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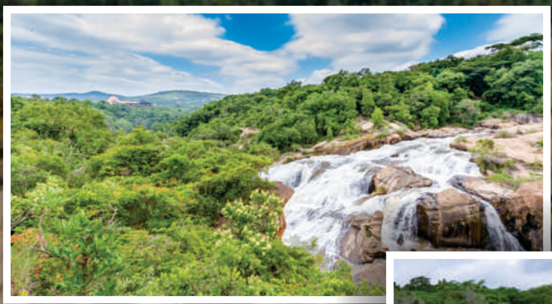
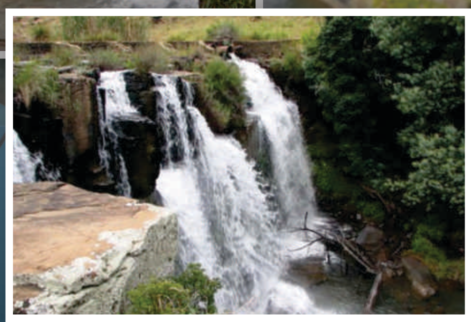
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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

Water Requirements and Return Flows Report





FINAL
SEPTEMBER 2018

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

WATER REQUIREMENTS AND RETURN FLOWS REPORT (FINAL)

SEPTEMBER 2018

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

WATER REQUIREMENTS AND RETURN FLOWS REPORT (FINAL)

SEPTEMBER 2018

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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	
Water Resources Analysis	5	
Infrastructure and Cost Assessment	6	
Updated Reconciliation Strategy	7	
Executive Summary: Updated Reconciliation Strategy	8	

Title:	**Water Requirements and Return Flows Report**
Authors:	**Study Team**
Project Name:	**Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area**
DWS Report No:	**P WMA 03/X22/00/6918**
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EXECUTIVE SUMMARY

Introduction

The Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area (this Study) follows on the *Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area (DWS, 2014)*. The overall objective of this Study is 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. The objective of this report is to document, describe, assess and develop the current and future projected water requirements and return flows (up to 2040) of all the water use sectors in the Study Area.

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 is 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 (BBR) 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 Injaka Dam in BBR LM, Kwena Dam in the Thaba Chweu LM, as well as smaller dams in the CoM LM such as Witklip Dam, Longmere Dam, Klipkopjes Dam, Primkop Dam and Da Gama Dam.

Background and Approach

The Water Requirements and Return Flows Report (this Report) summarises and presents the updated water requirements projections of all the water user sectors in the Study Area. The water use sectors include urban/domestic, industrial and irrigation components. Other water users such as Ecological Water Requirements (EWR), international obligations and stream flow reduction activities, which include commercial afforestation and Invasive Alien Plants (IAP) species, have also been considered. Return flows from the various users were revised and updated. The urban and industrial return flows are based on the capacities, or recorded Waste Water Treatment Works (WWTW) volumes in the Study Area. The irrigation return flows are based on irrigation efficiency factors, which depend on the various irrigation methods.

The *Inkomati Water Availability Assessment Study* (iWAAS) (***DWAF, 2011***) as well as the *Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area (**DWS, 2014**)* served as the foundation for this this Continuation of Water Requirements and Availability Reconciliation Strategy for the Mbombela Municipal Area. The Study Area consists of the Sabie and Crocodile (East) Sub- Catchment. The focus of this Study is on the City of Mbombela (CoM) Local Municipality (LM), former Umjindi LM, which was recently amalgamated with the CoM LM, and Bushbuckridge (BBR) LM. The remainder of the Study Area incorporates parts of the Emakhazeni LM, Thaba Chweu LM and Nkomazi LM.

Urban/Domestic and Industrial Water Requirements and Return Flows

The current and planned increase in Levels of Service (LOS) and recorded system input volumes (SIV), where available, were used to derive the water requirements (see **Section 3.2**) from 2016 to 2040, at each of the twenty two Water Supply Schemes (WSSs) in the focus area. The water requirements projections for the remaining area (parts of the Thaba Chweu LM, Nkomazi LM and Emakhazeni LM) were based on existing information sourced from the previous *DWS All Towns Studies*. A summary of the urban water requirement projections is presented in **Table (i).**

Mbombela (former Nelspruit), Nsikazi North and South, as well as portions of BBR LM are the largest demand centres in the Study Area. The projected 2040 water requirements for the CoM LM are estimated at 101.6 million m^3/a and BBR LM at 66.8 million m^3/a.

The majority of the light industrial water users are accounted for within the domestic requirements. The major industrial consumers that are excluded within the domestic requirements are Sappi Ngodwana Mill and the RCL (former TSB) Malelane Sugar Mill. The Sappi Ngodwana Mill uses about 14 million m^3/a, of which 2.8 million m^3/a is supplied from the Elands River (converted irrigation water use licenses), and the remaining 11.2 million m^3/a are supplied from the existing Ngodwana Dam on the Ngodwana River. The Sappi Ngodwana Mill water requirements are expected to remain constant, as an increase in water use efficiency is expected to cater for the planned expansion. The annual water requirement of the RLC Malelane Sugar Mill, which is located in the Lower Crocodile (East) River, was about 9 million m^3/a in 2014. No major expansions are planned for the large industrial consumers and it is expected that their water requirements will remain constant in the future.

Table (i): Summary of the Projected Urban Water Requirements

Local Municipality	Scenario	Projected Water Requirements (million m^3/a)						
		2016	2018	2020	2025	2030	2035	2040
City of Mbombela	Theoretical[1]	55.26	57.72	60.16	65.54	70.78	75.79	81.12
	High[2]	61.79	65.37	69.05	77.58	86.27	93.70	101.63
Bushbuckridge	Theoretical	34.28	34.78	35.30	36.56	37.79	39.01	40.20
	High	49.68	51.22	52.80	56.80	60.92	63.84	66.78
Emakhazeni	Scenario 4	2.60	2.75	2.90	3.40	3.80	4.35	4.98
Nkomazi	Scenario 3	2.81	2.90	2.99	3.29	3.58	3.83	4.07
Thaba Chweu	Scenario 1	2.59	2.61	2.63	2.69	2.75	2.82	2.89

1) Theoretical: The theoretically calculated water requirements according to nine level of service classes (**Section 3.2**).

2) High: The calibrated water requirements with changes in level of service over time (**Section 3.2**).

3) Scenario: The projection values were obtained from previous All Towns Reports and Water Reconciliation Strategies for BBR LM, Emakhazeni LM and Nkomazi LM (**Section 3.2**).

Irrigation Water Requirements and Return Flows

The largest irrigation water user in the Study Area is the Crocodile (East) Irrigation Board (IB) located along the Crocodile River. The Kaap (North and South) IB and White Waters IB are the other two major IB's in the Study Area. A Validation and Verification (V&V) Study is currently being finalised by the Inkomati Usuthu Catchment Management Agency (IUCMA). There are noticeable differences between the current V&V and the iWAAS (existing) Irrigation datasets. A desktop (high level) ground truthing exercise of the existing Irrigation datasets with land cover maps and satellite images was undertaken by the Professional Service Provider (PSP) during this Study Task. From the exercise, the V&V irrigation Dataset seems to be generally more realistic representation in the Crocodile (East) Sub- Catchment, and the iWAAS Irrigation dataset appears to be generally more realistic for the Sabie Sub-Catchment. The noticeable differences were discussed with the IUCMA, DWS, Department of Agriculture, Forestry and Fisheries (DAFF), and could not be confirmed by these stakeholders and it was reported that the verification process for the V&V Study is still in the process of being completed. The findings were presented to the Strategy Steering Committee (StraSC) where it was recommended and agreed that the iWAAS dataset will be applied for the purpose of this Study. A summary of the iWAAS Irrigation dataset is given in **Table (ii)**. The majority of the irrigation is located in the Middle Crocodile (X22) and the Lower Crocodile Tertiary Catchments (X24).

Table (ii): Inkomati Water Availability Assessment Irrigation Areas and Water Requirements

Tertiary Catchment	iWAAS (2009)	
	Area (km^2)	Water Requirements (million m^3/a)
Upper Crocodile (X21)	29	21
Middle Crocodile (X22)	212	149
Kaap (X23)	98	92
Lower Crocodile (X24)	162	192
Total for Crocodile	**501**	**454**
Sabie (X31)	102	82
Sand (X32)	26	17
Total for Sabie	**128**	**99**

Afforestation

There are noticeable differences between the V&V study data and the iWAAS Afforestation dataset. A high level ground truthing exercise was undertaken with satellite images, land use maps, as well as the iWAAS Afforestation data and V&V dataset shapefiles. It was established that the iWAAS Afforestation dataset was more representative of the actual afforestation area. The differences in afforestation areas were discussed with the stakeholders. It was confirmed that a small change in the afforestation area (±1% to 2%) has been noted, due to afforestation being replaced with Macadamia plantations and that the iWAAS dataset seems to be realistic. Afforestation occurs mostly in the Upper Crocodile (X21), Middle Crocodile (X22) and Sabie (X31) Tertiary Catchments as summarised in the afforestation summary in **Table (iii)**.

Table (iii): Inkomati Water Availability Assessment Study Afforestation Areas and Stream Flow Reduction

Tertiary Catchment	iWAAS (2009)	
	Area (km^2)	Streamflow reduction (million m^3/a)
Upper Crocodile (X21)	587	52
Middle Crocodile (X22)	901	66
Kaap (X23)	444	40
Lower Crocodile (X24)	12	0.4
Total for Crocodile	**1944**	**158**
Sabie (X31)	797	86
Sand (X32)	56	4
Total for Sabie	**853**	**90**

Reserve

The Reserve for the Crocodile (East) and Sabie Sub- Catchments was sourced from Government Gazette vol. 629 no. 41227. Reserve and Classification Studies that were undertaken previously, formed the foundation of the gazetted Reserve (DWS, 2015).

The National Water Act (Act No 26 of 1998) describes the reserve determination methodology in detail, under Chapter 3, Part 3. The two components of the Reserve are the basic human needs (BHN) and the ecological water requirements (EWR). The primary EWR Sites for the Study Area are summarised in **Table (iv).**

One of the primary objectives of the established reserve requirements for the Study Area is to meet the environmental water requirement for the Kruger National Park (KNP). The Crocodile (East) River forms the southern boundary of the KNP whilst the Sabie River flows through the KNP into Mozambique.

Table (iv): Primary Ecological Water Requirements Sites in the Study Area

Quaternary Catchment	Water Resource	Ecological Reserve (% of NMAR)[4]	Basic Human Needs Reserve (% of NMAR)[3]	Total Reserve (% of NMAR)[2]	NMAR (million m^3/a)[1]
X21A	Crocodile River (EWR 1: Valyspruit)	30.9	0.0	30.9	15.2
X21B	Crocodile (EWR 2: Goedenhoop)	57.0	0.0	57.0*	47.1
X21E	Crocodile (EWR 2: Poplar Creek)	55.2	0.1	55.3	169.9
X21G	Elands River (EWR ER 1)	48.8	0.3	49.1	50.1
X21K	Elands River (EWR ER 2)	45.0	0.0	45.0	50.1
X22K	Crocodile (EWR 4: KaNyamazane)	24.5	0.0	24.5	754.1
X23G	Kaap River (EWR 7: Honeybird)	26.8	0.0	26.8	169.0
X24D	Crocodile (EWR 5: Malelane)	40.2	0.0	40.2	1006.2
X24H	Crocodile (EWR 6: Nkongoma)	42.9	0.0	42.9	1062.1
X31B	Sabie River (EWR 1: Upper Sabie)	46.2	0.0	46.2	140.2
X31C	Mac Mac River (EWR 4: Mac Mac)	27.0	0.0	27.0	65.8
X31D	Sabie River (EWR 2: Aan de Vliet)	25.7	0.1	25.8	262.1
X31G	Marite River (EWR 5: Marite)	26.2	0.1	26.3	157.1
X31K	Sabie River (EWR 2: Kidney)	27.0	0.1	27.1	495.9
X32C	Tlulandziteka (Sand) River (EWR 7: Upper Sand)	21.7	0.6	22.3	28.9
X32F	Mutlumuvi River (EWR 6: Mutlumuvi)	22.2	0.4	22.6	45.0
X32J	Sand River (EWR 8: Lower Sand)	25.2	0.2	25.6	122.6

Source: Government Gazette vol. 629 no. 41227

1) NMAR is the Natural Mean Annual Runoff.

2) The total Reserve accounts for both the Ecological Reserve and the Basic Human Needs Reserve (BHN).

2) Represents the percentage of BHN.

4) This amount represents the long term mean based on the NMAR. If the NMAR changes, this volume will also change.

Invasive Alien Plants

Information about Invasive Alien Plants (IAPs) was sourced from previous Working for Water (WFW) datasets, which is an Invasive Alien Eradication Program under the Department of Environmental Affairs (DEA), iWAAS IAP dataset and the Agricultural Research Council (ARC) National Invasive Alien Plant Survey (NIAPS), which was completed in 2011 (***ARC, 2011***). From the dataset comparison, it is evident that the iWAAS IAP condensed areas are on average greater than those of the IAP Survey, except for the Upper Crocodile Tertiary Catchment. These discrepancies between the datasets need to be investigated in order to confirm the most realistic and accurate data set. A conservative approach for the purpose of this Study was followed by applying the iWAAS dataset, of which a summary is given in **Table (v)**, unless additional information is made available prior to this Water Resource Analysis Task that confirms the NIAP Survey as more realistic.

Table (v): Inkomati Water Availability Assessment Study Invasive Alien Plant Summary

Tertiary Catchment	iWAAS (2009)
	Condensed area (km^2)
Upper Crocodile (X21)	89
Middle Crocodile (X22)	122
Kaap (X23)	69
Lower Crocodile (X24)	15
Total for Crocodile	**295**
Sabie (X31)	81
Sand (X32)	22
Total for Sabie	**103**

International obligations

The Crocodile and Sabie Rivers form part of the Inkomati River system which is shared between Mozambique, the Republic of South Africa (RSA) and Swaziland, hence; there are international water obligations towards both Mozambique and Swaziland. The Tripartite Permanent Technical Committee (TPTC) between South Africa, Mozambique and Swaziland, has set out the required base flows out of the RSA.

The Piggs Peak Agreement (TPTC, 1990) specified a minimum flow of 2 m^3/s from the Crocodile (East) and Komati Rivers into Mozambique. The arrangement is that the Crocodile (East) River and the Komati River will contribute 0.9 m3/s and 1.1 m^3/s respectively. The Piggs Peak Agreement (TPTC, 1990) has been superseded by the Tripartite Interim

IncoMaputo 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 (TPTC, 2002). The Determination of Water Resource Classes and Associated Resource Quality Objectives in the Inkomati Water Management Area (**DWS, 2015**) reported that this agreement has yet to be implemented pertaining to the cross border flows, which have been increased from 2 m^3/s to 2.6 m^3/s. A minimum cross boarder flow of 0.6 m^3/s from the Sabie River into Mozambique at the Lower Sabie River has also been specified.

Summary of Water Use Sectors

The projection base year (2016) for domestic, industrial, irrigation and afforestation water requirements, as well as any transfers into and out of the entire Crocodile (East) and Sabie Sub- Catchments are summarised in **Table (vi)**. The base year (2016) on which the urban/domestic water requirement projections are based, was selected for the demographic projection, since this is the latest official demographic data from Statistics South Africa (StatsSA) 2016 Community Survey.

The irrigation and forestry sectors are the largest water users in the Study Area, with the largest domestic, irrigation and afforestation water requirements are located in the Middle Crocodile, Lower Crocodile and Upper Sabie Tertiary Catchments respectively. The reduction in runoff due to IAP species is not a planned consumption and is therefore not included in the Water Requirements Summary **Table (vi)**.

Table (vi): Water Requirements Summary for 2016

Tertiary Catchments	Water Requirements in 2016 (million m^3/a)				
	Domestic and light Industrial	Industrial	Irrigation	Forestry	Total
Upper Crocodile (X21)	2	15	21	52	90
Middle Crocodile (X22)	56	-	149	66	271
Kaap (X23)	6	-	92	40	138
Lower Crocodile (X24)	14	9	192	0.4	215
Total for Crocodile	**78**	**24**	**454**	**158**	**714**
	11%	**3%**	**64%**	**22%**	**100%**
Upper Sabie (X31)	39	-	82	86	207
Sand (X32)	13	-	17	4	34
Total for Sabie	**52**	**0**	**99**	**90**	**241**
	21%	**0%**	**41%**	**37%**	**100%**

The summary **Table (vi)** of the water requirements for the Study Area is illustrated as pie chart in **Figure (i)**, indicating that the irrigation sector has the greatest water requirements component in the Study Area, followed by commercial afforestation (forestry), domestic and industrial users.

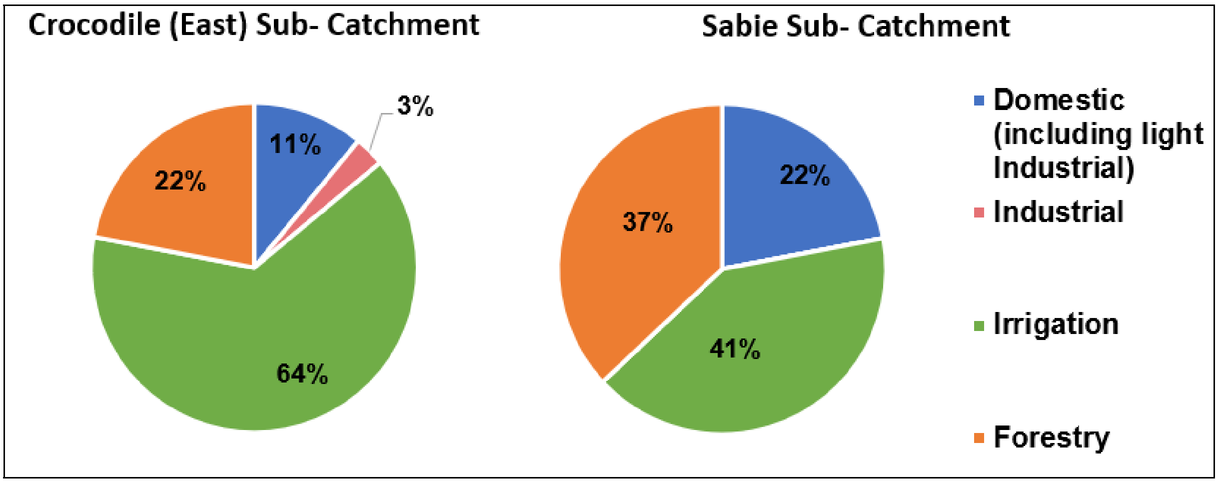

Figure (i): Summary of water requirements for 2016

The Reserve water requirements were not included in the above summary as these requirements are variable and related to the flow in the river. The international obligations were also not included in the above summary as they are minimum flows that need to be adhered to. The Water Resource Analyses task will confirm whether any additional support, over and above the EWRs is required.

Stakeholder Engagement

Stakeholder engagement formed an essential component of the information gathering process. The engagement consisted of meetings, telephonic conversations and emails with the IUCMA, Sembcorp Silulumanzi, CoM LM, BBR LM and Rand Water. Stakeholder inputs to the task process and results also took place through the Technical Support Group (TSG) and StraSC meetings held, where the findings presented in this report were presented and discussed.

Conclusions and Recommendations

The Water Requirements and Return Flows Task provides an overview of both the Sabie and Crocodile (East) Sub- Catchment. The majority of the water requirements in both Sub-Catchments are for irrigation, followed by commercial afforestation, domestic and industrial users.

Some of the major demand centres, such as Nsikazi South, Nsikazi North, and detailed information on the bulk supply scheme and transfer volumes in the BBR LM, had limited information available on the current and historic water use.

It was found that rural portions of Study Area, such as Nsikazi North, Nsikazi South and portions of BBR LM have intermittent water supply, which indicate either system inefficiencies, insufficient water treatment and distribution infrastructure or water resources. Noticeable differences were found in the current irrigation and afforestation areas from the V&V and iWAAS datasets, it was determined that the iWAAS Afforestation dataset is generally more realistic for the entire Study Area. It was reported that the verification process of the V&V study had not been completed and it was thus recommended by the PSP and agreed by the TSG that the iWAAS Dataset will be applied in the study. It is however recommended that the presented discrepancies in irrigation areas should be further investigate and confirmed as part of the finalisation of the V&V.

From the comparison of IAP Datasets, it was evident that the condensed iWAAS IAP areas were on average greater than the NIAP Survey areas, except for the Upper Crocodile Tertiary Catchment. These discrepancies should be investigated and confirmed. A conservative approach will be followed by applying the iWAAS dataset, unless additional information is made available prior to the Water Resource Analysis task that confirms the NIAP Survey as more realistic.

It is recommended that the following actions be taken to rectify and improve the current water use and water supply information in the Study Area:

- Metering of the water use in all the demand centres should be prioritised and datasets should also be made available. This would allow for improved operations and planning by the relevant authorities in future.
- The differences between the V&V Dataset and iWAAS Irrigation and Afforestation Datasets should be investigated and confirmed during the finalisation of the V&V Study.
- The IAP Datasets should be investigated to confirm the most realistic and accurate dataset pertaining to the iWAAS IAP Dataset and the NIAP Survey Dataset.
- The intermittent supply and illegal connections should be addressed from a political and institutional level, with stakeholder engagement to allow for continuous reliable supply of water to all the residents in the rural and urban areas.

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LIST OF ABBREVIATIONS AND ACRONYMS

AADD	Average Annual Daily Demand
ARC	Agricultural Research Council
BHN	Basic Human Need
BBR	Bushbuckridge
BJE	Black Jills Engineers Pty Ltd.
CoM	City of Mbombela
DAFF	Department of Agriculture, Forestry and Fisheries
DM	District Municipality
DWA	Department of Water Affairs (now DWS)
DWAF	Department of Water Affairs and Forestry (now DWS)
DEA	Department of Environmental Affairs
DWS	Department of Water and Sanitation
EWR	Ecological Water Requirements
FSC	Full Supply Capacity
IAPs	Invasive Alien Plants
IDP	Integrated Development Plan
IB	Irrigation Board
IIMA	Interim IncoMaputo Agreement
IUCMA	Incomati Usuthu Catchment Management Agency
iX	iX Engineers Pty Ltd.
iWAAS	Inkomati Water Availability Assessment Study
JV	Joint Venture
KNP	Kruger National Park
LM	Local Municipality
LOS	Level of Service
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MEA	Mean Annual Evaporation
NIAPS	National Invasive Alien Plant Survey
NIS	National Information System
NMAR	Natural Mean Annual Runoff
NWRP	National Water Resource Planning
PSP	Professional Services Provider
RDP	Reconstruction and Development Programme
RFF	Return Flow Factor
RSA	Republic of South Africa
RWSS	Regional Water Supply Scheme
SANParks	South African National Parks
SAPWAT	Irrigation Water Requirements Software
SIV	System Input Volume
SSC	Strategy Steering Committee

StatsSA	Statistics South Africa
StraSC	Strategy Steering Committee
TPTC	Tripartite Permanent Technical Committee
TSG	Technical Support Group
V&V	Validation and Verification
WC/WDM	Water Conservation and Water Demand Management
WfW	Working for Water
WQT	Water Quality and Total Dissolved Salts (WQT) Model
WRP	WRP Consulting Engineers Pty Ltd.
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 Associations

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
million m^3/a	Million Cubic Metre per Annum
m^3/s	Cubic Metres per Second
%	Percentage

1 INTRODUCTION

1.1 Background to this Study

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 for the Mbombela Municipal Area, referred to as the Strategy hereafter, to be implemented, and for the Strategy to remain relevant in order 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.

1.2 Objectives of this Study

The overall objective of this Study is to systematically 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. In addition to the Mbombela Municipal Area, smaller towns in the neighbouring catchments were also considered at a desktop level of detail, namely Machadodorp, Waterval Boven, Dullstroom, Sabie, Graskop, Malelane, Hectorspruit and Komatipoort, which is an extension of the footprint 2015 Strategy.

1.3 Study Area

The Study Area includes 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 is 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 (BBR) 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.

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 and Nsikazi River. The Crocodile River finally merges with the Komati River close to Komatipoort, where it becomes the Incomati River. A major tributary of the Sabie River is the Sand River, which has its origin on the border of Thaba Chweu LM and BBR LM and the Marite River, which is regulated by releases from the Injaka Dam. The Sabie River impounds the Corumana Dam in Mozambique, which is upstream of the confluence with the Sabie River and the Incomati River within Mozambique, where it discharges into the Indian Ocean as the Incomati River to the north of the City of Maputo, Mozambique.

There are two major dams in the Study Area, which are the Injaka Dam in BBR LM, Kwena Dam in the Thaba Chweu LM, as well as smaller dams in the CoM LM such as Witklip Dam, Longmere Dam, Klipkopjes 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, followed by commercial afforestation. The shared watercourses with Mozambique are regulated by international water sharing obligation.

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.

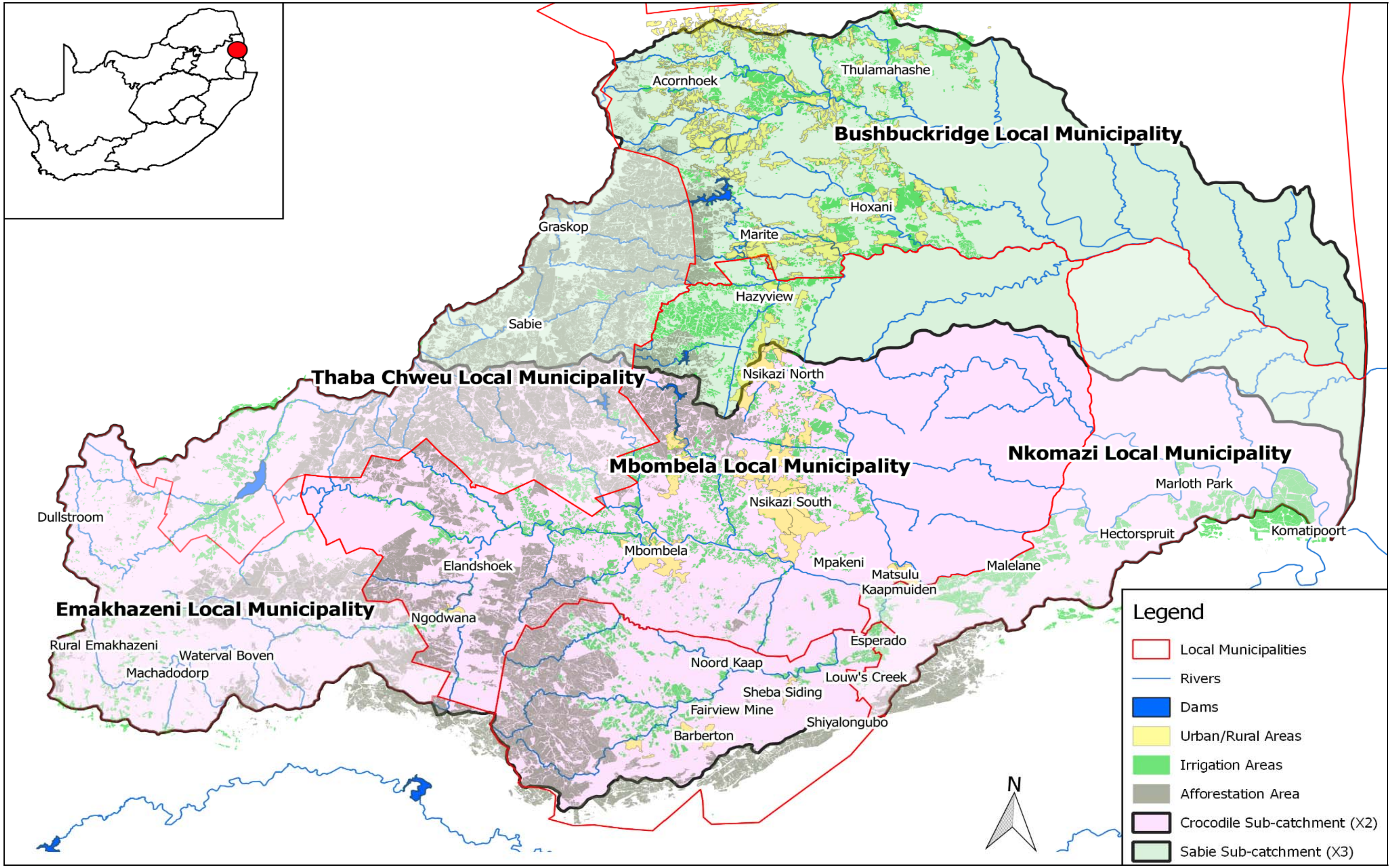

Figure 1-1: Map of the Study Area

1.4 Purpose and Structure of this Report

This report provides an overview and summary of the current (2016 base year) and projected (2040) water requirements and return flows of the various water use sectors in the focus Study Area. The purpose of this report is to:

- To develop a set of water requirement projections to the year 2040 for the Study Area, for subsequent use in the water resources and infrastructure planning tasks.
- Document, describe, evaluate, assess and develop the current and future projected water requirements (up to 2040) for all the water use sectors, to gain an understanding of the current and future water use in the Study Area.
- Document and describe the various water use information that was sourced and collated including the impact of IAP and commercial afforestation on the focus Study Area.
- Document and describe the current and future projected return flows generated by some of the water user sectors.

The report is structured as follows:

- **Section 1** provides a formal overview of the Study Area, this strategy and the methodology followed to obtain water requirements.
- **Section 2** presents an overview of the water sources (surface water and groundwater), water service providers and water and waste water treatment works.
- **Section 3** contains the domestic and industrial water requirements and return flows. The section is presented according the various LMs, for continuity and alignment with previous DWS All Town Reconciliation Strategies.
- **Section 4** presents the irrigation and afforestation water use sectors, as well as the irrigation return flows.
- **Section 5** covers the invasive alien plant (IAP) areas, gazetted Reserve volumes, international water sharing obligations and an overview of General Authorisation water use.
- **Section 6** provides summary of the total water requirements for the Study Area.
- **Section 7** presents an overview of stakeholder engagement for this Study Task.
- **Section 8** contains the conclusions and recommendations to this report.
- **Section 9** indicates the study references.

2 WATER RESOURCES AND SUPPLY

2.1 Water Supply Schematic

Various data sources were reviewed and collated to produce a simplified water supply schematic for the Study Area, shown in **APPENDIX B**. The schematic links the available water sources to the relevant demand centres and forms the basis for the descriptions in this report. The simplified schematic focuses on urban/domestic demand centres and their respective sources, as well as their return flows, where applicable. Information from the *iWAAS*, which was completed in 2011, previous *All Towns Reports and Water Reconciliation Strategy Reports*, which were completed for the various demand centres and LMs in the Study Area, were used as a foundation for the simplified schematic. An overview map of the large dams and demand centres in the Study Area is shown in **APPENDIX A**.

2.2 Water Services Providers

The Water Services Providers (WSPs) are responsible for raw water abstraction, treatment and distribution. In some cases, the LM performs treatment and abstraction and the WSP distributes the water. The BBR LM is unique, as Rand Water has taken over the treatment and bulk supply task, without owning the infrastructure. BBR LM is responsible for distributing the potable water. In CoM LM there are two WSPs namely, Sembcorp Silulumanzi and CoM LM. The WSP arrangements are discussed in **Section 2.2.1** to **Section 2.2.4**.

2.2.1 Mbombela Municipality

The CoM LM supplies water to White River and owns, maintains and operates the Kanyamazane and Hazyview water treatments works (WTW) adjacent to the Crocodile (East) River. The bulk water supply from the Kanyamazane WTW also supplies the Sembcorp Silulumanzi concession area with treated water.

2.2.2 Sembcorp Silulumanzi

Sembcorp Silulumanzi is the water service provider (WSP) operating on behalf of CoM LM for parts of the LM. The concession area includes parts of Nsikazi South, which are Tekwane, Msogwaba, Zwelisha, Kanyamzane Luphisi, Mbombela City, Matsulu and Mpakeni. Sembcorp operates and maintains the Mbombela WTW and Matsulu WTW within their concession area. An estimated population size of 350 000 people is served by the WSP and the raw water is abstracted primarily from the Crocodile (East) River, as well as some boreholes.

The CoM (former Nelspruit) abstracts raw water from a canal, which diverts water from the Crocodile River, and is supported by releases from Kwena Dam, which is treated at the Mbombela WTW. The Matsulu demand centre is supplied with water by the Matsulu WTW, which abstracts water from the Crocodile River. Parts of Kanyamazane (Nsikazi South) are also supplied by Sembcorp Silulumanzi, however the Kanyamazane WTW is operated by CoM LM as part of the regional water supply scheme. Luphisi and Mpakeni are supplied by Sembcorp Silulumanzi from groundwater which is disinfected before distribution.

2.2.3 Rand Water

Rand Water is contracted by DWS, BBR LM and CoM LM to operate and maintain Injaka WTW, Hoxane WTW, Thulamahashe and Acornhoek WTW, which are used to supply the BBR LM and Nsikazi North. The Injaka WTW is the largest with a design capacity of 36.5 million m^3/a (100 Ml/d).

2.2.4 Summary of Institutional Arrangement

A summary of WSP in the Study Area and their activity in larger demand centres is given in **Table 2-1**.

Table 2-1: Summary of WSP's

Demand Centres	Water Services Authorities	Water Services Providers	Raw Water Source(s)
Acornhoek	BBR LM	Rand Water, BBR LM	Injaka Dam and Acornhoek Dam
Hazyview	CoM LM	CoM LM	Sabie River
Hoxane	BBR LM	Rand Water, BBR LM	Injaka Dam and Sabie River
Karino Plaston Cor.	CoM LM	Sembcorp Silulumanzi	Injaka Dam and Primkop Dam
Marite	BBR LM	Rand Water, BBR LM	Injaka Dam and Marite Weir
Matsulu	CoM LM	Sembcorp Silulumanzi	Sabie River
CoM City	CoM LM	Sembcorp Silulumanzi	Sabie River
Ngodwana	CoM LM	CoM LM	Ngodwana Dam and Elands River
Nsikazi North	CoM LM	Rand Water	Sabie River and

Demand Centres	Water Services Authorities	Water Services Providers	Raw Water Source(s)
Nsikazi South	CoM LM	Rand Water CoM LM	Crocodile (East) River
Thulamahashe	BBR LM	Rand Water, BBR LM	Injaka Dam and Edinburgh Dam
Barberton	CoM LM	CoM LM	Lomati Dam and Kaap River
White River	CoM LM	CoM LM	Crocodile (East) River, smaller dams

2.3 Water and Waste Water Treatment Works

2.3.1 Water Treatment Works

There are six major WTW in the Study Area, namely the CoM WTW, Kanyamazane WTW, Matsulu WTW, Nyongane WTW, Injaka WTW and Hoxani WTW. In addition, there are also eight smaller package WTWs. The summary of the WTW's in BBR LM is shown in **Table 2-2**, CoM LM in **Table 2-3** and former Umjindi in

Table 2-4.

The data was sourced from *All Towns Reports*, *Blue Drop Reports* and *WSP's*. The presented information of some of the smaller package plants is lower in confidence or not available. A drought period was experienced during the 2015 to 2017 hydrological years, which restricted the production of some WTW, such as Thulamahashe WTW, Sand River WTW, Edinburgh WTW, Mshadza WTW, Dwaleni WTW and Mgaduzweni WTW. To ensure that the water requirements are not projected from a restricted production volume, the production volumes for those WTWs were not taken from actual readings, but from historic production volumes that increased in line with the population growth over the 2015 to 2017 hydrological years.

Table 2-2: Summary of Water Treatment Works in Bushbuckridge Local Municipality

Demand Centres	Water Treatment Works	Water Resource(s)	Average Production in 2016 (million m^3/a)	Average Annual Daily Demand (AADD) (Ml/d)
Marite	Injaka WTW	Injaka Dam	3.0	8.2
	Marite WTW	Nwaritjie Dam (releases from Injaka Dam)	0.9	2.5
Hoxane	Hoxane WTW	Sabie River (releases from Injaka Dam)	9.5	26.0
	Cork WTW	Sabie River	0.9	2.5
Thulamahashe	Injaka WTW	Injaka Dam	11.8	32.3
	Thulamahashe	Mutlumuvi River	2.3	6.3
	Edinburgh North and East WTW (combined)	Edinburgh Dam	0.6	1.6
	Thorndale WTW	Sabie River	0.5	1.4
	Dingleydale A&B WTW (combined)	Sabie River	0.7	1.9
	Sand River WTW	Sand River	0.3	0.8
Acornhoek	Injaka WTW	Injaka Dam	17.8	48.7
	Acornhoek (Rooiboklaagte) WTW	Acornhoek Dam and Klein Sand River	1.4	3.8
	Brooklyn WTW*	N/A	0.4	1.1
	Shatale Weir WTW	Marite River	0.4	1.1
	Zoeknog WTW	Nwarhele River	0.4	1.1
Total			**50.9**	**139.3**

* Supplemented by borehole water supply

Table 2-3: Summary of Water Treatment Works in City of Mbombela Local Municipality

Demand Centres	Water Treatment Works	Source	Average Production in 2016 (million m^3/a)	Average Annual Daily Demand (AADD) (Ml/d)
Hazyview	Hazyview WTW	Sabie River	1.1	3.0
Mbombela City	Nelspruit WTW	Crocodile River	19.7	53.9
White River	White River WTW	Sand River	2.1	5.7
	White River Country Estate WTW	White River	0.4	1.1
Karino/Plaston	Karino WTW	Crocodile River	0.4	1.1

Demand Centres	Water Treatment Works	Source	Average Production in 2016 (million m^3/a)	Average Annual Daily Demand (AADD) (Ml/d)
	Primkop WTW	White River	0.2	0.5
Nsikazi South	Kanyamazane WTW	Crocodile River	21.9	60.0
Nsikazi North	Mganduzweni WTW	Mganduzweni Dam	0.3	0.8
	Manzini WTW	Unknown	N/A	N/A
	Majika WTW	Unknown	N/A	N/A
	Mshadza	Nsikazi River	0.8	2.2
	Nyongane WTW	Sabie River	8.0	21.9
	Mjejane WTW	Nsikazi River	0.2	0.5
Matsulu	Matsulu WTW	Crocodile River	4.4	12.0
Elandshoek	Elandshoek WTW	Elands River	0.1	0.3
Ngodwana	Sappi Ngodwana WTW	Ngodwana Dam	18.3	50.1
Total (excluding the Manzini and Majika WTWs)			**77.9**	**213.1**

Table 2-4: Summary of WTW's in former Umjindi LM (currently CoM LM)

Demand Centres	Water Treatment Works	Source	Average Production in 2016 (million m^3/a)	Average Annual Daily Demand (AADD) (Ml/d)
Sheba Sliding	Sheba Siding WTW	Kaap/ Suidkaap	0.4	1.1
Barberton	Rimers Creek WTW	Lomati Dam (transfer)	6.8	18.6
	Emjindini Trust WTW	N/A	N/A	N/A
	Suid Kaap WTW	N/A	N/A	N/A
Total (excluding the Emjindini Trust and Suid Kaap WTWs)			**7.2**	**19.7**

2.3.2 Wastewater Treatment Works

WWTW treatment volumes were sourced from the *Green Drop Report* Sanitation is only present in formal parts of the Study Area such as CoM, White River, some areas of Nsikazi South, such as Kanyamazane, Matsulu, Barberton, portion of Acornhoek, and the town of Bushbuckridge. Informal areas rely on septic tanks and pit latrines for waste water disposal. The waste water treatment works (WWTW) information is summarised in **Table 2-5**.

Table 2-5: Summary of WWTW's for the Study Area

Demand Centres	Waste Water Treatment Works	Receiving Rivers/ Streams	Design Capacities (million m^3/a)	Average Releases (million m^3/a)
Marite	Maviljan WWTW	Stream upstream of Injaka Dam	0.3	0.3
Hoxane	Sand River Military Base WWTW	Sand River	0.5	0.2
	Manghwazi WWTW	Sabie River	N/A	0.0
	Hoxane WWTW		0.3	0.3
	Mkhuhlu WWTW		0.8	0.8
Thulamahashe	Thulamahashe WWTW	Sand River	0.6	0.6
	Dwarsloop WWTW	Nwarhela River	0.6	0.6
Acornhoek	Acornhoek WWTW	Unknown	0.2	0.2
	Acornhoek Police Station WWTW		0.4	0.03
	Tintswalo Hospital WWTW		0.6	0.6
Hazyview	Hazyview WWTW	Sabie River	0.3	0.3
	Hazyview new WWTW		2.0	1.6
Nelspruit	Kingstonvale Old and New WWTW (combined)	Crocodile (East) River	9.5	4.8
	Rockys Drift WWTW	Tributary of the Nels River	0.7	0.2
Nsikazi South	Kabokweni WWTW	Gutshwa River	1.4	0.7
White River	White River WWTW	White River Stream	2.2	0.9
Nsikazi South	Kanyamazane WWTW	Crocodile (East) River	4.4	1.6
	Emoyeni Package Plant		0.1	0.1
	Tekwane North Package Plant WWTW		0.1	0.1
Matsulu	Matsulu WWTW		2.2	0.9
Elandshoek	Elandshoek WWTW	Elands River	0.04	0.02
Ndogwana	Sappi Ngodwana WWTW	Ngodwana River	0.7	0.3
Barberton	Barberton WWTW	Farm dam to the Nels Creek River	3.1	4.6
Total			**31.1**	**19.8**

2.4 Water Resources

The two major dams in the Study Area are Kwena Dam and Injaka Dam, with Full Supply Capacities (FSCs) of 159 million m^3 and 125 million m^3 respectively. There are several smaller dams in the Crocodile (East) Sub- Catchment, such as the Ngodwana Dam that serves the town of Ngodwana and the Sappi Paper Mill. Furthermore, the Klipkopjes Dam, Longmere Dam and Primkop Dam are all on the Wit River, which is a tributary of the Crocodile River (East), and the town of White River and Rockys Drift are partially supplied by the Witklip Dam and Longmere Dam. See **APPENDIX A** for an overview map of the Study Area, indicating the large dam names.

Smaller irrigation dams in the Sabie Sub- Catchment, include Edinburgh Dam, Acornhoek Dam and Da Gama Dam. The White River IB owns and operates the Da Gama Dam.

The majority of the LMs in the Study Area make limited use of groundwater resources, except for the towns of Kaapsehoop, Luphisi (in Nsikazi South), Mpakeni, Thaba Chweu LM and smaller rural settlements throughout the Study Area. Rural areas in the BBR LM within the Thulamahashe Demand Centres are also supplied with groundwater from boreholes. Groundwater use information was generally unavailable from the WSP and sourced from the *All Towns Reports.*

A summary of the significant dams in the Study Area is presented in **Table 2-5** according to their respective catchments. The d was obtained from the *iWAAS report* which was completed in 2011. There are two sub- catchment transfers into the Study Area from the Lomati Dam on the Lomati River to the town of Barberton and from the Shiyalongubo Dam on the Ugutugulo River to the Shiyalongubo water supply area ***(DWAF, 2009)***.

Table 2-6: Summary of major dams in Study Area

Sub-Catchment	Reservoir Name	River	Full Supply Capacity (million m^3/a)	Purpose
Crocodile (East) (X2)	Klipkopjes Dam	Wit River	11.9	Domestic
	Kwena Dam	At confluence of Crocodile (East) River, Lunsklip River, Alexanderspruit River	158.9	Irrigation/ Domestic/ Industrial
	Longmere Dam	Wit River	4.3	Irrigation/ Domestic
	Ngodwana Dam	Ngodwana River	10	Irrigation/ Domestic/ Industrial
	Primkop Dam	Wit River	2	Domestic

Sub-Catchment	Reservoir Name	River	Full Supply Capacity (million m^3/a)	Purpose
	Witklip Dam	Sand River (Crocodile (East) Catchment	12.7	Domestic
Sabie (X3)	Da Gama Dam	White Water River	13.6	Irrigation
	Edinburgh Dam	Mphyanyana River	3.3	Irrigation/ Domestic
	Injaka Dam	Marite River	125	Domestic
	Kasteel Dam	Tributary of Tlulandsiteka River	1.2	Losses (evaporation & other)
	Maritsane Dam	Tributary of Sand River	2	Domestic
	Orinoco Dam	Tributary of Mutlumuvi River	1.9	Irrigation
Total			**346.8**	

Source: (***DWAF, 2009***)

3 URBAN/DOMESTIC AND INDUSTRIAL WATER REQUIREMENTS

3.1 Introduction to Urban/Domestic Use Sector

There are five LMs in the Study Area, which are discussed in **Section 3.3** to **Section 3.7**. They are presented in separate sections to allow for a consistent approach in comparing the data obtained in this Study with previous reports for the individual LMs, in addition this approach allows for the discussion of the information in a grouped spatial context.

The methodology as outlined in **Section 3.2** was applied to the focus area of the study (CoM LM, former Umjindi LM and BBR LM). For the remainder of the Study Area, existing information from the previous *Reconciliation Strategy Reports* and *All Towns Studies* was used. These other areas include parts of the Thaba Chweu LM, Nkomazi LM and Emakhazeni LM. The confidence in data obtained from the previous studies will be highlighted throughout this Report. The demand centres are shown in the summary overview map in **APPENDIX A**.

3.2 Methodology to Determine the Water Requirements and Return Flow Projections

The urban water use sector includes the water requirements for both domestic users and light industries. For the focus area, a total of 9 level of service (LOS) categories were formulated as summarised in **Table 3-1**. The population projections (realistic and high scenarios) and associated LOS for each demand centre were obtained from the *Economic Growth and Demographic Analysis Task*, *Report P WMA 03/X22/00/6818*, which was completed prior to the water requirements and return flow task (this report). The actual water volumes for 2016 were obtained through consultation with WSPs, LMs, previous All Towns Reports and other stakeholders.

The theoretical water requirement projections were calculated by means of applying the theoretical unit consumptions (refer to **Table 3-1**) to the population projections until 2040. The indirect requirements, which relate to additional services and industries, such as educational, medical and institutional facilities and light industry, were assumed as an additional 51% for medium towns and 38% for small towns and settlements (DWAF, 2001). Theoretical system distribution and WTW losses were assumed to be 20% as recommended by the RDP Rural Water Supply Design Criteria Guidelines (DWAF, 1997). The theoretical water requirements projections assumed a constant LOS throughout the projection period.

Table 3-1: LOS categories

Category		Demand Category	Unit Consumption (l/c/d)
Formal	1	Flats	226
	2	Clusters	255
	3	Low Income	101
	4	Medium Income	189
	5	High Income	304
	6	Very High Income	442
Informal	7	Below RDP* Level	12
	8	RDP* Level	40
	9	Above RDP* Level	80

* RDP = Reconstruction and Development Programme

** Note that the current national average per capita water use is 237 ℓ/c/d. The DWS National Water and Sanitation Master Plan states that this should be reduced to the world average value of 173 ℓ/c/d world average.

The theoretical water requirement projections were calibrated against the water use data for the 2016 base year.

Two projected LOS increase scenarios were defined for the water requirements projections through consultation with the Technical Support Group (TSG) for this Study. A scenario was selected for each demand centre based on the current LOS.

Scenario 1 is applicable to intermediate towns (current LOS formal and informal) and the projected increase in LOS is summarised below:

- The minimum LOS is assumed to be at RDP Level by 2030.
- Residential Low-Income LOS increases by 5% from 2016 to 2030 and a further 6% increase by 2040 (total of 11%).
- Residential Medium Income LOS 2.5% from 2016 to 2030 and a further 2.3% increase by 2040 (total of 4.8%).

Scenario 2 is applicable to informal villages (current LOS mostly informal), where most of the residents only receive below RDP LOS and free basic water and the projected increase in LOS is summarised below:

- The minimum LOS is assumed to be at RDP Level by 2030.
- RDP Level increase by 5% from 2016 to 2030 and a further 6.7% increase by 2040 (total of 11.7%).

- Residential Low Income increases by 2.5% from 2016 to 2030 and a further 3% increase by 2040 (total of 5.5%).

The changes in the LOS were assumed to occur linearly over the reference time. The following steps were undertaken to derive water urban domestic requirements projections for the focus Study Area of this Study:

- The population projection and associated LOS's were obtained for the projection base year of 2016 for each demand centre from *Economic Growth and Demographic Analysis Task*, *Report P WMA 03/X22/00/6818* for this Study.
- The theoretical LOS water use categories were applied to the population figures that were split into the different LOS categories (see **Table 3-1**). It was assumed that the additional water requirements by indirect users, was 51% for intermediate towns or small cities and 38% for smaller towns and settlements (DWAF, 2001), and the treatment and distribution losses were of 20% (DWAF, 1997) for the purpose of the theoretical water use calculation.
- The population projection was multiplied with the theoretical unit consumption per LOS category, indirect use component and losses in order to obtain the theoretical projections.
- The theoretical projections were calibrated against the actual 2016 water use values by applying a constant factor to the unit consumption for all LOS categories. The projected increase in LOS over time was applied according to the selected LOS scenario and the demand centre characteristics.
- The return flow projections were derived by applying the Return Flow Factors (RFFs) to the water requirement projections for each of the demand centre. The RFFs will likely increase in future as additional sanitation services are implemented with improved level of services. A constant RFF was assumed which is conservative from a water resources perspective.

3.3 City of Mbombela Local Municipality (including former Umjindi Local Municipality)

3.3.1 Historical Water Use in the City of Mbombela Local Municipality

The demand centre in the CoM LM are Elandshoek, Ngodwana, White River, CoM (former Nelspruit), Karino Plaston Corridor, Matsulu, Mpakeni, Nsikazi North and Nsikazi South

Cluster. The major demand centres in the area are Matsulu, CoM, Nsikazi North, Nsikazi South and White River.

The demand centres within the former Umjindi LM are Barberton and smaller mining and agricultural towns, such as Sheba Siding, Fairview Mine and Shiyalongubo. A summary of the historic was use and associated information sources for all the demand centres are presented in **Table 3-2** (CoM LM) and **Table 3-3** (Umjindi LM).

The data presented in **Table 3-2** is a collation of System Input Volumes (SIV) from the previous *Reconciliation Strategy* for Mbombela and Umjindi LM, as well as the *Municipal Water and Sanitation Master Plan* and WSPs. Priority was given to data from bulk water meter readings provided by the WSP (Sembcorp Silulumanzi and Rand Water). Where the bulk meter data was not plausible due to major annual variation, values were then sourced from previous *Reconciliation Strategies* and the *Mbombela Water and Sanitation Master Plan.* The gaps in the historic data indicate missing base data, which could not be sourced.

Data for the smaller towns and settlements such Ngodwana and Elandshoek was estimated and extrapolated from previous *All Towns* and Blue Drop *Reports*. Data for the larger demand centres such as CoM, White River, Karino Plaston, Matsulu and Hazyview was obtained directly from the WSP and regarded as high confidence. For Nsikazi North and South data was sourced from the previous *Reconciliation Strategy for Mbombela LM* (for 2011) as well as the *Mbombela Municipal Water and Sanitation Master Plan* (for 2016).

Nsikazi North had an estimated SIV of 6.9 million m^3/a in 2005 which increased to an estimated annual SIV of 7.24 million m^3/a in 2008 according to the *All Towns Report which was completed in 2011* ***(DWA, 2011m)***. The *Reconciliation Strategy for Mbombela LM* reported a 2013 SIV of 8 million m^3/a. These volumes are however low when compared to the theoretically calculated SIV of 10.3 million m^3/a. Both studies also reported intermittent water supply to portions of the demand centre, which is why the reported SIVs are lower. The calculated theoretical water use was thus accepted as the 2016 base value.

Nsikazi South showed a noticeable variance in historic SIVs from the various sources. The previous *All Towns Report* which was completed in 2011 and indicates a SIV of 19.7 million m^3/a for 2005 and an estimated 21 million m^3/a for 2008 ***(DWA, 2011m)***. The *Municipal Water and Sanitation Master Plan* indicates a SIV of only 10.6 million m^3/a for 2016. The water use license for the demand centre is only 11.2 million m^3/a. and the Kanyamzane WTW design capacity is 21.9 million m^3/a. The theoretically calculated SIV is 19.2 million m^3/a, which is similar to the total Kanyamazane WTW production volume supplying the area accepted as the 2016 base water use volume for Nsikazi South.

Furthermore, it should be noted that a drought was experienced during the 2015 to 2017 hydrological period and therefore the base water requirements value was increased to the expected water requirements without restrictions where applicable. It would have been incorrect to make projections from restricted base value. See **APPENDIX A** for overview map of demand centres.

Table 3-2: Historic Water Use of former Mbombela LM

Demand Centres	Historical System Input Volume for 2016 (million m^3/a)						Source
	2012	2013	2014	2015	2016	2017	
Ngodwana	-	-	0.5	-	0.7	-	DWA, 2014
Elandshoek	0.1	-	-	-	0.1	-	DWA, 2012 DWS, 2016a
City of Mbombela (only City)	13.9	12.6	13.0	13.6	13.2	11.8	Sembcorp, 2018
White River	3.4	2.7	3.6	4.0	4.0	4.4	Master Plan, 2018
Karino/ Plaston	1.5	1.5	1.7	1.7	1.6	1.8	Sembcorp, 2018
Nsikazi North	4.9	-	-	-	10.1	-	Theoretical, this study
Nsikazi South	16.8	-	-	-	19.2	-	Theoretical, this study
Mpakeni	0.03	0.03	0.04	0.05	0.05	0.03	Sembcorp, 2018
Matsulu	5.7	5.6	6.0	6.1	6.0	6.2	Sembcorp, 2018
Hazyview	1.2	1.8	1.7	1.5	1.5	1.2	Master Plan, 2016
Total	**47.53**	**24.23**	**26.54**	**26.95**	**56.45**	**25.43**	

Data availability for the former Umjindi LM was limited, therefore only data (2016) for the base year of the projection is shown in **Table 3-3**. The 2016 SIV for Barberton was extrapolated from previous All Towns Study. The theoretically calculated SIV's for the remaining demand centres were adopted.

Table 3-3: Historic Water Use of former Umjindi LM

Demand Centres	Historic System Input Volume 2016 (million m^3/a)	Source	Method
Barberton	5.22	DWA, 2011c	Previous Study
Sheba Siding	0.1	This study	Theoretical
Shiyalongubo	0.02		
Kamadakwa	0.3		
Fairview Mine	0.1		
Noord Kaap	0.1		
Total	**5.84**	**-**	**-**

3.3.2 Future Water Requirements in the City of Mbombela Local Municipality

The CoM LM water requirements projections are summarised in **Table 3-4**. Both the theoretical the high (with either Scenario 1 or 2 selected) projections are presented. The theoretical projection presents the population growth (high scenario) over the projection period and the High (Scenario 1 or Scenario 2) were calibrated against the SIV for the base year of 2016, where available, and take into account the projected increase in LOS over time. The average annual compounded growth rate for the period from 2016 to 2040 is shown in the last column of the table. The presented projections include the light industrial and commercial consumers within each demand centre.

Nsikazi North and South have lowest average annual growth rates (1.3% and 1.4% respectively) due to out migration of population from these areas, and the growth is largely driven by the projected increase in LOS. High growth is expected in White River, (4.1%), largely due to the projected increase in population.

Table 3-4: Future Water Use Projections for CoM LM

Demand Centre	Scenario	Future Water Requirements (million m^3/a)							Average Annual Growth
		2016	2018	2020	2025	2030	2035	2040	
Elandshoek (domestic)	Theoretical	0.10	0.11	0.12	0.14	0.15	0.16	0.17	2.2%
	High (Scenario 2**)	0.10	0.11	0.12	0.14	0.16	0.17	0.19	2.7%
Hazyview	Theoretical	0.58	0.62	0.67	0.78	0.90	0.97	1.01	2.4%
	High (Scenario 1*)	1.50	1.61	1.76	2.09	2.47	2.70	2.84	2.7%
Matsulu	Theoretical	4.31	4.47	4.64	4.99	5.37	5.75	6.15	1.5%
	High (Scenario 2**)	6.20	6.49	6.80	7.50	8.25	8.98	9.76	1.9%
City of Mbombela	Theoretical	10.56	11.39	12.28	14.23	16.10	17.78	19.63	2.6%
	High (Scenario 1*)	14.10	15.30	16.60	19.55	22.47	24.99	27.79	2.9%
Mpakeni	Theoretical	0.05	0.06	0.06	0.06	0.07	0.07	0.08	1.5%
	High (Scenario 2**)	0.05	0.05	0.06	0.06	0.07	0.08	0.09	2.4%
Ngodwana	Theoretical	0.32	0.34	0.36	0.43	0.51	0.59	0.69	3.3%
	High (Scenario 2**)	0.70	0.75	0.81	0.96	1.14	1.35	1.59	3.5%

Demand Centre	Scenario	Future Water Requirements (million m^3/a)							Average Annual Growth
		2016	2018	2020	2025	2030	2035	2040	
Nsikazi N	Theoretical	10.31	10.47	10.64	11.02	11.40	11.77	12.15	0.7%
	High (Scenario 2**)	10.10	10.44	10.79	11.63	12.51	13.13	13.75	1.3%
Nsikazi S	Theoretical	19.20	19.58	19.98	20.96	21.96	22.96	23.97	0.9%
	High (Scenario 2**)	19.20	19.83	20.48	22.14	23.87	25.30	26.77	1.4%
White River	Theoretical	3.88	4.53	5.09	6.19	7.17	8.11	9.18	3.7%
	High (Scenario 1*)	4.00	4.72	5.36	6.70	7.98	9.11	10.39	4.1%
Barberton	Theoretical	5.22	5.34	5.46	5.79	6.13	6.49	6.87	1.1%
	High (Scenario 1*)	5.22	5.39	5.57	6.05	6.56	7.02	7.51	1.5%
Sheba Siding	Theoretical	0.07	0.08	0.08	0.09	0.10	0.10	0.11	1.9%
	High (Scenario 2**)	0.10	0.11	0.12	0.15	0.18	0.19	0.21	3.2%
Shiyalongubo	Theoretical	0.01	0.01	0.02	0.02	0.02	0.02	0.02	2.0%
	High (Scenario 2**)	0.02	0.02	0.03	0.03	0.04	0.04	0.05	3.5%
Kamadakwa	Theoretical	0.41	0.46	0.50	0.55	0.60	0.65	0.70	2.2%
	High (Scenario 2**)	0.30	0.35	0.38	0.45	0.52	0.57	0.63	3.1%
Fairview Mine	Theoretical	0.09	0.09	0.09	0.10	0.11	0.12	0.12	1.6%
	High (Scenario 2**)	0.10	0.10	0.11	0.12	0.13	0.14	0.15	1.7%
Noordkaap	Theoretical	0.15	0.17	0.18	0.20	0.22	0.24	0.27	2.5%
	High (Scenario 2**)	0.10	0.12	0.13	0.14	0.16	0.18	0.19	2.8%
Total Theoretical		**55.26**	**57.72**	**60.16**	**65.54**	**70.78**	**75.79**	**81.12**	**1.6%**
Total High		**61.79**	**65.40**	**69.11**	**77.72**	**86.51**	**93.95**	**101.90**	**2.1%**

***Scenario 1:** The minimum LOS is assumed to be at RDP Level by 2030. Residential Low-Income LOS increases by 5% from 2016 to 2030 and a further 6% increase by 2040 (total of 11%). Residential Medium Income LOS 2.5% from 2016 to 2030 and a further 2.3% increase by 2040 (total of 4.8%). (refer to **Section 3.1**)

****Scenario 2:** The minimum LOS is assumed to be at RDP Level by 2030. RDP Level increase by 5% from 2016 to 2030 and a further 6.7% increase by 2040 (total of 11.7%). Residential Low Income increases by 2.5% from 2016 to 2030 and a further 3% increase by 2040 (total of 5.5%). (refer to **Section 3.1**)

Future growth is associated with various residential, commercial and industrial developments as discussed in the *Economic Growth and Demographic Analysis Task, Report P WMA 03/X22/00/6818*. Nkosi City is one of the larger planned agricity developments within the City of Mbombela demand centre. A layout of the proposed development is illustrated in **Figure 3-1**.

It is important to note that the urban/domestic water requirements of Nkosi City (including the indirect use) are included within the City of Mbombela projection presented in **Table 3-4**. The Nkosi City urban/domestic water requirements component were calculated based on the information received (2237 RDP Houses, 1158 Affordable Bonded Houses, 1000 Apartments, schools, college, industrial area and lodge) and are presented in **Table 3-6**. The Nkosi City development also includes a planned irrigation development. The estimated additional irrigation water requirements are discussed in **Section 4.1**.

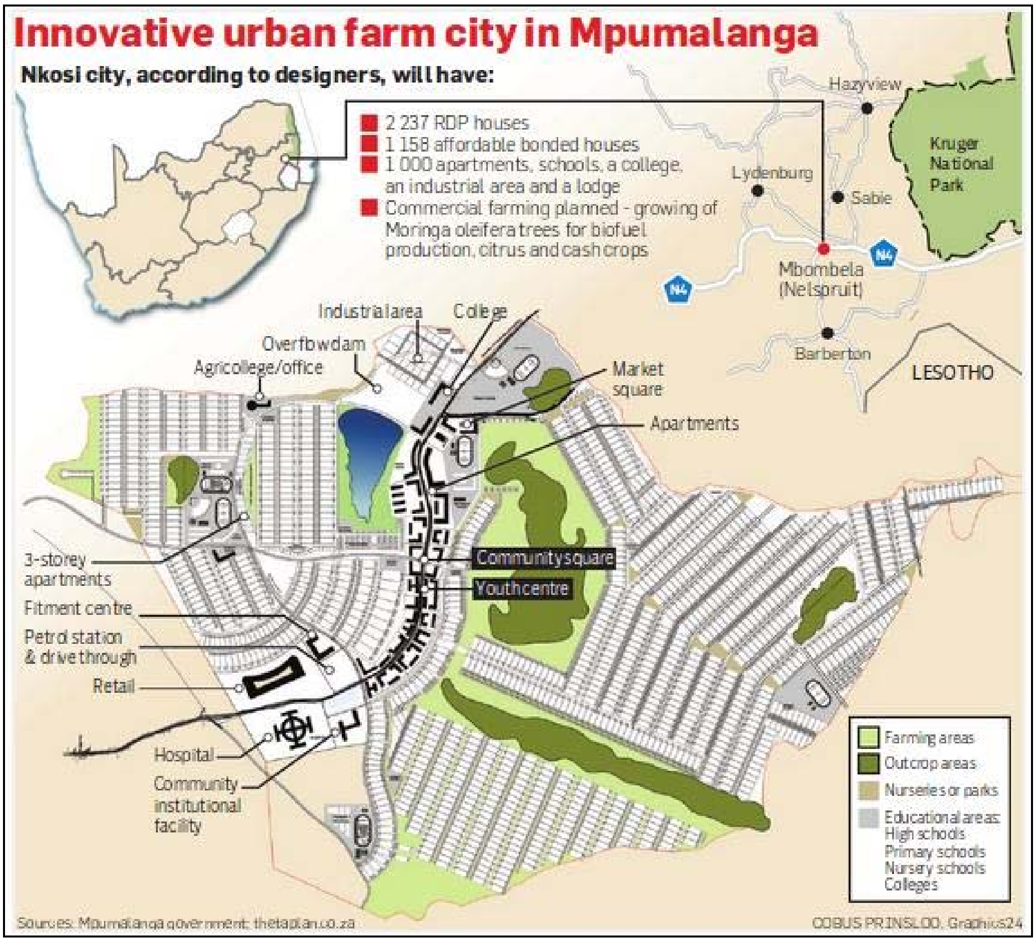

Figure 3-1: Proposed Nkosi City Layout

Table 3-5: Nkosi City Future Water Use (Fully Developed)

Nkosi City	Fully Developed Water Requirement (million m^3/a)
Domestic	0.82
Indirect use	0.42
Total	**1.24**

Water requirement projection graphs are shown for the six major demand centres in CoM LM in **Figure 3-2** to **Figure 3-7**. Each of the figures illustrate actual measured historic data (light blue square markers), previous reconciliation strategy projections, which were completed in 2014 blue line (high) and yellow line (low) and the most recent water and sanitation master plan projection (green line) where applicable. The projected water requirements derived for this study are shown for the high (grey line) and theoretical (orange line) scenarios.

The water requirements projections for Hazyview are shown in **Figure 3-2**, with the average annual compounded growth rate per projection scenario given in brackets in the legend. The previous *Reconciliation Strategy* projections are positioned between the current theoretical projection and the high projection. The high projection was projected from the 2016 water use figure. The projected growth is higher than the previous *Reconciliation Strategy*. The previous *Reconciliation Strategy* projections is similar to the *Mbombela Water and Sanitation Master Plan* projection. The noticeable difference between the high and the theoretical projection highlights the potential for WC/WDM savings. The master plan indicates major growth between 2018 and 2022. It is assumed that this phenomenon occurs because the projection started from a very low base below the historical water use figures.

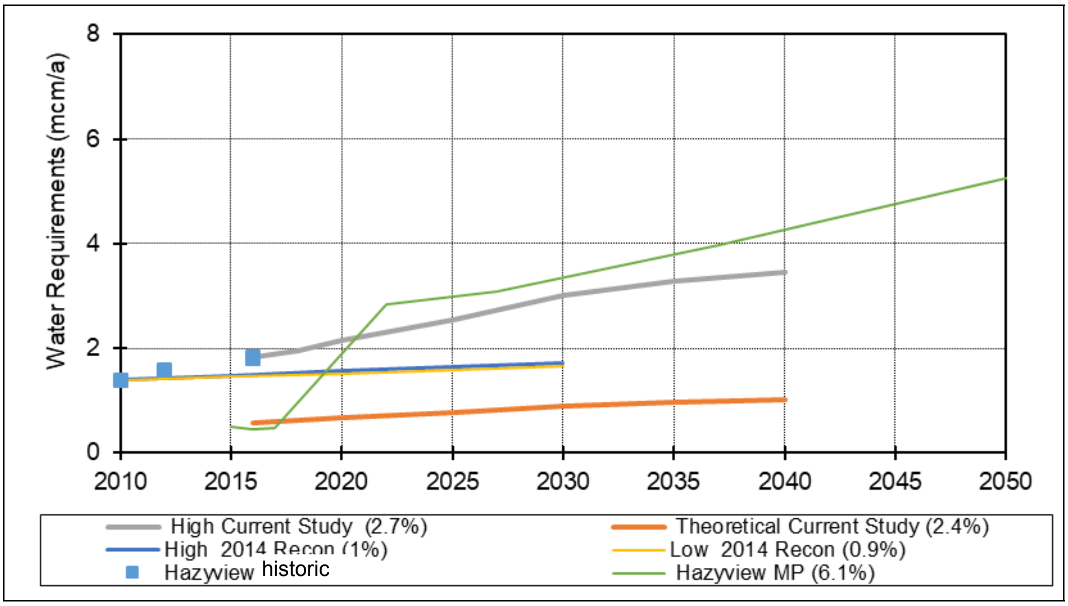

Figure 3-2: Water Requirements Projections for Hazyview

The water requirements projection for the City of Mbombela are presented in **Figure 3-3.** The high projection was projected from the 2016 water use figure and is slightly below the previous *Reconciliation Strategy*, high and the *Mbombela Water and Sanitation Master Plan* projection. All three of the discussed projections have similar growth rates over the medium to long term. The noticeable difference between the high and the theoretical projection highlights the potential for WC/WDM savings.

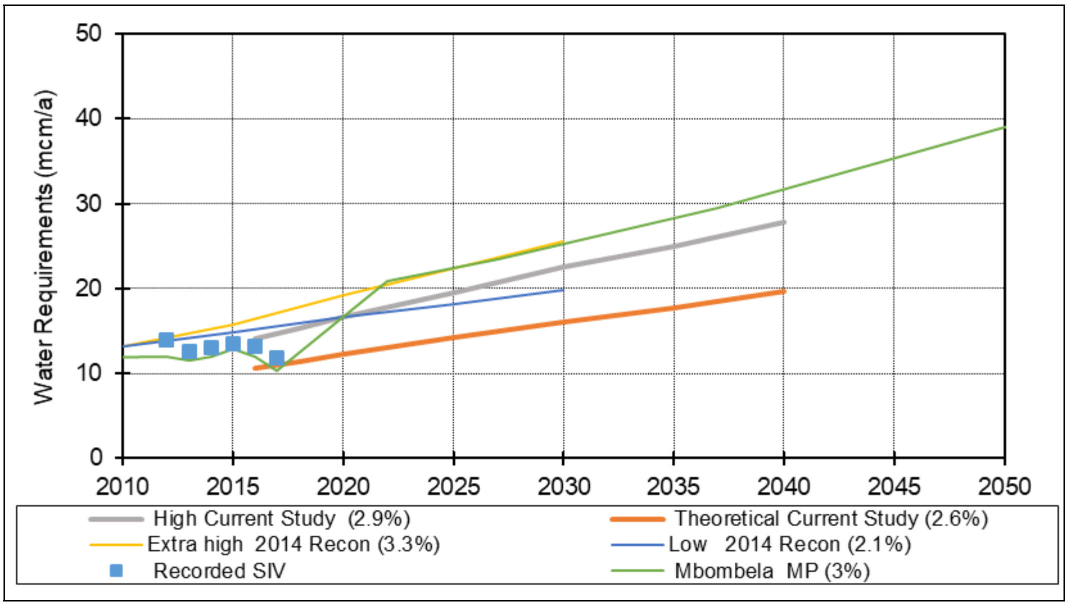

Figure 3-3: Water Requirements Projection for Mbombela

The production volume of the *Blue Drop Report* was the only available actual historic data for the Nsikazi North demand centre, as shown in **Figure 3-4**. This value, if extrapolated, would mimic the *Mbombela Water and Sanitation Master Plan* projection. The previous recon projection as well as the updated high and theoretical projections are however much higher Blue Drop WTW production volume. The projections are based on theoretically calculated water requirements, as no actual recorded water use data was available. It has been reported that the Nsikazi North experiences intermittent water supply due to infrastructure constraints which is why the Blue Drop WTW production volume and reported SIVs (**Section 3.3.1**) are lower than the calculated theoretical requirements, which were adopted.

The water requirements projection for the Nsikazi South are presented in **Figure 3-5.** The high projection was projected from the 2016 water use figure (similar to the theoretical) with a starting point more or less on the previous Reconciliation strategy projection, but then increases at a higher growth rate. The *Mbombela Water and Sanitation Master Plan* projection starts from a low base below the historical water use data and there is major growth between 2018 and 2022 and then again from 2038 onwards. It is assumed that the 2018 to 2022 growth occurs because the projection started from a very low base.

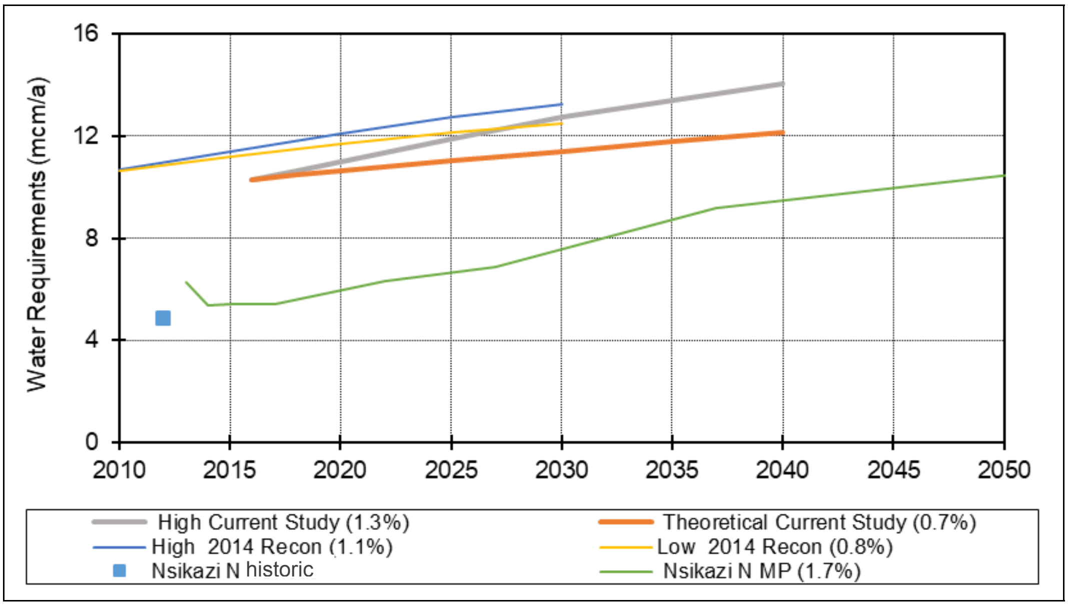

Figure 3-4: Water Requirements Projection for Nsikazi North

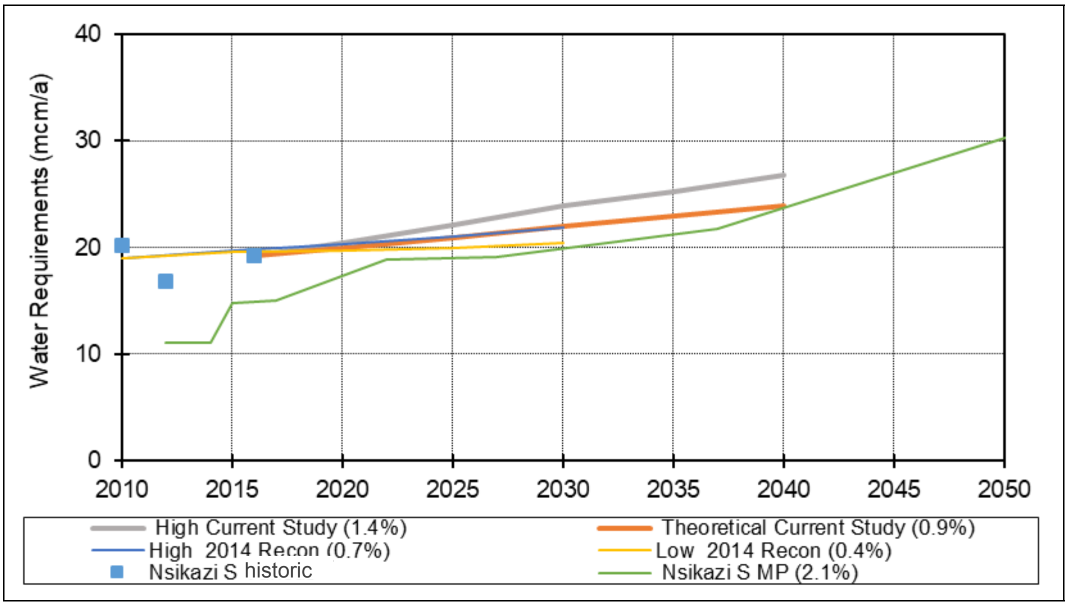

Figure 3-5: Water Requirements Projection for Nsikazi South

The high projection for White River was projected from the 2016 water use figure (similar to the theoretical 2016 figure) with a starting point more or less on the previous Reconciliation strategy projection, but increases at a slightly higher growth rate as shown in **Figure 3-6**. The *Mbombela Water and Sanitation Master Plan* projection starts from a low base below the historical water use data and there is major growth between 2018 and 2022 and exceeds the high projection from 2024 onwards. It is again assumed that the 2018 to 2022 growth occurs because the projection started from a very low base.

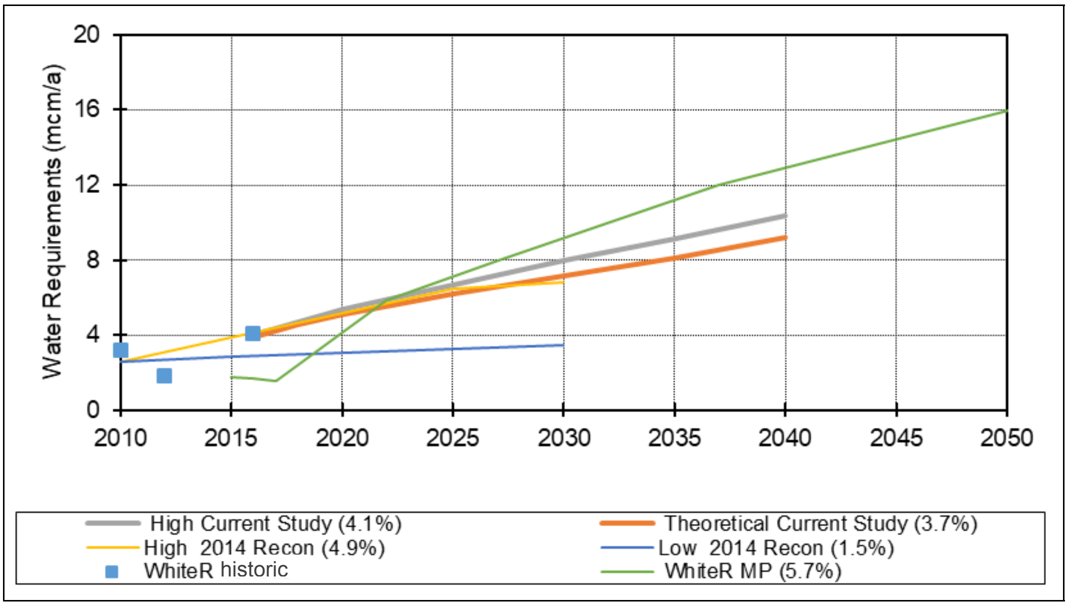

Figure 3-6: Water Requirements Projection for White River

The water requirements projection for Barberton are presented in **Figure 3-7.** The high projection was projected from the 2016 water use figure (similar to the theoretical 2016 figure). The starting point for the projection is more or less on the previous Reconciliation Strategy projection, but increases at a slightly higher growth rate. The *Mbombela Water and Sanitation Master Plan* projection starts from a low base below the historical water use data and there is major growth between 2018 and 2022 and exceeds the high projection from 2024 onwards. It is again assumed that the 2018 to 2022 growth occurs because the projection started from a very low base.

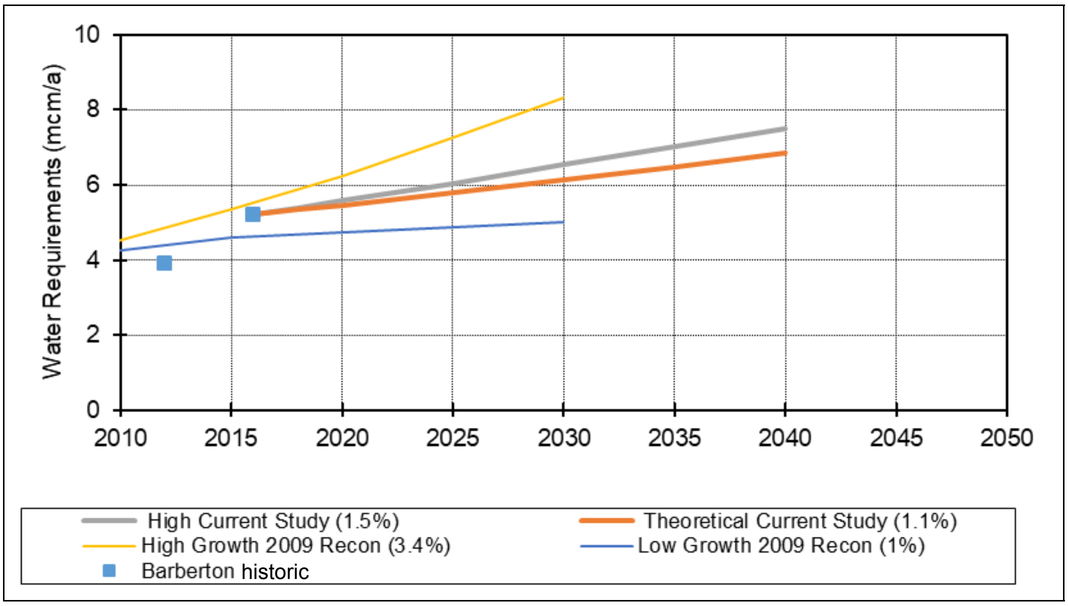

Figure 3-7: Water Requirements Projection for Barberton

3.3.3 Industrial Water Requirements and Major Water Users in the City of Mbombela Local Municipality

The industrial sector historic water use is summarised in **Table 3-6**. The majority of the industrial water users, being light industrial, are accounted for in the domestic requirements components. The top consumers in the CoM are the Manganese Metal Company, the Nelspruit prison and the University of Mpumalanga, which have respective historic water requirements of 0.49 million m^3/a, 0.23 million m^3/a and 0.08 million m^3/a. There is a light industrial area to the south of White River called Rockys Drift, which is accounted for in the domestic portion of the historic data and obtains its water from the CoM transfer.

Other major consumers not included in the domestic component are Sappi Ngodwana Mill, which a historic water use of 14 million m^3/a on average, of which 2.8 million m^3/a is sourced from the Elands River (converted irrigation water use licenses) and 11.2 million m^3/a from the existing Ngodwana Dam on the Ngodwana River. The future water requirements of Sappi Ngodwana are expected to remain constant, as the planned expansions will be supported by an increase in water use efficiency.

Table 3-6: Commercial and Industrial Water Use for City of Mbombela Local Municipality

Consumer Names	Historic Water Requirements from Major Consumers (million m^3/a)			
	2014	**2015**	**2016**	**2017**
Manganese Metal Company	0.48	0.48	0.49	0.50
Nelspruit Prison	0.27	0.21	0.23	0.21
University of Mpumalanga	0.09	0.09	0.08	0.09
Sappi Ngodwana	14.00	14.00	14.00	14.00
Total	**14.84**	**14.78**	**14.80**	**14.80**

3.3.4 Return Flows in City of Mbombela Local Municipality

The domestic and industrial return flows for CoM LM are summarised in **Table 3-7** and the return flows projections, based on the RFFs, shown in **Table 3-8**. Only the major towns and settlements have formal sanitation and sewer networks, these areas include the CoM, Ngodwana, Matsulu, Karino, Plaston, Barberton, Hazyview and the formal portions of Nsikazi South. The remainder of the areas make use of septic tanks or pit latrines. The return flow values where either obtained from the WSP's or from previous Green Drop Reports. The historic RFF for 2016 indicate that the CoM indicates the greatest RFF of 0.48 and 0.38 for Barberton (***DWA, 2013***).

Table 3-7: Return flows in the City of Mbombela Local Municipality

Demand Centres	Historic Return Flows (million m^3/a)				Water Use (million m^3/a)	Historic Return Flow Factors
	2013*	2014**	2015**	2016***	2016	2016
Hazyview	-	0.09	0.07	0.06	1.50	0.04
CoM	6.47	7.35	7.08	6.81	14.10	0.48
Nsikazi South	1.93	1.94	3.08	2.18	19.20	0.11
Matsulu	1.15	0.57	0.62	0.81	6.20	0.13
White River	-	1.26	1.18	1.13	4.00	0.28
Barberton	2.10	-	-	2.00	5.20	0.38
Total	**11.65**	**11.21**	**12.03**	**12.99**	**50.20**	**0.26**

* Source: *Green Drop Report* (***DWA, 2013***)

** Source: *WSPs*

Table 3-8: Return flows Projections in the City of Mbombela Local Municipality

Demand Centres	Return Flows Projections (million m^3/a)						
	2016	2018	2020	2025	2030	2035	2040
Hazyview	0.06	0.06	0.07	0.08	0.10	0.11	0.11
CoM	6.77	7.34	7.97	9.41	10.80	12.00	13.34
Nsikazi South	2.11	2.18	2.26	2.43	2.63	2.78	2.95
Matsulu	0.87	0.91	0.95	1.05	1.16	1.26	1.37
White River	1.12	1.32	1.51	1.88	2.24	2.55	2.91
Barberton	1.98	2.05	2.13	2.28	2.51	2.66	2.85
Total	**13.0**	**14.0**	**15.0**	**17.2**	**19.6**	**21.5**	**23.7**

It is evident that the return flows form the major supply areas are much less than their SIV. This can be attributed to the major informal component of the Study Areas, which do not have formalised waterborne sanitation systems.

3.3.5 Groundwater Use in City of Mbombela Local Municipality

Groundwater resources are utilised in number of smaller demand centres and rural settlements such as, Kaapsehoop, Luphisi and a portion Matsulu, which used 0.031 million m^3/a, 0.012 million m^3/a and 0.050 million m^3/a of groundwater in 2016 respectively. Nsikazi North and South also make use of limited groundwater and the current state of the boreholes and estimated use could not be provided by the WSP. The former Umjindi LM has no records on groundwater use, it is however expected that there is groundwater use in the former LM.

3.4 Bushbuckridge Local Municipality

The BBR LM is located to the north of CoM LM, and consists of five major demand centres, namely Bushbuckridge, Acornhoek, Thulamahashe, Hoxane and Marite. For this report the BBR demand centre was combined with Acornhoek water supply area into one, as they have the same primary source, namely the Injaka Dam. See **APPENDIX A** for overview map of demand centres.

3.4.1 Historical Water Use in the Bushbuckridge Local Municipality

Data from the BBR LM has been flagged in previous reports as recorded water use data not being available, and theoretical values were thus calculated. Data was received from Rand Water, which was however provided as the total average WTW production volumes, without the actual split into the various major demand centres. The total SIV was then split into the different demand centres in accordance with the population numbers and current bulk water understanding as summarised in **Table 3-9**. It is evident form **Table 3-9** that Marite is the smallest demand centre, followed by Thulamahashe and Hoxane, with Acornhoek being the largest.

Table 3-9: Historic Water Use in the Bushbuckridge Local Municipality

Major Demand Centre	Historic Water Requirements for 2016 (million m^3/a)
Acornhoek	19.6
Hoxane	13.7
Marite	3.3
Thulamahashe	13.0
Total	**49.6**

Source: Average SIV obtained from Rand Water, which was divided in accordance to the population numbers and current bulk water understanding.

3.4.2 Future Water Requirements in the Bushbuckridge Local Municipality

The future growth in water requirements for BBR LM is summarised in **Table 3-10**. The same methodology as with CoM LM was followed to obtain the water requirement projections for BBR LM (**Section 3.3.1)**. The greatest water requirements average compounded growth rates can be observed for Marite and Hoxane, as these areas have higher population growth than Thulamahashe and Acornhoek, located further north.

Table 3-10: Future Water Requirements Projections for the Bushbuckridge Local Municipality

Major Demand Centre	Scenario	Future Water Requirements (million m^3/a)							Average Annual Growth
		2016	2018	2020	2025	2030	2035	2040	
Acornhoek	Theoretical	14.4	14.6	14.8	15.4	15.9	16.4	16.9	0.7%
	High (Scenario 2)	19.6	20.2	20.8	22.2	22.9	25.0	26.0	1.2%
Hoxani	Theoretical	8.5	8.7	8.8	9.2	9.6	9.9	10.2	0.8%
	High (Scenario 2)	13.7	14.2	14.7	16.0	17.2	18.2	19.2	1.4%
Marite	Theoretical	2.2	2.2	2.3	2.4	2.5	2.6	2.7	0.9%
	High (Scenario 2)	3.3	3.4	3.6	3.9	4.3	4.6	4.8	1.6%
Thulamahashe	Theoretical	9.2	9.2	9.4	9.6	9.9	10.1	10.3	0.5%
	High (Scenario 2)	13.0	13.4	13.7	14.6	15.4	16.0	16.6	1.0%
Total Theoretical		**34.3**	**34.7**	**35.3**	**36.6**	**37.9**	**39**	**40.1**	**0.6%**
Total High		**49.6**	**51.2**	**52.8**	**56.7**	**59.8**	**63.8**	**66.6**	**1.5%**

The water requirements projections for the four major demand centres are summarised in **Figure 3-8** to **Figure 3-11**. The Hoxane demand centre experiences intermittent water supply, due to the amount of illegal connections and losses in the system. Some of the settlement and small towns have been reported to only receiving water once every two weeks. The combination of the illegal connections and distribution losses were taken into consideration when the base calibration SIV was derived for 2016. The updated water requirement projection is slightly higher than the previous Reconciliation Strategy projection.

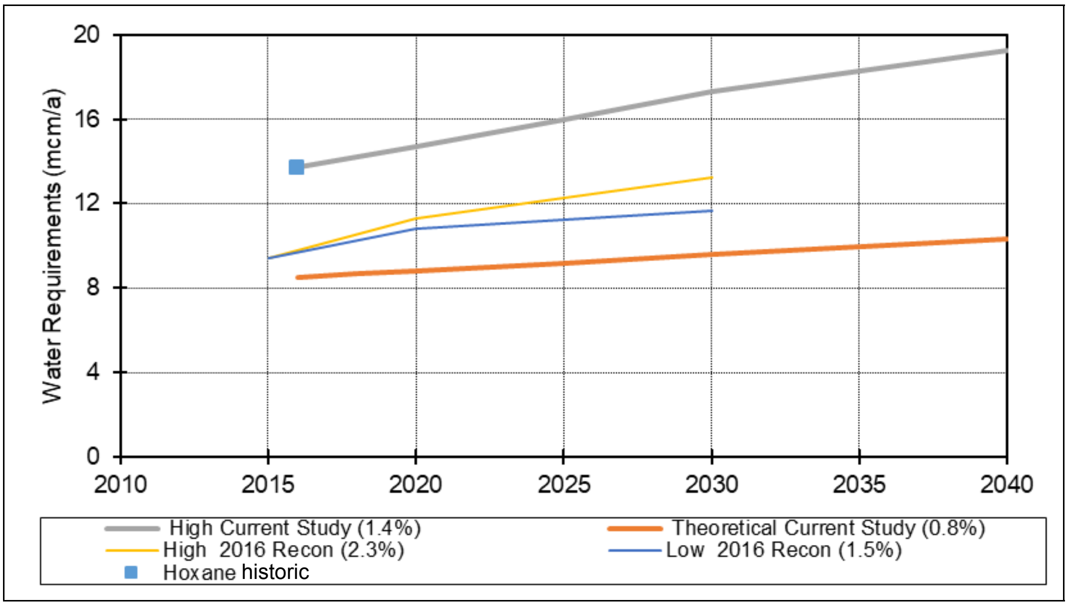

Figure 3-8: Water Requirements Projection for the Hoxane Demand Centre

The base water requirements for Marite is slightly lower compared to the previous Reconciliation Strategy projection (**Figure 3-9**), but has a similar growth rate to the previous High projection.

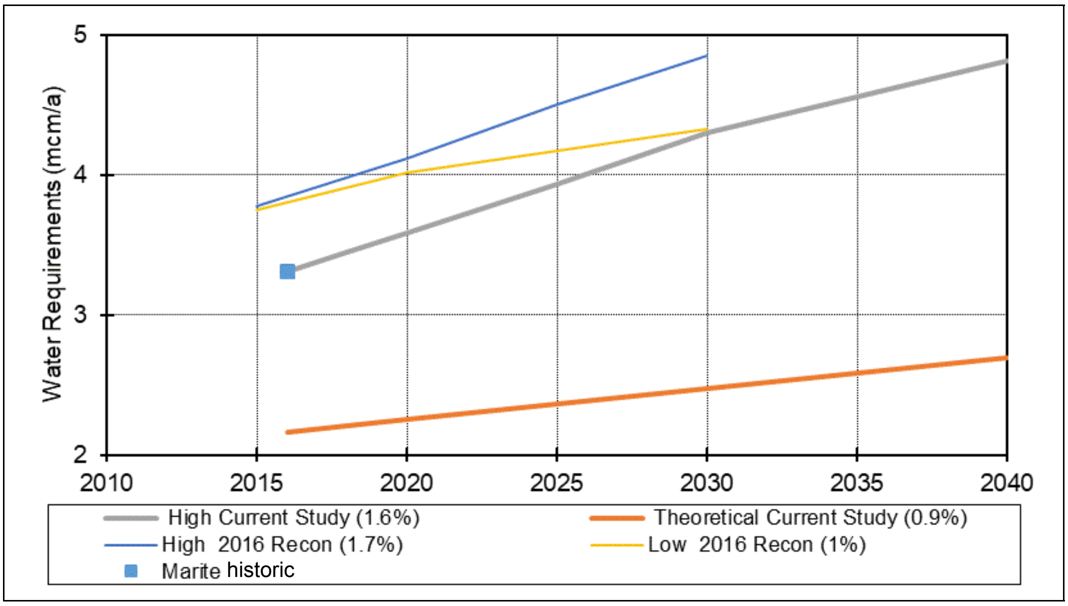

Figure 3-9: Water Requirements Projection for the Marite Demand Centre

Similar to the water requirements projections for the Hoxani demand centre, the Thulamahashe demand centre also indicates a much larger base water requirement value compared to the previous Reconciliation Strategy **Figure 3-10**, with a similar growth rate

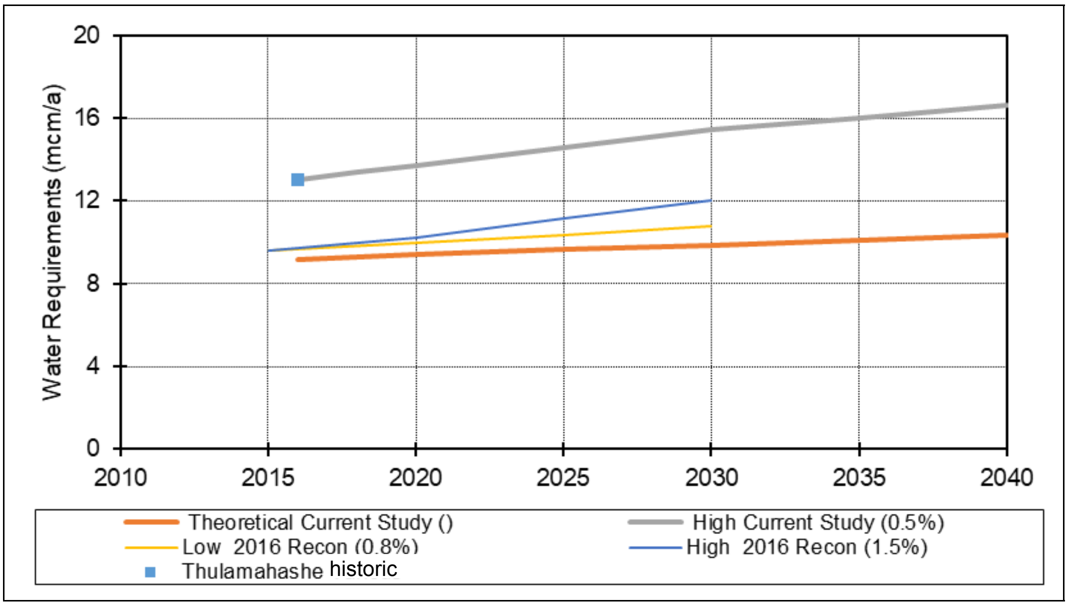

Figure 3-10: Water Requirements Projection for Thulamahashe Demand Centre

The water requirements projections for Acornhoek (combined Acornhoek and BBR demand centres), as shown in **Figure 3-11**, are very similar to the water requirements projected in the previous *Reconciliation Strategy* projection, which was completed in 2016.

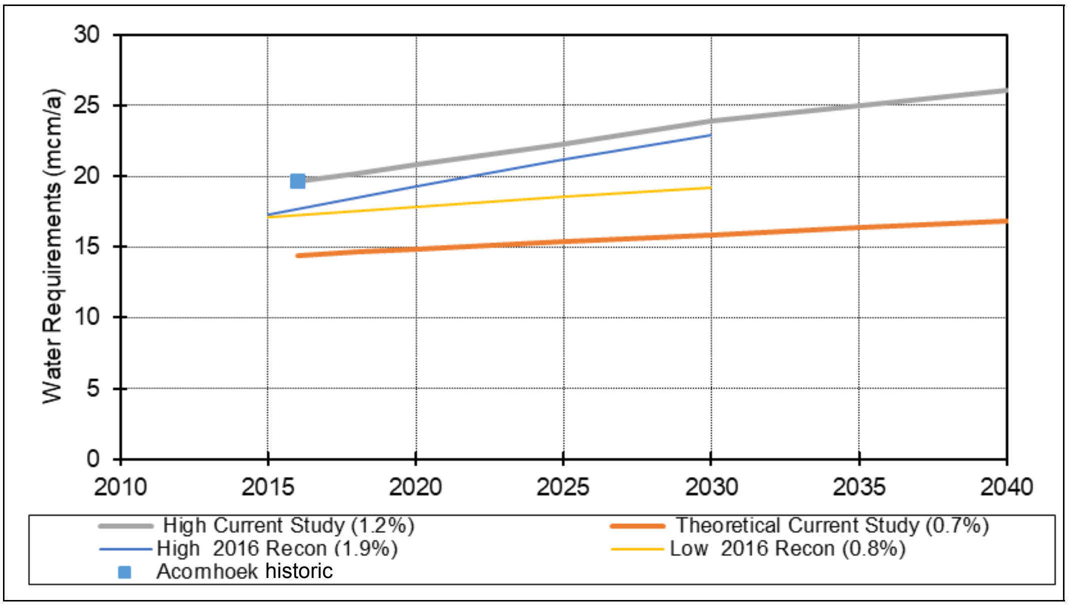

Figure 3-11: Water Requirements Projection for the Acornhoek Demand Centre

The noticeable difference between the high and the theoretical projections for the major demand centres in the BBR LM highlights the potential for WC/WDM savings, which will be confirmed by the WC/WDM Task of this Study.

3.4.3 Industrial Requirements for the Bushbuckridge Local Municipality

There are currently no major industries in BBR LM. There are however some light industries in major towns such as Bushbuckridge. The water requirements of these light industries are already accounted for in the historic and projected domestic water requirements.

3.4.4 Return Flows for the Bushbuckridge Local Municipality

Only formal towns and settlements are served by formal sanitation infrastructure (waterborne sanitation). The remainder of the settlements and rural villages do not have any sewer networks, they make use of pit latrines. Limited information is available, which is summarised in **Table 3-11** from the *Green Drop Report* (***DWA, 2012b***). The return flow projections are summarised in **Table 3-8**.

Table 3-11: Return flows in the Bushbuckridge Local Municipality

Major Demand Centre	Historic Return Flows for 2016 in (million m^3/a)	Water Use for 2016 (million m^3/a)	Return flow factor
Marite	0.2	3.3	0.06
Hoxane	1.2	13.7	0.09
Thulamahashe	1.1	13	0.08
Acornhoek	0.7	19.6	0.04
Total	**3.2**	**49.6**	**0.06**

Table 3-12: Return flows Projections in the Bushbuckridge Local Municipality

Demand Centres	Return Flows Projections (million m^3/a)						
	2016	2018	2020	2025	2030	2035	2040
Hazyview	0.20	0.20	0.22	0.23	0.26	0.28	0.29
CoM	1.23	1.28	1.32	1.44	1.55	1.64	1.73
Nsikazi South	1.04	1.07	1.10	1.17	1.23	1.28	1.33
Matsulu	0.78	0.81	0.83	0.89	0.92	1.00	1.04
Total	**3.2**	**3.36**	**3.47**	**3.73**	**3.95**	**4.19**	**4.38**

3.4.5 Groundwater Use in the Bushbuckridge Local Municipality

Records of current groundwater use in the BBR LM are not available from the BBR LM and Rand Water. According to the *All Towns* Report, the estimated groundwater use in the total BBR LM is approximately 0.8 million m^3/a (***DWS, 2016b***). The DWS regional office confirmed that a great deal of the boreholes is currently inactive, due to lack of maintenance.

3.5 Emakhazeni Local Municipality Water Requirements

3.5.1 Historical Water Use in the Emakhazeni Local Municipality

Emakhazeni LM, which forms part of the Crocodile River (East) Sub- Catchment, contains the demand centres of Dullstroom, Machadodorp and Waterval Boven. Existing information from Previous *Reconciliation Strategies* and *All Towns Reports* was used to collate the water requirements data. The historic water requirements are summarised for the three major demand centres in **Table 3-13**. See **APPENDIX A** for overview map of demand centres.

Table 3-13: Historic Water Use in the Emakhazeni Local Municipality

Demand Centre	Historic Water Requirements (million m^3/a)				
	2004	2005	2006	2008	2016
Dullstroom	-	0.44[2]	0.49[2]	-	0.69
Machadodorp	0.7[1]	-	-	-	0.9
Waterval Boven	-	-	0.68[3]	0.71[3]	0.84
Total	**0.7**	**0.44**	**1.17**	**0.71**	**2.43**

Source: (1) (***DWA, 2011n***)**,** (2) (***DWA, 2011o***) *and* (3) (***DWA, 2011p***)

There are some minor industries which are included in the historic water requirements, however Assmag Chrome near Machadodorp used 0.6 million m^3/a of groundwater in 2009. This is reported to affect the base flow in the Elands River Sub- Catchment (***DWA, 2011p***).

3.5.2 Future Water Requirements in the Emakhazeni Local Municipality

The future water requirements for the Emakhazeni LM demand centres, sourced from the All Towns study, are summarised in **Table 3-14**. It is important to note that these water requirements were projected up to the year of 2020 and were thus extended. Three different population databases were used to obtain three of the four water requirement projection scenarios, namely the DWAF NIS, Census and Lidwala Consulting. The Scenario 2 (historical projection) is based on the previous All Towns Report, and is regarded as the most realistic. Scenario 4 (high) was however adopted for planning purposes in each case.

Table 3-14: Future water requirements summary for Emakhazeni LM

Town	Scenario	Future Water Requirements (million m^3/a)					
		2016	2020	2025	2030	2035	2040
Machadodorp	Scenario 1 (DWAF NIS)	0.8	0.9	0.9	1.0	1.1	1.2
	Scenario 2 (historical projection)	0.9	0.9	1.0	1.1	1.2	1.3
	Scenario 3 (Census)	0.9	1.0	1.1	1.2	1.3	1.4
	Scenario 4 (Lidwala)	0.9	1.0	1.2	1.4	1.5	1.6
Waterval Boven	Scenario 1 (Census)	0.8	0.8	0.9	1.0	1.1	1.2
	Scenario 2 (DWAF NIS)	0.8	0.9	1.0	1.0	1.1	1.2
	Scenario 3 (Lidwala)	0.9	1.0	1.1	1.2	1.3	1.4
	Scenario 4 (historical projection)	0.9	1.0	1.1	1.2	1.3	1.4
Dullstroom	Scenario 1 (DWAF NIS)	0.7	0.8	0.8	0.9	1.0	1.1
	Scenario 2 (Lidwala)	0.7	0.8	0.8	0.9	1.0	1.1
	Scenario 3 (Census)	0.8	0.9	1.0	1.1	1.2	1.3
	Scenario 4 (historical projection)	0.8	0.9	1.1	1.2	1.3	1.4

Total	**Total for Scenario 1**	**2.3**	**2.5**	**2.6**	**2.9**	**3.2**	**3.5**
	Total for Scenario 2	**2.4**	**2.6**	**2.8**	**3**	**3.3**	**3.6**
	Total for Scenario 3	**2.6**	**2.9**	**3.2**	**3.5**	**3.8**	**4.1**
	Total for Scenario 4	**2.6**	**2.9**	**3.4**	**3.8**	**4.1**	**4.4**

Source: (***DWA, 2011n***), (***DWA, 2011o***) and (***DWA, 2011p***)

3.5.3 Industrial Water Requirements in the Emakhazeni Local Municipality

There is just one major industry, namely the Machadodorp Assmang chrome smelters, of which parts of the operation have been idle since 2012. The majority of their water requirements, which were estimated as 0.6 million m^3/a in 2008 (***DWA, 2011p***) are supplied from groundwater.

3.5.4 Return Flows in the Emakhazeni Local Municipality

The return flow volumes and RFF in the Emakhazeni LM for 2016 are summarised in **Table 3-15** and the return flow projections are shown in

Table 3-16.The WWTWs are all operating at capacity or over their capacity (***DWA, 2012b***).

Table 3-15: Return Flows in the Emakhazeni Local Municipality

Demand Centre	Historic Return Flows for 2016 (million m^3/a)	Water Use for 2016 (million m^3/a)	Return Flow Factor
Dullstroom	0.27	0.8	0.34
Machadodorp	0.55	0.9	0.61
Waterval Boven	0.55	0.9	0.61
Total	**1.37**	**2.6**	**0.53**

Table 3-16: Return flows Projections in the Emakhazeni Local Municipality

Demand Centres	Return Flows Projections (million m^3/a)					
	2016	2020	2025	2030	2035	2040
Dullstroom	0.27	0.30	0.37	0.41	0.44	0.47
Machadodorp	0.55	0.61	0.73	0.85	0.92	0.98
Waterval Boven	0.55	0.61	0.67	0.73	0.79	0.85
Total	**1.37**	**1.52**	**1.77**	**1.99**	**2.15**	**2.30**

3.5.5 Groundwater Use in the Emakhazeni Local Municipality

According to the *All Towns* Report, Dullstroom, Machadodorp and Waterval Boven currently do not utilise any groundwater (***DWA, 2011n***). Assmang is a large industrial user in the Machadodorp, which primarily utilises groundwater, with an estimated use of 0.49 million m^3/a (***DWA, 2011o***).

3.6 Nkomazi Local Municipality

3.6.1 Historical Water Use in the Nkomazi Local Municipality

The Nkomazi LM consists of Louieville, Malelane, Hectorspruit, Marloth Park, and Komatipoort, as well as some smaller settlements. The historic water use is summarised in **Table 3-17**, was obtained from the previous *All Towns Report* for the Nkomazi LM (***DWS, 2016***). It is evident that these smaller towns, which are separate WSS, have minor water requirements compared to the other LMs. See **APPENDIX A** for overview map of demand centres.

Table 3-17: Historic water use of Nkomazi Local Municipality

Water Supply Scheme	Historic Water Requirements (million m^3/a)			
	2005	2008	2012	2015
Louieville	0.06	0.07	0.12	0.12
Malelane	0.52	0.62	0.69	0.69
Hectorspruit	0.07	0.08	0.28	0.28
Marloth Park	0.68	0.80	0.85	0.87
Komatipoort	0.69	0.87	0.81	0.81
Total	**2.02**	**2.44**	**2.75**	**2.77**

Source: Nkomazi Reconciliation Strategy ***(DWS, 2016)***

3.6.2 Future Water Requirements in the Nkomazi Local Municipality

The future water requirements Nkomazi LM are summarised in **Table 3-18** (***DWS, 2016***). It is again recommended that the High Growth scenario is adopted for planning purposes.

Table 3-18: Future Water Requirements Projections for the Nkomazi Local Municipality

Water Supply Scheme	Growth Scenarios	Future Water Requirements (million m³/a)					
		2016	2020	2025	2020	2025	2040
Louieville	High	0.13	0.16	0.18	0.2	0.2	0.21
	Median	0.13	0.16	0.17	0.2	0.2	0.19
	Low	0.13	0.15	0.16	0.2	0.2	0.17
Malelane	High	0.70	0.75	0.82	0.9	0.9	0.99
	Median	0.69	0.74	0.79	0.8	0.9	0.89
	Low	0.67	0.62	0.66	0.7	0.7	0.7
Hectorspruit	High	0.27	0.22	0.25	0.28	0.40	0.42
	Median	0.27	0.21	0.22	0.25	0.26	0.27
	Low	0.26	0.20	0.21	0.22	0.22	0.22
Marloth Park	High	0.89	0.95	1.04	1.12	1.19	1.26
	Median	0.88	0.94	1.00	1.05	1.09	1.12
	Low	0.87	0.92	0.96	1.00	1.00	1.00
Komatipoort	High	0.83	0.91	1.00	1.08	1.14	1.19
	Median	0.82	0.88	0.95	1.00	1.02	1.06
	Low	0.81	0.86	0.89	0.92	0.92	0.92
Total	**High**	**2.82**	**2.99**	**3.29**	**3.58**	**3.83**	**4.07**
	Median	**2.79**	**2.93**	**3.13**	**3.3**	**3.47**	**3.53**
	Low	**2.74**	**2.75**	**2.88**	**3.04**	**3.04**	**3.01**

Source: Nkomazi Reconciliation Strategy ***(DWS, 2016)***

3.6.3 Industrial Water Requirements in the Nkomazi Local Municipality

The RLC (TSB) Malelane Sugar Mill is located in the Lower Crocodile (East) River Catchment, and has an annual water requirement of 9 million m³/a, which is supplied from the Crocodile (East) River. No major expansions are planned for the RLC Malelane Mill and it is therefore expected that the water requirements will remain constant in the future.

3.6.4 Return Flows in the Nkomazi Local Municipality

The 2008 total return flows were 0.27 million m³/a for Malelane (***DWA, 2011h***), 0.01 million m³/a for Hectorspruit (***DWA, 2011d***), 0.16 million m³/a for Marloth Park (***DWA, 2011i***) and 0.79 million m³/a for Komatipoort (***DWA, 2011f***). The average WWTW volumes are the same as given in the 2012 *Green Drop Report* (***DWA, 2012***). The RFF were calculated as 0.39, 0.04, 0.18 and 0.95 for Malelane, Hectorspruit, Marloth Park and Komatipoort respectively, as summarised in **Table 3-19**. The return flows projections are presented in **Table 3-20**.

Table 3-19: Return Flows in the Nkomazi Local Municipality

Demand Centre	Historic Return Flows for 2016 (million m^3/a)	Water Use for 2016 (million m^3/a)	Return Flow Factor
Malelane	0.27	0.70	0.39
Hectorspruit	0.01	0.27	0.04
Marloth Park	0.16	0.89	0.18
Komatipoort	0.79	0.83	0.95
Total	**1.23**	**2.69**	**0.46**

Table 3-20: Return flows Projections in the Emakhazeni Local Municipality

Demand Centres	Return Flows Projections (million m^3/a)					
	2016	**2020**	**2025**	**2030**	**2035**	**2040**
Malelane	0.27	0.29	0.32	0.35	0.35	0.39
Hectorspruit	0.01	0.01	0.01	0.01	0.02	0.02
Marloth Park	0.16	0.17	0.19	0.20	0.21	0.23
Komatipoort	0.79	0.86	0.95	1.03	1.08	1.13
Total	**1.23**	**1.34**	**1.47**	**1.59**	**1.66**	**1.76**

3.6.5 Groundwater Use in the Nkomazi Local Municipality

No official groundwater use could be obtained for the portion of the Nkomazi LM. The *All Towns Report* estimated the groundwater use at about 0.16 million m^3/a in the LM (***DWS, 2016***).

3.7 Thaba Chweu Local Municipality

3.7.1 Historical Water Use Thaba Chweu Local Municipality

Only the major demand centres in the Thaba Chweu LM are located within the Study Area and include the towns of Graskop and Sabie, which also includes Hendriksdal. Sabie abstracts water from an old abandoned mine shaft, and Graskop obtains water from a well-constructed around natural fountains.

The historic water use is summarised in **Table 3-21**. According to the Water Services Development Plan (WSDP), Sabie and Graskop's 2007 water use was recorded as 1.55 million m^3/a and 0.71 million m^3/a respectively (***DWA, 2011***).

The DWS *Blue Drop Report* recorded a total Sabie WTW design capacity of 7.21 million m^3/a for Sabie, which operated at 4.28 million m^3/a (***DWA, 2012***). No WTW capacities are presented for Graskop. The Sabie WTW operational volumes are not in agreement with the population figures obtained for the same period.

As a result, the 2007 historic water use figures, were extended or projected to 2011 and 2016 (**Table 3-21**) according to the population growth for the same period. See **APPENDIX A** for overview map of demand centres.

Table 3-21: Historic Water Use Thaba Chweu Local Municipality

Demand Centre	Historic Water Requirements (million m^3/a)		
	2007	2011	2016
Graskop	0.71	0.75	0.81
Sabie (including Hendriksdal)	1.55	1.66	1.78
Total	**2.26**	**2.41**	**2.59**

3.7.2 Future Water Requirements in the Thaba Chweu Local Municipality

The future water requirements for the Thaba Chweu LM were obtained from the previous *All Towns Study*. The towns of Sabie and Graskop were part of the remainder of Thaba Chweu Schemes (Thaba Chweu Cluster). The population growth from 2007 to 2020 was estimated as 0.1% per annum for the low growth scenario and 0.5% per annum for the high growth scenario (***DWA, 2011***).

The high-level population projection derived for this Study, resulted in average growth rates of 1.48% per annum for Sabie and 1.28% per annum for Graskop., which are noticeably higher than the *DWS All Towns Strategy*.

The water requirements were projected from 2016 to 2040 based on the updated population projections are presented in **Table 3-22**.

Table 3-22: High-level Water Requirements Projection for Thaba Chweu Local Municipality

Demand Centre	Water Requirements Projections for this Strategy (million m^3/a)				Average Annual Growth Rates
	2016	2020	2030	2040	
Graskop	0.81	0.85	0.97	1.10	1.28%
Sabie (including Hendriksdal)	1.78	1.78	1.78	1.79	1.48%
Total	**2.59**	**2.63**	**2.75**	**2.89**	**1.48%**

3.7.3 Industrial Water Requirements in the Thaba Chweu Local Municipality

There are no major industries in and around Sabie and Graskop, except for the Sabie York Timber Sawmill. It is understood that the saw mills water use forms part of the Sabie Demand Centre consumption.

3.7.4 Return Flows in the Thaba Chweu Local Municipality

Sabie and Graskop have a formal sewer network and the *Green Drop Report* stated a WWTW design capacity of 0.72 million m^3/a for Sabie WWTW and 0.55 million m^3/a for Graskop WWTW. Sabie WWTW and Graskop WWTW operate at full capacity. The design capacity for the Graskop WWTW was confirmed in the earlier *All Towns Report*, however the Sabie WWTW plant design capacity was stated at a much larger value of 1.82 million m^3/a for the year of 2007. Both WWTW are reported to be in a poor state (***DWA, 2012b***). The RFFs for Sabie and Graskop towns are 0.41 and 0.68 respectively, as shown in **Table 3-23**.

Table 3-23: Return Flows in the Thaba Chweu Local Municipality

Demand Centre	Historic Return Flows for 2016 (million m^3/a)	Water Use for 2016 (million m^3/a)	Return Flow Factor
Graskop	0.55	0.81	0.68
Sabie (excluding Hendriksdal)	0.72	1.76	0.41
Total	**1.27**	**2.57**	**0.49**

Table 3-24: Return flows Projections in the Emakhazeni Local Municipality

Demand Centres	Return Flows Projections (million m3/a)			
	2016	2020	2030	2040
Graskop	0.55	0.58	0.66	0.75
Sabie (excluding Hendriksdal)	0.72	0.72	0.72	0.72
Total	**1.27**	**1.29**	**1.37**	**1.46**

3.7.5 Groundwater Use in the Thaba Chweu Local Municipality

Sabie abstracts water from an old abandoned mine shaft, and Graskop obtains water from a well-constructed around natural fountains. The estimate 2016 consumption from Sabie and Graskop is 1.78 million m^3/a and 0.81 million m^3/a respectively.

4 AGRICULTURAL WATER REQUIREMENTS AND AFFORESTATION

4.1 Irrigation Water Requirements

Irrigation data was sourced from the 2011 *Inkomati Water Availability Assessment* Strategy (iWAAS) for the Sabie/Sand River Sub- Catchment and Crocodile (East) River Sub-Catchment. The irrigation areas and irrigation boards (IBs) are shown in **Figure 4-1**. The Crocodile (East) Sub-Catchment consists of the Upper (X21), Middle (X22) and Lower (X24) Tertiary Catchments, as well as Kaap (X23). The following 11 IBs are active in the Study Area: Crocodile Main River IB, Elands River, Sand River, White River Valley, White Waters, Noord Kaap, Suid Kaap, Queens, Eureka, Louws Creek and Lower Kaap IB. The Crocodile Main River IB is the largest IB in the Crocodile (East) Sub- Catchment. In addition, there are three minor IB, namely the Friedenheim, Malelane and Tenbosh IBs. The Sabie Sub-Catchment (X3) comprises of two IBs, namely Injaka and Sabie River IB (***DWAF, 2009***).

The irrigation areas and their requirements that were sourced from the iWAAS and the more recent IUCMA Validation and Verification (V&V) Study are summarised in **Table 4-1**. The largest irrigation areas occur in the Middle (X22) and Lower (X24) Crocodile (East) Tertiary Catchments. The irrigation and areas and requirements are presented at a quaternary level (higher resolution) in **APPENDIX C**.

Table 4-1: Irrigation dataset comparison

Tertiary Catchment	iWAAS (2009)		ICUMA V&V Study (2014)	
	Area (km^2)	Water Requirements (million m^3/a)	Area (km^2)	Water Requirements (million m^3/a)
Upper Crocodile (X21)	29	21	140	54
Middle Crocodile (X22)	212	149	179	124
Kaap (X23)	98	92	106	92
Lower Crocodile (X24)	162	192	192	220
Total for Crocodile	**501**	**454**	**617**	**490**
Sabie (X31)	102	82	176	101
Sand (X32)	25	17	112	46
Total for Sabie	**127**	**99**	**288**	**147**

Source: iWAAS (***DWAF, 2009***) and IUCMA (personal communication)

There are noticeable differences in between the areas of the iWAAS (2004) and the IUCMA V&V Study (2018) datasets in the Upper, Middle and Lower Crocodile (East) Tertiary Catchments. The unit water requirements per tertiary catchment are different for the two presented datasets. A desktop (high level) ground truthing exercise of the existing datasets with land cover maps and satellite images was undertaken for the purpose of this Study. From this ground truthing exercise's results it seems that the IUCMA V&V Irrigation dataset is generally a more realistic representation Crocodile (East) Sub- Catchment while in the Sabie Sub- Catchment the iWAAS Data is more realistic.

The noticeable differences were discussed with the IUCMA, DWS and the Department of Agriculture, Forestry and Fisheries (DAFF), and could not be confirmed by these stakeholders and it was reported that the verification process for the V&V Study is still in the process of being completed. The findings and were presented to the Strategy Steering Committee (StraSC) where it was recommended and agreed that the iWAAS dataset will be applied for the purpose of this Study. It is recommended that the presented discrepancies in irrigation areas and water requirements should be further investigated as part of the finalisation of the V&V.

The water requirements for the iWAAS as well as the IUCMA V&V irrigation areas were determined with the water quality and total dissolved salts (WQT) model and SAPWAT 2 respectively. The SAPWAT program is used to determine the irrigation water requirements, depending on the soils, crop types, irrigation method and annual precipitation (MAP). It is known that some versions of SAPWAT 2 underestimated the irrigation water requirements. A detailed list of irrigation areas and water requirements in quaternary catchment resolution is shown in **APPENDIX C**.

The Nkosi City development (presented in **Section 3.3.2**) also includes a planned irrigation development of 228 ha, which equates to an additional requirement of approximately 1.60 million m^3/a (assumed 7000 m^3/ha/a). The actual irrigation requirements will depend on the soil types, crop combinations and irrigation systems that will be applied.

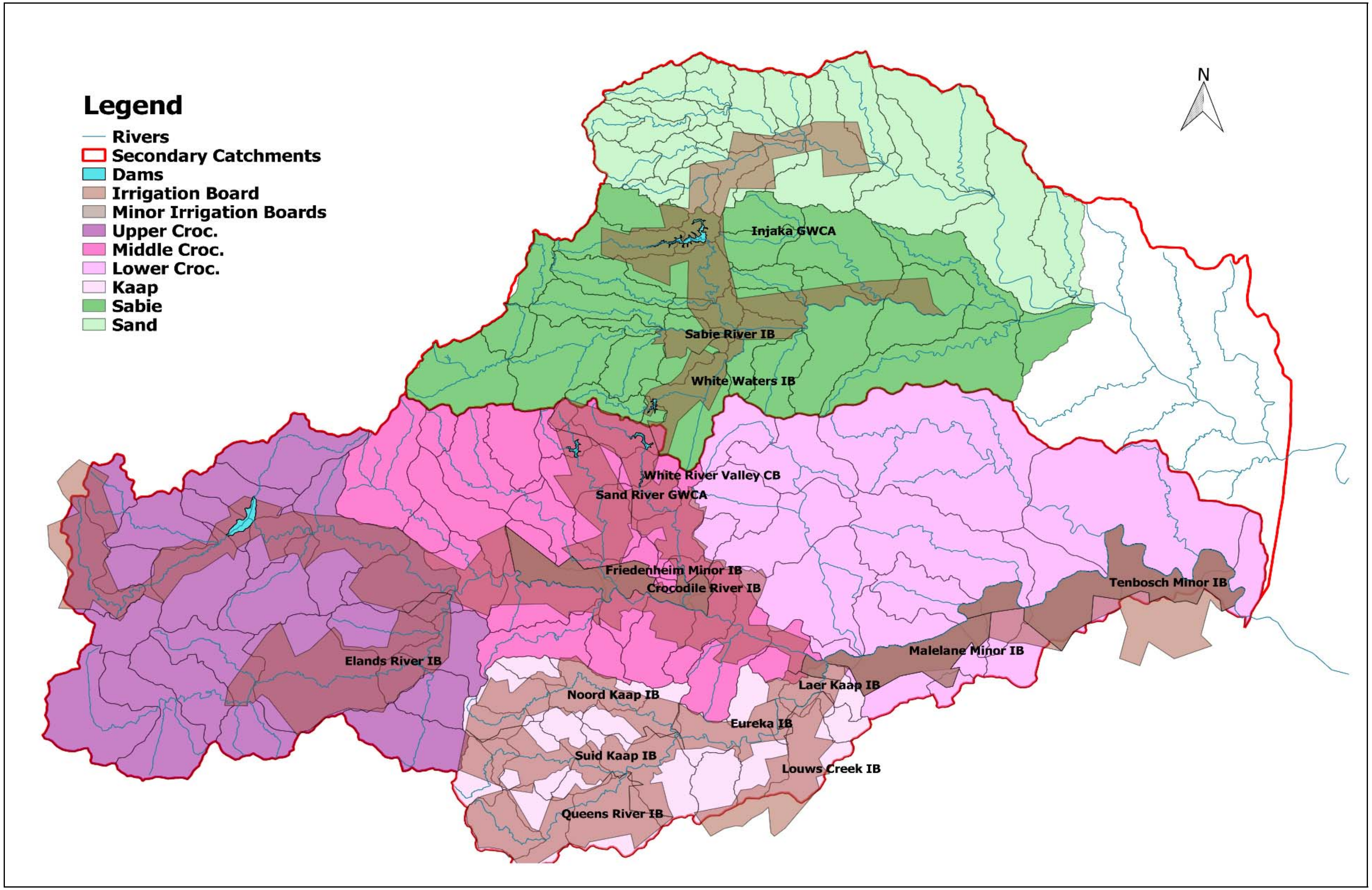

Figure 4-1: Irrigation Boards and Sub- Catchments in the Study Area

4.2 Irrigation Return Flows

The irrigation return flows, which were sourced from the *iWAAS Report*, are summarised in **Table 4-2** (***DWAF, 2009***). It is expected, and confirmed from various local stakeholders that only minor changes in irrigation water requirements have occurred and no drastic changes in the irrigation system types have occurred and it thus expected that the return flows would have remained more or less constant since 2011. Severe drought conditions or abnormally high or low rainfall events will have an effect on irrigation water requirements. If high rainfall is experienced less water will have to be used for irrigation whereas in low rainfall years more water is used for irrigation at a lower assurance of supply.

The irrigation return flows were obtained from the *iWAAS Report* in which it was state that the WQT model was used (***DWAF, 2009***), as actual recorded return flow datasets do not exist and depend on various factors such as the irrigation system type, soil type, hydraulic gradient, groundwater depth etc..

Table 4-2: Irrigation Return Flows for the Study Area

Tertiary Catchment	Irrigation Water Requirements (million m^3/a)	Return Flows (million m^3/a)	Return Flow Factor
Upper Crocodile (X21)	21	1.5	7%
Middle Crocodile (X22)	149	9.2	6%
Kaap (X23)	92	6.7	7%
Lower Crocodile (X24)	192	8.5	4%
Total for Crocodile	**454**	**26**	**6%**
Sabie (X31)	102	2.2	3%
Sand (X32)	25	1.1	6%
Total for Sabie	**127**	**3.3**	**3%**

Source: iWAAS ***(DWAF, 2009)***

4.3 Afforestation and Stream Flow Reduction

Large areas of the Study Area are covered by commercial forestry plantations which will significantly impact on the water resources availability. Afforestation areas are therefore carefully controlled in South Africa.

Afforestation areas are mostly located in the Upper and Middle Crocodile (East) Tertiary Catchments as indicated in the afforestation summary in **Table 4-3**. From the two dataset sources (iWAAS and IUCMA V&V Study) it appears that the area of afforestation has decreased in the Crocodile (East) River Sub- Catchment from by 25% from 1944 km^2 to 1465 km^2. For the Sabie/Sand River Sub- Catchment a similar decrease of 27% is observed, from 852 km^2 to 622 km^2%.

A high level ground truthing exercise was conducted with satellite images, land use maps, as well as the comparison of shapefiles for the iWAAS and IUCMA V&V Datasets was undertaken. It was determined that the iWAAS Afforestation Dataset was a more realistic representation, compared to the IUCMA V&V Study Dataset. The differences in afforestation areas were discussed with local stakeholders who confirmed that a small change in afforestation area was noted due to some afforestation being replaced with Macadamia plantations, which is only estimated to be a 1% to 2% reduction in area. It was agreed that the iWAAS data was more realistic and will be applied in further analysis of the study. The afforestation areas and streamflow reduction are presented at a quaternary level (higher resolution) in **APPENDIX D**.

Table 4-3: Afforestation and Stream Flow Reduction

Tertiary Catchment	iWAAS (2009)		IUCMA V&V Study (2014)	
	Area (km^2)	Streamflow reduction (million m^3/a)	Area (km^2)	Streamflow reduction (million m^3/a)
Upper Crocodile (X21)	587	52	505	45
Middle Crocodile (X22)	901	66	656	57
Kaap (X23)	444	40	294	22
Lower Crocodile (X24)	12	0.4	10	0.2
Total for Crocodile	**1944**	**158**	**1465**	**124**
Sabie (X31)	797	86	596	75
Sand (X32)	56	4	27	2
Total for Sabie	**853**	**90**	**623**	**77**

Source: iWAAS **(DWAF, 2009)** and IUCMA (personal communication)

5 OTHER WATER REQUIREMENTS

5.1 Reserve

The Reserve for the Crocodile (East) Sub- Catchment and the Sabie Sub- Catchment, was sourced from *Government Gazette Vol 629 No 41237* and are given in **Table 5-1** and **Table 5-2** respectively. The reserve determination methodology is described in in the *National Water Act (Act No 26 of 1998)*, under Chapter 3, Part 3. The reserve comprises of two components, being the basic human needs (BHNs) component and the ecological water requirements (EWRs). One of the primary objectives of the Reserve requirements for the Study Area is the Kruger National Park (KNP). The Crocodile (East) River is the southern boundary of the KNP and the Sabie River flows through the KNP into Mozambique.

Table 5-1: Gazetted Ecological Water Environmental Requirements for the Crocodile (East) River Sub- Catchment

Quaternary Catchment	Water Resource	Ecological Reserve (% of NMAR)[4]	Basic Human Needs Reserve (% of NMAR)[3]	Total Reserve (% of NMAR)[2]	NMAR (million m^3/a)[1]
X21A	**Crocodile River (EWR 1: Valyspruit)**	**30.90**	**0.02**	**30.92**	**15.19**
X21B	Lunsklip	31.30	0.12	31.42	25.80
X21B	**Crocodile (EWR 2: Goedenhoop)**	**57.00**	**0.01**	**57.01***	**47.11**
X21C	Alexanderspruit	31.50	0.11	31.61	28.80
X21D	Crocodile	24.00	0.02	24.02	124.80
X21E	**Crocodile (EWR 3: Poplar Creek)**	**55.20**	**0.09**	**55.29**	**169.90**
X21F	Elands	35.50	0.17	35.67	50.80
X21G	**Elands River (EWR ER 1)**	**48.82**	**0.26**	**49.08**	**50.10**
X21H	Ngodwana	22.10	0.01	22.11	59.60
X21J	Elands	30.50	0.01	30.51	151.50
X21K	**Elands River (EWR ER 2)**	**45.02**	**0.01**	**45.03**	**50.10**
X22A	Houtbosloop	41.30	0.01	41.31	75.30
X22C	Gladdespruit	20.90	0.07	20.97	16.30
X22D	Nels	29.60	0.02	29.62	20.60
X22E	Kruisfonteinspruit	26.60	0.00	26.60	11.10
X22F	Nels	24.10	0.01	24.11	125.40
X22H	Wit	14.90	0.00	14.90	43.00

Quaternary Catchment	Water Resource	Ecological Reserve (% of NMAR)[4]	Basic Human Needs Reserve (% of NMAR)[3]	Total Reserve (% of NMAR)[2]	NMAR (million m^3/a)[1]
X22K	**Crocodile (EWR 4: KaNyamazane)**	**34.50**	**0.01**	**34.51**	**754.10**
X23B	Noordkaap	23.50	0.01	23.51	50.90
X23C	Suidkaap	39.50	0.01	39.51	61.80
X23E	Queens	27.10	0.01	27.11	39.50
X23F	Suidkaap	31.00	0.45	31.45	109.80
X23G	**Kaap River (EWR 7: Honeybird)**	**36.80**	**0.02**	**36.82**	**169.00**
X24A	Nsikazi	40.60	4.25	44.85	11.70
X24B	Nsikazi	44.00	3.70	47.70	42.40
X24C	Nsikazi	40.50	3.21	43.71	52.30
X24D	**Crocodile (EWR 5: Malelane)**	**40.20**	**0.01**	**40.21**	**1006.20**
X24H	**Crocodile (EWR 6: Nkongoma)**	**43.90**	**0.01**	**43.91**	**1063.10**

Source: Government Gazette vol. 629 no. 41227

1) NMAR is the Natural Mean Annual Runoff.

2) The total Reserve amount accounts for both the Ecological Reserve and the Basic Human Needs Reserve (BHN).

2) Represents the percentage of BHN.

4) This amount represents the long term mean based on the NMAR. If the NMAR changes, this volume will also change.

*Gazette stated 50.01% which is incorrect

Table 5-2: Gazetted Ecological Water Environmental Requirements for the Sabie River Sub- Catchment

Quaternary Catchment	Water Resource	Ecological Reserve (% of NMAR)[4]	Basic Human Needs Reserve (% of NMAR)[3]	Total Reserve (% of NMAR)[2]	NMAR (million m^3/a)[1]
X31A	Klein Sabie	23.00	0.73	23.73	14.60
X31B	**Sabie River (EWR 1: Upper Sabie)**	**46.30**	**0.00**	**46.30**	**140.18**
X31C	**Mac Mac River (EWR 4: Mac Mac)**	**37.00**	**0.03**	**37.03**	**65.78**
X31E	Marite	34.70	0.36	35.06	79.90
X31F	Motitsi	26.50	0.05	26.55	43.90
X31D	**Sabie River (EWR 2: Aan de Vliet)**	**35.70**	**0.08**	**35.78**	**262.10**
X31G	**Marite River (EWR 5: Marite)**	**36.30**	**0.07**	**36.37**	**157.09**
X31H	White Waters	31.40	0.00	31.40	28.90
X31J	Noord-Sand	16.00	0.63	16.63	45.10
X31K	**Sabie River (EWR 2: Kidney)**	**37.00**	**0.07**	**37.07**	**495.86**
X31L	Saringwa	24.50	3.45	27.95	10.90
X31M	Musutlu	19.00	10.94	29.94	1.80
X32B	Motlamogatsana	25.70	0.69	26.39	15.40
X32C	**Tlulandziteka (Sand) River (EWR 7: Upper Sand)**	**31.70**	**0.57**	**32.27**	**28.88**
X32E	Nwarhele	26.10	2.87	28.97	10.60
X32F	**Mutlumuvi River (EWR 6: Mutlumuvi)**	**32.20**	**0.42**	**32.62**	**44.99**
X32G	Khokhovela	17.00	8.57	25.57	3.90
X32H	Phungwe	26.10	2.33	28.43	7.60
X32J	**Sand River (EWR 8: Lower Sand)**	**25.30**	**0.30**	**25.60**	**133.61**

Source: Government Gazette vol. 629 no. 41227

1) NMAR is the Natural Mean Annual Runoff.

2) The total Reserve amount accounts for both the Ecological Reserve and the Basic Human Needs Reserve (BHN).

2) Represents the percentage of BHN.

4) This amount represents the long term mean based on the NMAR. If the NMAR changes, this volume will also change.

5.2 Invasive Alien Plants

The reduction in runoff due to IAPs is documented and described according to Le Maitre et al. (2000), in the assessment on the impact of AIPs on stream flow reduction. IAP reduce available runoff in a catchment, more than an indigenous species. The IAPs are grouped as small, medium and large trees, it is assumed that IAPs located in close proximity to natural streams utilise more water, due to the greater availability thereof. Therefore, IAPs close to a natural stream are called riparian IAP and are handled separately to the upland species. IAP runoff reduction factors are applied depending on the size classification and location (riparian or upland).

The IAP information was sourced from previous Working for Water datasets, which is an alien invasive eradication program under the Department of Environmental Affairs (DEA), and the NIAP Survey (***ARC, 2011***). The extent of the areas covered by IAP from the iWAAS and NIAP Survey are summarised in **Table 5-3** per sub- catchment.

From the comparison, it is evident that the iWAAS IAP data is on average greater than that of the IAP Survey, except for the Upper Crocodile (East) Tertiary Catchment. A conservative approach will be followed by applying the iWAAS dataset, unless additional information is made available prior to the Water Resource Analysis task that confirms the IAP Survey as more realistic.

The IAP eradication and clearing efforts are difficult to trace and measure, as IAP densities and regrowth are not documented in great detail by the relevant authorities and initiatives. The Upper and Middle Crocodile (East) Tertiary Catchments have the largest IAP areas. The previous *Reconciliation Study* recommended the clearing of the IAP upstream of the Kwena Dam as an intervention option in order to increase its yield significantly. A strict clearing and control schedule will have to be implemented to successfully remove existing IAP areas upstream of the Kwena Dam and control regrowth areas, to ensure that the additional yield is realised.

Table 5-3: Summary of Invasive Aline Plants from the 2011 National Invasive Alien Plant Survey and the Inkomati Water Availability Assessment Study

Tertiary Catchment	iWAAS (2009)	NIAP Survey (2011)	
	Condensed Area (km^2)	Condensed Area (km^2)	Uncondensed Area (km^2)
Upper Crocodile (X21)	89	129	2 084
Middle Crocodile (X22)	122	47	585
Kaap (X23)	69	20	227
Lower Crocodile (X24)	15	-	-

Tertiary Catchment	iWAAS (2009)	NIAP Survey (2011)	
	Condensed Area (km²)	Condensed Area (km²)	Uncondensed Area (km²)
Total for Crocodile	**295**	**196**	**2 896**
Sabie (X31)	81	6	96
Sand (X32)	22	17	122
Total for Sabie	**103**	**23**	**220**

5.3 International Obligations

The RSA has international water obligations towards Mozambique and Swaziland. RSA's neighbouring countries, through which the Inkomati River (Crocodile, Komati and Sabie) system flows towards the Indian Ocean. The Tripartite Permanent Technical Committee (TPTC) between South Africa, Mozambique and Swaziland, have set required base flows at specific gauging and measuring points, in close proximity to the border with Mozambique.

The Piggs Peak Agreement (***TPTC, 1990***) specified a minimum flow of 2 m^3/s into Mozambique from the Crocodile and Komati Rivers. The arrangement is that the Crocodile River will contribute 0.9 m^3/s and the Komati 1.1 m^3/s as shown in **Table 5-4**. The Piggs Peak Agreement (***TPTC, 1990***) has been superseded by the IncoMaputo Water Use Agreement (***TPTC, 2002***).

Table 5-4: International Obligations

Agreement	Minimum Flows (m^3/s)			
	Sabie River	Crocodile River	Komati River	Total
Piggs Peak Agreement (TPTC, 1990)	(0.6)	0.9	1.1	2
IncoMaputo Water Agreement (TPTC, 2002)	0.6	1.18	1.42	3.2

5.4 General Authorisation

General Authorisation according to the National Water Act (Act No 26 of 1998) states that no water use license is required until the General Authorisation is revoked (SA, 1998). A revision of the General Authorisation water use was gazetted in the *Government Gazette No 40243 of 10 November 2016* (***SA, 2016***). The updated Gazette indicates that 2000 m^3/a may be abstracted per person on communal land or per property for surface water throughout the year in the Inkomati Catchment (**Table 5-5**). This applies to rural communal land and other properties, which are not part of formal WSSs and have access to the watercourse. For groundwater the abstraction volume is given per property size for different quaternary catchments, as listed in **Table 5-6**. Where no General Authorisation volume is provided for a catchment, an application for a water use license has to be completed.

Table 5-5: Surface water abstraction and storage (*SA, 2016*)

Drainage Region	**Main River**	**Maximum volume of surface water that may be abstracted on each property or by each person on communal land in terms of the authorisation (m^3/a)**	**Maximum rate at which surface water may be abstracted by on each property or by each person on communal land in terms of the authorisation (l/s)**	**Months in which water may be abstracted in terms of this authorisation**	**Maximum volume that may be stored on each property or by each person on communal land in terms of the authorisation (m^3)**
X	Inkomati, Crocodile, Sabie	2000	1	whole year	2000

Table 5-6: Groundwater Abstraction Rates (*SA, 2016*)

Quaternary Catchments	**Abstraction Rate ($m^3/ha/a$)**
X23G-X23H X24D	0
X21A-X21G X21J X22A - X22B X22D - X22K X24A-X24C X24E - X24H X31 A - X31 M X32A - X32J X33A - X33D X40A-X40D	45
X21H X21K X22C X23A - X23F	75

For the purpose of this Report the following assumptions were made; that the Study Area has a rural population of approximately 15 000, which are not supplied by any formal water supply schemes. The population number was obtained by subtracting the population number serviced by formal water supply schemes in the demand centres from the total population in the Study Area. This information was sourced from the Stats SA Population Datasets and from the *Economic Growth and Demographics Analysis Report P WMA 03/X22/00/6918*. If it is assumed that only 10% of the rural population has direct access to a watercourse and that an average property located next to a watercourse has four occupants, there would be approximately 375 properties. If each property uses 2000 m^3/a, this would add additional requirements of approximately 0.75 million m^3/a for the Study Area, which is relatively small compared to the total requirements summarised in **Section 6**.

Similar to the surface water, a groundwater calculation was conducted for the Study Area. The rural area not formerly covered by a water supply scheme was estimated as 45 000 ha, which is 3 percent of the total study area of 1.5 million ha. If the quaternary areas are assumed to be split 80% and 20% in the 45 $m^3/ha/a$ and 75 $m^3/ha/a$ categories respectively, the total groundwater use for the study area would be approximately 2.3 million m^3/a. This requirement is an indicative estimate with a great deal of uncertainty and it also assumed that the properties have the resources available to implement and operate borehole infrastructure. Furthermore, there is a possibility of double counting the rural water requirements component included in the basic human need (BHN) component of the reserve.

Due to the relatively small consumption based on a low confidence estimate, as well as the possibility that a portion or all of this has already been included in the BHN component of the reserve it is not recommended that the General Authorisation consumption is included as an additional requirement in the study.

6 SUMMARY OF WATER REQUIREMENTS

The domestic, industrial, irrigation and afforestation water requirements are summarised in **Table 6-1**. The dataset is based on the analysis starting values in 2016 (base year). The reduction in runoff due to IAP is not a planned consumption and will therefore form part of the Water Resources Analysis Task for the purposes of this Study.

Irrigation and forestry are the largest water use sectors in the Study Area. The largest domestic, irrigation and afforestation water requirements are located in the Middle Crocodile, Lower Crocodile and Upper Sabie Tertiary Catchments.

Table 6-1: Summary of Water Requirements in million m^3/a (2016)

Tertiary Catchments	Water Requirements in 2016 (million m^3/a)				
	Domestic and light Industrial	Industrial	Irrigation	Forestry	Total
Upper Crocodile (X21)	2	15	21	52	90
Middle Crocodile (X22)	56	-	149	66	271
Kaap (X23)	6	-	92	40	138
Lower Crocodile (X24)	14	9	192	0.4	215
Total for Crocodile	**78**	**24**	**454**	**158**	**714**
	11%	**3%**	**64%**	**22%**	**100%**
Upper Sabie (X31)	39	-	82	86	207
Sand (X32)	13	-	17	4	34
Total for Sabie	**52**	**0**	**99**	**90**	**241**
	22%	**0%**	**41%**	**37%**	**100%**

The summary of the water requirements for the Crocodile (East) Sub- Catchment and Sabie Sub- Catchment are shown as pie chart in **Figure 6-1** and **Figure 6-2** respectively. The figures clearly illustrate that irrigation makes up the largest portion of water requirements in the Study Area, followed by commercial forestry (afforestation), domestic and industrial water requirements.

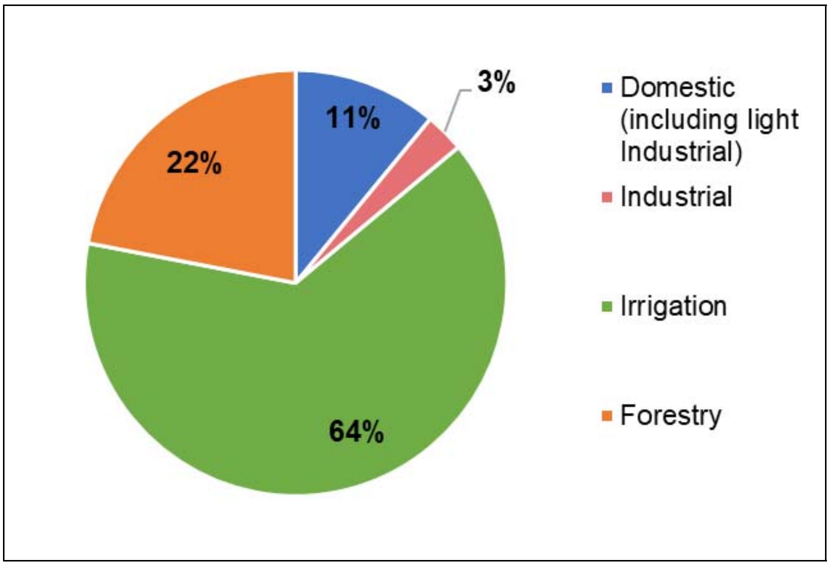

Figure 6-1: Summary of Water Requirements for Crocodile (East) Sub- Catchment

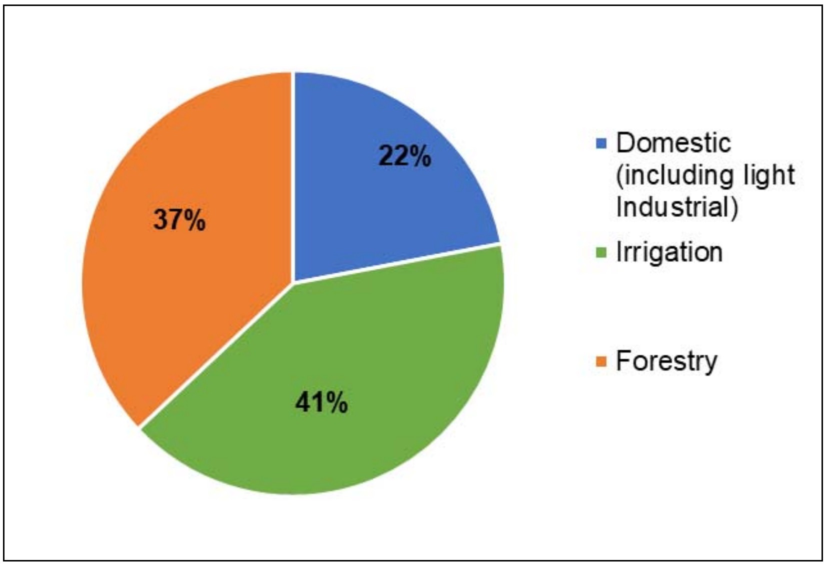

Figure 6-2: Summary of Water Requirements for Sabie Sub- Catchment

The Reserve water requirements were not included in the above summary as these requirements are variable and related to the flow in the river. The main Reserve sites at the lowest points in the tertiary catchments are summarised in **Table 6-2**. It should be noted that the Reserve water requirements cannot be summed, as they are given as a mean flow requirement at a specific point.

Table 6-2: Primary Reserve site per Tertiary Catchment

Tertiary Catchment	Water Resource	Total Reserve (% of NMAR)[2]	NMAR (million m^3/a)[1]	Average Reserve Requirements (million m^3/a)
X21	Crocodile (EWR 3: Poplar Creek)	55.29	169.9	93.9
X22	Crocodile (EWR 4: KaNyamazane)	34.51	754.1	260.2
X23	Kaap River (EWR 7: Honeybird)	36.82	169	62.2
X24	Crocodile (EWR 6: Nkongoma)	43.91	1063.1	466.8
X31K	Sabie River (EWR 2: Kidney)	37.07	495.86	183.8
X32J	Sand River (EWR 8: Lower Sand)	25.6	133.61	34.2

1) NMAR is the Natural Mean Annual Runoff.

2) The total Reserve amount accounts for both the Ecological Reserve and the Basic Human Needs Reserve (BHN).

The international obligations are specified as minimum required flows into Mozambique, which can be summarised as 2.6 m^3/s (82.1 million m^3/a) from the Crocodile (East) River and Inkomati River and 0.6 m^3/s (18 million m^3/a) from the Sabie River. These minimum flow values were not included in the water requirements summary as they are minimum flows that need to be adhered to. The Water Resource Analyses task will confirm whether any additional support, over and above the EWRs is required.

The transfer out of the Upper Sabie is for water supplied from the Nyongane WTW to Nsikazi North. There are two transfers into the Kaap River Catchment (former Umjindi LM) from the neighbouring Lomati Catchment. The first transfer is 3.2 million m^3/a from Lomati Dam on the Lomati River to the Rimers Creek WTW, which supplies water to Barberton. The second transfer is 5.8 million m^3/a from the Shiyalongubo Dam on the Ugutugulo River to the Shiyalongubo Demand Centre, which includes some mines and the Shiyalongubo town with an informal settlement.

7 STAKEHOLDER ENGAGEMENT

Stakeholder engagement formed an essential component of the information gathering process. The engagement consisted of meetings, numerous telephonic conversations and emails with the various stakeholders is listed in **Table 7-1**. Stakeholder inputs to the task process and results engagement also took place through the Technical Support Group (TSG) and StraSC meetings held, where the findings presented in this report were presented and discussed.

Table 7-1: Stakeholders engaged with during the execution of the task

Name	Organisation	Contact	Communication	Information
Louis Klapprott	Sembcorp Silulumanzi	Louis.Klapprott@sembcorp.com	Meeting, emails, phone	Historical use & future requirements
Theo Botha	CoM LM	Theo.Botha@mbombela.gov.za	Meeting, emails, phone	Historical use & future requirements
Erik Loubser	GLS (Consultant)	erik@gls.co.za	emails, phone	Historical use & future requirements, WTW & WWTW volumes: urban sector (CoM LM)
Thys Venter	Former Umjindi LM	thys.venter@mbomela.gov.za	Meeting, emails, phone	System layout and status quo, no historic data received
Richards Baloiy	BBR LM	rodgersbaloyi@yahoo.com	Meeting, emails, phone	System layout and status quo, no historic data received
Brendan Mashabane	DEA	BMashabane@environment.gov.za	Emails, phone	IAP information and updates on eradicated areas
Tendai Sawunyama	IUCMA	sawunyamat@iucma.co.za	Meeting, emails, phone	Historical use & future requirements, V&V dataset
Sampie Shabangu	IUCMA	shabangus@iucma.co.za	Meeting, emails, phone	Historical use & future requirements, V&V dataset
Vutlhari Matsane	IUCMA	matsanev@iucma.co.za	Emails, phone	V&V dataset queries
Marius van Rooyen	DAFF	mvanrooyen@gmail.com	Emails, phone	Irrigation areas confirmation and input
Andre van der Merwe	Crocodile Irrigation Board	Andre.vandermerwe@rlcfoods.cpm	Emails, phone	Irrigation areas confirmation and input
Mpho Makhavhu	Rand Water	mmakhavh@randwater.co.za	Emails, phone	Historic use and changes in LOS
Mia Smith	(Sappi Ngodwana)	Mia.Smith@sappi.com	Emails, phone	Historical use & future requirements

8 CONCLUSIONS AND RECOMMENDATIONS

The Water Requirements and Return Flows Task of the project is the collation and formulation of water requirements and return flows projections for the various demand centres and water use sectors. The largest water requirements in both the Crocodile (East) and Sabie Sub- Catchments are for irrigation, followed by commercial afforestation, domestic and industrial users.

The municipal water requirements projections of the study focus area, namely the CoM LM, former Umjindi LM and BBR LM were derived from first principles. The water requirements projections for the remaining area, which includes parts of the Thaba Chweu LM, Nkomazi LM and Emakhazeni LM were based on existing information sourced from the previous *DWS All Towns Studies*.

Limited current and historic water use data was available for some demand centres, such as Nsikazi South and Nsikazi North and theoretically water requirements were adopted for these areas. Current and historic water use data for the individual demand centres was not available and the total SIV BBR LM was split into the different demand centres in accordance with the population numbers and current bulk water understanding. Intermittent water supply is experienced in these areas, which either indicates system inefficiencies and/or infrastructure or water resources constraints.

Noticeable differences were found in the current irrigation and afforestation areas from the V&V and iWAAS datasets. A desktop (high level) ground truthing exercise was undertaken and it was established that the V&V irrigation dataset is generally more realistic for the Crocodile (East) Sub- Catchment, the iWAAS irrigation dataset for the Sabie Sub- Catchment and iWAAS afforestation dataset for the entire study area. The noticeable differences were discussed with the IUCMA, DWS and the Department of Agriculture, Forestry and Fisheries (DAFF), and could not be confirmed by these stakeholders and it was reported that the verification process for the V&V Study is still in the process of being completed. The findings and were presented to the Strategy Steering Committee (StraSC) where it was recommended and agreed that the iWAAS dataset will be applied for the purpose of this Study.

From the comparison of IAP Datasets, it was evident that the condensed iWAAS IAP areas were on average greater than the NIAP Survey areas, except for the Upper Crocodile Tertiary Catchment. A conservative approach will be followed by applying the iWAAS dataset, unless additional information is made available prior to the Water Resource Analysis task that confirms the NIAP Survey as more realistic.

It is recommended that the following actions be taken to rectify and improve the current water use and water supply information in the Study Area:

- Metering of the water use in all the demand centres should be prioritised and datasets should also be made available. This would allow for improved operations and planning by the relevant authorities in future.
- The differences between the V&V Dataset and iWAAS Irrigation and Afforestation Datasets should be investigated and confirmed during the finalisation of the V&V Study.
- The IAP Datasets should be investigated to confirm the most realistic and accurate dataset pertaining to the iWAAS IAP Dataset and the NIAP Survey Dataset.
- The intermittent supply and illegal connections should be addressed from a political and institutional level, with stakeholder engagement to allow for continuous reliable supply of water to all the residents in the rural and urban areas.

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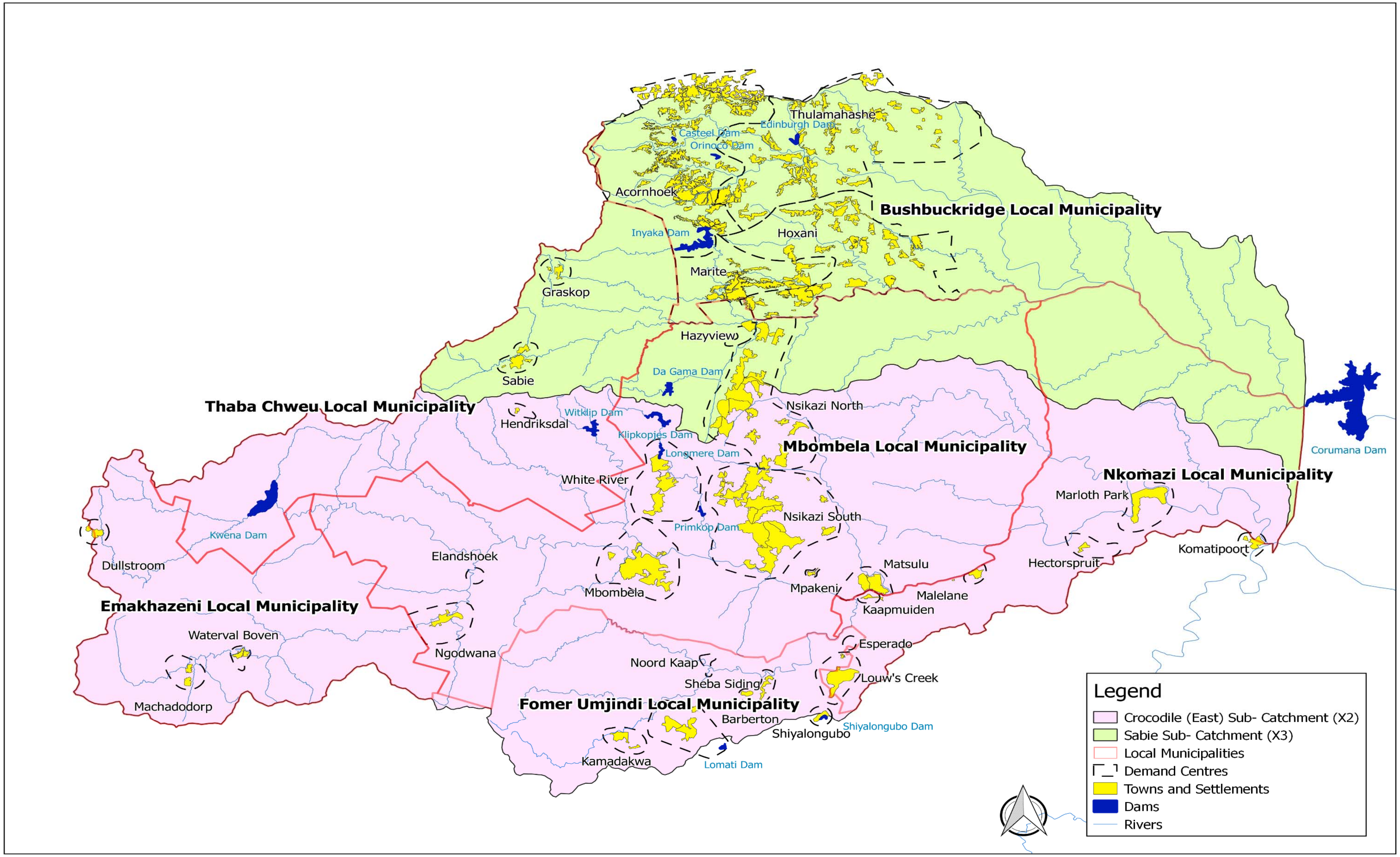
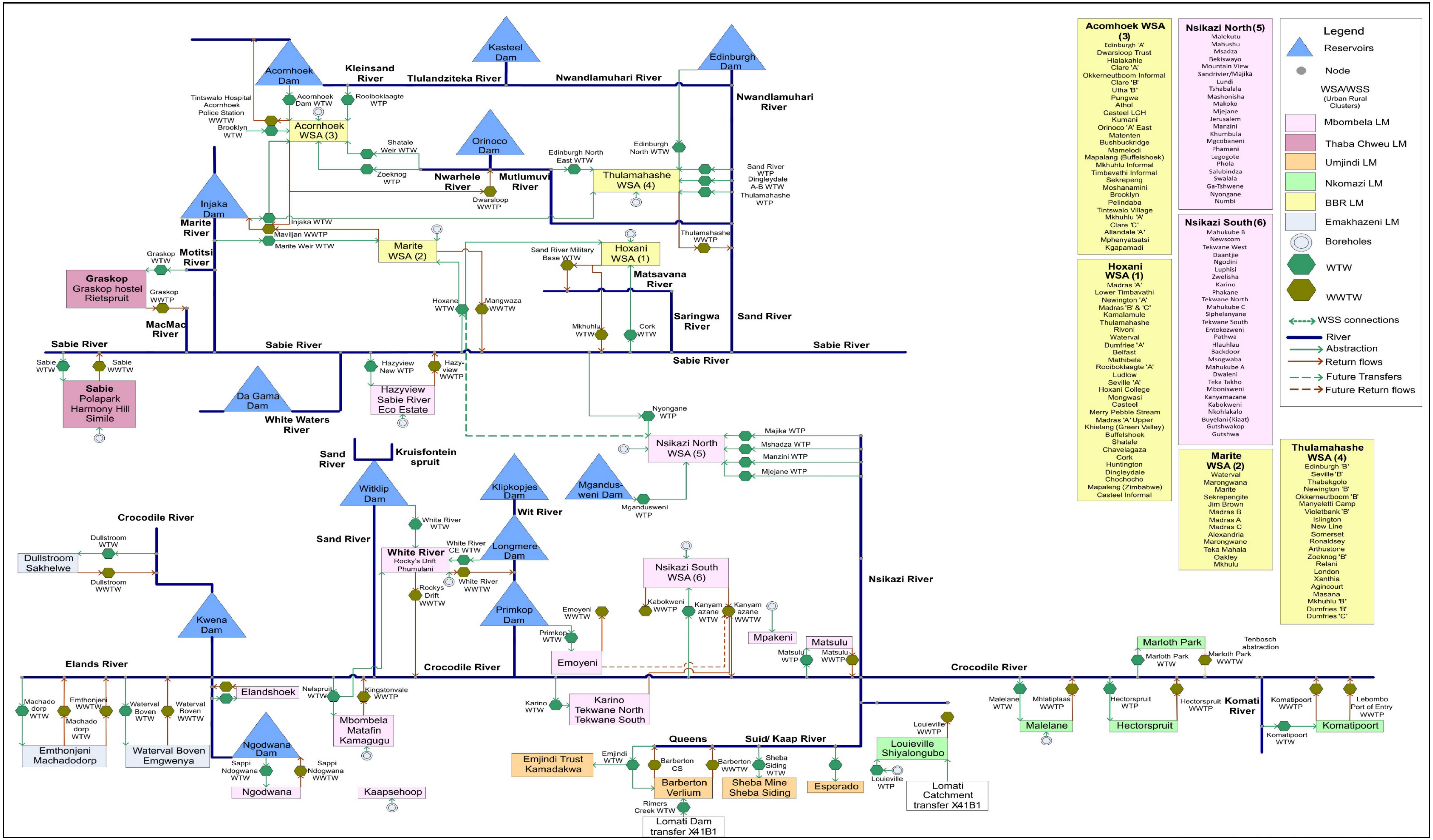
APPENDIX A

Overview Map of Demand Centres and Dam s in the Study Area



APPENDIX B

Simplified Water Supply Schematic for the Study Area



APPENDIX C

Irrigation Areas and Water Requirements

Quaternary	Total Area (km^2)	iWAAS Irrigation Area (km^2)	iWAAS Irrigation Water Requirements (million m^3/a)
X21A	294	0.0	0.0
X21B	420	4.2	2.0
X21C	345	4.8	2.3
X21D	244	3.5	1.5
X21E	384	10.9	7.5
X21F	442	0.0	0.0
X21G	387	0.0	0.0
X21H	255	0.2	0.0
X21J	395	15.0	7.8
X21K	273	0.2	0.1
Upper Crocodile Total	**3439**	**38.8**	**21.2**
X22A	279	0.1	0.1
X22B	252	10.2	6.3
X22C	407	70.7	54.8
X22D	305	0.3	0.0
X22E	170	0.7	0.0
X22F	236	38.5	25.7
X22G	119	0.3	0.0
X22H	222	41.1	24.2
X22J	267	33.2	23.8
X22K	373	17.4	14.2
Middle Crocodile Total	**2630**	**212.5**	**149.1**
X23A	141	1.3	1.1
X23B	255	11.8	12.2
X23C	91	0.0	0.0
X23D	203	18.6	15.8
X23E	201	1.0	0.8
X23F	345	25.3	22.2
X23G	251	10.2	10.3
X23H	341	29.9	29.2
Kaap Total	**1828**	**98.10**	**91.6**
X24A	276	0.0	0.0
X24B	372	0.6	0.5
X24C	318	10.1	11.8
X24D	336	53.7	58.9
X24E	585	20.8	24.6
X24F	291	16.8	19.1

Quaternary	Total Area (km^2)	iWAAS Irrigation Area (km^2)	iWAAS Irrigation Water Requirements (million m^3/a)
X24G	688	0.0	0.0
X24H	855	60.8	77.5
Lower Crocodile Total	**3721**	**162.8**	**192.4**
X31A	253	0.0	0.0
X31B	208	0.2	0.0
X31C	170	0.0	0.0
X31D	220	56.6	42.7
X31E	236	3.8	2.6
X31F	101	0.0	0.0
X31G	188	5.9	3.9
X31H	64	0.2	0.1
X31J	171	20.9	16.2
X31K	542	3.2	2.9
X31L	371	0.7	0.7
X31M	743	11.7	13.0
Sabie Total	**3267**	**103.2**	**82.1**
X32A	103	0.0	0.0
X32B	60	0.0	0.0
X32C	273	13.3	8.5
X32D	107	0.5	0.4
X32E	88	0.0	0.0
X32F	180	8.7	6.2
X32G	375	2.1	1.9
Sand Total	**1186.0**	**24.6**	**17.0**

APPENDIX D

Afforestation Areas and Water Requirements

Quaternary	iWAAS Afforestation Area (km^2)	iWAAS Afforestation Streamflow Reduction (million m^3/a)
X21A	4.5	0.5
X21B	19.6	1.7
X21C	32.4	2.7
X21D	39.9	3.0
X21E	96.6	8.6
X21F	13.3	1.3
X21G	67.4	5.0
X21H	76.8	7.7
X21J	108.2	10.0
X21K	128.4	11.2
Upper Crocodile Total	**587.1**	**51.6**
X22A	4.5	0.5
X22B	19.6	1.7
X22C	32.4	2.7
X22J	39.9	3.0
X22K	96.6	8.6
X22D	13.3	1.3
X22E	67.4	5.0
X22F	76.8	7.7
X22G	108.2	10.0
X22H	128.4	11.2
Upper Crocodile Total	**901.3**	**65.8**
X23A	95.2	9.9
X23B	35.0	1.6
X23C	71.9	8.2
X23D	87.0	10.7
X23E	122.1	8.0
X23F	15.5	0.6
X23G	0.7	0.0
X23H	16.0	0.7
Kaap Total	**443.4**	**39.7**
X24A	4.5	0.5
X24B	19.6	1.7
X24C	32.4	2.7
X24D	39.9	3.0
X24E	96.6	8.6

Quaternary	iWAAS Afforestation Area (km^2)	iWAAS Afforestation Streamflow Reduction (million m^3/a)
X24F	13.3	1.3
X24G	67.4	5.0
X24H	76.8	7.7
Upper Crocodile Total	**11.6**	**0.4**
X31A	153.7	20.4
X31B	142.1	13.4
X31C	102.1	13.2
X31D	55.2	4.8
X31E	136.1	14.6
X31F	74.3	7.8
X31G	58.8	5.0
X31H	49.0	4.8
X31J	25.0	1.8
X31K	0.4	0.0
X31L	0.6	0.0
X31M	0.0	0.0
Sabie Total	**797.3**	**85.8**
X32A	13.7	0.9
X32B	8.7	0.6
X32C	0.0	0.0
X32D	16.9	1.5
X32E	15.5	0.9
X32F	0.0	0.0
X32G	0.0	0.0
X32H	0.0	0.0
X32J	0.0	0.0
X33A	0.0	0.0
X33B	0.0	0.0
X33C	0.0	0.0
X33D	0.0	0.0
X40A	0.0	0.0
X40B	0.0	0.0
X40C	0.0	0.0
X40D	0.0	0.0
Sand Total	**54.8**	**3.9**