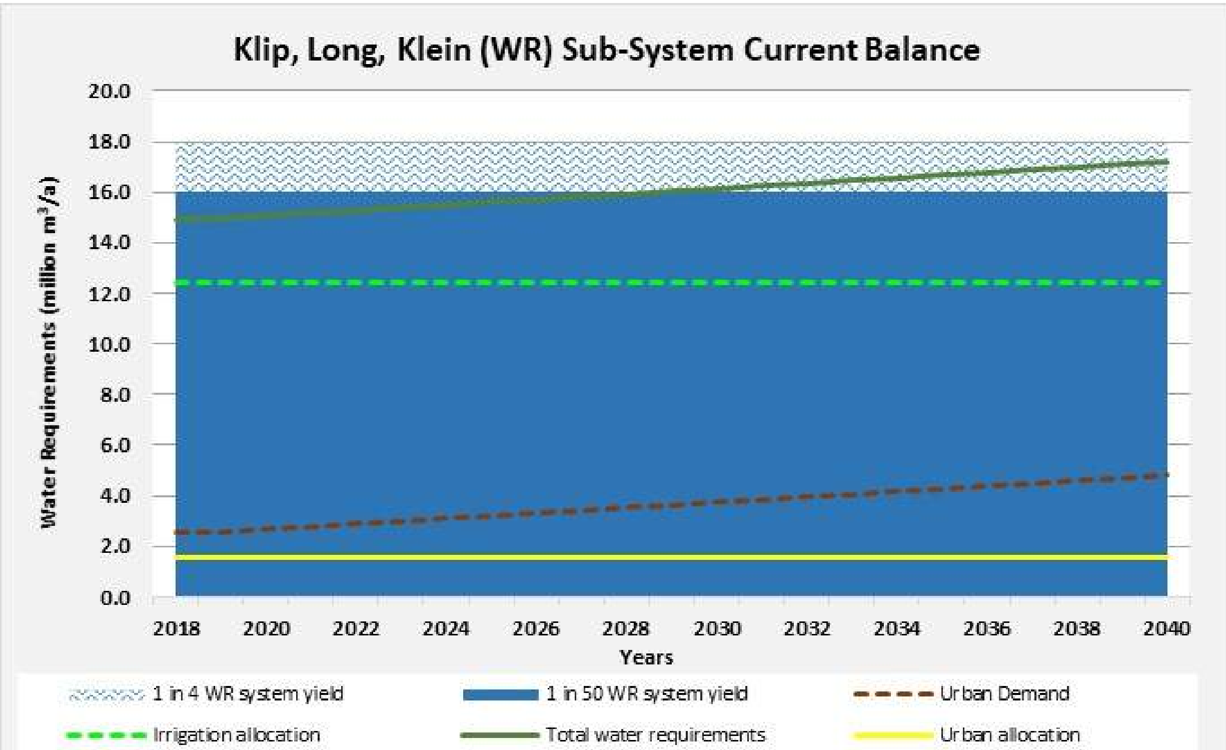


Figure 5-4: Current Water Balance, White River Sub-System

The water balance produced using the current water resources and future water requirement growth indicates that the White River sub-system is in balance whereas the Witklip Dam is in a deficit.

5.3 Sabie-Sand System

The Sabie system water balance (**Figure 5-5**) is produced for users within the Sabie catchment that have access to the Inyaka Dam. The water users included in the Sabie system water balance are as follows:

- City of Mbombela LM (Nsikazi North, Hazyview),
- Bushbuckridge LM (Hoxani, Marite, Acornhoek and Thulamahashe) and
- Irrigators (Inyaka, Waterval, Madras State Land, Calcutta, Cork, Belfast and Lisbon).

As mentioned is **Section 2.3**, not all the irrigation allocations are currently being utilised, and for the purpose of the water balance, a time frame of seven years (till 2025) is given to allow for unused irrigation to be taken up once again.

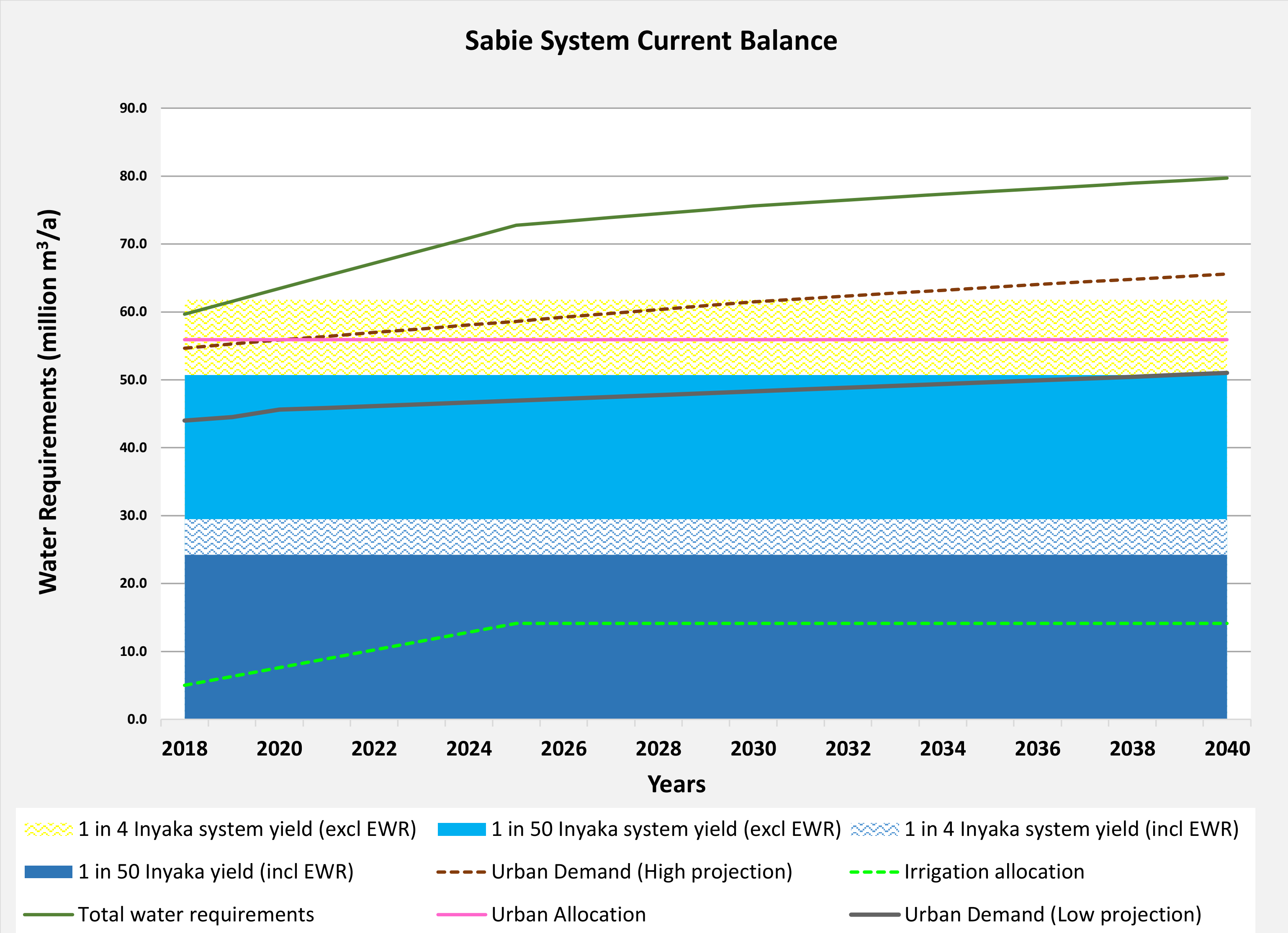


Figure 5-5: Current Water Balance, Sabie system

The existing water resources have been presented on the plot to show the balance with and without EWR releases. Under the condition of no EWR releases, the urban water requirements already exceed the available resources at a 98% assurance of supply level. When the irrigation allocations are added to the urban requirements, the resources are insufficient for both the requirements with and without EWR releases options. The graph shows that the existing balance is in severe deficit if the EWR releases are made prior to an intervention option.

5.4 Other Smaller Towns

5.4.1 City of Mbombela LM

Umjindi-Barberton Supply System

The Umjindi-Barberton urban area obtains its water from two sources, namely, the Lomati Dam in the neighbouring Komati catchment via a transfer to Rimers Creek WTW and the river abstraction from the Queens river in the Kaap catchment taking water to the Suid Kaap WTW.

The Lomati dam has a yield of 4.8 million m^3/annum. The typical abstraction from the dam for Umjindi-Barberton is 4 million m^3/annum. Previous reports (DWAF, 2008) indicate that significant losses occur with the transfer. **Figure 5-6** provides the current water balance for the scheme.

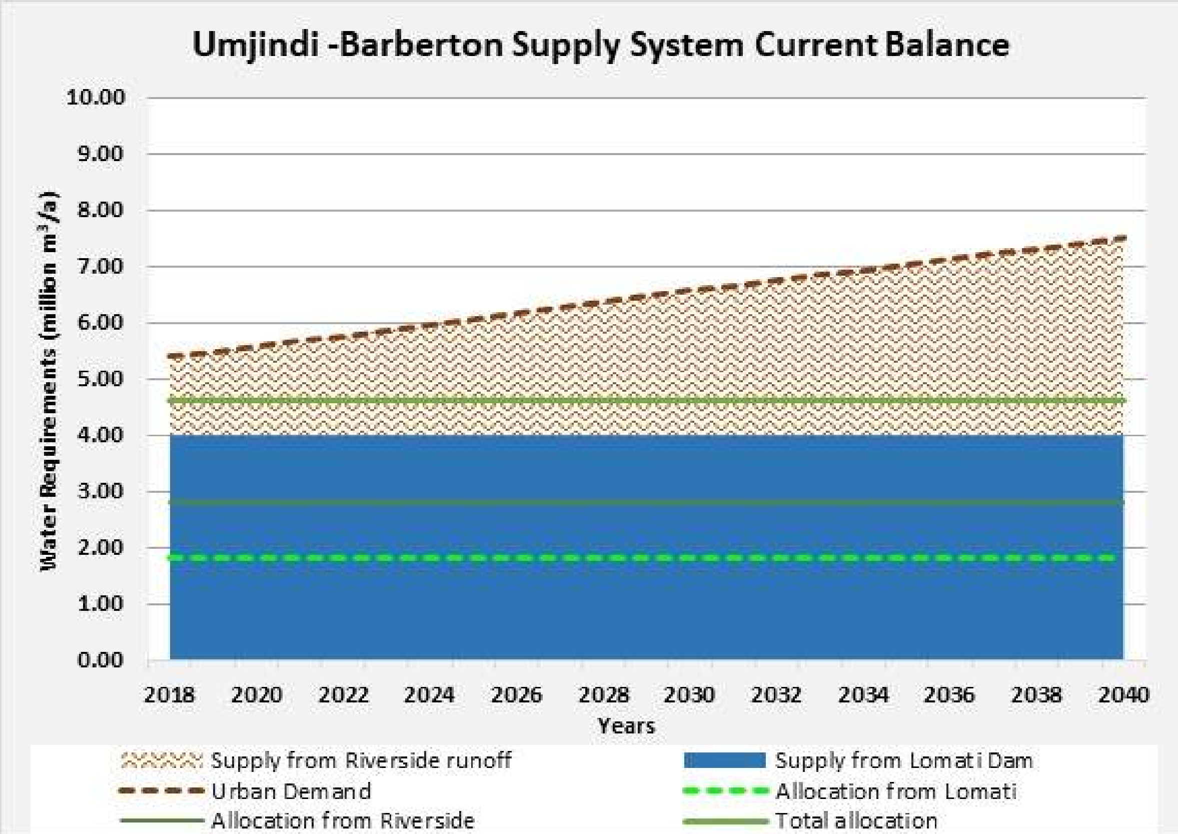


Figure 5-6: Current Water Balance, Umjindi-Barberton supply system

The water resources simulation showed that the run of river abstraction in combination with the Lomati Dam transfer is sufficient to supply the Barberton area urban demand for the full projection period. However, information from the operators indicates that Barberton has constraints on the river abstraction, mostly in the months of September and October when environmental flows are required to remain in the river. In addition, the existing allocations to the CoM are below the current requirement as well as the growth in future requirements. The allocation from the Lomati Dam is less than half of the volume of water being used from the Dam.

Elandshoek

Elandshoek receives its water from a mountain stream which gravity feeds into the WTW. As indicated in the water balance presented in **Figure 5-7**, the water resources simulation indicated that the resource is sufficient to supply the current and future growth in requirements.

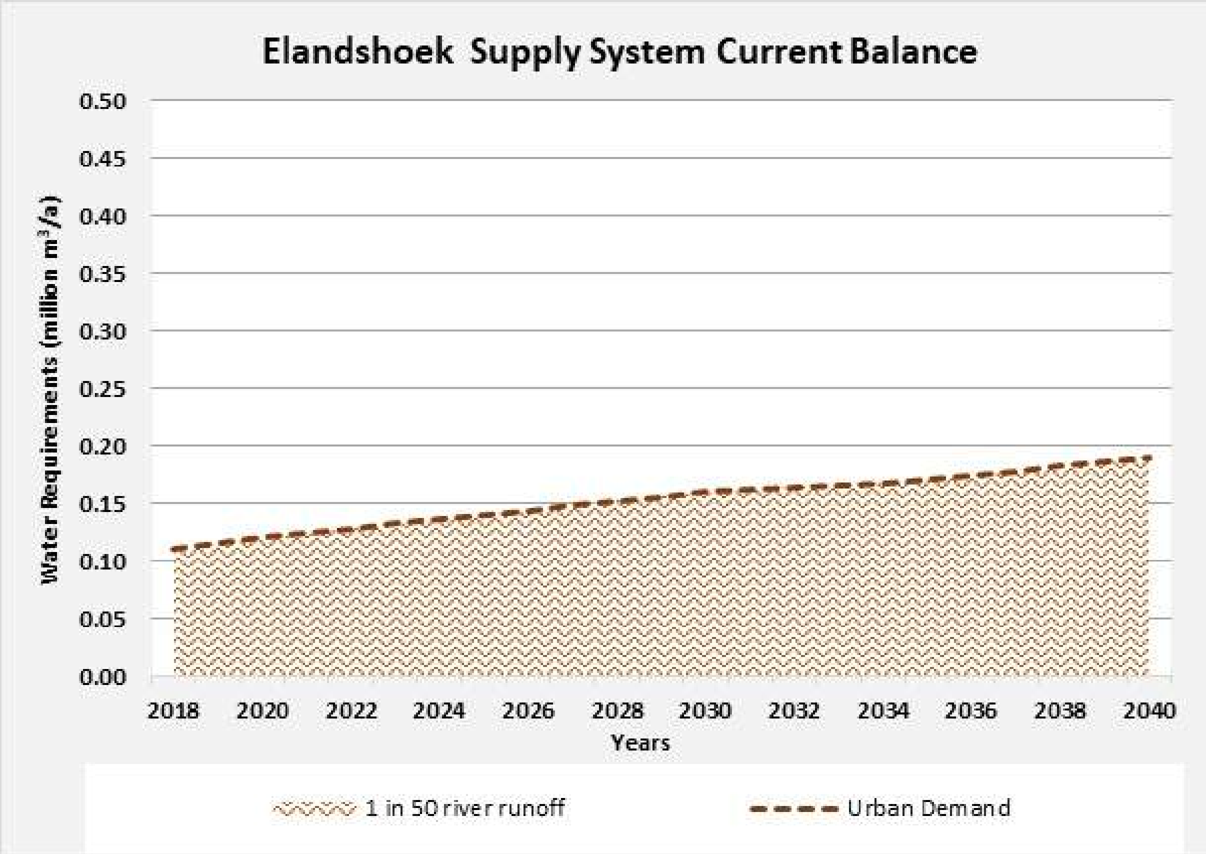


Figure 5-7: Current Water Balance, Elandshoek Supply System

Ngodwana

The domestic area of Ngodwana receives water from the Ngodwana dam and shares this dam with the Sappi paper mill. Both these users are included in the Ngodwana Dam balance which is presented in **Figure 5-8**. The balance indicates surplus water available in Ngodwana Dam for the full projection period.

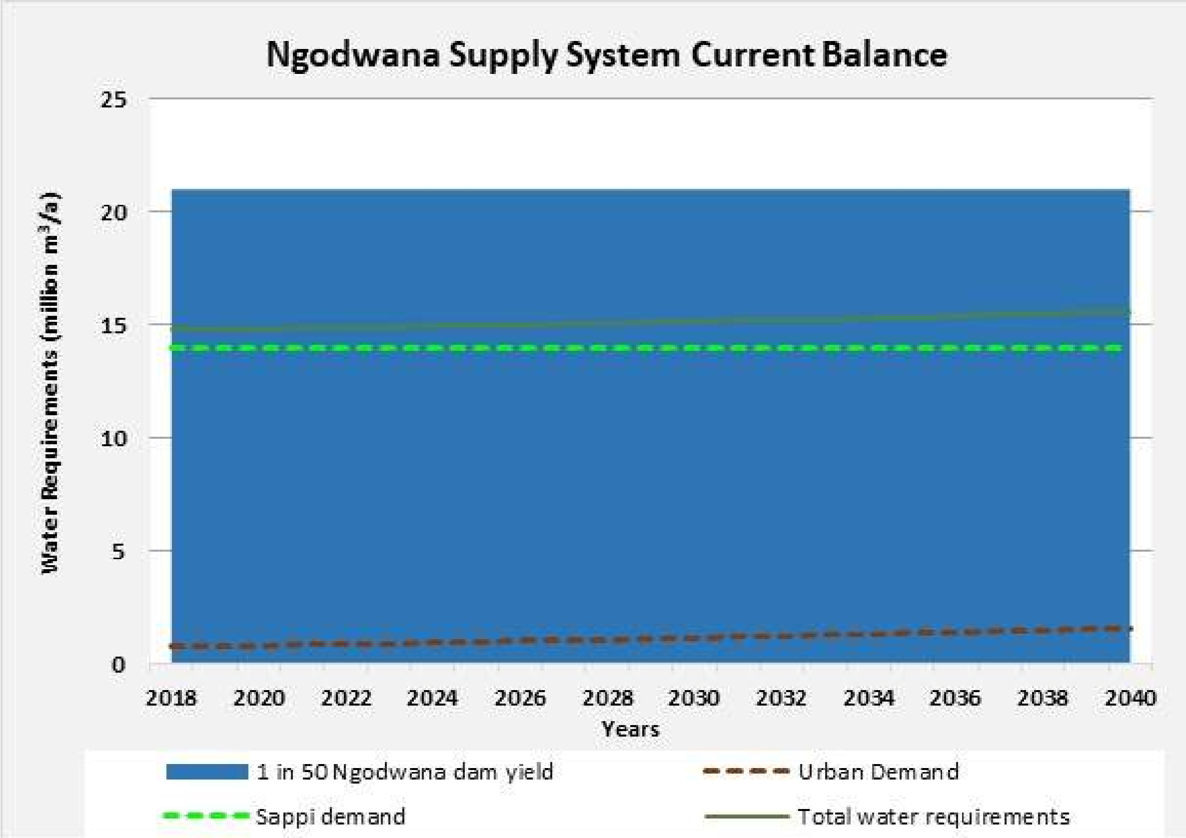


Figure 5-8: Current Water Balance, Ngodwana Supply System

5.4.2 Emakhazeni LM

Dullstroom & Sakhelwe Supply System

The domestic areas of Dullstroom and Sakhelwe have access to water resources from the Dorps, Jansen and Suikerbosch Dams. **Figure 5-9** presents the water balance using the current resources compared to the future water requirements. The balance indicates that the existing resources will no longer be able to supply the growing demand by the year 2026.

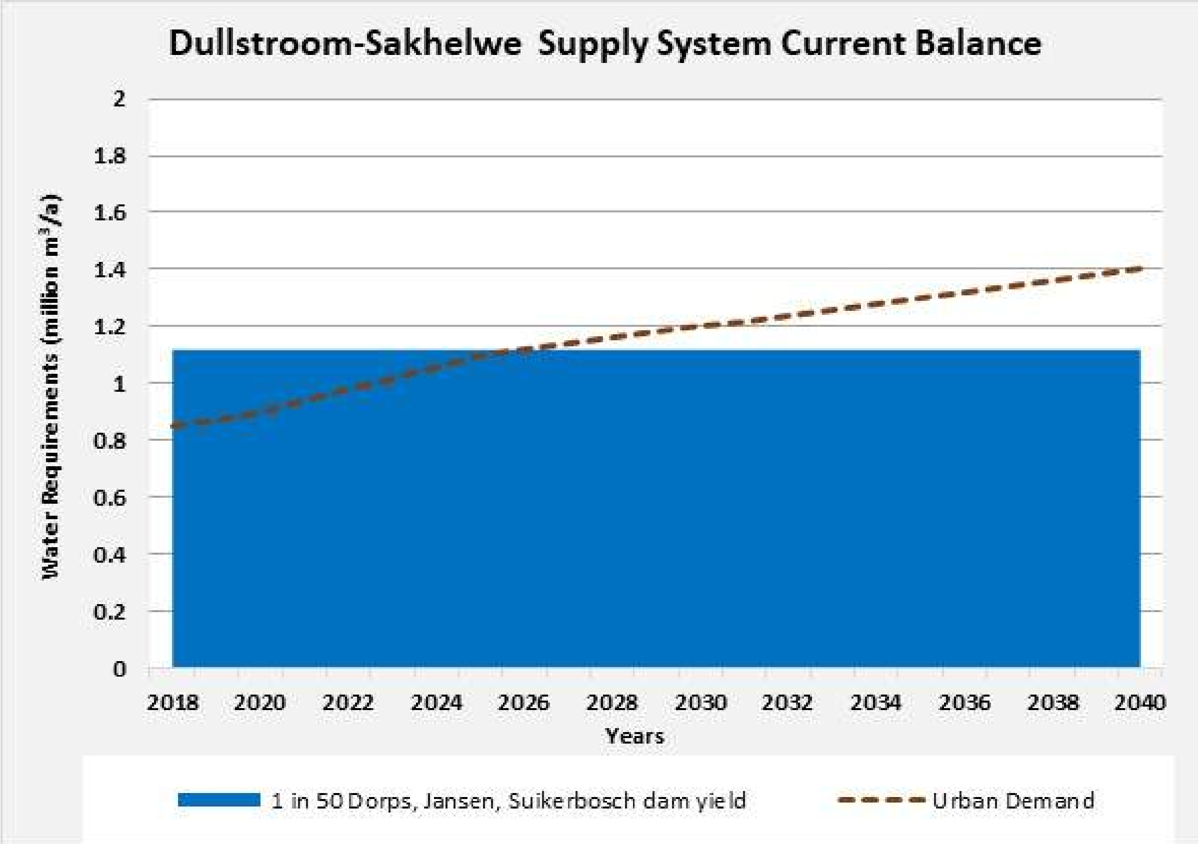


Figure 5-9: Current Water Balance, Dullstroom-Sakhelwe Supply System

Waterval Boven – Emgwenya & Machadodorp – Emthonjeni Supply Systems

Both the Waterval Boven-Emgwenya and the Machadodorp – Emthonjeni domestic areas have the Elands river as their water resource. No storage exists for the abstractions. **Figure 5-10** and **Figure 5-11** present the water balances, and in both cases indicate that the resource is sufficient to supply the requirements for the full projection period.

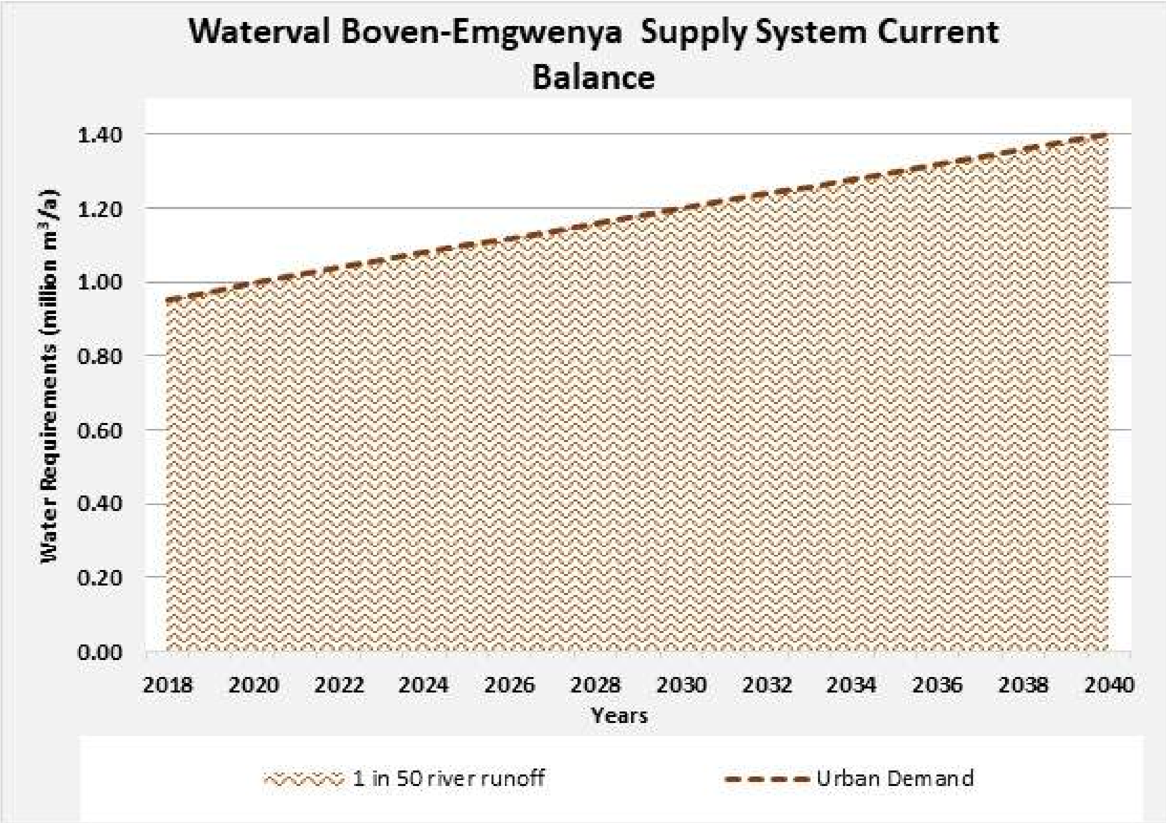


Figure 5-10: Current Water Balance: Waterval Boven-Emgwenya Supply System

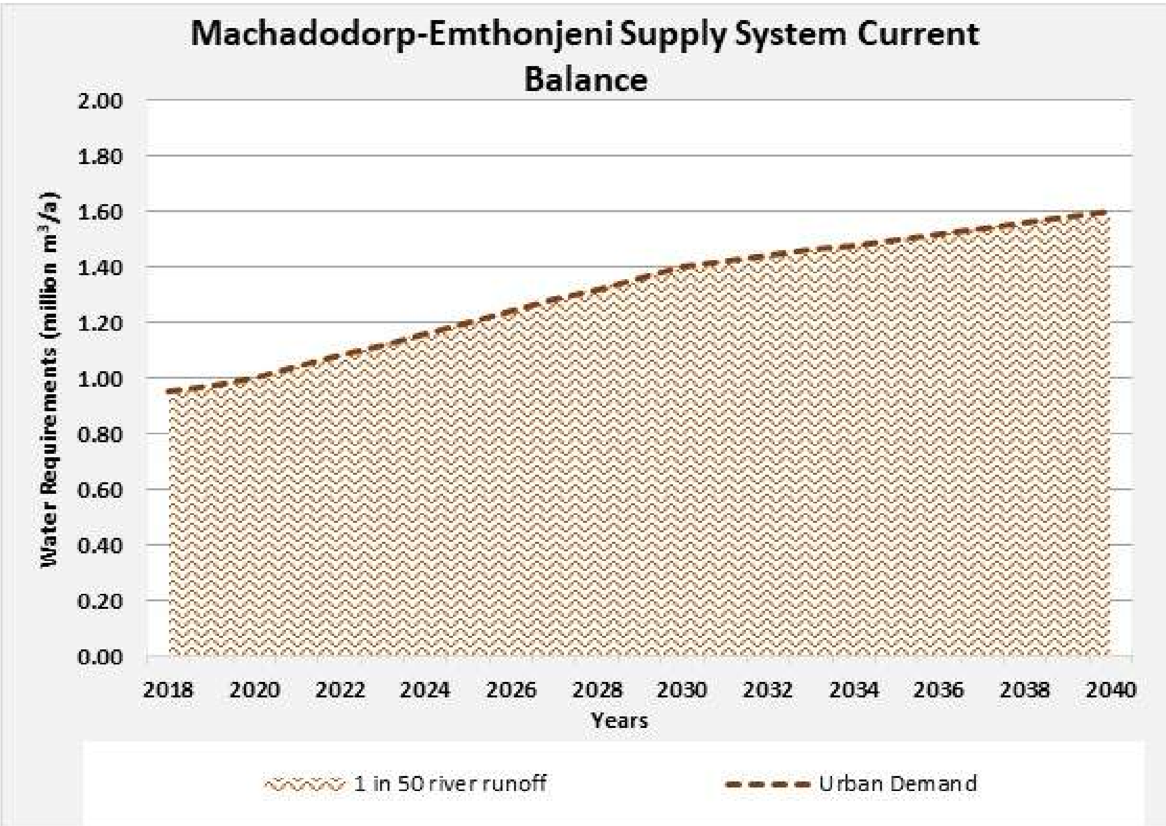


Figure 5-11: Current Water Balance: Machadodorp-Emthonjeni Supply System

5.4.3 Thaba Chewu

Sabie Supply System

The Sabie urban area makes use of groundwater by pumping from an old mineshaft. The resource is estimated to yield 2.05 million m^3/annum. The current water balance presented in **Figure 5-12** indicates a surplus in water availability for the full projection period.

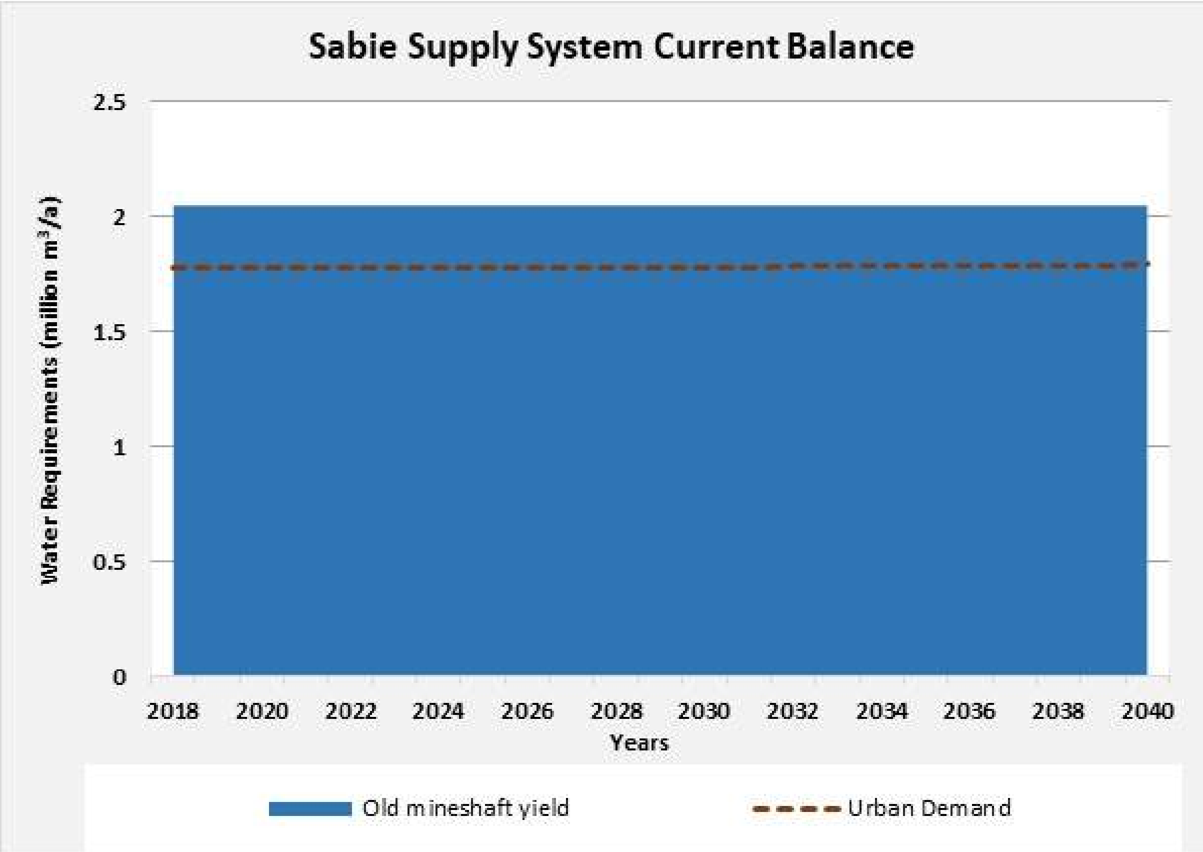


Figure 5-12: Current Water Balance: Sabie Supply System

Graskop Supply System

The Graskop urban area makes use of groundwater by abstracting from a well, constructed around a fountain. The resource is estimated to yield 1.31 million m^3/annum. The current water balance presented in **Figure 5-13** indicates a surplus in water availability for the full projection period.

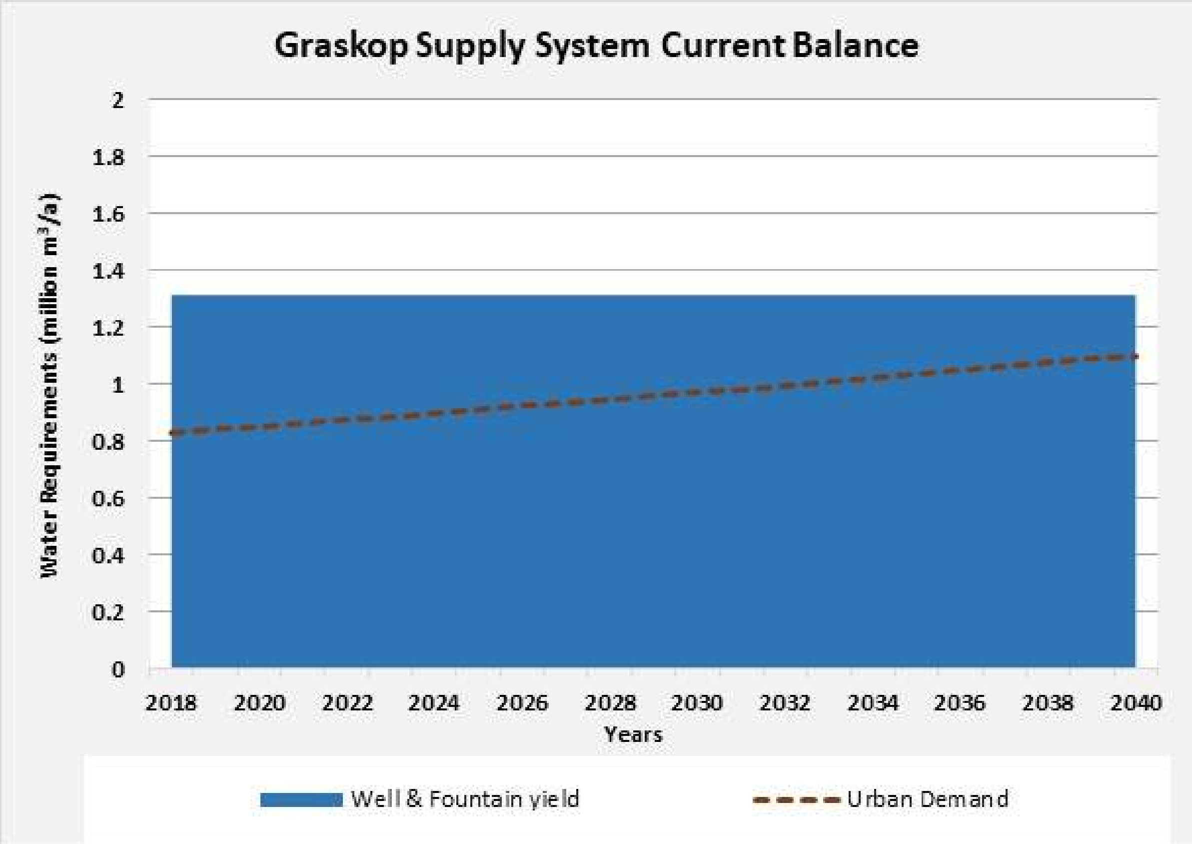


Figure 5-13: Current Water Balance: Graskop Supply System

6 POSSIBLE INTERVENTION OPTIONS

Intervention options comprise the implementation of various combinations of reconciliation options over time and can be divided into two main categories, namely:

- Reconciliation options used to reduce the water requirements; and
- Reconciliation options that will increase the yield available from the existing water resources.

This section summarises all the possible intervention options that exist for the study area. Options as defined in the Reconciliation Strategy (DWA, 2014) have been included, and the level of their ongoing validity for this Strategy update have been discussed. In addition, new intervention options that have been determined as part of this update are presented.

6.1 Reconciliation Options that will reduce Water Use

6.1.1 WCWDM

Reducing water demand by introducing WCWDM measures is a necessary intervention for all water reconciliations. The previous Mbombela Reconciliation Strategy (DWA, 2014), predicted a total reduction of 6 million m^3/annum could be made to the growing demand between the years 2014 to 2019. This was an estimated 11% reduction on the total demand of 53 million m^3. The Sabie River Reconciliation Strategy (DWS, 2016) estimated that 6 million m^3 could be saved on the demand of 45 million m^3, equating to 13%, over the years 2017 to 2020.

On the surface, it appears that WCWDM implementation did not progress at the projected rate over the past five years. However, feedback during Stakeholder engagement meetings on intervention implementation progress has confirmed that the Mbombela LM has started with formal WCWDM implementation from 2019. The Bushbuckridge LM are to appoint a service provider shortly to assist with WCWDM implementation after which savings should start to be achieved.

Notwithstanding the slow progress of WCWDM initiatives since the development of the strategies in 2014 and 2016, this intervention option should still form part of the updated intervention options. As discussed in **Section 3**, a detailed WCWDM assessment was undertaken for the Study area resulting in realistic and optimistic targets for reducing water wastage. The outcome of the assessment is that the CoM LM could potentially save 10% (6.1 million m^3) of the requirements by implementing WCWDM and the Bushbuckridge LM could save 15% (7 million m^3).

6.1.2 Reduce canal losses

Canals transport water for urban requirements in a number of cases throughout the Study area summarized as follows:

- An unlined canal transports raw water from the Crocodile River to the Nelspruit WTW for treatment;
- Hazyview WTW can be supplied with raw water from the Sabie Irrigation Board canal;
- A concrete lined canal takes water from Longmere dam to the White River urban area;
- White River town also has an allocation from Witklip Dam which is fed by a canal.
- A canal provides an inter-catchment transfer between the Sand catchment upstream of Witklip Dam and the White River catchment upstream of Klipkopje Dam.

There is scope for saving on water losses by transporting the water in a more efficient manner. In addition to savings, other operational and management aspects can be improved on if the Municipality owns and operates the infrastructure required for water transfers.

Possible solutions that require further investigation are:

- A large diameter pipe directly from Longmere Dam to White River which will immediately gain 15% (0.19 million m^3/annum) more abstraction rights as this is what is being deducted for conveyance losses.
- A new direct abstraction facility for the Nelspruit WTW. A comparative pre-feasibility study will give guidance if this will save water.
- Only making use of direct abstraction for Hazyview from the Sabie River rather than the support from the Sabie IB canal as the canal is associated with many operational management issues.

In theory, it is likely that any canal losses from the Nelspruit WTW canal return to the river as a result of the canal's close proximity to the river. The losses are therefore used by other users downstream. Further pre-feasibility investigations relating to the canal losses and potential savings should be undertaken in the White River area, after which a decision can be made whether or not reducing these losses will add to the water balance and if it is cost effective.

6.1.3 Remove alien vegetation

As with WCWDM, removing alien vegetation is a standard intervention measure for saving water in all Reconciliation Strategies, and is very important in severely water stressed catchments.

The Mbombela Reconciliation Strategy (DWA, 2014) assumed that removal of invasive alien pants (IAPs) upstream of the Nelspruit diversion works on the Crocodile River would make water available that could be allocated to CoMLM. It was estimated that up to 8 million m^3/annum could be made available if the IAPs upstream of Kwena Dam in the Crocodile catchment, were removed. However, the strategy further stated that, since it is not realistic or cost effective to remove all IAPs, it is suggested that a more realistic estimate of increased yield would be half this amount, and was estimated as 4 million m^3/annum. The Sabie River Reconciliation Strategy (DWS, 2016) did not consider this intervention option.

This intervention implementation appears to have been slow over the years. However, the World Wildlife Fund – South Africa through the co-ordination of SANParks and the Kruger2Canyons Biosphere (DWS, 2020b) have now started with initiatives to undertake IAP removal in the Sabie catchment. In water stressed catchments such as the Crocodile and the Sabie this intervention is necessary. It is an intervention that requires continuous attention. A review of the locations of IAPs as presented in **Figure 2-5** indicates the intervention would be beneficial in the Sabie catchment due to the locations upstream of Inyaka dam, and it estimated that approximately 3 million m^3/annum could be added to the yield of the dam by removing IAPs. The denser distribution of IAPs in the Crocodile catchment are located around tributary and run of river resources.

6.1.4 Water use entitlement exchange from irrigation to urban

In the previous Mbombela Reconciliation Strategy (DWA, 2014) as well as some of the smaller town strategies (Machadodorp, WatervalBoven, Dullstroom), the conversion of water entitlements from irrigation to primary use featured as a prominent intervention. The Sabie Reconciliation Strategy (DWS, 2016) did not include this as an intervention option.

The Mbombela Strategy (DWA, 2014) provided water balances using allocations (entitlements) as the water resource availability. Adding additional allocations (from the irrigation sector) therefore provided a larger resource to the water balance. The Mbombela Strategy (DWA, 2014) anticipated that an additional 5.4 million m^3/annum could be added to the total “resource” (allocation) of 46.5 million m^3/annum as a result of the license conversions. In recent years, CoMLM have received new licenses totaling, 2.04 million m^3/a, however, it is not clear if these are a result of entitlement conversions. Some of the property names indicate they are.

Since the completion of the Strategy (2014) a decision has been made by DWS regarding the process for license conversions. The approach to be followed is for the existing user to surrender their allocation to the Minister (DWS) and for the Municipality to then apply to the DWS to obtain the additional water entitlement (DWS, 2014b). The previous approach to ***conversions*** used the NWA Section 25 as a guide, and allowed for users to negotiate amongst themselves. However, these applications have been met with resistance from DWS and Municipalities have been instructed to follow the new approach, by first surrendering to the State and then the State reallocating to the Municipality, so that there is no water trading taking place.

The CoMLM currently has one application in the Mbombela urban area for a license conversion pending on the farm Orchards for a volume of 0.448 million m^3/annum. The farm has surrendered the allocation to DWS and the Municipality has applied for this volume. Another farm owned by Halls (Riverside Extensions 31-36) has also indicated their intention to surrender their irrigation water rights in the future which would amount to approximately 0.58 million m^3/annum when converted to urban water use. The time frame of this is approximately 5 years.

In the Umjindi-Barberton area, the CoMLM have attempted to gain water allocations from the irrigation sector by purchasing farms and then obtaining the water allocations that belong to the farms. This amounts to a volume of 1.47 million m^3/annum. However, subsequent to purchasing the farms, the CoMLM attempted to convert the water allocations that were obtained with the farms from irrigation to primary use. This application was denied, and they were informed that this conversion cannot be carried out.

6.1.5 Eliminating unlawful uses

The Mbombela Reconciliation Strategy (DWA, 2014) indicated the following with regards to eliminating unlawful uses:

"*The first step in developing a Water Allocation Reform (WAR) Plan for the WMA is through the validation and verification of water use. The IUCMA therefore initiated a study named 'Finalise the data collection and lawfulness assessment in support of the verification of existing lawful use within the Inkomati Water Management Area'. The three focus water uses for this study in terms of the NWA are Section 21(a) Taking water from a water resource, Section 21(b) Storage of water and Section 21(d) Engaging in a stream flow reduction activity.*

The aims of the study will be to identify and stop unlawful water uses, and also to identify and quantify lawful water uses. Since, pending the study, the extent of unlawful water use is not yet known, this particular intervention has not yet been taken into account in the reconciliation.

It can be factored in when the Continuation Study is undertaken if a timeous reliable estimate of the unlawful water use upstream of Nelspruit is made. However, this strategy is not expected to make much water available."

Information received as part of this Strategy update indicates that the Validation and Verification process is still underway and has yet to be finalised. It is estimated that the process is only 60% complete at the time of writing this report. In order to quantify the impact that this intervention will have on the water balance, it is essential that the verification (determination of lawful) part of the Validation and Verification study be concluded. This can be factored into the water balance once it is known.

6.1.6 Compulsory licensing

The NWA allows the Minister of Water and Sanitation to require the licensing of all water use, implying that nearly all existing users would be compelled to apply for new licenses. The Minister considers all the license applications, taking cognisance of the water availability, and may license and, where required, reduce the existing uses to ensure that International Obligations, the Reserve (Basic Human Needs (BHN) and EWR) and water for strategic use are met within the water balance. The Minister may also reallocate the available water in a fair and equitable manner.

The procedure for Compulsory Licensing is described in Sections 43 to 48 of the NWA 1998 (Act No. 36 of 1998). The process is started when the responsible authority issues a notice in the Government Gazette that water users must apply for licenses within a certain period of time.

The IUCMA indicated that their plan is to undertake Compulsory Licensing after the completion of the Validation and Verification process and the development of a Water Allocation Plan. At best, the process is envisaged to start in 3-4 years' time.

6.1.7 Water Reuse

Return flows from the main urban centre of the CoMLM are incorporated into the water balance and use is made thereof by the downstream users which are mainly irrigators. If the CoMLM decides to reuse this water, the catchment balance will be affected as it will mean it is no longer available for the downstream users. This would mean that the downstream users will abstract more water from Kwena Dam, and in affect, no water savings are achieved from a water balance perspective. There may, however, be other benefits for reuse such as reducing the pollution load to the river system, water treatment cost savings to replace supply to industrial users that are currently receiving potable water and can tolerate a lower quality water feed.

On the Sabie-Sand catchment, however, there is scope for adding to the water balance if reuse is considered. Currently, the schemes in the Sabie and Sand River catchment do not have formal wastewater treatment works since the wastewater is managed through oxidation ponds. The water stays in the ponds after treatment, evaporates and only limited volumes are returned to the river system for potential downstream use.

The location of the oxidation ponds, particularly in the Sand catchment, indicates that downstream users, including the EWR, could benefit from return flows of treated effluent into the system. This would only be applicable, however, after the inclusion of a new dam, whereby dam releases for the EWR could be reduced due to the treated and discharged wastewater. The feasibility of this requires further investigation.

6.2 Reconciliation Options that will increase Water Supply

6.2.1 Interim Restriction Rule to Benefit Priority (Primary) Users

One of the reasons for requiring a catchment to undergo Compulsory Licensing is as a result of that catchment being in a water deficit when comparing the available water resources with the water allocations. Compulsory licensing is then undertaken to reduce the allocations (permanently) and in so doing obtain a water balance.

A way to manage the current shortfall over the short term and potentially avoid the permanent reduction of allocations (referred to as curtailment), is to implement adaptive restriction rules using variable short-term availability based on water in storage and catchment state, while allowing growth for primary water users. This can be done as an interim measure during the time period before a major intervention becomes operational to augment the deficit.

The approach is to apply a strict restriction rule to the lower priority users, in this case the irrigators. The rule would need to be revisited each year as the growth in primary use occurs in order to allow for the required assurance of supply to the primary users. In this way, the rule is dynamic. Low priority users will receive their full allocations only in the time when the system has sufficient resources to supply all users. A portion of the irrigator water use will be provided at a very low assurance, however, the benefit will be that permanent curtailment can be avoided in the interim until a new resource is available. This approach was applied in the WRPM analysis for Scenarios B-F as described in Section 5 of the Water Resources Report (DWS, 2020a).

6.2.2 Efficient system operation

In order to practically manage the operating and restriction rules outlined in **Section 6.2.1**, efficient, real time, dynamic systems operation is imperative. The IUCMA currently operates the system by assessing flows at various points, and interacting with users regarding the quantities they can abstract based on the flows at key gauges. This approach should be maintained in the Crocodile catchment and expanded to the Sabie catchment. Gauging points should be maintained in order to obtain accurate flow measurements. Real time data of flows should also be constantly gathered, and again, the maintenance of the existing telemetry system should be continued.

6.2.3 Groundwater Development

The Mbombela Reconciliation Strategy (DWA, 2014) stated that there is only limited scope for groundwater development for primary water supply. The main reason for this is the potential reduction in surface water baseflows in the Mbombela area should the groundwater be abstracted. The localized areas for which it was mentioned that further groundwater could potentially be used are as follows:

- Karino, Nsikazi South: 200 000 m^3/annum
- Matsulu: 100 000 m^3/annum
- Elandshoek: can consider as an option however mentioned that there is a low successful borehole drilling rate
- Hazyview, Nsikazi north: 200 000 m^3/annum

The availability of groundwater in the Sabie River catchment provides for the potential conjunctive use of groundwater and surface water resources in the future as the water requirements increase. Groundwater is currently not being used conjunctively with the surface water supplies in the municipality and the boreholes that were drilled before the construction of Inyaka Dam have been decommissioned. An assessment of the groundwater potential in Bushbuckridge Municipality indicated that there is approximately ***10.5 million m^3/annum*** of exploitable groundwater in the area (DWS, 2016).

6.2.4 New Dam Construction & Existing Dam Raising

If the system allows for it, a new resource in the form of infrastructure is often the intervention that adds the most in terms of water availability to a system. However, this intervention is also usually the most expensive, especially in terms of capital costs. A number of potential infrastructure resources have been evaluated in previous assignments (DWA, 2014), and a shortlist has been produced which excludes discarded options. These discarded options are listed below and reference to the reasons are provided:

- Montrose Dam, high cost and high environmental impact;
- Lepulelu Dam, high unit reference value
- Strathmore Dam, high cost due to location at mine
- Raising of Ngodwana Dam, high unit reference value

The options that remain on the shortlist for further consideration are as follows:

- Mountain View Dam (Crocodile catchment);
- Boschjeskop Dam (Crocodile catchment);
- Dingleydale Dam (Sabie catchment);
- New Forest Dam (Sabie catchment); and
- Raising of Primkop Dam (Crocodile catchment).

The potential additional yields as determined in the detailed infrastructure cost assessment task (DWS, 2020c) are presented in **Table 6.1**.

Table 6.1: Yields of new infrastructure resources assessed

Dam	Full Supply Capacity (million m^3)	Yield (million m^3/annum)
Boschejskop Dam	131	31.2
Mountain View Dam	185	78.1
Dingleydale Dam	63	20.6
New Forest Dam	82	19.6
Raised Primkop	8 < FSC < 30	1.2 < HFY < 5.9

Table 6.2 indicates the total estimated capital costs for the proposed dams (excluding downstream infrastructure) at August 2020 rates, including miscellaneous, preliminaries and general (P&G), contingencies and design fees, but excluding VAT.

Table 6.2: Total Estimated Capital Costs (excluding downstream infrastructure)

Dam Option	Total Estimated Costs[1]		
	Excluding downstream infrastructure	Including downstream infrastructure	Requirements of Downstream Infrastructure
Boschjeskop Dam	R1,119,934,266	R1,119,934,266	None

Mountain View Dam	R873,422,420	R873,422,420	None
Dingleydale Dam	R1,387,989,189	R3,059,576,926	Water treatment works, pump station, rising and gravity mains.
New Forest Dam	R1,677,250,768	R3,517,494,920	Water treatment works, pump station, rising and gravity mains.
Raising of Primkop Dam	See Note 2 below	See Note 2 below	None

(1) Excluding VAT, Operation and Maintenance Costs, as well as energy (pumping) costs.

(2) An investigation funded by the City of Mbombela (CoM) confirmed the technical feasibility to raise the Primkop Dam wall. A Terms of Reference for the Feasibility Study was issued in late 2019. This Study needs to be updated with the results of the Feasibility Study.

The capital cost was spread out over various construction periods and the economic life of all components was taken as 45 years. All the costs were discounted to the base year which is 2020. Unit reference values (URV) were determined for discount rates of 6%, 8% and 10%, and for a 45 year period (from completion of construction). The URV's are summarised in Table 6.3 and Table 6.4.

Table 6.3: Summary of Unit Reference Values: Crocodile Catchment

Dam Option	Discount Rate	Total Discounted Costs	Total Discounted Yield (million m³)	URV Rand/m³
Boschjeskop Dam	6%	839,757,728	320.71	2.62
Mountain View Dam	6%	655,827,506	802.79	0.82
Boschjeskop Dam	8%	753,788,822	220.43	3.42
Mountain View Dam	8%	589,473,151	551.79	1.07
Boschjeskop Dam	10%	679,751,438	157.92	4.31
Mountain View Dam	10%	532,223,251	395.28	1.35

From **Table 6.3** it is evident that the Mountain View Dam offers significantly lower unit reference values than Boschjeskop Dam. In addition the yield of Mountain View Dam (78.1 million m³/a) is more than double that of the Boschjeskop Dam (32.1 million m³/a).

From an engineering economic point of view the proposed Mountain View Dam is the preferred option. It is recommended that the proposed Mountain View Dam be considered for higher levels of investigation (feasibility).

Table 6.4: Summary of Unit Reference Values: Sand River Catchment

Dam Option	Discount Rate	Total Discounted Costs	Total Discounted Yield (million m³)	URV Rand/m³
Dingleydale Dam(1)	6%	1,041,109,029	211.75	4.92
New Forest Dam(1)	6%	1,258,038,130	201.47	6.24
Dingleydale Dam(2)	6%	2.561.650.988	211.75	12,10
New Forest Dam(2)	6%	2,912,176,817	201.47	14.46
Dingleydale Dam(1)	8%	935,402,444	145.54	6.43
New Forest Dam(1)	8%	1,129,770,523	138.48	8.16
Dingleydale Dam(2)	8%	2,228,887,522	145.54	15,31
New Forest Dam(2)	8%	2,540,326,084	138.48	18.35
Dingleydale Dam(1)	10%	844,231,897	104.26	8.10
New Forest Dam(1)	10%	1,019,229,407	99.20	10.28
Dingleydale Dam(2)	10%	1,964,898,210	145.54	18,85
New Forest Dam(2)	10%	2,243,533,945	138.48	22.62

(1) Excluding downstream infrastructure costs.

(2) Including downstream infrastructure costs.

From Table 6.4 it is evident that the Dingleydale Dam has the lowest unit reference values. Yields of both dams are relatively low, Dingleydale Dam (20.6 million m³/a and New Forest Dam 19.6 million m³/a).

Unit reference values for both dams are quite high, especially when the costs of the downstream infrastructure (water treatment works, pump station, rising and gravity mains) are included.

Although from an engineering economic point of view the proposed Dingleydale Dam is the preferred option it is recommended that both dams be considered for higher levels of investigation (feasibility). Social and environmental impacts have not been addressed as part of this Study and may have an impact on the selection of the most feasible option.

Two additional infrastructure options were mentioned in the Water Allocation Plans for the White River and Kaap catchments. These are a White River Dam and Hilversum Dam. The information only became available towards the end of this study and the options were therefore not evaluated in detail. They are mentioned as options in the WAPs, however, no indication is given of the impacts that the dams would have on the downstream users. If this is assessed, it is likely that the Dams, which are both relatively small and therefore yield small amounts, will not be a viable solution to the overall catchment resources deficit.

6.2.5 Water transfers

Water transfers from neighboring catchments is a standard practice in the water scarce country of South Africa. Many systems are augmented with water transfers from elsewhere, some involving complex infrastructure and operating rules to minimize costs. A regional assessment was undertaken to determine if this option is a possibility for the Crocodile catchment. **Figure 6-1** provides a perspective of the catchments in the context of surrounding water resources.

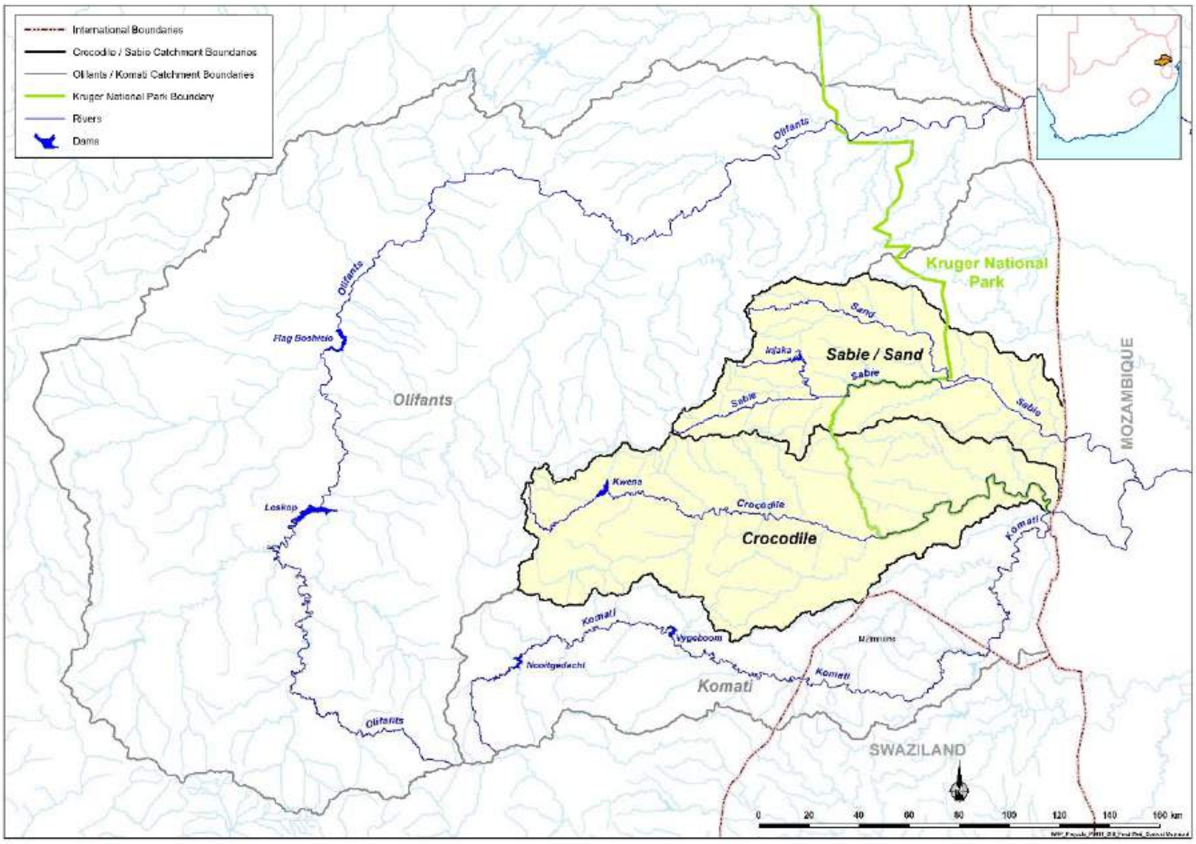


Figure 6-1: Crocodile and Sabie neighbouring catchments

The only potential transfer that could be an option from a locality perspective for the Crocodile catchment is from the Vygeboom Dam in the Inkomati catchment. Vygeboom Dam is a main resource for Eskom power stations and transfers occur from both Nooitgedacht and Vygeboom dams to the Olifants catchment for this purpose. This is included as part of the Integrated Vaal River System. Due to the current decrease in water requirement projections for Eskom, the Vaal system water balance indicates that Vygeboom Dam will have surplus water in the future.

The Olifants system's water balance has considered this surplus as an option to augment the future deficits in the Olifants catchment by transferring this water and routing it downstream to the middle Olifants mining areas. Whether this intervention will be implemented in the Olifants is still unknown.

The transfer of water from Vygeboom could be considered as an option for the Crocodile catchment, however, the users would be competing with the Olifants' primary and mining sectors for this water. Considering the transfer to the Crocodile catchment will benefit mostly irrigation users, it is unlikely that the costs of the transfer would make the option attractive. Eskom would need to be included in the discussions around this option, and preliminary information indicates they are not in favour of the proposal.

7 RECONCILING WATER REQUIREMENTS WITH IDENTIFIED INTERVENTION OPTIONS

The water balances presented in **Section 5** indicate that the implementation of interventions will be critical to ensure sufficient water supply to the year 2040 for almost all the small and large water supply systems. In the main systems deficits are severe.

Section 6 describes the potential intervention options that are applicable to the Study Area. The following section presents water balances, including the growths in requirements and the potential intervention options applicable to each system, over a time line till 2040. The systems, sub-systems and smaller supply systems as laid out in **Figure 5-1** are again used to represent individual water balances in this Section.

7.1 Crocodile River System

The current water balance presented in **Section 5.1** shows the Crocodile catchment in a severe deficit. **Figure 7-1** provides the water balance including possible intervention scenarios. Options for reconciliation for the Crocodile system include the following:

- WCWDM;
- Removal of IAPs;
- Surrender of irrigation allocations;
- Strict restriction rules on low priority users;
- Releases from Ngodwana Dam; and
- Construction of Mountain View Dam.

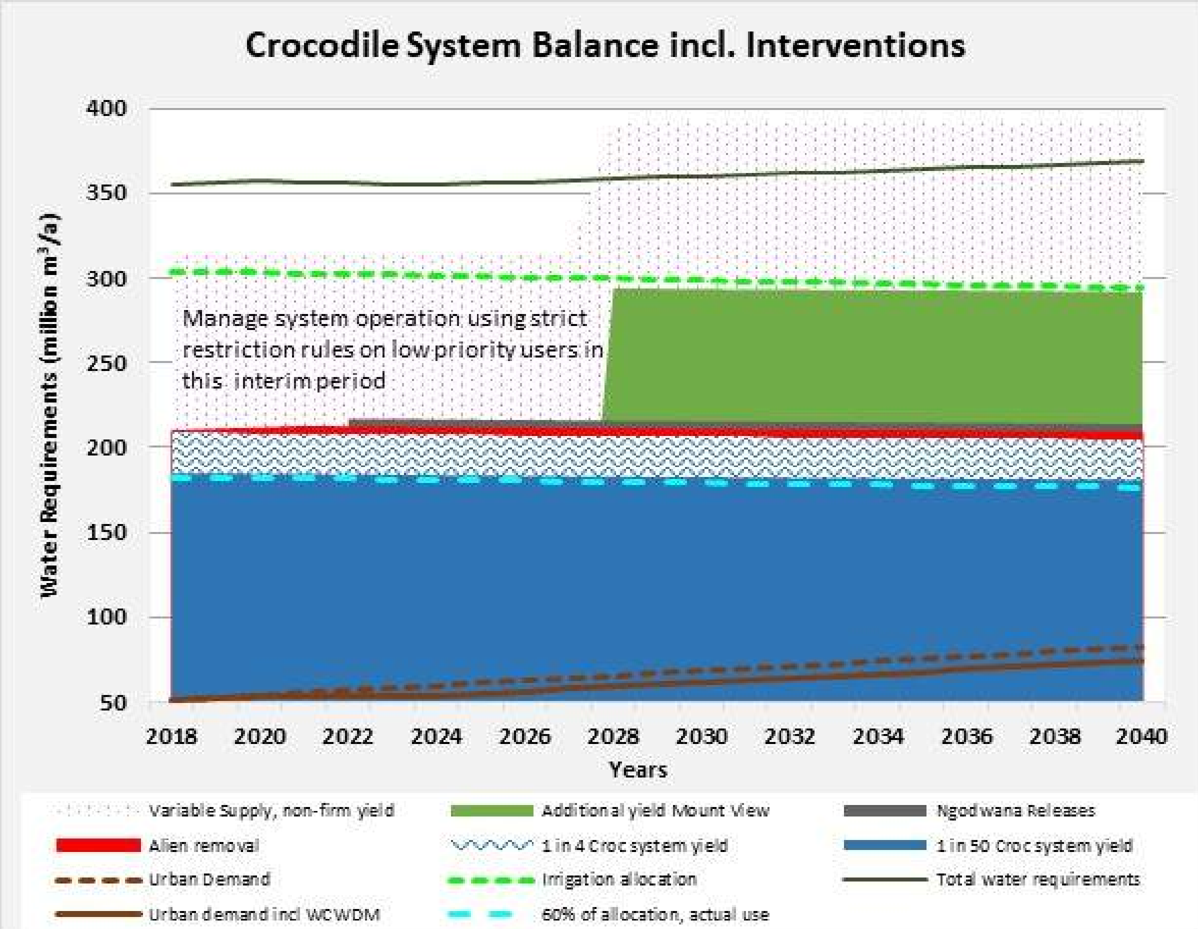


Figure 7-1: Water balance including interventions: Crocodile System

From **Figure 7-1** it should be noted that:

- It has been assumed that the surrender of water allocations from the irrigation sector amounts to 10 million m^3/annum over the planning period;
- While still necessary, the options of WCWDM, removal of AIPs and releases from Ngodwana dam provide relatively small improvements to the overall deficit in the water balance;
- The intervention option with the largest impact is the construction of the Mountain View Dam and this is necessary and urgent for the system;
- In the interim period until the Dam is constructed, the Crocodile system should be managed with dynamic operating rules that apply strict restrictions to lower priority users (irrigators) and maintain a higher assurance of supply to primary users. These rules should still allow for growth in the urban sector and allocations can be provided to support this.

7.2 White River Sub-System

The current water balance presented in **Section 5.2** shows the White River catchment in surplus whilst the Witklip Dam is in a deficit. Intervention options for the sub-system catchment include WCWDM and the reduction of canal losses.

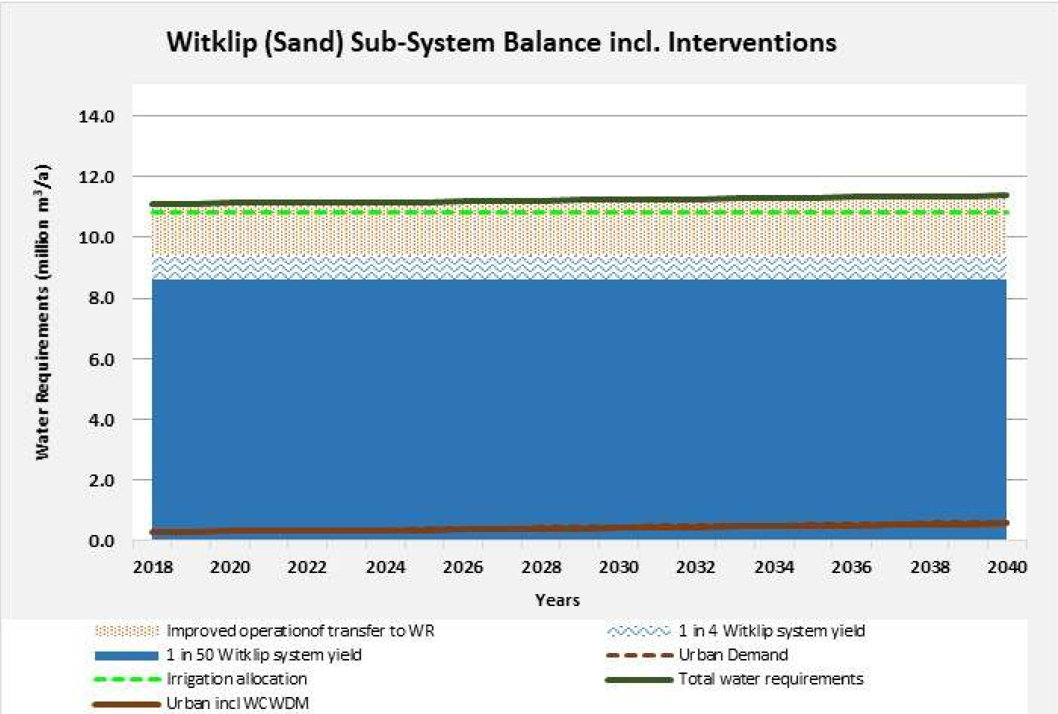


Figure 7-2: Water balance including interventions: Sand River Sub-System

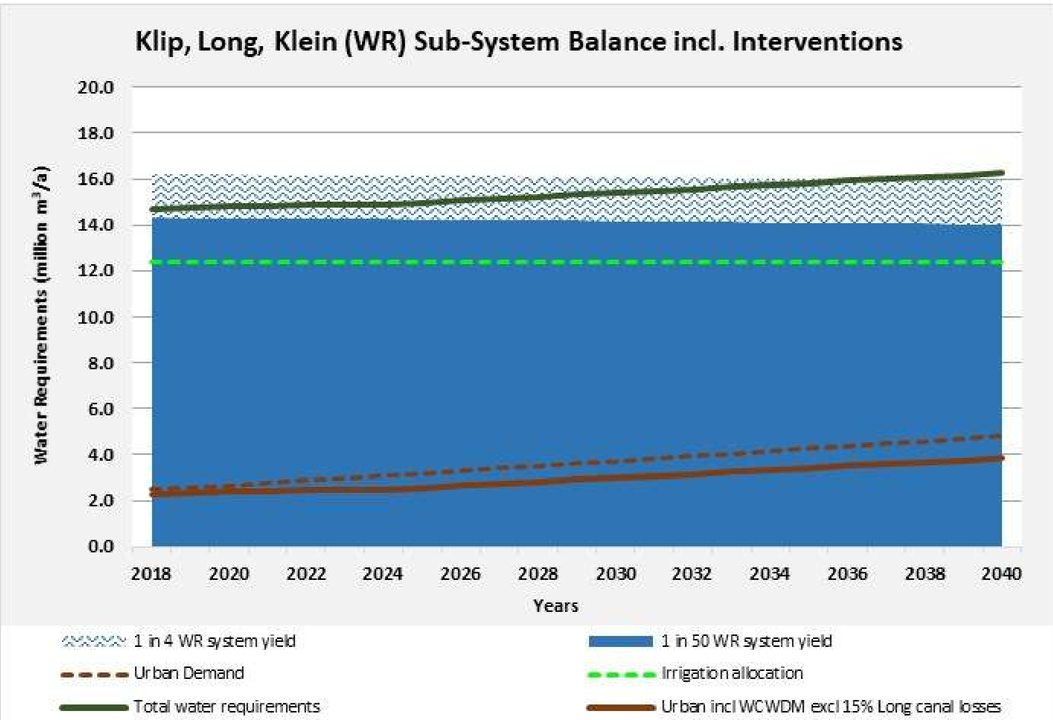


Figure 7-3: Water balance including interventions: White River Sub-System

Furthermore, it should be noted that the systems are linked via a transfer from the Sand catchment to the White River catchment. Overall, the system is in a balance if one reduces some of the surplus in the White River and decreases the deficit in the Sand River catchment. This should be done with improved operating rules to maintain a balance, and to not transfer water to the White River should deficits occur in the Sand River.

7.3 Sabie-Sand System

The current water balance presented in **Section 5.3** shows the Inyaka Dam in a deficit, both with and without releases for the EWR. **Figure 7-1** provides the water balance including possible intervention scenarios. The Classification Study (DWS, 2014a) indicated that the recommended EWR should only be implemented after a future water resource in the form of a dam is implemented in the Study Area. At this point, the existing system yield will drop, as indicated in the water balance, due to the implementation of EWR releases. Options for reconciliation for the Sabie system include the following:

- WCWDM;
- Removal of IAPs;
- Development of groundwater;
- New Dam; and
- Additional return flows from conversion of oxidation ponds to treated effluent

If the above intervention options are implemented timeously, the Sabie-Sand system will achieve a water balance in the planning period.

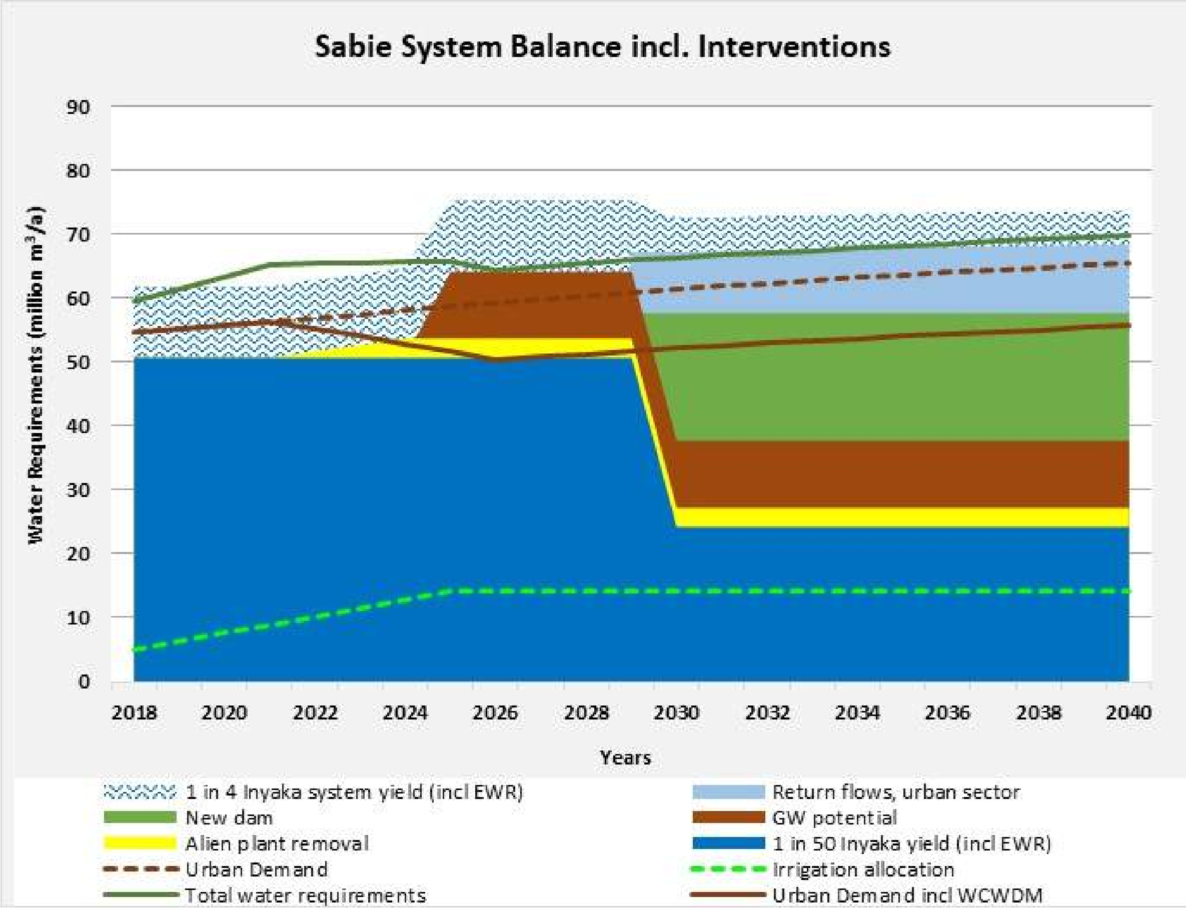


Figure 7-4: Water balance including interventions: Sabie-Sand System

7.4 Other Towns

7.4.1 Umjindi-Barberton

The current water balance presented in **Section 5.4.1** shows that the Umjindi-Barberton requirements are sufficiently supplied using the existing resources. WCWDM should still be implemented in the area, afterwhich the water balance will be as indicated in **Figure 7-5**.

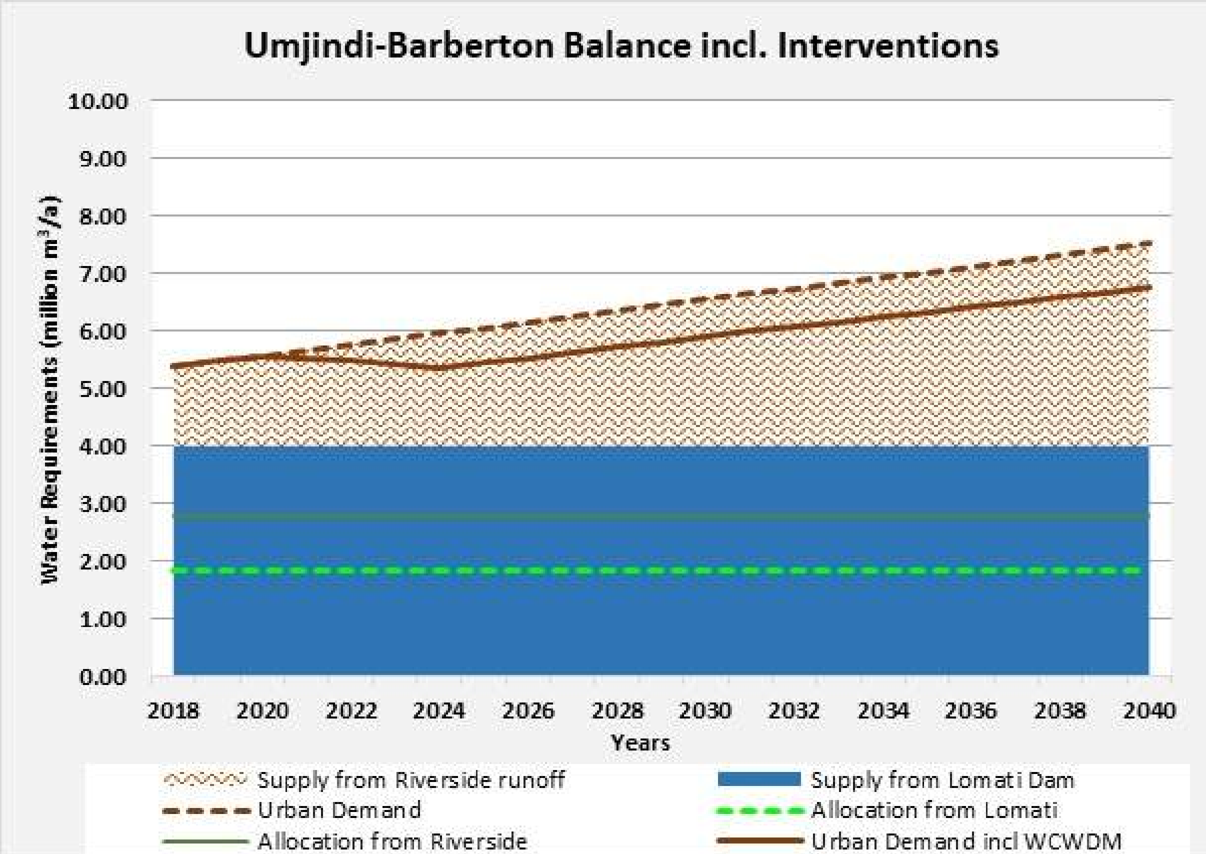


Figure 7-5: Water balance including interventions: Umjindi-Barberton

7.4.2 Dullstroom

The current water balance presented in **Section 5.4.2** shows the Dullstroom-Sakhelwe system in balance until the year 2026 at which time the requirements start to exceed the availability. Intervention options for the system include catchment include WCWDM, which will push the year of exceedance to 2033. Thereafter, the intervention option included for the system is for the Municipality to apply to DWS for additional water that may have been surrendered back to the State from unused irrigation allocations in the area. The balance in presented in **Figure 7-6**.

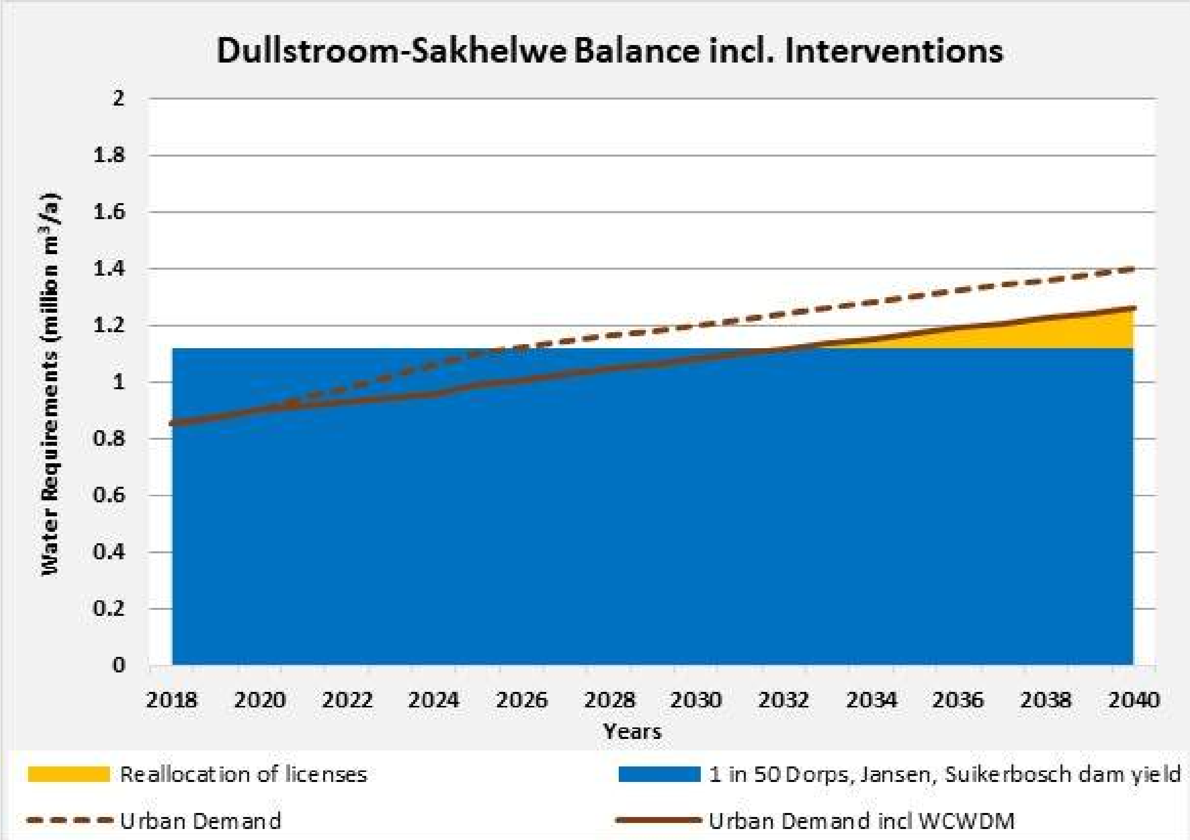


Figure 7-6: Water balance including interventions: Dullstroom-Sakhelwe

The current water balances for the schemes of Waterval Boven, Machadodorp, Sabie, Graskop, Elandshoek and Ngodwana all show that the existing resources supply the requirements over the projection period at a satisfactory level of assurance. However, WCWDM should still continue as an intervention in these areas. The Ngodwana system shows a surplus of water, and this could be used for augmentation of the Crocodile system, as indicated in the Crocodile system balance in **Figure 7-1**.

8 IMPLEMENTATION ARRANGEMENTS AND ACTION PLAN

It important to note that DWS, as custodian of the country's water resources, is only facilitating the process of water reconciliation *planning*, and that *implementation* is the responsibility of several other institutions. This Section provides an overview of the various intervention options, their required timing as well as the organization deemed responsible for the implementation of the option. This action plan can be used as a basis for the Strategy Steering Committee (StraSC) to track and monitor future progress of implementation, by obtaining feedback from the various institutions and organisations on the status of implementation at future StraSC meetings.

Typically, implementation of options is carried out by three main organisations within a catchment as follows:

- The DWS National Office is responsible for implementation of options that will benefit the water balance from a Regional perspective. This would include most large scale infrastructure options.
- The DWS Regional Office and/or a Catchment Management Agency are typically responsible for addressing options that relate to a localised perspective and will still benefit multiple user sectors.
- Municipalities are responsible for implementation options that fall within their local boundaries for the benefit of either increasing their supply (smaller infrastructure schemes) or reducing their requirements.

Table 14.1 outlines the different interventions that have been considered for achieving a water balance, the required actions, and the institutional responsibility for those actions. It should be noted that allocations of responsibility and target dates are indicative.

Table 8.1: Institutional responsibilities and target dates

Intervention	Description of Actions	Primary Responsibility	Comments	Target Date (priority)
WCWDM	Implementation of proposed WCWDM plan: **Institutional**: Improved political backing, capacity building **Financial**: Enhance revenue collection, improved tariff structure **Social**: Raise public awareness **Technical**: reduce water wastage, pressure management, bulk metering	Local Municipalities: City of Mbombela LM, Bushbuckridge LM, Emakhazeni LM, Thaba Chweu LM Nkomazi LM	Bushbuckridge LM to finalise process to appoint service provider to assist with WCWDM activities City of Mbombela to continue with and increase existing WCWDM programme	High priority, implementation to continue/start immediately CoM: 10% savings, reduction in growth by 2023 Bushbuckridge: 15% savings, reduction in growth by 2023
Reduce canal losses	Investigate potential savings and impact on water balance at a pre-feasibility level	City of Mbombela LM	Focus on canal supplying Nelspruit WTW and canals in the White River area	Medium priority level, as and when funds available
Remove alien vegetation	Implement programme to systematically clear alien vegetation and continuously maintain cleared areas Rehabilitate land and re-establish indigenous vegetation	Department of Environmental Affairs, WWF, Sanparks & IUCMA	Focus on areas upstream of Inyaka and Kwena Dams as well as Lomati Dam in the Inkomati catchment	High priority, implementation to continue/start immediately
Water use entitlement exchange from irrigation to urban	Identify irrigation users that are willing to surrender allocations Create awareness amongst irrigators that this option exists Determine status of existing CoM applications and reasons for delay	Department of Water and Sanitation: Directorate to be confirmed City of Mbombela, IUCMA	Follow procedure for reallocation of water licenses as laid out by DWS. It is important that the reasons behind the delay in	High priority, implementation to continue/start immediately

Intervention	Description of Actions	Primary Responsibility	Comments	Target Date (priority)
			process are understood in order to streamline future applications	2021 for existing applications Ongoing for additional applications
Eliminating unlawful uses	Complete Validation process Complete Verification process Establish unlawful users Remove and prosecute unlawful users	IUCMA	The process of V and V has taken significant time and requires completion before any action can take place on this intervention	High priority, implementation to continue/start immediately Target date: 2022
Compulsory licensing	Establish need for Compulsory licensing as last resort intervention Determine economic impact of Compulsory licensing Send out call for license applications Reissue licenses	IUCMA	Should it be deemed necessary that Compulsory licensing take place, a detailed Stakeholder engagement process should be incorporated into the process in order to gain support from user sectors The process should be transparent and clearly defined objectives communicated	Target date: 2025 if required
Water Reuse	Determine viability at a pre-feasibility level including impact of intervention on water balance	Bushbuckridge LM	This intervention is focused on the Bushbuckridge LM supply area and is designed to add additional resources after the implementation of a new dam	Medium priority level, when new dam constructed

Intervention	Description of Actions	Primary Responsibility	Comments	Target Date (priority)
Interim Restriction Rule to Benefit Priority (Primary) Users	Carry out annual operating analyses to determine level of restrictions to be imposed on users on an annual basis, water requirement dependent Implement restrictions on lower priority users according to priority classification table Continuously monitor water use of large users to confirm actual growth is in line with projections	DWS: Directorate Water Resources Planning Systems, IUCMA	DWS has recently awarded a study to a professional service provider that can assist with annual operating analyses for three years. This study will produce dynamic operating rules	Immediate and ongoing
Efficient system operation	Continuous maintenance of real time flow monitoring system, both data capture (measurement) and data sharing (cloud based) Enhancement of real time system based on pre-determined strategic monitoring points	IUCMA and users	The existing system should not be allowed to fail, and should be expanded to additional key flow monitoring points throughout the catchments. It is specifically important to improve the flow monitoring in the White River in order to undertake a more accurate hydrological assessment.	Immediate and ongoing
Groundwater Development	Completion of IUCMA detailed Groundwater assessment Further development of Groundwater resources dependent on outcome of study	IUCMA, Local Municipalities,	This intervention is focused on the Bushbuckridge LM supply area, however, could also benefit the City of Mbombela if the detailed study indicates so	Ongoing
New Dam Construction & Existing Dam Raising	Feasibility Study into three Dam options:	DWS: Options Analyses (large dams, CoM (Primkop)	Tendering to be undertaken by implementing agent,	Urgent and requires fast tracking.

Intervention	Description of Actions	Primary Responsibility	Comments	Target Date (priority)
	Dingleydale and New Forest, first prioritise using pre-feasibility Mountain View requires detailed feasibility including site selection, design and then construction Raising of Primkop Dam Reconnaissance assessment into raising of Wtklip Dam	DWS: NWRP for Wtiklip (part of future Recon update)	Construction to be outsourced. Explore further options of Public Private Partnership	Construction to be complete by 2030.
Water releases from Ngodwana Dam	Detailed assessment of potential water availability in Ngodwana Dam Discussions and negotiations between Sappi and CoM LM to agree on option	DWS: NWRP CoMLM, Sappi	This option requires further investigation in terms of the water availability and viability of the release. Closer monitoring of Ngodwana dam should be undertaken in order to quantify the excess water available	Medium priority level

9 RECOMMENDATIONS FOR FURTHER WORK

Over and above the implementation actions assigned to various Institutions presented in **Table 8.1**, additional activities can be undertaken as part of a future Reconciliation Strategy update in order to enhance the Strategy and provide the water balance results with improved accuracy. The following is recommended for further work in a Strategy update:

- At the same time of carrying out this Strategy update, the IUCMA undertook a hydrological assessment to update and extend the hydrology of the Crocodile and Sabie catchments to an end date of September 2016 (IUCMA, 2019a). Unfortunately, the updated hydrology was not completed and available in time for use in this Study. As part of a future Study it is recommended that the updated hydrology be incorporated into the standard DWS water resources models used in this Study. This would also involve the development and verification of stochastic flow sequences. Updated yield analyses should then be undertaken which will incorporate the effects of the recent dryer years of rainfall. If major yield differences occur, further investigations will need to be undertaken to understand and explain the reasons why.
- The catchment landuse (farm dams, afforestation and diffuse irrigation) has also been updated as part of the hydrological update and extension. This latest information should also be incorporated into the water resources models used to prepare the water balance.
- Accurate water use and water requirement projections is an important input to the water balances, specifically relating to the timing of required intervention activities. Future updates of the Strategy should include a water requirement assessment and update given that this Strategy obtained actual use data till 2017. Extending the actual use and comparing it with the projected requirements will assist in establishing the accuracy of the water requirement projections.
- A more detailed assessment on the actual use from the irrigation sector is required. Water allocations have typically been used in the water balances, with information relating to the actual use only being obtained towards the end of the Study.
- At the time of undertaking this Study, the IUCMA have produced water allocation plans for some of the catchments (IUCMA, 2019b,c) as well as a Catchment Management Strategy. It is important that this Reconciliation Strategy align itself with these two documents, which have recently (2020)

become available. A closer review of this work is required and relevant aspects should be incorporated into a future Strategy update.

- Results from the IUCMA's detailed groundwater assessment should be incorporated into a future Strategy update.
- After the completion of the detailed demographic assessment and subsequent determination of urban water requirement projections, the Bushbuckridge Local Municipality queried the figures and requested that additional information from their population database be incorporated. Unfortunately, this information was not forthcoming and was therefore not included as part of the Strategy. It is recommended that further engagement take place with the Municipality in a future update in order to understand the reasons for the differences in population statistics and to select the most appropriate set of figures for further use.
- Further Strategy updates should include the ongoing monitoring of intervention implementation and coordination in terms of facilitation of Strategy Steering Committee meetings. These meetings should be convened twice each year at which institutions responsible for the various interventions can provide feedback of progress.

10 REFERENCES

DWAF (2008) Inkomati Water Management area: WC/WDM study: Umjindi LM - Situation Assessment & Water Audit, prepared by Water for Africa for DWAF Directorate: Water Use Efficiency

DWAF (2009) Inkomati Water Availability Assessment – Water Requirements: Report PWMA 05/X22/00/1708 compiled by Water for Africa Environmental Engineering & Management Consultants (Pty) Ltd in 2009 for the Department of Water Affairs and Forestry, Directorate: Water Resource Planning Systems, Pretoria, South Africa.

DWA (2012) IWAAS Maintenance/Licensing project; by Water for Africa Environmental Engineering & Management Consultants (Pty) Ltd in 2012 for the Department of Water Affairs and Forestry, Directorate: Water Resource Planning Systems, Pretoria, South Africa.

DWA (2014) Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area: Final Reconciliation Strategy compiled by Water for Africa (Pty) Ltd in association with Africon (Pty) Ltd, Water Geosciences and Charles Sellick and Associates in 2014, for the Department of Water Affairs Directorate: Water Resource Planning Systems, Pretoria, South Africa.

DWS (2014a) Department of Water Affairs, South Africa, September 2014. The determination of water resource classes and associated resource quality objectives in the Inkomati Water Management Area. Operational Scenarios and recommended Water Resource Classes. Authored by Huggins G, Louw MD, Mallory S, Van Jaarsveld P and Van Rooyen P. DWS Report, RDM/WMA05/00/CON/CLA/0214.

DWS (2014a) Department of Water and Sanitation, South Africa. National Water Policy Review (NWPR) Approved Water Policy Positions

DWS (2016) Water reconciliation strategy update for the schemes in the Sabie and Sand River system in Bushbuckridge Local Municipality for 2015 -2045 compiled by Tlou Consulting (Pty) Ltd. in 2016 for the Department of Water and Sanitation, Directorate: Water Resource Planning Systems, Pretoria, South Africa.

DWS (2018a) Department of Water and Sanitation, South Africa. Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area: Economic Growth and Demographic Analysis Report. Compiled by IX/BJ/WRP Joint Venture

DWS (2018b) Department of Water and Sanitation, South Africa. Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area: Water Requirements and Return Flows Report. Compiled by IX/BJ/WRP Joint Venture

DWS (2019) Department of Water and Sanitation, South Africa. Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area: Water Conservation and Water Demand Management Report. Compiled by IX/BJ/WRP Joint Venture

DWS (2020a) Department of Water and Sanitation, South Africa. Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area: Water Resources Report. Compiled by IX/BJ/WRP Joint Venture

DWS (2020b) Department of Water and Sanitation, South Africa. Minutes of Strategy Steering Committee Meeting no. 4 held in May 2020

DWS (2020c) Department of Water and Sanitation, South Africa. Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area: Infrastructure and Cost Assessment Report. Compiled by IX/BJ/WRP Joint Venture

IUCMA (2019a) Update of the Hydrology for Crocodile River Catchment, compiled by Stephen Mallory and Anne Beater; IWR Water Resources Pty Ltd for the IUCMA

IUCMA (2019b) Water Allocation Plan for the White River Catchment, Final Water Allocations Scenarios Report. Compiled by S Mallory for the IUCMA, Report no. IUCMA /14/1/2/3

IUCMA (2019c) Water Allocation Plan for the Kaap River Catchment, Final Water Allocations Scenarios Report. Compiled by S Mallory for the IUCMA, Report no. IUCMA /14/1/2/3

MISA (2016) Water and Sanitation Service Delivery Implementation Plan, City of Mbombela WSA.

MISA (2016b) Water and Sanitation Service Delivery Implementation Plan, Thaba Chweu WSA.

MISA (2016c) Water and Sanitation Service Delivery Implementation Plan, Nkomazi WSA.

MISA (2017) Water and Sanitation Service Delivery Implementation Plan, Bushbuckridge WSA.

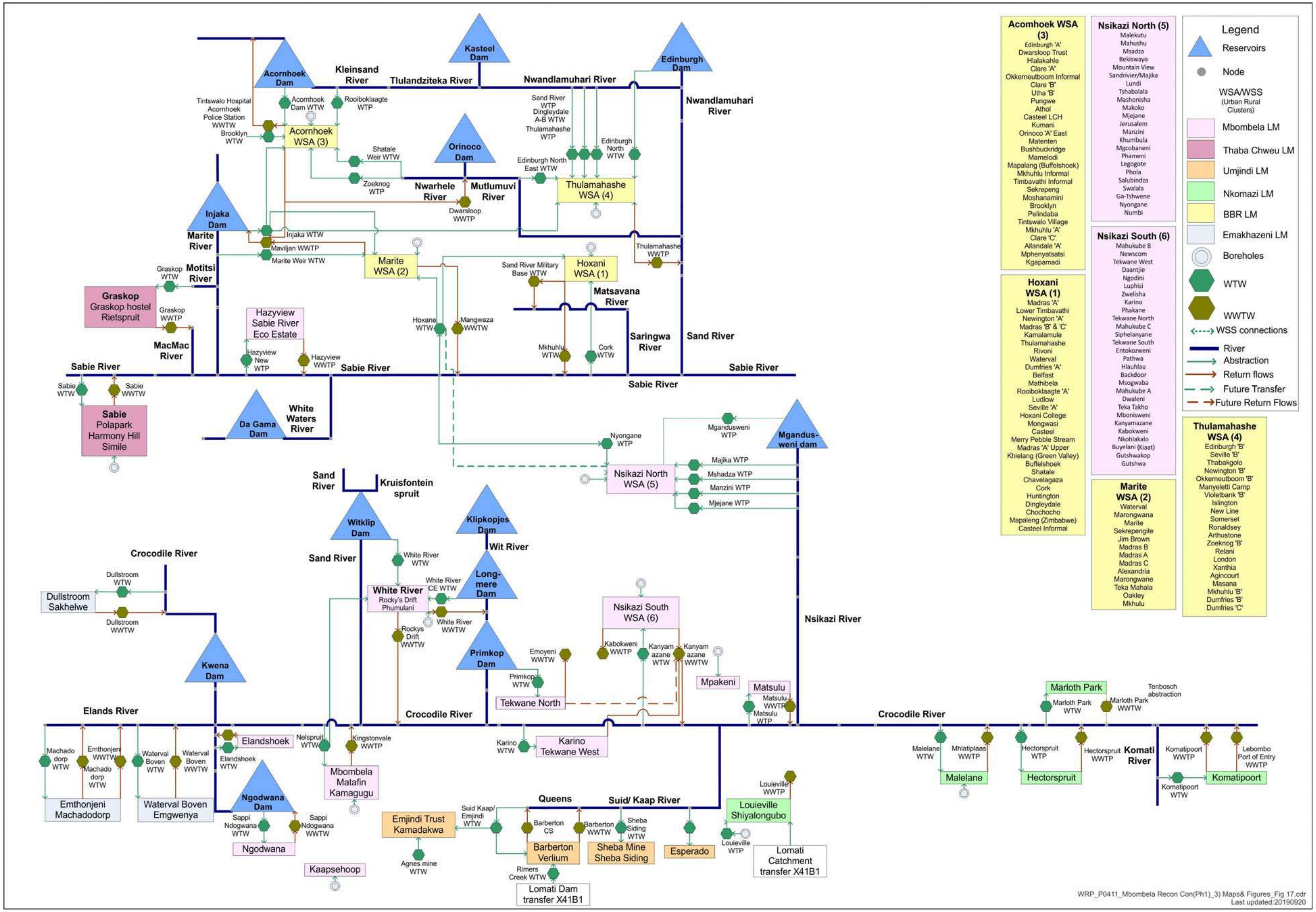
Musa, F., E., Zhou, Y., Maskey, S., Masih, I., and Uhlenbrook, S., (2015) Groundwater as an emergency source for drought mitigation in theCrocodile River catchment, South Africa. Hydrol. Earth Syst. Sci., 19, 1093–1106. doi:10.5194/hess-19-1093-2015. https://www.hydrol-earth-syst-sci.net/19/1093/2015/hess-19-1093-2015.pdf. Accessed on the 10 December 2019

SANBI (2020) Website www.sanbi.org

TPTC (2002) Tripartite Permanent Technical Committee. The Tripartite Interim Agreement between the Republic of Mozambique and the Republic of South Africa and the Kingdom of Swaziland for Co-operation on the Protection and Sustainable Utilisation of the Incomati and Maputo Watercourses

WFW (2014). Working for Water, shapefiles downloaded from SANBI website, accessed 20 July 2020. Contact kotzei@arc.agric.za

APPENDIX A



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

iX engineers

CONTINUATION OF WATER REQUIREMENTS AND AVAILABILITY RECONCILIATION STRATEGY FOR THE MBOMBELA MUNICIPAL AREA

Simplified Schematic of Study Area
(Work in Progress)

A-1

APPENDIX B

Data: Crocodile System Balance

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 Croc system yield	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8	184.8
1 in 4 Croc system yield	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7	208.7
Increase upstream dems	0.0	0.2	0.3	0.5	0.7	0.9	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.4	2.6	2.7	2.9	3.0	3.2	3.4	3.5	3.7	3.9
1 in 50 Croc system yield reduced	184.8	184.6	184.5	184.3	184.1	183.9	183.7	183.5	183.3	183.1	182.9	182.7	182.5	182.4	182.2	182.1	181.9	181.8	181.6	181.4	181.3	181.1	181.0
1 in 4 Croc system yield reduced	208.7	208.5	208.4	208.2	208.0	207.8	207.6	207.4	207.2	207.0	206.8	206.6	206.4	206.3	206.1	206.0	205.8	205.7	205.5	205.3	205.2	205.0	204.9
Urban Demand	51.3	52.4	53.8	55.2	56.7	58.1	59.5	61.0	62.4	63.8	65.3	66.7	68.1	69.6	71.0	72.4	73.9	75.3	76.8	78.2	79.6	81.1	82.5
Urban allocation	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4	49.4
Irrigation allocation	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0	304.0
Total water requirements	355.3	356.4	357.8	359.2	360.7	362.1	363.5	365.0	366.4	367.8	369.3	370.7	372.1	373.6	375.0	376.4	377.9	379.3	380.8	382.2	383.6	385.1	386.5
Irrigation allocation Reduction	304.0	303.5	303.1	302.6	302.2	301.7	301.3	300.8	300.4	299.9	299.5	299.0	298.5	298.1	297.6	297.2	296.7	296.3	295.8	295.4	294.9	294.5	294.0
Urban demand incl WCWDM	51.3	52.4	53.8	53.9	53.8	53.7	53.6	54.9	56.2	57.5	58.7	60.0	61.3	62.6	63.9	65.2	66.5	67.8	69.1	70.4	71.7	73.0	74.3
Reduced Total water requirements	355.3	355.9	356.9	356.5	356.0	355.5	354.9	355.7	356.5	357.4	358.2	359.0	359.9	360.7	361.6	362.4	363.2	364.1	364.9	365.7	366.6	367.4	368.3
Additional yield Mount View	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	293.8	293.6	293.4	293.3	293.1	293.0	292.8	292.7	292.5	292.3	292.2	292.0	291.9
Alien removal	1.0	2.0	3.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Alien removal total yield	209.7	210.5	211.4	212.2	212.0	211.8	211.6	211.4	211.2	211.0	210.8	210.6	210.4	210.3	210.1	210.0	209.8	209.7	209.5	209.3	209.2	209.0	208.9
Ngodwana Releases					5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Ngodwana Releases total yield					217.0	216.8	216.6	216.4	216.2	216.0	215.8	215.6	215.4	215.3	215.1	215.0	214.8	214.7	214.5	214.3	214.2	214.0	213.9
60% of allocation, actual use	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4	182.4
60% of allocation, actual use, reduced allocation	182.4	182.1	181.9	181.6	181.3	181.0	180.8	180.5	180.2	179.9	179.7	179.4	179.1	178.9	178.6	178.3	178.0	177.8	177.5	177.2	176.9	176.7	176.4
Variable Supply, non-firm yield	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3
Total yield	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	313.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3	391.3

Data: White River System Balance

WITKLIP	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 Witklip system yield	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6	8.6
1 in 4 Witklip system yield	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
Urban Demand	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6
Urban allocation	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Irrigation allocation	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8	10.8
Total water requirements	11.1	11.1	11.1	11.1	11.2	11.2	11.2	11.2	11.2	11.2	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.4	11.4	11.4	11.4	11.4	11.4
Urban incl WCWDM	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6
Improved operationof transfer to WR	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.4	11.4
Total water requirements incl WCWDM	11.1	11.1	11.1	11.1	11.1	11.1	11.1	11.2	11.2	11.2	11.2	11.2	11.2	11.2	11.3	11.3	11.3	11.3	11.3	11.3	11.3	11.4	11.4

KLIP,LONG,PRIMK	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 WR system yield	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
1 in 4 WR system yield	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9	17.9
Reduced 1 in 50 yield due to lower transfer from Sand	14.3	14.3	14.3	14.3	14.3	14.3	14.3	14.2	14.2	14.2	14.2	14.2	14.2	14.2	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.0	14.0
Reduced 1 in 4 yield due to lower transfer from Sand	16.2	16.2	16.2	16.2	16.2	16.2	16.2	16.1	16.1	16.1	16.1	16.1	16.1	16.1	16.0	16.0	16.0	16.0	16.0	16.0	16.0	15.9	15.9
Urban Demand	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8
Urban allocation	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
Irrigation allocation	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4	12.4
Total water requirements	14.9	15.0	15.1	15.2	15.3	15.4	15.5	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.3	16.5	16.6	16.7	16.8	16.9	17.0	17.1	17.2
Urban incl WCWDM excl 15% Long canal losses	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.8
Total water requirements incl WCWDM, Ex canl loss	14.7	14.7	14.8	14.8	14.9	14.9	14.9	15.0	15.1	15.1	15.2	15.3	15.4	15.5	15.6	15.6	15.7	15.8	15.9	16.0	16.1	16.2	16.2

Data: Sabie-Sand System Balance

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 Inyaka yield (incl EWR)	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
1 in 4 Inyaka system yield (incl EWR)	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5
1 in 50 Inyaka system yield (excl EWR)	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7
1 in 4 Inyaka system yield (excl EWR)	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8	61.8
Urban Demand	54.7	55.3	55.9	56.4	57.0	57.5	58.1	58.6	59.2	59.8	60.3	60.9	61.5	61.9	62.3	62.8	63.2	63.6	64.0	64.4	64.8	65.2	65.6
Urban Allocation	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9	55.9
Irrigation allocation	5.0	6.3	7.6	8.9	10.2	11.5	12.8	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
Total water requirements	59.7	61.6	63.5	65.3	67.2	69.0	70.9	72.7	73.3	73.9	74.5	75.0	75.6	76.0	76.5	76.9	77.3	77.8	78.1	78.5	78.9	79.3	79.7
1 in 50 Inyaka yield	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	50.7	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2	24.2
1 in 4 Inyaka yield	61.8	61.8	61.8	61.8	62.8	63.8	64.8	75.3	75.3	75.3	75.3	75.3	72.6	72.7	72.8	73.0	73.1	73.3	73.3	73.4	73.5	73.6	73.7
New dam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	57.7	57.7	57.7	57.7	57.7	57.7	57.7	57.7	57.7	57.7	57.7	57.7
Urban Demand incl WCWDM	54.7	55.3	55.9	56.4	55.2	54.1	52.8	51.6	50.3	50.8	51.3	51.8	52.3	52.6	53.0	53.4	53.7	54.1	54.4	54.8	55.1	55.4	55.8
Alien plant removal	50.7	50.7	50.7	50.7	51.7	52.7	53.7	53.7	53.7	53.7	53.7	53.7	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
GW potential								10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Incl GW potential	50.7	50.7	50.7	50.7	50.7	50.7	50.7	64.2	64.2	64.2	64.2	64.2	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7	37.7
Total water requirements	59.7	61.6	63.5	65.3	65.5	65.6	65.7	65.7	64.4	64.9	65.4	65.9	66.4	66.7	67.1	67.5	67.8	68.2	68.5	68.9	69.2	69.5	69.9
Return flows, urban sector													9.6	9.7	9.8	10.0	10.1	10.3	10.3	10.4	10.5	10.6	10.7
Total incl Return flows, urban sector	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.3	67.3	67.4	67.5	67.7	67.8	68.0	68.0	68.1	68.2	68.3	68.4

Data: Barberton Umjindi

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Supply from Lomati Dam	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Supply from Riverside runoff	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5
Total Supply	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5
Urban Demand	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5
Allocation from Lomati	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Allocation from Riverside	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Urban Demand incl WCWDM	5.4	5.5	5.6	5.5	5.5	5.4	5.4	5.4	5.5	5.6	5.7	5.8	5.9	6.0	6.1	6.2	6.2	6.3	6.4	6.5	6.6	6.7	6.8
Total allocation	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6	4.6

Elandshoek

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 river runoff	0.11	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.18	0.18	0.19	0.19
Urban Demand	0.11	0.12	0.12	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.16	0.16	0.16	0.16	0.17	0.17	0.17	0.17	0.18	0.18	0.19	0.19
Urban Demand incl WCWDM	0.11	0.12	0.12	0.12	0.12	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.16	0.16	0.16	0.17	0.17

Ngodwana

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 Ngodwana dam yield	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
Urban Demand	0.75	0.78	0.81	0.84	0.87	0.90	0.93	0.96	1.00	1.03	1.07	1.10	1.14	1.18	1.22	1.27	1.31	1.35	1.40	1.45	1.49	1.54	1.59
Sappi demand	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Total water requirements	14.75	14.78	14.81	14.84	14.87	14.90	14.93	14.96	15.00	15.03	15.07	15.10	15.14	15.18	15.22	15.27	15.31	15.35	15.40	15.45	15.49	15.54	15.59

Dullstroom

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 Dorps, Jansen, Suikerb	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
Urban Demand	0.85	0.88	0.90	0.94	0.98	1.02	1.06	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40
Total water requirements	0.85	0.88	0.90	0.94	0.98	1.02	1.06	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40
Urban Demand incl WCWDM	0.85	0.88	0.90	0.92	0.93	0.94	0.95	0.99	1.01	1.03	1.04	1.06	1.08	1.10	1.12	1.13	1.15	1.17	1.19	1.21	1.22	1.24	1.26
Reallocation of licenses															1.12	1.13	1.15	1.17	1.19	1.21	1.22	1.24	1.26

Waterval Boven

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 river runoff	0.95	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40
Urban Demand	0.95	0.98	1.00	1.02	1.04	1.06	1.08	1.10	1.12	1.14	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36	1.38	1.40

Machadodorp

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
1 in 50 river runoff	0.95	0.98	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36	1.40	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.56	1.58	1.60
Urban Demand	0.95	0.98	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.28	1.32	1.36	1.40	1.42	1.44	1.46	1.48	1.50	1.52	1.54	1.56	1.58	1.60

Graskop

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Well & Fountain yield	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314	1.314
Urban Demand	0.83	0.84	0.85	0.86	0.87	0.89	0.90	0.91	0.92	0.93	0.95	0.96	0.97	0.98	1.00	1.01	1.02	1.04	1.05	1.06	1.07	1.09	1.10

Sabie

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Old mineshaft yield	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048	2.048
Urban Demand	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.78	1.79	1.79	1.79	1.79	1.79	1.79

	Yields		Allocations			
Dam/Resource	**1 in 50 yield**	**1 in 4 yield**	**Urban**	**Agriculture**	**Source/User**	**Total Allocation**
Kwena	57.8	67.6				
Run of River	127	141.1				
			16.63		Nelspruit	
			19.17		Nsikzai South	
			7.24		Matsulu	
			5.53		Karino	
			0.835		Emoyeni	
Total Croc System	184.8	208.7	49.41	304	River/stream	353.41
Witklip	8.6	9.4	0.75	10.8	Witklip	
Klipkopje/Longmere/Primkop	16	17.9	1.53	12.4	Klipkopje/Longmere/Primkop	
Sand-White River System	24.6	27.3	2.28	23.2		25.48
Inyaka (incl EWR)	24.2	29.5				
Inyaka (excl EWR)	50.7	61.8	37.94		BBR LM (Hoxane & Inyaka WTW)	
			1.36		Hazyview	
			16.59		Nsikazi North	
				10.9	Sabie River Irrigation Board	
Acornhoek	0.33	-	0.844			
Edinburgh	2.29	-	0.967			
Da Gama	10.3	12		15.6	White Rivers Irrigation Board	
Total Sabie-Sand System (excl EWR)	63.62	-				
Total Sabie-Sand System (incl EWR)	37.12	-				84.20
Ngodwana Dam	21		N/A		Elandshoek	
			14		Sappi	
				28.7	Elands Irrigation Board	
Run of River	1.4		N/A		Waterval Boven	
Run of River	1.6		N/A		Machadodorp	
Total Elands	24					N/A
Lomati Dam	4.8		1.825			
Run of River @ Riverside	3.5		2.79		Riverside Barberton	
Run of River for irrigation	N/A					
Total Kaap	N/A			36.1	Kaap Irrigation Board	40.72