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THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE CROCODILE (WEST) WATER SUPPLY SYSTEM

Current and Future Water Requirements and Return Flows

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LIST OF STUDY REPORTS

THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOT THE CROCODILE (WEST) WATER SUPPLY SYSTEM:	REPORT NUMBER	
	DWAF	BKS
Inception Report	P WMA 03/000/00/3307	H4125-01
Summary of Previous and Current Studies	P WMA 03/000/00/3408	H4125-02
Current and Future Water Requirements and Return Flows and Urban Water Conservation and Demand Management	**P WMA 03/000/00/3508**	**H4125-05**
Water Resource Reconciliation Strategy: Version 1	P WMA 03/000/00/3608	H4125-06
WRPM Analyses	P WMA 03/000/00/3708	H4125-07
Executive Summary	P WMA 03/000/00/3908	H4125-09
Water Requirements and Availability Scenarios for the Lephalale Area	P WMA 03/000/00/4008	H4125-10

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The Development of a Reconciliation Strategy for the Crocodile (West) Water Supply System: Current and Future Water Requirements and Return Flows and Urban Water Conservation and Demand Management

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The Development of a Reconciliation Strategy for the Crocodile (West) Water Supply System

Current and Future Water Requirements and Return Flows

EXECUTIVE SUMMARY

INTRODUCTION

This report describes the current and future water requirements and return flows as well as the urban water conservation and demand management of the Crocodile (West) River Catchment for the Crocodile (West) Reconciliation Strategy (CWRS). The Department of Water Affairs and Forestry (DWAF) Regional Offices, relevant Metropolitan Councils, Irrigation Boards, Mines and Industries were contacted to ascertain, verify and/or supplement the present and projected future water requirements where necessary. In addition, a population-driven approach was used to assess current and future primary water requirements.

The Terms of Reference refers to current and future urban requirements. Due to the complex nature of the catchment, the PSP, however, believed that it was necessary to also consider the other sectors of water use, particularly mining (and the projected growth in mining), irrigation and rural water supply in this report. Consideration was also given to major return flows, as these form significant contributions to the water resources of the area. Separate supporting tasks investigated irrigation water requirements and groundwater.

WATER USERS

The study area covers the Crocodile (West) River catchment, which forms the major part of the Crocodile (West) and Marico Water Management Area (WMA), but excludes the Marico River. The study area is shown in ***Appendix A****. It extends northwards from the Witwatersrand catchment divide in central Johannesburg (where the Crocodile (West) originates), to the Limpopo River on the northern border of South Africa with Botswana.*

The study area includes large parts of the highly urbanised and economically dynamic metropolises in Gauteng Province, rapidly developing mining enterprises particularly around Rustenburg in the North-West Province, as well as extensive rural areas featuring both commercial and subsistence agriculture.

CURRENT AND FUTURE WATER REQUIREMENTS

Data were collected for urban, irrigation, industrial, power generation and mining water requirements. The study team collected the historical, current and future water use related information in a single data collection exercise. Meetings were held with the relevant Water Services Authorities operating within the Crocodile (West) River catchment (Rand Water, Johannesburg Water and Magalies Water) and information was obtained from these organisations.

Information on future urban and rural primary water requirements was derived based on population projections, and in the case of urban requirements, by making use of a water requirements and return flows model.

Urban Water Requirements and Return flows

Magalies Water and Rand Water are the bulk suppliers of potable water in the study area. The City of Tshwane supplies some of its own requirements through abstractions from the Rietvlei Dam, Rietvlei Springs and Sterkfontein Springs. Groundwater is also used as a supplementary water source, particularly by rural authorities.

Return flows are significant, particularly in the Upper Crocodile (West) sub-catchment, as sewage is pumped north from Johannesburg Metro over the catchment divide to be treated at the Johannesburg Northern Works.

Irrigation

Satellite images from 1998 and 2004 (current) were digitised to determine irrigation areas for the entire Crocodile River catchment. It is expected that the irrigation water requirements will not change significantly in future.

Industrial

Very few industries in the Crocodile (West) River catchment receive bulk water supplies, as most industries are connected to the municipal supply systems. Effluent discharges are mostly to municipal waste water treatment works (WWTW).

Power Generation

There are three small thermal Power Stations in the Crocodile (West) River Catchment, namely the Kelvin Power Station (Kempton Park), Pretoria West Power Station and the Rooiwal Power Station. The Kelvin Power Station is situated in the Upper Crocodile (West) sub-catchment and the Pretoria West and Rooiwal Power Stations are situated in the Apies-Pienaars River sub-catchment.

Mining

Mining is an important sector of the regional economy of the Crocodile (West) River catchment. Minerals mined include platinum, gold, iron ore, diamonds, granites, limestone, palladium, chrome, manganese, mineral sands, vanadium and andalusite.

Observed Total water requirements and return flows

*The water requirements for the various sectors are summarised in **Table A** and the return flows are summarised in **Table B**, based on the information collected.*

Table A: Observed Total water requirements (Mm^3/a) in the Crocodile (West) River catchment (2003)

Sub-catchment	Urban	Rural	Irrigation	Mining	Industrial	Power Generation	Stock Watering	Total requirements
Upper Crocodile	363.26	3.01	169.37	14.00	6.48	10.95	3.87	570.94
Elands	40.69	2.06	7.16	30.00	1.38	0.00	2.53	83.82
Apies-Pienaars	207.12	6.67	44.21	0.68	0.00	23.49	5.01	287.18
Lower Crocodile	4.52	2.72	138.47	14.00	0.00	0.00	10.15	169.86
TOTAL	**615.59**	**14.46**	**359.21**	**58.68**	**7.86**	**34.44**	**21.56**	**1111.80**

Table B: Observed Return flows *(Mm^3/a)* **in the Crocodile (West) River catchment (2003)**

Sub-catchment	Urban	Rural	Irrigation	Mining	Industrial	Power Generation	Stock Watering	Total Return Flows
Upper Crocodile	170.16	0.00	14.71	0.84	1.52	0.86	0.00	188.09
Elands	2.63	0.00	2.91	0.68	0.00	0.00	0.00	6.22
Apies-Pienaars	107.22	0.00	9.55	0.00	0.00	6.53	0.00	123.30
Lower Crocodile	0.60	0.00	7.41	7.41	0.00	0.00	0.00	15.42
TOTAL	**280.61**	**0.00**	**34.58**	**8.93**	**1.52**	**7.39**	**0.00**	**333.03**

UPDATING OF CURRENT AND FUTURE PRIMARY WATER REQUIREMENTS

The purpose of this section is to assess current and future populations, and present the updated corresponding primary water requirements.

<u>Approach</u>

Initially, the study was to review the DWAF Integrated Water Resources Planning (IWRP) population and water use estimates for the Crocodile (West) River catchment in relation to the census of 2001. Since this time, additional data became available that superseded this data set, of which the most important are:

- *The Vaal River System: Large Bulk Water Supply Reconciliation Strategies Study (BWSR) (DWAF, 2007), and associated primary water requirements and return flow database.*
- *The Statistics SA (2007) Population Projection, 2001-2030.*

The most recent authoritative population statistics were contained in the Statistics SA population projection. GIS analysis was used to calculate the populations falling within the study area. The Statistics SA projection was used as the "base population scenario".

High and low variants of the Statistics SA population projection were developed in order to provide a planning envelope, see ***Figure A*** *below.*

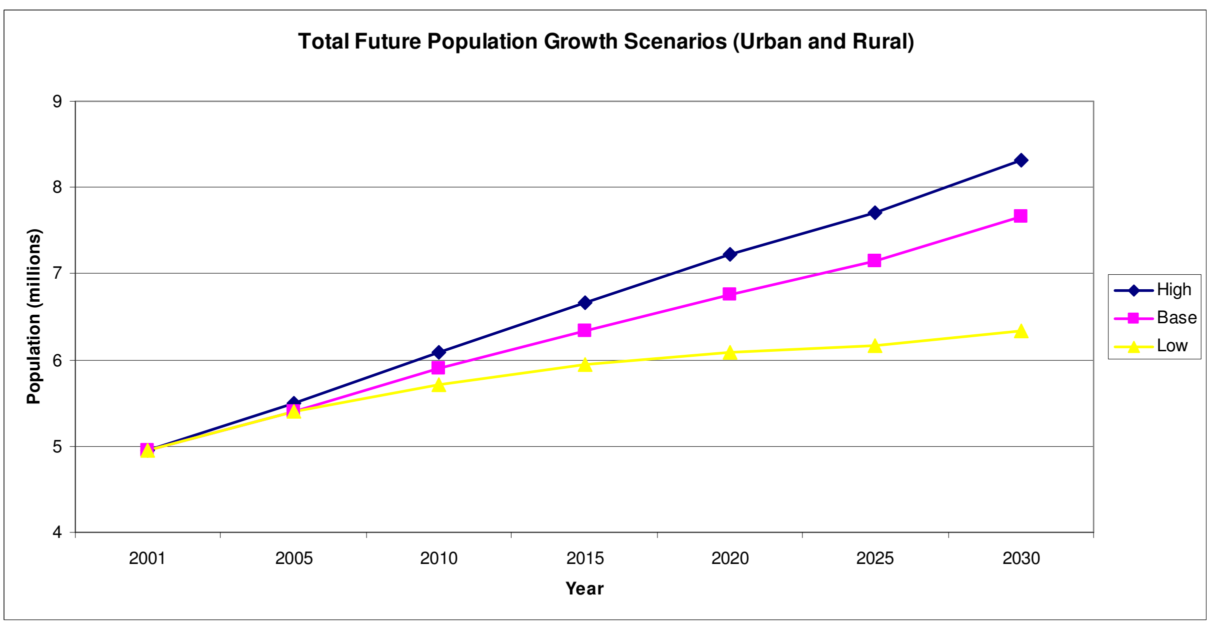

Figure A: Future Populations: Base, High and Low

Future water requirements and return flows calculated for the Crocodile (West) Water Supply System were based on the above three population projections and three Water Conservation/Water Demand Management (WC/WDM) scenarios. The WC/WDM scenarios were:

- *Scenario B: No water demand management*
- *Scenario C: High water demand management efficiency*
- *Scenario D: Medium water demand management efficiency*

Urban water requirements linked to these population projections and WC/WDM scenarios were therefore initially prepared for following nine scenarios:

- *Scenario B: High = no water demand management, high population growth*
- *Scenario B: Base = no water demand management, base population growth*
- *Scenario B: Low = no water demand management, low population growth*
- *Scenario C: High = high water demand management efficiency, high population growth*
- *Scenario C: Base = high water demand management efficiency, base population growth*
- *Scenario C: Low = high water demand management efficiency, low population growth*
- *Scenario D: High = medium water demand management efficiency, high population growth*
- *Scenario D: Base = medium water demand management efficiency, base population growth*
- *Scenario D: Low = medium water demand management efficiency, low population growth*

Only WC/WDM Scenarios C and D were finally used in the future planning as was proposed in the WC/WDM report of the Vaal BWSR (DWAF, 2007b), although results of all scenarios will be provided.

The BWSR and CWRS study areas overlap only partially. A comparison of common urban areas was made in order to assess the BWSR and CWRS base populations. The results of this comparison are given in ***Table C*** *below, showing that the CWRS base urban population is between 6 and 7% higher than the BWSR population overall.*

Table C: Comparison of common areas from the BWSR and CWRS

POPULATION		2001	2005	2010	2015	2020	2025	2030
Source	**Description**							
Vaal BWSR	Vaal SDAs in CWRS Study Area	3 573 366	3 925 209	4 382 708	4 802 555	5 183 517	5 468 408	5 769 105
CWSR	Vaal SDAs	3 838 758	4 221 565	4 684 897	5 108 836	5 492 005	5 838 036	6 206 883
Comparison	Difference	265 392	296 356	302 189	306 281	308 488	369 628	437 778
	% Difference	**6.91%**	**7.02%**	**6.45%**	**6.00%**	**5.62%**	**6.33%**	**7.05%**

The urban water requirements and return flows model used for the Vaal River System: Large Bulk Water Supply Reconciliation Strategies Study (DWAF, 2007), hereafter referred to as the Vaal BWSR, was updated using the urban populations derived from the Statistics SA information. Requirements for areas where the model had not been set up previously were calculated drawing on per capita water requirements for similar areas that had already been modelled in detail.

*Rural water requirements were calculated based on stepped per capita water requirements, (see **Table D**) after discussion with the Chief Directorate of Water Services indicated that this was more reasonable than an assumption of a constant unit requirement. The increase in per capita rural water requirements to 2010 is in line with the commitment of the DWAF to progressively increase the minimum level of water supplied, to at least 50 ℓ/capita/day, clear the sanitation backlog and eradicate the bucket system by that date.*

The high urbanisation of large parts of the study area suggests that dense rural settlements are likely to continue to emerge and grow, with associated growth in rural per capita requirements.

Table D: Rural per capita water requirements used

Year	2001	2005	2010	2015	2020	2025	2030
ℓ/c/day	40	40	60	60	80	80	100

Results

*The results generated from the approach outlined above are summarised in **Tables E** and **F**.*

Table E: Total water requirements (million m³/a) for the study area for all scenarios

Scenario	User/Sector	2005	2010	2015	2020	2025	2030
Scenario B: High (million m^3/a)	Urban	628.3	704.8	782.8	854.3	914.1	978.4
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	128.8	144.6	151.5	151.7	150.6
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1160.4**	**1277.1**	**1370.3**	**1452.2**	**1512.7**	**1583.9**
Scenario B: Base (million m^3/a)	Urban	618.5	683.8	744.3	799.1	848.0	900.1
	Rural	7.8	11.4	10.7	14.0	14.3	21.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	126.3	138.7	144.2	144.9	144.8
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1150.5**	**1253.4**	**1325.6**	**1389.2**	**1439.0**	**1498.5**
Scenario B: Low (million m^3/a)	Urban	617.3	660.4	695.7	716.3	727.6	739.2
	Rural	7.8	11.0	9.9	12.5	12.2	17.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	124.4	136.3	141.6	142.3	142.3
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1149.3**	**1227.7**	**1273.8**	**1302.3**	**1313.9**	**1331.2**
Scenario C: High (million m^3/a)	Urban	628.3	661.4	680.7	714.0	746.8	807.4
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	128.8	144.6	151.5	151.7	150.6
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1160.4**	**1233.8**	**1268.1**	**1311.9**	**1345.3**	**1412.9**
Scenario C: Base (million m^3/a)	Urban	618.5	641.7	647.2	667.8	692.8	742.8
	Rural	7.8	11.4	10.7	14.0	14.3	21.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	126.3	138.7	144.2	144.9	144.8
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1150.5**	**1211.4**	**1228.4**	**1258.0**	**1283.8**	**1341.2**
Scenario C: Low (million m^3/a)	Urban	617.3	619.8	605.2	599.2	595.3	611.1
	Rural	7.8	11.0	9.9	12.5	12.2	17.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	124.4	136.3	141.6	142.3	142.3
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1149.3**	**1187.1**	**1183.3**	**1185.2**	**1181.6**	**1203.0**
Scenario D: High (million m^3/a)	Urban	628.3	657.0	730.6	797.3	852.8	915.8
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	128.8	144.6	151.5	151.7	150.6
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1160.4**	**1229.3**	**1318.0**	**1395.3**	**1451.3**	**1521.3**
Scenario D: Base (million m^3/a)	Urban	618.5	637.4	694.6	745.8	791.1	842.6
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	126.3	138.7	144.2	144.9	144.8
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1150.6**	**1207.2**	**1276.2**	**1336.5**	**1382.8**	**1442.3**
Scenario D: Low (million m^3/a)	Urban	617.3	615.6	649.4	668.8	679.1	692.4
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	124.4	136.3	141.6	142.3	142.3
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1149.4**	**1183.6**	**1228.6**	**1256.9**	**1268.2**	**1289.6**

Table F: Total return flows (million m^3/a) for the study area for all scenarios

Scenario	User/Sector	2005	2010	2015	2020	2025	2030
Scenario B: High (million m^3/a)	Urban	324.4	369.6	415.6	457.6	492.6	530.4
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	20.2	22.7	23.8	23.8	23.6
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**375.8**	**426.7**	**475.2**	**518.3**	**553.3**	**591.0**
Scenario B: Base (million m^3/a)	Urban	318.6	357.1	392.6	424.6	453.1	483.5
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.8	21.8	22.6	22.7	22.7
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**370.0**	**413.8**	**451.2**	**484.1**	**512.7**	**543.2**
Scenario B: Low (million m^3/a)	Urban	317.9	343.1	363.6	375.3	381.3	387.5
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.5	21.4	22.2	22.3	22.3
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**369.3**	**399.5**	**421.9**	**434.4**	**440.6**	**446.8**
Scenario C: High (million m^3/a)	Urban	324.4	347.2	366.9	389.6	414.3	445.3
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	20.2	22.7	23.8	23.8	23.6
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**375.8**	**404.3**	**426.5**	**450.3**	**475.0**	**505.8**
Scenario C: Base (million m^3/a)	Urban	318.6	335.4	346.4	361.3	380.8	405.7
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.8	21.8	22.6	22.7	22.7
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**370.0**	**392.1**	**405.1**	**420.9**	**440.5**	**465.4**
Scenario C: Low (million m^3/a)	Urban	317.9	322.3	320.9	319.5	320.6	325.3
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.5	21.4	22.2	22.3	22.3
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**369.3**	**378.7**	**379.2**	**378.6**	**379.9**	**384.6**
Scenario D: High (million m^3/a)	Urban	324.4	358.3	401.8	441.5	475.0	510.6
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	20.2	22.7	23.8	23.8	23.6
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**375.8**	**415.5**	**461.4**	**502.2**	**535.7**	**571.1**
Scenario D: Base (million m^3/a)	Urban	318.6	346.2	379.5	409.6	436.8	465.4
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.8	21.8	22.6	22.7	22.7
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**370.0**	**402.9**	**438.2**	**469.1**	**496.4**	**525.0**
Scenario D: Low (million m^3/a)	Urban	317.9	332.6	351.5	362.1	367.6	373.0
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.5	21.4	22.2	22.3	22.3
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**369.3**	**389.1**	**409.8**	**421.2**	**426.9**	**432.2**

The Development of a Reconciliation Strategy for the Crocodile (West) Water Supply System

Current and Future Water Requirements and Return Flows

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LIST OF ABBREVIATIONS

ASSA	Actuarial Society of South Africa
BSMISE	Business Support for the development of Management, Interfacing and Socioeconomic Systems
CRFAS	Crocodile (West) River Return Flow Analysis Study (Report No: P 03/00/00/1004)
CTMM	City of Tshwane Metropolitan Municipality
CWMS	Crocodile (West) Modelling Study
CWRS	Crocodile (West) Reconciliation Study
DBSA	Development Bank of Southern Africa
DME	Department of Minerals and Energy
DSL	Dead Storage Level
DWAF	Department of Water Affairs and Forestry
ERWAT	East Rand Water Care Company
EWR	Environmental Water Requirements
FSA	Full Supply Area
FSC	Full Supply Capacity
FSL	Full Supply Level
GWS	Government Water Scheme
HFY	Historical Firm Yield
IB	Irrigation Board
IDP	Integrated Development Plan
IFR	In-stream Flow Requirement
ISP	Internal Strategic Perspectives Study
IWRP	Integrated Water Resources Planning
MAE	Mean Annual Evaporation
mamsl	metres above mean sea level
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NWRS	National Water Resource Strategy
SDA	Sewage Drainage Area
SMP	Strategic Management Plan
Vaal BWSR	Vaal River System: Large Bulk Water Supply Reconciliation Strategies Study
WC/WDM	Water Conservation and Water Demand Management
WMA	Water Management Area
WQT	Water Quality TDS model
WR90	Water Resources of South Africa, 1990

WRC	Water Research Commission
WRPM	Water Resource Planning Model
WRSAS	Water Resources Situation Assessment Study (Report No: P 03000/00/0301)
WRSM2000	Water Resources Simulation Model (Enhanced – Version 4 June 2007)
WRYM	Water Resources Yield Model
WSA	Water Services Authority
WSP	Water Services Provider
WWTW	Waste Water Treatment Works

1 INTRODUCTION

1.1 BACKGROUND

The Department of Water Affairs and Forestry (DWAF) initiated a study "*The development of a reconciliation strategy for the Crocodile West Water Supply System*". This study is hereafter referred to as the *Crocodile West Reconciliation Study* (CWRS).

The DWAF initiated a parallel study "*The assessment of water availability in the Crocodile (West) River Catchment by means of water resource related models in support of the planned future licensing process*". This is referred to as the *Crocodile West Modelling Study* (CWMS).

The CWRS focuses on strategies for resolving imbalances between water requirements and water availability based on data gathered for and results from the models set up as part of the CWMS.

1.2 PURPOSE OF THE CROCODILE (WEST) RECONCILIATION STRATEGY

The objective of the reconciliation study is to **formulate a detailed strategy** to ensure the sufficient and reliable supply of water of appropriate quality to all existing and future users together with the best utilisation of resources in the catchment, at the lowest cost and in an environmentally sustainable manner. Both water quantity and quality need to be considered, currently and into the future.

The Strategy is targeted at water related issues. It caters for existing as well as future needs and is sufficiently comprehensive and flexible to enable quick response to changing circumstances.

1.3 PURPOSE AND CONTEXT OF THIS REPORT

The objective of the tasks being reported on was to determine the current and future water requirements and return flows as well as the impact of water conservation and water demand management measures on current and future water requirements and return flows for the Crocodile (West) River Catchment. DWAF regional offices, relevant Metropolitan Councils, Irrigation Boards, Mines and Industries were contacted to ascertain, verify and/or supplement the present and projected future water requirements where necessary.

The Terms of Reference refers to Current and Future Urban requirements. Due to the complex nature of the catchment, the PSP, however, believed that it is necessary to consider all sectors of water use, particularly mining (and the projected growth in mining), irrigation, rural water supply and groundwater utilisation for this task. Consideration was also given to major return flows, as these form significant contributions to the water resources of the area. Separate supporting tasks investigated irrigation water requirements and groundwater.

1.4 STUDY AREA

The study area covers the Crocodile (West) River catchment, which forms the major part of the Crocodile (West) and Marico Water Management Area (WMA), but excludes the Marico River. The study area is shown in **Appendix A**. It extends northwards from the Witwatersrand catchment divide in central Johannesburg (where the Crocodile (West) River originates), to the Limpopo River on the northern border of South Africa with Botswana. The Limpopo River is an international river basin, shared between South Africa, Botswana, Zimbabwe and Mozambique, originating from the confluence of the Crocodile (West) and Marico Rivers. The total catchment area is approximately 29 350 km^2.

The study area (A2 secondary catchment) has been divided into four sub-catchments (A21, A22, A23 and A24 tertiary catchments), which were further sub-divided into forty quaternary catchments. The four sub-catchments (with main tributaries) are:

- <u>Upper Crocodile</u> (Crocodile, Jukskei, Hennops, Magalies and Skeerpoort Rivers);
- <u>Apies-Pienaars</u> (Pienaars, Apies and Plat Rivers);
- <u>Elands</u> (Elands, Hex, Koster and Selons Rivers); and
- <u>Lower Crocodile</u> (Sand, Bierspruit and Brakspruit Rivers).

2 METHODOLOGY

The study team collected the historical, current and future water use and return flows related information. Due to the complex nature of the catchment, it was decided that all sectors of water use, particularly urban, rural and mining water supply needed specific consideration. Separate supporting tasks investigated irrigation and groundwater requirements.

The Vaal Dam is an important water source to the Crocodile (West) River Catchment as Rand Water obtains water from the dam to supply the large and increasing urban and rural areas of the catchment. In addition to the water supply from the Vaal Dam, it is envisaged that in the future return flows from Waste Water Treatment Works in the Vaal River catchment can be redirected over the escarpment that divides the two River catchments, to the Crocodile (West) River catchment to alleviate high water demands from the dam. Due to the importance of this linkage between the two catchments it was deemed important to include discussions with the Vaal River Study team surrounding current and future water demands to attain an understanding and agreement of the demands placed on both catchments in order to assess the water availability situation in both catchments for current and future planning.

The methodology to derive the current and future urban water requirements and return flow scenarios in this study was based on procedures applied in the *Crocodile (West) River Return Flow Analysis Study* (CRFAS) (DWAF, 2004a). The process involves five main steps which has the objective of updating the model to determine future urban water requirements and return flow scenarios. Brief descriptions of these steps are presented below.

- Obtain Data and information pertaining to existing primary water supplies, population census and projections, land use and possible water savings from the implementation of Water Conservation and Demand Management measures in the study area.
- Define Sewage Drainage Areas (SDAs) and update the Urban Return Flow Model for the study area based on the same algorithms as the model developed for the Crocodile (West) Return Flow Analysis Study.
- Setup scenarios for future urban water requirements and return flows based on population projections, municipal development plans and most probable WCDM measures.
- Calibrate the developed Urban Return Flow Model using historical data for year 2001.
- Calculate future urban water requirements and return flows.

Furthermore and consistent with previous studies and initiatives, greater focus was accorded to the large water consumers. These were directly approached and discussions held on their future demands.

During the *Crocodile (West) River Return Flow Study* the drainage areas were thoroughly analysed, therefore in the current study the majority of activities related to that area concentrated on updating the population data for the calibration year of 2001 (with the Census 2001 results and incorporating updated population scenarios).

Separate questionnaires were compiled to target mines, industries and metropolitan municipalities. These were sent to the various mines, industries and metropolitan councils within the study area. The response however was not satisfactory and where possible the metropolitan municipalities, mines and industries were visited to obtain information.

Meetings were held with the relevant Water Services Authorities operating within the Crocodile (West) River catchment (Rand Water, Johannesburg Water and Magalies Water) and information was obtained from these organisations.

Where explicit estimates of future water requirements were available, these were used. In the case of primary water requirements, it was assumed that the main driver was population. The selected unit used for analysing the relationship between water supply and return flow used in the urban return flow model was the SDA served by individual sewage treatment works. It was, therefore necessary to quantify the water supply into, and sewage effluent volumes from each of the sewage drainage areas.

Formal discussions were held on a regular basis with the study team of the *Vaal River Reconciliation Study* to discuss the approach followed in the Vaal River and to extend the approach into the Crocodile (West) River study and to compare results. This was the case with population projections as well as the growth in water requirements and return flows and to take due cognisance of the assumptions used in the consideration of the various scenarios.

High and low population scenarios were thus developed and used to provide a planning envelope. Adjustment of fine-grained parameters such as per-capita water requirements and the ratio of internal to external water use were not applied in the running of the high and low population scenarios. The water conservation and demand management scenarios indicate the impact of these kinds of effects, and are applied in conjunction with the population scenarios. This allows the impacts to be separated out.

Data had also been collected on water conservation and water demand management measures and their impact on current and future water requirements and return flows. It was suggested that the current and future water requirements report and the WC/WDM status report be combined due to the fact that the implementation of interventions like WC/WDM are necessary and likely to improve water use efficiency. If these measures are implemented in a structured way it could have an impact on future water requirements and return flows. Scenarios to reflect this have been developed as well as the impacts on future projected water requirements and return flows.

3 DATA COLLECTION

The study team collected the historical, current and future water use related information in a single data collection exercise for users in the study area. Due to the complex nature of the catchment, it was decided that all sectors of water use, particularly urban, rural and mining water supply needed specific consideration. Separate supporting tasks investigated irrigation and groundwater requirements.

3.1 DATA COLLECTION PROCESS

The work undertaken included a substantial data collection and verification component. Numerous calls were made to water services authorities, municipalities, other water service providers and important end-users, particularly mines. Follow-up visits were also made to the more significant organisations where required. Despite co-operation in many cases, it was difficult to obtain reliable data as has been noted by previous studies (DWAF, 2004 and 2007). Estimation and considered judgement had to be applied in making use of the data obtained.

Data collected for the urban sector included land use and infrastructure information for the different SDAs within the study area. A questionnaire was compiled based on the outcome of discussions amongst the team members involved in different sectors as to what information was of utmost importance for the success of the study. It was agreed that the urban sector would have a different questionnaire to that of the irrigation, mining and industries sectors. The questionnaire was formulated to specifically address the data requirement and was sent to the appropriate Regional DWAF Offices, Water Services Authorities (WSAs) and Water Services Providers (WSPs) in the study area. The questionnaire was accompanied by a letter from the Client providing the background information on the study and requesting the cooperation of the stakeholder to provide the requested information. The aim of the questionnaire was to avoid the need for different team members to engage with the stakeholders separately, thus minimising the number of meetings. This was based on the perceived and sometimes confirmed information request overload experienced by municipalities, WSPs and WSAs.

The requested information for the urban sector included the following:

- Background information covering the details of the stakeholder;
- Water and waste water related information with regards to reports, previous studies and format of data;
- Water supply information regarding sources of water, historic, current and planned water abstractions and requirements and historic water quality;
- Effluent Discharges information from Waste Water Treatment works regarding discharge locations, water quality and historic discharge volumes; and

- Water services information pertaining to land use, waste water works/ sewerage plant drainage areas and cadastral information with erven sizes.

3.2 DATA SOURCES AND DATA ASSESSMENT

The Crocodile (West) River catchment falls into three provinces, namely Gauteng, North West and Limpopo. **Table 3.1** and **Figure 3.1** provides the names and layout of the District/Metropolitan and Local Municipalities for the three provinces within the study area, respectively.

Table 3.1: The list of the District/Metropolitan and Local Municipalities within the Crocodile (West) Catchment Study Area

GAUTENG PROVINCE		NORTH WEST PROVINCE		LIMPOPO PROVINCE	
District/Metropolitan Municipality	**Local Municipality**	**District/Metropolitan Municipality**	**Local Municipality**	**District/Metropolitan Municipality**	**Local Municipality**
Metsweding	Nokeng tsa Taemane	Bojanala	Moretele	Waterberg	Thabazimbi
	Kungwini		Local Municipality of Madibeng		
West Rand	Randfontein				
	Mogale City		Rustenburg		Bela-Bela
Ekurhuleni [1]			Kgetlengriver		
City of Johannesburg [2]			Moses Kotane		
City of Tshwane [3]					

[1] – Only includes Germiston, Benoni, Edenvale, Modderfontein, Kempton Park and Tembisa
[2] – Only includes Sandton, Alexandra, Bedfordview and Randburg
[3] – Only includes Babelegi, Ga-Rankuwa, Mamelodi, Pretoria, Centurion and Akasia

The metropolitan councils and local municipalities mentioned above, the mines and industries as well as previous study reports were consulted. Data was collected for urban, irrigation, industrial, power generation and mining water requirements. The study team collected the historical, current and future water use and return flows related information in a single data collection exercise. Meetings were held with the relevant WSPs operating within the Crocodile (West) River Catchment (Rand Water, Johannesburg Water and Magalies Water) and information was obtained from these organisations.

The results of this extensive data gathering exercise proved to be disappointing. Obtaining data from mining operations and industries proved to be difficult, even somewhat impossible. Most of the municipalities were unable to provide data for the period prior to the year 2000, mainly due to the amalgamation of local municipalities into the City of Tshwane Metropolitan Municipality or District Municipalities resulting in the loss of such data.

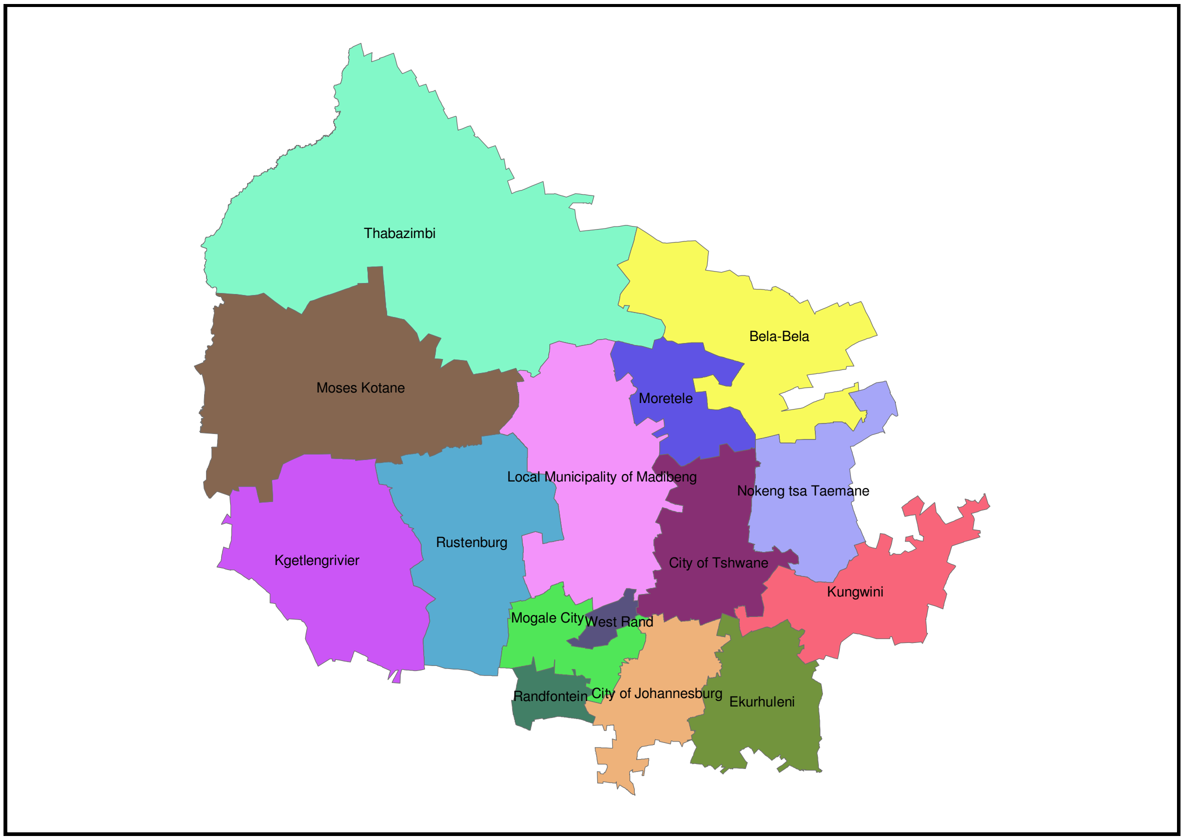

Figure 3.1: Metropolitan and Local municipalities existing within the Crocodile (West) River catchment

The water use data needed to be incorporated in the monthly time step models (such as the WRSM2000 (Enhanced), WRYM, WQT and WRPM) used in the CWMS. The data obtained from mines, industries, metropolitan councils, local municipalities and water boards varied vastly in temporal distribution as well as in the level of detail. As a result it was required to process the raw data obtained from the various stakeholders.

Despite co-operation in many cases, it was difficult to obtain reliable data as has been noted by previous studies (DWAF, 2004 and 2007). Estimation and considered judgement had to be applied in making use of the data obtained.

3.3 URBAN WATER REQUIREMENTS AND RETURN FLOWS MODEL

A return flows model was developed for the Crocodile (West) River catchments as part of the *Crocodile (West) River Return Flow Analysis Study* (DWAF, 2004) completed in 2004. It was the first time that such a model was used in a water resources study. In the *Vaal River Reconciliation Study* (DWAF, 2007) this model was once again applied and the growth in return flows in the Crocodile (West) River was determined. This model was also used to determine the impact of various scenarios of water use in the Vaal River supply area on the return flows in the Crocodile (West) River catchment.

Urban water requirements comprise two main components, which are (i) domestic or household use of water and (ii) the commercial, industrial and public use of water. The domestic use of water is directly related to the population, as well as the standard of living, which determines the per capita water use. Population projections and changes in the standard of living were therefore used for the estimation of future water requirements. The commercial/industrial use of water in urban areas can normally be expressed as a ratio of the domestic use. In this regard the ratio as observed in the past was assumed to remain unchanged during the period of projection.

The water requirements and return flows model, used for the *Vaal River System: Large Bulk Water Supply Reconciliation Strategy Study* (DWAF, 2007), was also used for the Crocodile River catchment using the urban population figures derived from the Statistics SA information. Requirements for areas where the model had not been set up previously were calculated drawing on per capita water requirements for similar areas that had already been modelled in detail.

3.4 DESCRIPTION OF THE WATER REQUIREMENTS AND RETURN FLOWS MODEL

(Source: DWAF, 2007, Vaal River System: Large Bulk Water Supply Reconciliation Strategies)

The Water Requirements and Return Flows Model is best described through in **Appendix B**, which shows schematically all the components of the model. SDAs are the main building block within which all the serviced land use activities are quantified. The land use was grouped firstly into two main categories, serviced housing related land use and other land uses that are serviced by water supply and or sanitation systems. The serviced housing land use was further split into seven serviced housing categories. Land use other than housing, is defined in six categories namely, Business/Commercial, Industrial, Hospitals/Clinics, Parks, Education and Sport Stadiums. Allowances are made for distribution losses in the supply network that occur between the bulk water supply meter and the user. Rainfall and groundwater infiltration into the sewer network are also taken into consideration. Losses during the treatment of the sewage are included as well as direct re-use usage, which could be for irrigation or other purposes. Detailed information on all the components of the model is presented in the following chapters.

3.5 SEWAGE DRAINAGE AREAS (SDA)

Due to the main building block of the Water Requirements and Return Flows Model being the SDA, it was decided to also delineate the sewage drainage areas of the Crocodile (West) River catchment as done in the Vaal River Study. The structure of the SDAs implemented by WRP was not adjusted due to the onerous data collection and validation requirements associated with this. Similarly, the parameters governing the relationship of water use and return flows were not adjusted as part of this task. Where urban populations were identified outside of the SDA framework developed by WRP, a per capita water use estimate was used to assess domestic water use. This per capita water use was assigned with reference to the lower end of the range established in the return flow model. **Table 3.2** gives a list of the SDAs located in the study area, which were included in the analysis and are graphically represented in **Appendix C**. An SDA is defined as the area of a catchment where effluent and waste water are serviced by one WWTW. Each WWTW receives the waste water via a closed sewage network pipeline connecting the works to the built-up or urbanised areas in the catchment.

Each of the SDAs in the study area comprises one WWTW that forms a point of disposal or effluent discharge to the catchment area downstream. During the data collection process, SDAs were identified and in each case the model was configured by populating the parameters that characterise that specific SDA.

Table 3.2: Sewage drainage areas used in the analysis in the Crocodile (West) River catchment study

Metropolitan Municipality/ Local Municipality	Sewage Drainage Area
Bela Bela LM	Bela-Bela WWTW
City of Johannesburg MM	JHB Northern WWTW
	Roodepoort Driefontein WWTW
City of Tshwane MM	Baviaanspoort WWTW
	Zeekoegat WWTW
	Daspoort WWTW
	Rooiwal WWTW
	Rietgat WWTW
	Temba WWTW
	Babelegi WWTW
	Sandspruit WWTW
	Sunderland Ridge WWTW
	Klipgat WWTW
Ekurhuleni MM	Hartbeesfontein WWTW
	Estherpark WWTW
	Olifantsfontein WWTW
Kgetlengrivier LM	Borolelo/Swartruggens WWTW
	Koster WWTW
LM of Madibeng	Brits WWTW
Mogale City LM	Percy Stewart WWTW
Randfontein LM	Randfontein WWTW
Thabazimbi LM	Thabazimbi WWTW
Rustenburg LM	Bafokeng WWTW
	Rustenburg WWTW
Moses Kotane LM	Moses Kotane WWTW
Moretele LM	Apies WWTW

4 POPULATION

4.1 CENSUS 2001

The purpose of this chapter is to discuss the assessment of the 2001 population, the need to update the corresponding water requirements and to present the results of this work.

The methodology proposed was a detailed review, including a GIS analysis of the DWAF Integrated Water Resources Planning (IWRP) population and water use estimates, as used in WSAM, in relation to the census of 2001 for the Crocodile (West) River catchment.

Since 2001, additional data sources have become available that also needed to be considered:

- An assessment of the IWRP population database in terms of the municipalities demarcated in 2000, produced as part of the study Business Support for the development of Management, Interfacing and Socioeconomic Systems (DWAF, 2006a). This study is hereafter referred to as the BSMISE.
- *The Vaal River System: Large Bulk Water Supply Reconciliation Strategies Study* (DWAF, 2007), and associated primary water requirements and return flows database.
- The Statistics SA (2007) Population Projection, 2001-2030.

The assessment of the IWRP population database in municipalities was compared to the Statistics SA (2007) information, and it was determined that the IWRP high population scenario was closest to the 2007 population projection. The high IWRP population scenario figures are used in all further comparisons with this data set in this report.

The *Vaal River System: Large Bulk Water Supply Reconciliation Strategies Study* (DWAF, 2007), hereafter referred to as the Vaal BWSR, undertook the updating of the original *Crocodile West Return flow Analysis Study* (based on the Census 1996 populations) with the Census 2001 population. A substantial amount of information relating to the planning of water and sanitation provision was collated in support of this study. This is summarised in the following section.

It should be noted that Statistics SA released a mid-year population update (SSA, 2006a), which indicated a revised estimate for the population of Gauteng in 2001, which differed substantially from the Census 2001 release. As a result, the population input to the Vaal Study was revised and was obtained from the BSMISE study.

4.1.1 Additional data obtained

The most relevant information received from these studies is summarised in **Table 4.1** and **Table 4.2.**

Table 4.1: Population information made available by DWAF (DWAF, 2006b, c)

Information category	Description
Reports	"Adjustment of the IWRP Future Population Estimates to Align with Municipal Boundaries" "Report on Gauteng Population Update"

Table 4.2: Relevant information received from the Vaal BWSR (WRP, 2006)

Information category	Description
Database	Updated Primary Water Requirements and Return-flow Database
Reports	Tshwane Infrastructure Planning Reports: Masterplan 2004
	Bulk Water Report 2002
	A Strategy And Master Plan For Bulk Water Supply, Storage And Distribution 2002
	Sanitation Services 2004
	Bulk Sanitation Strategy 2020
	Tshwane WSDP 2005
	Additional supporting documents and maps

The database received from the Vaal River Study was reviewed, to determine the contribution made towards the goals of this task. **Figure 4.1** shows the extent of the area for which data was received.

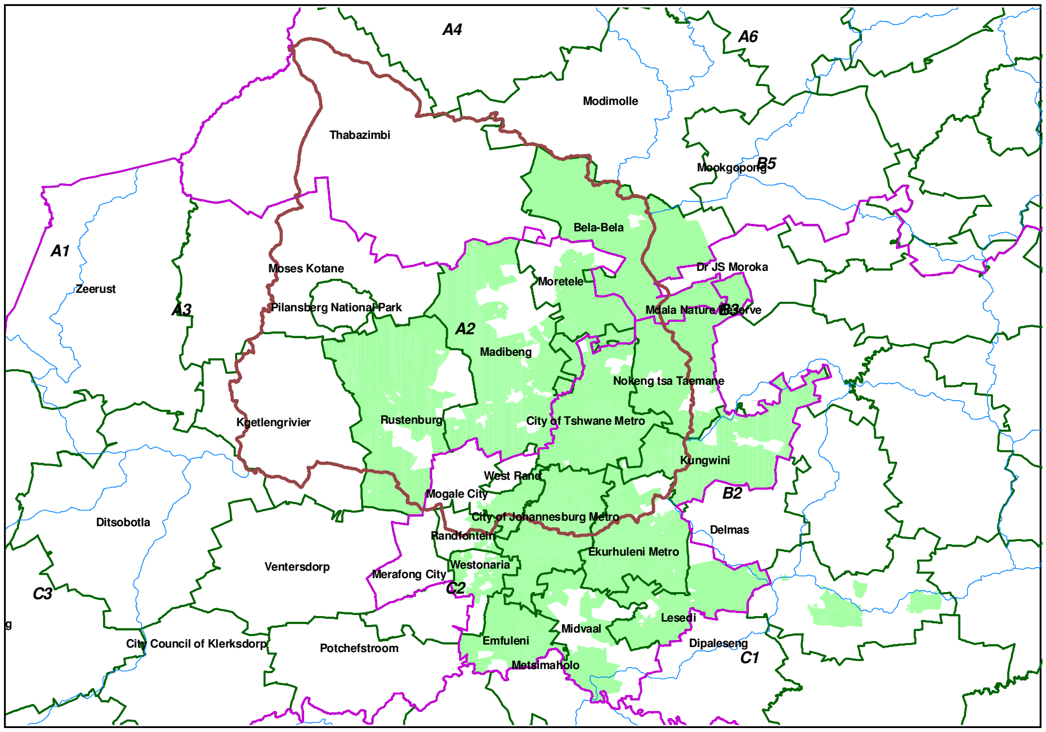

Figure 4.1: Geographic extent of data received from the Vaal BWSR

It can be seen that the Vaal BWSR provided information for only a portion of the overall study area, but it was nevertheless of great significance as it dealt with the major metropolitan areas in the study.

The Census 2001 population figures were reviewed by Statistics SA in their 2007 mid-year population update. **Table 4.3** shows a comparison of population and annual average growth (compound) from 1996 to 2001 based on the figures published by Statistics SA in July 2007.

Table 4.3: Comparison of population and annual average growth for census and statistics SA mid-year adjustment figures (based on Statistics SA, 2007)

Province	Census results (October)			Stats SA mid-year adjustments	
	1996	2001	Average annual growth rate	2001	Average annual growth rate
Eastern Cape	6 302 525	6 436 763	0.42	6 929 869	2.01
Free State	2 633 504	2 706 775	0.55	2 893 541	1.99
Gauteng	7 348 423	8 837 178	3.69	8 254 103	2.46
KwaZulu-Natal	8 417 021	9 426 017	2.55	9 263 134	2.03
Limpopo	4 929 368	5 273 642	1.35	5 474 683	2.22
Mpumalanga	2 800 711	3 122 990	2.18	3 103 451	2.18
Northern Cape	840 321	822 727	-0.42	870 657	0.75
North-West	3 354 825	3 669 349	1.79	3 686 162	2.00
Western Cape	3 956 875	4 524 335	2.68	4 207 044	1.30
Total	***40 583 573***	***44 819 776***		***44 682 644***	

Table 4.3 shows that while the total population for the country are very similar after the 2007 mid-year adjustment (within 0.5%), the population for certain provinces in 2001 (and associated growth rates) has changed significantly. In particular, the population of Gauteng in 2001 has been adjusted downwards by over half a million persons, and the associated average annual growth rate has declined from 3.69 to 2.46% per annum. This growth rate is still the highest of all the provinces, but it now lies closer to other rapidly growing provinces such as Limpopo and Mpumalanga.

The population of Limpopo was moved upwards by over 200 000 persons in the 2007 mid-year adjustment. This represented an increase from 1.35 to 2.22% per annum.

The changed estimates for the 2001 population noted above are significant for any review of population in the study area.

4.1.2 Review of census 2001 population

The original IWRP projections were undertaken before the demarcation of the “wall-to-wall” municipalities, while transitional local councils were in effect. In order to provide a sound basis for long-term population and water use estimates, approximately seven hundred and twenty “consumption centres” were identified for the country. These consisted of both formal serviced settlements, and those unserviced settlements which were considered likely to exert considerable water demand in the future, taking into account water services roll-out and population growth prospects. Those areas not classified as consumption centres were classified as rural. The “consumption centres” for the study area are listed in **Table 4.4**, together with the 1996 Magisterial District they fall into, and to which the rural population was allocated.

Table 4.4: Consumption centres in the study area

Province	Consumption centre	Magisterial District (1996)
Gauteng	Cullinan (Incl.Pta) / Rayton / Refilwe	Cullinan
Gauteng	Johannesburg	Johannesburg
Gauteng	Kempton Park / Tembisa Metro	Kempton Park
Gauteng	Krugersdorp / Kagiso / Munsiville / Muldersdrift	Krugersdorp
Gauteng	Magaliesburg	Krugersdorp
Gauteng	Pretoria (Ex Cullinan)	Pretoria
Gauteng	Randburg	Randburg
Gauteng	Randfontein / Mohlakeng / Hillside / Rietvallei	Randfontein
Gauteng	Roodepoort	Roodepoort
Gauteng	Wonderboom	Pretoria
North-West	Barseba	Brits
North-West	Hartbeespoort / Kosmos / Schoemansville / Ifafi / Meerhof	Brits
North-West	Hartebeesfontein	Rustenburg
North-West	Koster / Reagile	Rustenburg
North-West	Madikwe	Rustenburg
North-West	Mogwase	Mankwe
North-West	Mooinooi	Brits
North-West	Phatsima	Mankwe
North-West	Rustenburg	Rustenburg
North-West	Sonop	Brits
North-West	Sun City Hotels	Mankwe
North-West	Swartruggens / Borolelo	Rustenburg
North-West	Zeerust / Ikageleng	Madikwe
Northern Province	Amandelbult	Thabazimbi
Northern Province[1]	Northam	Thabazimbi
Northern Province[1]	Pienaarsrivier	Warmbad
Northern Province[1]	Swartklip	Thabazimbi
Northern Province[1]	Thabazimbi	Thabazimbi

[1] – As Limpopo Province was known at the time (2001)

The report on the IWRP population information (DWAF, 2006b) providing an assessment of the IWRP population figures in terms of the municipal demarcation of 2000 became available in the course of the study. The IWRP high population scenario information is presented together with the updated 2001 population information provided for the Vaal BWSR and the corresponding Statistics SA (2006) information in **Table 4.5**.

Table 4.5: Comparison of IWRP estimate of 2001 population (DWAF, 2006b), the Vaal BWSR and the Statistics SA 2006 distribution

Municipality	Urban Population: 2001		
	IWRP High Pop	Vaal BWSR	Stats SA 2006
City of Johannesburg Metro	3 232 831	2 909 970	2 919 965
City of Tshwane Metro	1 768 374	1 683 920	1 688 925
Ekurhuleni Metro	1 806 373	2 228 720	2 242 267
Emfuleni	536 511	715 580	725 425
Kungwini	57 384	3 100	78 604
Lesedi	85 512	47 380	63 597
Madibeng	110 137	0	88 900
Midvaal	375 878	5 490	57 581
Mogale City	238 690	225 930	214 734
Moretele	0	5 320	8 384
Nokeng tsa Taemane	79 983	8 040	38 539
Randfontein	122 044	51 310	107 299
Rustenburg	137 023	278 060	189 194
Westonaria	170 735	2 240	83 114
Grand Total	***8 721 475***	***8 165 060***	***8 506 528***

It can be seen that while the population totals are all within 10% of each other, the distribution of the Vaal and Statistics SA populations are more similar to each other than to the IWRP population. There are still significant differences at the level of the smaller municipalities between the former two, with the Statistics SA often indicating higher urban populations.

The population in the study area was assessed using GIS analysis to calculate the proportions of the municipalities falling into the study area. The Census 2001 was used to distribute the population at more detailed levels. The Statistics SA population distribution is presented in rural and urban divisions by municipalities in the study area in **Table 4.6** below.

Table 4.6: Population distribution in the study area by urban and rural (SSA, 2007)

Province	Municipality	Population (2001)		
		Urban	Rural	Total
Gauteng	City of Johannesburg Metro	1 103 611	2 319	1 105 930
Gauteng	City of Tshwane Metro	1 772 063	86 843	1 858 906
Gauteng	Ekurhuleni Metro	553 106	1 548	554 654
Gauteng	Kungwini	26 862	7 352	34 215
Gauteng	Mogale City	59 108	9 098	68 206
Gauteng	Moretele	6 351	173 459	17 810
Gauteng	Nokeng tsa Taemane	8 082	25 440	33 522
Gauteng	Randfontein	105 997	3 980	109 977
Gauteng	West Rand	0	5 080	5 080
Limpopo	Bela-Bela	32 502	12 934	45 436
Limpopo	Thabazimbi	12 022	44 423	56 445
North-West	Kgetlengrivier	16 806	13 005	29 811
North-West	Madibeng	32 150	312 182	344 332
North-West	Moses Kotane	9 438	202 450	211 888
North-West	Rustenburg	319 538	58 372	377 910
Total		***4 057 637***	***958 486***	***5 016 123***

4.1.3 The statistics SA population projection

Various population projections have been used in previous studies. The Statistics SA population projection provided to DWAF in 2007 was based on the best information available at the time, and gives total population numbers at the municipal level in urban and rural categories. The time span covered is 2001 to 2030.

The Statistics SA approach was based on the established cohort-component methodology, with extensions based on the UN approach to sub-national demographic modelling. Migration streams were modelled to the level of District Councils.

The Statistics SA population projection includes the 2007 updates to the mid-year population estimates, and supersedes the Census 2001 as discussed in the previous chapter. It should be noted that all long-term populations projections, and particularly those that provide a detailed geographic breakdown, are subject to significant levels of uncertainty.

Table 4.7 below compares the Statistics SA population projection to the NWRS (high) information and a number of other projections for SA. The Vaal BWSR projection is the only other one to include the adjusted provincial growth as published in the 2007 mid-year population estimate, and drew on early figures prepared by Statistics SA.

Table 4.7: Comparison of Statistics SA and other long-term population projections (x 1000)

		1995	2000	2005	2010	2015	2020	2025	2030
IWRP (Low)	Population	40 801	43 433	46 236	46 890	47 553	47 871	48 190	-
	Growth	-	-	1.26%	-	0.28%	-	0.13%	-
IWRP (High)	Population	40 801	43 640	46 676	48 177	49 726	50 844	51 988	-
	Growth	-	-	1.35%	-	0.63%	-	0.45%	-
DBSA (Low)	Population	40 650	45 290	50 200	55 300	-	-	-	-
	Growth	-	2.19%	2.08%	1.95%	-	-	-	-
DBSA (High)	Population	40 650	45 440	50 600	56 100	60 700	65 600	-	-
	Growth	-	2.25%	2.17%	2.09%	1.59%	1.56%	-	-
ASSA 2003	Population	40 988	44 864	47 361	48 893	49 982	50 819	51 468	-
Provincial	Growth	-	1.82%	1.09%	0.64%	0.44%	0.33%	0.25%	-
SSA (2007)	Population	-	44 683	46 892	49 017	50 455	51 757	52 883	53 858
	Growth	-	-	1.21%	1.11%	0.73%	0.64%	0.54%	0.46%

Notes: ASSA – Actuarial Society of South Africa
IWRP – Projections are every ten years (1995/2005 etc). Small font indicates interpolations to allow comparison with other projections
DBSA Low projection does not extend beyond 2010 because of HIV/AIDS uncertainties

The Crocodile (West) Return Flow Analysis (DWAF, 2004) compared the figures used for the NWRS (IWRP scenarios) with population figures from the DWAF Chief Directorate: Water Services and provincial population projections obtained from the Development Bank of Southern Africa (DBSA, 2000). It was recommended that the NWRS population figures be used at the time. Since then, the Census 2001, revised Statistics SA population figures for 2001 and the results of the Vaal BWSR study have become available.

It is evident from the table that the Statistics SA (2007) projection figures are closest to the IWRP (High) population projection. The annual compound growth rate is closer to the IWRP (Low) projection initially, but the Statistics SA future growth rates are somewhat higher than those of the IWRP (High) projection in the long term (0.54% compared to 0.45% in 2025).

The Statistics SA population projection was used as the "base population scenario" driving the updating of water requirements.

4.1.4 Updates and population scenarios

High and low variants of the Statistics SA population projection were developed in order to provide a planning envelope. Population growth in an area has two main components:

- Internal growth – due to the fertility and mortality patterns of the resident population.
- Migration – due to the movement of people in and out of the area.

Migration is the dynamic that has the most effect on overall population growth trends at sub-national levels (Statistics SA, 2007a).

<u>Migration</u>

A review of literature on migration in South Africa with particular reference to Gauteng was carried out in order to identify empirical evidence on the nature and rate of migration to the province.

Kok *et al* (2003) made a study of migration in South Africa based on the migration questions in the 1996 Census. These authors contend that despite popular belief that urbanisation has increased substantially in South Africa since 1990, patterns of internal migration have remained static since the late-1970s.

Research has continued on the subject of migration, with questions on migration being included in the 2001 Census. In addition, the HSRC conducted a survey of migration in 2001 on a large sample of respondents. These data sets have been analysed by numerous researchers, most recently documented in Kok *et al* (2006). However, there is limited information on the quantitative aspects of migration into Gauteng, although it has been confirmed as a prime destination for internal migration.

The bulk of migration to Gauteng is to informal areas, and unemployment among recent migrants is generally high. Migrants are therefore perceived as a drain on the resources of local authorities, and in Gauteng local authorities have begun to clamp down on informal settlements since around 2003. Most migrants are motivated by the need to find work, followed closely by a desire to find improved housing (Wentzel *et al*, 2006).

It is important to note that internal migration to Gauteng from other provinces is much larger than migration from other countries.

Taken together, these findings indicate that the relative better chance of finding employment and/or formal housing available in Gauteng are likely to lead to continue to drive in-migration to Gauteng for the foreseeable future.

<u>Internal Growth</u>

Fertility is usually the dominant factor governing internal growth (natural growth) trends. HIV/AIDS has a major impact in South Africa, and the use of a quantitative model (the Actuarial Society of South Africa (ASSA) model (2003)) was investigated to determine possible trends.

The ASSA (2003) (Dorrington *et al*, 2005) is the most advanced freely available demographic projection model in South Africa. It includes a number of parameters that allow the examination of the impacts of different interventions on demographic projections. The ASSA (2003) model is also available in a form that can be run separately for each province.

The ASSA (2003) model for Gauteng was assessed, and it became apparent that the latest available version had been calibrated to match the dramatic growth rate implied by the Census 2001 over 2006 (> 3% per annum). A complete recalibration of the model would have had to be performed to remedy this, and could unfortunately not be undertaken within the constraints of the project. The ASSA model was therefore used with caution to provide an indication of the ranges within which internal growth might be expected to vary given different interventions in the course of the HIV/AIDS.

<u>Synthesis of Driving Factors</u>

The results of the research discussed above were synthesised and grouped into drivers associated with high and low variants of population growth and are summarised in **Table 4.8**.

Table 4.8: Main characteristics/drivers associated with different future population variants

Future Population Variant	Main Characteristics	Dominant Drivers
High	Strong economic growth in Gauteng. Effective service delivery. Effective HIV/AIDS interventions.	Migration
Base (Statistics SA Projection)	"Most likely" conditions based	Extension of current trends (Migration)
Low	Sluggish economic growth Constrained service delivery HIV/AIDS lowers internal growth rate	Internal growth relatively more important than in High variant

The Statistics SA projection is based on an extension of the current situation of high levels of in-migration. The high variant is driven largely by increased migration into urbanised areas with employment opportunities and sound service provision, particularly of housing. It is anticipated that a rural-rural migration stream will also develop, as the urban areas will be unable to accept all intending migrants. High structural unemployment in the South African economy is seen as limiting the amount by which migration can increase the population in the study area.

The low future population variant is driven substantially by internal growth. A marked impact from HIV/AIDS is experienced and population growth slows substantially, recovering from 2025.

Although the birth rate in the catchment is below the national average (attributable to urbanisation and socio-economic conditions), the overall population growth will continue to exceed the national average, mainly as a result of migration into the area stimulated by economic opportunities.

Provisional indications are that the current (2005) total population (urban plus rural) in the catchment of about 5.5 million could grow to between 6.4 million and 8.3 million by year 2030. Virtually all of the population growth is expected to be in the urban areas.

4.1.4.1 Urban population growth

Population projections for the urban areas were determined for high, base and low growth scenarios. The total urban population projections for the study area for these scenarios are summarised in **Table 4.9**.

Table 4.9: Total urban population growth figures

Urban Population growth Scenarios	2001	2005	2010	2015	2020	2025	2030
High	4 436 343	4 952 225	5 553 902	6 166 334	6 723 721	7 188 481	7 684 353
Base	4 436 343	4 873 580	5 385 148	5 856 832	6 281 155	6 659 602	7 060 469
Low	4 436 343	4 867 502	5 211 339	5 494 735	5 661 126	5 753 272	5 847 567

4.1.4.2 Rural population growth

Population projections for the rural areas were also made for high, base and low growth scenarios. The total urban population projections for the study area for these scenarios are summarised in **Table 4.10**.

Table 4.10: Total rural population growth figures

Rural Population growth Scenarios	2001	2005	2010	2015	2020	2025	2030
High	516 817	538 951	530 664	500 953	498 228	511 772	629 887
Base	516 817	534 714	521 289	487 222	479 776	487 950	594 470
Low	516 817	533 416	502 595	454 058	428 147	416 123	486 035

The total base, low and high future populations are shown graphically in **Figure 4.2**.

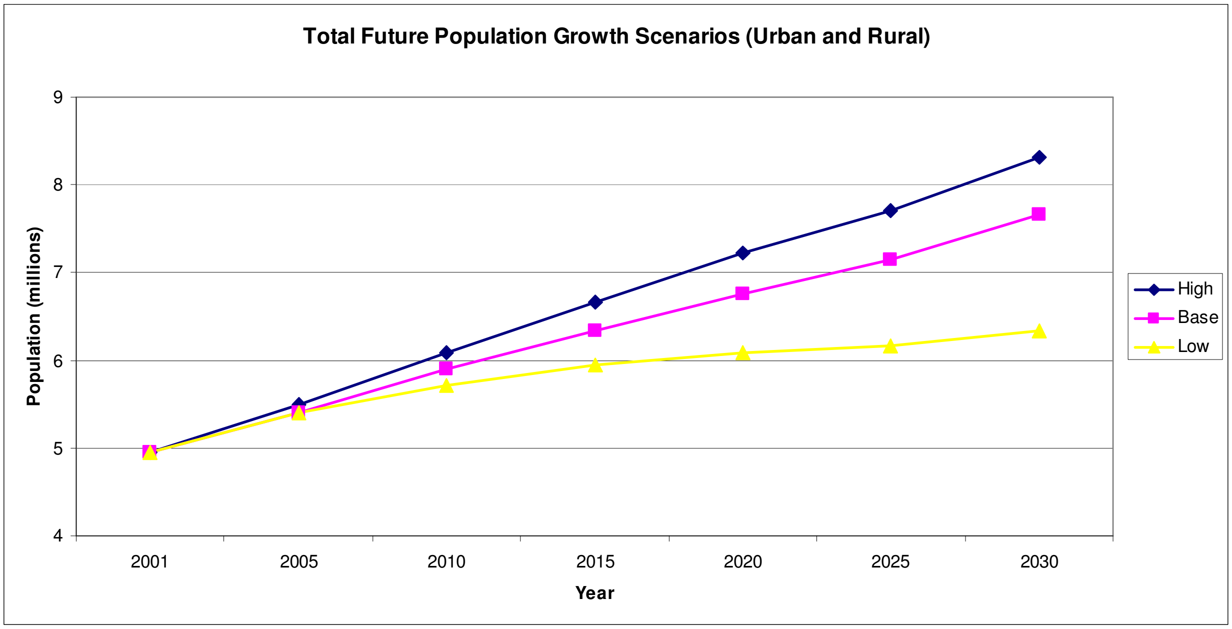

Figure 4.2: Future population growth for Urban and Rural

The total base, low and high future populations are summarised in **Table 4.11**.

Table 4.11: Total Future population growth

Total Population growth Scenarios	2001	2005	2010	2015	2020	2025	2030
High	4 953 160	5 491 176	6 084 566	6 667 287	7 221 949	7 700 253	8 314 240
Base	4 953 160	5 408 294	5 906 437	6 344 054	6 760 931	7 147 552	7 654 939
Low	4 953 160	5 401 361	5 730 924	5 979 787	6 138 353	6 238 154	6 438 412

5 MODEL CALIBRATION (2001)

5.1 GENERAL

The Return flow model developed by WRP provided the opportunity to build on the extensive work that had gone into the development of the model for the Crocodile (West) (2004) and Vaal Bulk Water Reconciliation studies (2007). This also had the advantage that:

- The previous studies had involved substantial field verification of the information that had gone into the model;
- It also made it possible to assess the magnitude of return flows linked to urban requirements, which is an important component in assessing the water resources of the Vaal and Crocodile (West) study areas; and
- Versions of the model had been developed to investigate various Water Conservation and Demand Management scenarios.

The most recent version of the return flow model (dated April 2007) was acquired from WRP. The approach adopted in the CWRS demographic and domestic water use task was to make use of the groundwork done in previous studies, while adding value in a cost-effective manner. After reviewing the return flow model received and assessing the work associated with the revision of the model, it became apparent that the demographic information (based on 2006 interim information) was in need of revision. The use of the 2007 Stats SA population projections provided to DWAF was therefore proposed, and was approved by DWAF.

5.2 UPDATING THE RETURN FLOW MODEL

The Urban Return Flow Model, developed by WRP Consulting Engineers, was used to quantify the return flows in the Crocodile (West) River catchment. The Urban Return Flow Model links water requirements with return flows and the study team calibrated the model by using existing historical information. The base population distribution for 2001 (in enumerator areas) and the future population growth in the model were therefore updated based on the 2007 Stats SA population projections. The structure of the SDAs implemented by WRP was not adjusted due to the onerous data collection and validation requirements associated with this. The parameters governing the relationship of water use and return flows were adjusted accordingly as part of this task.

Where urban populations were identified outside of the SDA framework developed by WRP, a per capita water use estimate was used to assess domestic water use. This per capita water use was assigned with reference to the lower end of the range established in the return flow model.

The requirements and return flow model was used as a basis for the updating of the urban portion of the primary water requirements. Adopting this approach also had the benefit that the model includes components dealing with serviced land use including housing and non-housing use, network losses, and return flow proportions both to and from WWTW.

5.2.1 Water Requirements and Return Flows

The Crocodile (West) River Return Flow Analysis Study (DWAF, 2004) used the IWRP population database as a basis for modelling direct water requirements. The current study was to update this data set using the Census 2001.

The requirements and return flows model developed for the Crocodile (West) River Return Flows Analysis Study (DWAF, 2004), and updated for the Vaal BWSR, was made available for use in this study (WRP, 2006). As in **Figure 4.1**, the model was established for urban areas drawing on the Vaal River supply system. Once the population for the study area had been determined based on the latest information, this was used to update the model. Requirements for areas where the model had not been set up previously were calculated drawing on per capita water requirements for similar areas that had already been modelled in detail.

Rural water requirements were calculated based on stepped per capita water requirements. The approach used is discussed in more detail in the following chapter. The water requirements and return flows per SDA for the study area are given in **Table 5.1**.

Table 5.1: Updated water requirements for 2001

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Observed Water Requirement (million m^3)	Observed Return Flows (million m^3)
Bela Bela LM	Bela-Bela	2.99	0.00
City of Johannesburg MM	Roodepoort Driefontein	11.36	5.36
	Johannesburg Northern	176.05	92.67
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	150.40	79.82
	Zeekoegat + Baviaanspoort	43.75	25.10
	Sandspruit	1.82	1.47
	Babelegi	2.17	1.18
	Temba	6.56	2.01
	Rietgat	7.04	2.70
	Klipgat	16.03	10.00
Ekurhuleni MM	Hartebeestfontein + Estherpark	20.49	7.95
	Olifantsfontein	31.54	20.01
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	2.96	0.33
LM of Madibeng	Brits (Madibeng)	12.96	3.58
Mogale City LM	Percy Stewart	11.01	4.83
Moretele LM	Apies	2.34	0.00
Moses Kotane LM	Moses Kotane	7.56	0.00
Randfontein LM	Randfontein	6.34	3.13
Rustenberg LM	Bafokeng and Rustenberg	23.74	2.93
Thabazimbi LM	Thabazimbi	1.74	0.20
Totals		**538.86**	**263.27**

The model results showed acceptable calibration between the modelled water requirements and return flow figures and the observed results. The comparison is shown and discussed in **Section 5.4**.

5.3 APPROACH TO FUTURE PRIMARY WATER REQUIREMENTS UPDATING

The approaches adopted in the CRFAS and Vaal BWSR Studies were reviewed.

Copies of the model and data sets developed in the course of these studies were obtained (WRP, 2006). This requirements and return flows model was used as a basis for the updating of the urban portion of the primary water requirements. The model was calibrated in detail in the course of the CWRFA, and updated for the Vaal BWRS.

Urban populations are assigned to different water requirement categories in the return flow model, as used in the NWRS, and given in **Table 5.2**. These unit consumption figures were adjusted as part of the calibration of the return flow model in the CWRFA and Vaal BWRS.

Table 5.2: Housing categories used in the return flow model

Category number	Category description	Default water requirement (ℓ/c/d)
1	Full Service: Houses on large erven >500m^2	320
2	Flats, Town Houses, Cluster Houses with full service	320
3	Full Service: Houses on small erven <500m^2	160
4	Basic RDP houses and informal houses with water connection to site only but no or minimal sewerage service	90
5	Informal houses and shacks with service by communal tap only	10
6	No service from any water distribution system	6
7	Other/Miscellaneous (includes hostels, military camps, hospitals, schools etc).	90

Primary water requirements in rural areas were based on the assumption of a fixed per capita consumption, initially 50ℓ/c/day. After discussion with personnel from the Water Services Chief Directorate it became apparent that this was not adequate, and a stepped approach was taken to rural water requirements (see **Table 5.3**).

Table 5.3: Rural per capita requirements

Year	2001	2005	2010	2015	2020	2025	2030
ℓ/c/day	40	40	60	60	80	80	100

The increase in per capita rural water requirements to 2010 is in line with the commitment of the DWAF to progressively increase the minimum level of water supplied to at least 50ℓ/capita/day, clear the sanitation backlog and eradicate the bucket system by that date. As the study area includes several large metropolitan centres it was considered reasonable to set the requirement somewhat higher than the national target.

For similar reasons, further growth beyond this requirement was anticipated in the long-term due to:

- The electrification of rural areas adjoining metropolitan areas and consequent increase in water requirements with the installation of devices such as geysers;
- The gradual introduction of flush toilets; and
- The development of businesses and institutions within dense rural settlements e.g. car repair shops and schools.

Note that this reflects the water requirements of the population, and does not take requirements due to other activities of rural households such as stock watering into account.

5.4 CALIBRATION RESULTS

The return flow model was calibrated against the figures on water use and return flow for 2001 at SDA level for which results are provided in **Table 5.4**.

Table 5.4: Comparison between the calibration results and the observed water requirements and return flows (2001)

Model Drainage Area / WWTW	Water Requirements (2001)				Return Flows (2001)			
	Observed Water Requirement (million m3)	Calibrated Water Requirement (million m3)	Difference (million m3)	% Difference	Observed Return Flows (million m3)	Calibrated Return Flows (million m3)	Difference (million m3)	% Difference
Bela-Bela	2.99	3.08	0.09	3.16	0.00	0.00	0.00	0.00
Roodepoort Driefontein	11.36	11.11	-0.25	-2.19	5.36	5.80	0.44	8.19
Johannesburg Northern	176.05	178.02	1.97	1.12	92.67	94.23	1.56	1.68
Sunderland + Rooiwal + Daspoort	150.40	151.26	0.86	0.58	79.82	88.20	8.38	10.50
Zeekoegat + Baviaanspoort	43.75	45.14	1.39	3.18	25.10	28.82	3.72	14.81
Sandspruit	1.82	1.85	0.03	1.63	1.47	1.40	-0.07	-5.07
Babelegi	2.17	2.19	0.02	1.13	1.18	1.08	-0.10	-8.68
Temba	6.56	6.73	0.17	2.60	2.01	3.70	1.69	83.99
Rietgat	7.04	7.38	0.34	4.79	2.70	1.97	-0.73	-27.03
Klipgat	16.03	16.23	0.20	1.28	10.00	10.18	0.18	1.83
Hartebeestfontein + Estherpark	20.49	19.88	-0.62	-3.01	7.95	12.00	4.05	51.00
Olifantsfontein	31.54	32.71	1.16	3.68	20.01	19.25	-0.76	-3.81
Swartruggens+Koster +Kgetlengrivier	2.96	1.10	-1.86	-62.70	0.33	0.33	0.00	-0.70
Brits (Madibeng)	12.96	13.26	0.30	2.29	3.58	8.85	5.27	147.09
Percy Stewart	11.01	10.71	-0.30	-2.75	4.83	0.00	-4.83	-100.00
Apies	2.34	2.37	0.03	1.39	0.00	0.00	0.00	0.00
Moses Kotane	7.56	7.22	-0.34	-4.48	0.00	0.00	0.00	0.00
Randfontein	6.34	6.62	0.28	4.43	3.13	4.42	1.29	41.35
Bafokeng and Rustenberg	23.74	23.01	-0.73	-3.07	2.93	12.66	9.73	332.25
Thabazimbi	1.74	3.55	1.81	104.27	0.20	0.54	0.34	169.86
TOTAL	**538.86**	**543.44**	**4.58**	**0.85**	**263.27**	**293.42**	**30.15**	**11.45**

The calibrated results in comparison to the observed figures at SDA level confirm that the calibration achieved was of acceptable standards. The table indicates that the calibrated water requirements are well within 1% of the observed water requirements. The result obtained for the comparison between return flows are within 12% of the observed return flows, which was considered acceptable. The acceptance of the calibration results motivated for the continuation of the estimation of future water requirements and return flows for the catchment. The results of the projections per municipal area are discussed in the following chapter.

6 URBAN WATER REQUIREMENTS AND RETURN FLOWS: POPULATION SCENARIOS

6.1 OVERVIEW

The drivers associated with the change in population growth are what have been used to derive the future population variants, high, base and low scenarios. The base variant foundation is the Statistics SA projections which have been characterised as the most likely population growth to occur in Gauteng. The high population variant takes into account the possibility of increased economic growth, above normal, effective service delivery and effective HIV/AIDS interventions which will all contribute to the increase in population migration to Gauteng. The opposite of the abovementioned characteristics for the high variant forms the basis of the low population variant. Sluggish economic growth due to constrained service delivery as well as the decrease in internal population growth due to HIV/AIDS restricting the influx of people to the province.

6.2 BASE POPULATION GROWTH SCENARIO

Population growth was based on the trends projected from the Statistics SA projections. **Table 6.1 gives** the total urban and rural population growth scenarios for the entire catchment and **Table 6.2** provides the population breakdown per municipality in the study area.

Table 6.1: Total urban and rural population projections – base population scenario

Population category	2005	2010	2015	2020	2025	2030
Urban	4 873 580	5 385 148	5 856 832	6 281 155	6 659 602	7 060 469
Rural	534 714	521 289	487 222	479 776	487 950	594 470
Total	**5 408 294**	**5 906 437**	**6 344 054**	**6 760 931**	**7 147 552**	**7 654 939**

Table 6.2: Total municipal urban and rural population projections – base population scenario

Urban Population						
Municipality	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Ekurhuleni MM	691 233	764 852	828 224	883 356	935 764	991 282
City of Tshwane MM	1 931 034	2 174 777	2 396 645	2 599 221	2 792 172	2 999 445
City of Johannesburg MM	1 112 998	1 214 916	1 314 789	1 405 560	1 477 309	1 552 720
Mogale City LM	52 875	58 759	63 700	68 717	73 819	79 299
Randfontein LM	116 968	130 688	143 024	153 937	161 912	170 301
Rustenberg LM	336 093	353 870	368 769	380 753	388 979	397 380
Moretele LM	74 358	83 886	92 643	100 713	108 417	116 706
LM of Madibeng	323 974	349 892	374 385	391 232	398 566	403 468
Thabazimbi LM	12 604	13 214	13 854	14 525	15 228	15 965
Bela Bela LM	33 991	35 549	37 177	38 881	40 662	42 525
Kgetlengrivier / Kunqwini	18 356	20 049	21 898	23 917	26 123	28 532
Moses Kotane LM	169 096	184 696	201 724	220 343	240 651	262 846
SUBTOTAL	***4 873 580***	***5 385 148***	***5 856 832***	***6 281 155***	***6 659 602***	***7 060 469***
Rural Population						
Municipality	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Ekurhuleni MM	733	0	0	0	0	0
City of Tshwane MM	104 925	92 968	72 578	71 225	78 497	192 274
City of Johannesburg MM	0	0	0	0	0	0
Mogale City LM	10 125	11 253	12 201	13 165	14 147	15 107
Randfontein LM	4 459	4 936	5 309	5 740	6 278	622
Rustenberg LM	61 215	58 811	53 887	50 871	49 489	46 561
Moretele LM	181 789	188 050	191 852	195 245	197 685	199 426
LM of Madibeng	37 730	25 581	10 020	1 206	0	0
Thabazimbi LM	48 069	52 007	54 449	56 448	57 786	58 516
Bela Bela LM	14 896	17 046	17 935	18 402	18 292	17 619
Kgetlengrivier / Kunqwini	13 282	13 038	12 129	10 955	9 394	7 500
Moses Kotane LM	57 491	57 599	56 862	56 519	56 382	56 846
SUBTOTAL	***534 714***	***521 289***	***487 222***	***479 776***	***487 950***	***594 470***
TOTAL POPULATION	**5 408 294**	**5 906 437**	**6 344 054**	**6 760 931**	**7 147 552**	**7 654 939**

6.3 HIGH POPULATION GROWTH SCENARIO

Population growth was based on the following characteristics; 1) Strong economic growth in Gauteng, 2) Effective service delivery; and 3) Effective HIV/AIDS interventions. **Table 6.3** provides the total urban and rural population growth scenarios for the entire catchment and **Table 6.4** provides the population breakdown per municipality in the study area.

Table 6.3: Total urban and rural population projections – high population scenario

Population category	2005	2010	2015	2020	2025	2030
Urban	4 952 225	5 553 902	6 166 334	6 723 721	7 188 481	7 684 353
Rural	538 951	530 664	500 953	498 228	511 772	629 887
Total	**5 491 176**	**6 084 566**	**6 667 287**	**7 221 949**	**7 700 253**	**8 314 240**

Table 6.4: Total municipal urban and rural population projections – high population scenario

Urban Population						
Municipality	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Ekurhuleni MM	702 208	788 387	871 193	944 452	1 008 938	1 077 829
City of Tshwane MM	1 961 564	2 241 547	2 520 691	2 778 887	3 010 446	3 261 300
City of Johannesburg MM	1 130 634	1 252 286	1 382 919	1 502 725	1 592 685	1 688 033
Mogale City LM	53 711	60 564	67 001	73 471	79 586	86 210
Randfontein LM	118 823	134 709	150 442	164 584	174 576	185 174
Rustenberg LM	341 405	364 734	387 855	407 072	419 384	432 066
Moretele LM	75 534	86 463	97 437	107 676	116 892	126 897
LM of Madibeng	334 299	371 704	414 143	447 188	463 310	476 976
Thabazimbi LM	12 604	13 214	13 854	14 525	15 228	15 965
Bela Bela LM	33 991	35 549	37 177	38 881	40 662	42 525
Kgetlengrivier / Kunqwini	18 356	20 049	21 898	23 917	26 123	28 532
Moses Kotane LM	169 096	184 696	201 724	220 343	240 651	262 846
SUBTOTAL	***4 952 225***	***5 553 902***	***6 166 334***	***6 723 721***	***7 188 481***	***7 684 353***
Rural Population						
Municipality	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Ekurhuleni MM	739	0	0	0	0	0
City of Tshwane MM	105 756	94 640	74 623	73 964	82 329	203 729
City of Johannesburg MM	0	0	0	0	0	0
Mogale City LM	10 205	11 455	12 545	13 672	14 838	16 006
Randfontein LM	4 494	5 024	5 459	5 961	6 584	659
Rustenberg LM	61 700	59 869	55 406	52 827	51 905	49 335
Moretele LM	183 230	191 432	197 259	202 754	207 337	211 308
LM of Madibeng	38 029	26 041	10 302	1 252	0	0
Thabazimbi LM	48 450	52 942	55 984	58 619	60 607	62 002
Bela Bela LM	15 014	17 353	18 440	19 110	19 185	18 669
Kgetlengrivier / Kunqwini	13 387	13 272	12 471	11 376	9 853	7 947
Moses Kotane LM	57 947	58 635	58 465	58 693	59 134	60 232
SUBTOTAL	***538 951***	***530 664***	***500 953***	***498 228***	***511 772***	***629 887***
TOTAL POPULATION	**5 491 176**	**6 084 566**	**6 667 287**	**7 221 949**	**7 700 253**	**8 314 240**

6.4 LOW POPULATION GROWTH SCENARIO

Population growth was based on the following characteristics; 1) Sluggish economic growth in Gauteng, 2) Constrained service delivery; and 3) HIV/AIDS lowers internal growth rate. **Table 6.5** gives the total urban and rural population growth scenarios for the entire catchment and **Table 6.6** provides the population breakdown per municipality in the study area.

Table 6.5: Total urban and rural population projections – low population scenario

Population category	2005	2010	2015	2020	2025	2030
Urban	4 867 502	5 211 339	5 494 735	5 661 126	5 753 272	5 847 567
Rural	533 416	502 595	454 058	428 147	416 123	486 035
Total	5 400 918	5 713 934	5 948 793	6 089 273	6 169 395	6 333 602

Table 6.6: Total municipal urban and rural population projections – low population scenario

Urban Population						
Municipality	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Ekurhuleni MM	689 589	737 449	771 910	788 307	798 044	807 903
City of Tshwane MM	1 926 351	2 096 638	2 233 332	2 319 345	2 381 147	2 444 595
City of Johannesburg MM	1 110 335	1 171 399	1 225 300	1 254 269	1 259 777	1 265 310
Mogale City LM	52 747	56 650	59 363	61 320	62 948	64 619
Randfontein LM	116 682	125 992	133 274	137 353	138 054	138 759
Rustenberg LM	335 275	341 156	343 642	339 758	331 719	323 865
Moretele LM	74 178	80 871	86 328	89 868	92 457	95 118
LM of Madibeng	328 298	347 676	366 933	373 240	366 462	357 530
Thabazimbi LM	12 604	13 214	13 854	14 525	15 228	15 965
Bela Bela LM	33 991	35 549	37 177	38 881	40 662	42 525
Kgetlengrivier / Kunqwini	18 356	20 049	21 898	23 917	26 123	28 532
Moses Kotane LM	169 096	184 696	201 724	220 343	240 651	262 846
SUBTOTAL	***4 867 502***	***5 211 339***	***5 494 735***	***5 661 126***	***5 753 272***	***5 847 567***
Rural Population						
Municipality	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Ekurhuleni MM	732	0	0	0	0	0
City of Tshwane MM	104 670	89 634	67 638	63 560	66 942	157 202
City of Johannesburg MM	0	0	0	0	0	0
Mogale City LM	10 100	10 849	11 370	11 748	12 065	12 351
Randfontein LM	4 448	4 759	4 948	5 122	5 354	509
Rustenberg LM	61 066	56 702	50 219	45 397	42 204	38 068
Moretele LM	181 348	181 306	178 793	174 234	168 586	163 049
LM of Madibeng	37 638	24 664	9 338	1 076	0	0
Thabazimbi LM	47 952	50 142	50 743	50 374	49 280	47 842
Bela Bela LM	14 860	16 435	16 714	16 422	15 599	14 405
Kgetlengrivier / Kunqwini	13 250	12 570	11 303	9 776	8 011	6 132
Moses Kotane LM	57 351	55 534	52 992	50 437	48 082	46 477
SUBTOTAL	***533 416***	***502 595***	***454 058***	***428 147***	***416 123***	***486 035***
TOTAL POPULATION	***5 400 918***	***5 713 934***	***5 948 793***	***6 089 273***	***6 169 395***	***6 333 602***

7 URBAN WATER REQUIREMENTS AND RETURN FLOWS: WC/WDM SCENARIOS

7.1 BACKGROUND

There are a number of large urban areas in the Crocodile (West) River catchment. The catchment divide that runs through the City of Johannesburg is of particular importance and forms the boundary of the Crocodile (West) River catchment and the Upper Vaal Water Management Area. The northern suburbs of Johannesburg, which include Sandton, Alexandra, Bedfordview and Randburg, fall into the Crocodile (West) River catchment, as well as parts of the Ekurhuleni Metropolitan Municipality (Edenvale, Modderfontein, Kempton Park and Tembisa) and the West Rand District Municipality (Roodepoort, Randfontein, Magaliesburg and Krugersdorp). Other large urban areas are the City of Tshwane Metropolitan Municipality (Babelegi, Ga-Rankuwa, Mamelodi, Pretoria, Centurion and Akasia), the Bojanala Platinum District Municipality (Rustenburg, Koster, Brits, Hartbeespoort and Skeerpoort) and the Waterberg District Municipality (Bela-Bela and Thabazimbi). The primary water suppliers and sources of water are shown in **Table 7.1**.

Table 7.1: Primary water supply

SUB-CATCHMENT	LOCAL AUTHORITY	TOWNS	WATER SUPPLIER	SOURCES
Upper Crocodile	Johannesburg Metropolitan Council	Johannesburg	Rand Water	Vaal River
		Roodepoort		
		Alexandra		
		Midrand		
	Randfontein Local Municipality	Randfontein	Rand Water	Vaal River
	Mogale City Local Municipality	Mogale	Rand Water	Vaal River
	City of Tshwane Metropolitan Council	Centurion	Rand Water	Vaal River
			Own Sources	Rietvlei Dam
				Fountains
	Ekurhuleni Metropolitan Council	Kempton Park	Rand Water	Vaal River
		Tembisa	Rand Water	Vaal River
	Madibeng Local Municipality	Brits	Magalies Water	Crocodile River
		Hartbeespoort		Hartbeespoort Dam
Elands	Rustenburg Local Municipality	Rustenburg	Rand Water	Vaal River
			Own Sources	Bospoort Dam
	Kgetleng River Municipality	Koster	Magalies Water	Koster Dam
		Swartruggens	Magalies Water	Elands River
	Moses Kotane Municipality	Mogwase	Magalies Water	Vaalkop Dam
				Elands River
Apies-Pienaars	City of Tshwane Metropolitan Council	Pretoria	Rand Water	Vaal River
			Own Sources	Rietvlei Dam
				Fountains
		Ga- Rankuwa	Rand Water	Vaal River
		Mabopane		
	Moretele Local Municipality	Temba	Magalies Water	Apies River
				Pienaars River
		Babelegi		Roodeplaat Dam
	Nokeng Tsa Taemane Local Municipality	Wallmansthal	Magalies Water	Pienaars River
				Roodeplaat Dam
	Bela-Bela Local Municipality	Bela-Bela	Magalies Water	Pienaars River
				Roodeplaat Dam
			Own Sources	Plat River
				Boreholes
Lower Crocodile	Thabazimbi Municipality	Thabazimbi	Magalies Water	Vaalkop Dam

(Source: Crocodile West River Return flow Analysis Study, Report number P WMA03/000/00/0904)

Water Conservation and Demand Management (WC/WDM) is a complicated strategy in the Crocodile (West) River catchment since most of the water requirements in the catchment are supplied from the Vaal River system, which is augmented by transfer schemes from, *inter alia*, the Orange (Lesotho Highlands), the Usutu and the Thukela Rivers. An estimated 53% of the water resources available to downstream users consist of return flows from mainly Johannesburg and Tshwane. Effective WC/WDM practices will reduce these return flows with an associated reduction in available water resources. On the other hand, schemes to augment the water transfers are costly and WC/WDM measures, focusing on effective use of return flows, should be implemented to delay further augmentation schemes. Water losses in the catchment were estimated as 30% of the total water requirements (*Water Resources Situation Assessment Study*, DWAF Report No. P WMA03000/00/0301) and should be addressed.

The components of urban water use relevant for Water Conservation and Demand Management (WC/WDM) are shown in **Figure 7.1**. Unaccounted for Water is either unauthorised use or losses.

AUTHORISED	Billed metered	
	Unbilled metered	
	Billed not metered (“flat rate”)	
	Unbilled not metered	
UNAUTHORISED	Unlawful use	
LOSSES	Real losses	
	Apparent losses	Unlawful use
		Meter error

Figure 7.1: Urban water use

An improvement in real losses will result in a reduction in the water requirement, while a reduction in apparent losses will result in the same requirement but more of the water use will be billed. During discussions with the City of Johannesburg and Tshwane Metros it was explained that urban WC/WDM strategies in these metros focus on increasing payment for water use instead of conserving water. An increase in payment can result in a reduction in water use, for example the average water use in Soweto decreased from 60 kilolitres per day (kℓ/d) to 11 kℓ/d since the instalment of pre-paid meters (R. McKenzie, personnel communication).

7.1.1 Definition of WC/WDM

The definition of Water Conservation is clearly stipulated in the *Water Conservation and Demand Management strategy* (DWAF, 1999) as “The minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water.” Similarly, water demand management is defined as “The adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water demand and usage of water in order to meet any of the following objectives: economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services, and political acceptability."

The need for water conservation and demand management arises due to the high capital cost of water resources supply development as well as the limitation of water resources to cope with the rapid increase in water demand. Many countries such as Denmark, Israel, Australia, and others, have benefited from this kind of initiative.

In general, water conservation and demand management initiatives have three major components namely, technical, institutional and socio-economical. The technical aspect comprises the installation of equipment that enhances efficient water utilization and reduces water losses such as pressure control in the domestic sector and changing from less efficient systems, such as flood irrigation to more efficient systems, such as drip irrigation, in the irrigation sector.

Technical interventions, without functional institutional arrangements, are unlikely to bring sustainable improvement in terms of water conservation and demand management. Thus a well-structured and equipped institutional setup, which promotes the smooth transfer of information, accountability and transparency, is crucial in water conservation and demand management. The socio-economic aspect includes, among others, creating awareness, creating sense of ownership, and promoting competition among users to attain best management practice.

Unfortunately, in South Africa, water for irrigation is supplied via a quota system, and farmers pay for their quota irrespective of the amount of water used. This provides little incentive for farmers to be more efficient in their application, particularly since most of them are not currently utilising their full quota.

However, before embarking on proposing or implementing a water conservation and demand management initiative, the following three stages must be fulfilled:

- An audit of current practices;
- Calculation of efficiency measures and indices and benchmarking; and
- Application of efficiency measures and indices to the audit.

7.1.2 WC/WDM Scenarios

Urban water requirements linked to high, base and low population growth projections were initially prepared for following water demand scenarios:

- Scenario B: High = no water demand management, high population growth
- Scenario B: Base = no water demand management, base population growth
- Scenario B: Low = no water demand management, low population growth
- Scenario C: High = high water demand management efficiency, high population growth
- Scenario C: Base = high water demand management efficiency, base population growth
- Scenario C: Low = high water demand management efficiency, low population growth
- Scenario D: High = medium water demand management efficiency, high population growth
- Scenario D: Base = medium water demand management efficiency, base population growth
- Scenario D: Low = medium water demand management efficiency, low population growth

Although the final WC/WDM scenarios used in the future planning are Scenarios C and D as proposed in the WC/WDM report of the Vaal BWSR (DWAF, 2007b), results of all scenarios will be displayed.

Proportional requirement and return flow reductions per SDA based on the Vaal BWSR study were applied to the water use figures derived in the current study. This took account of the varying effectiveness of measures taken in SDAs with different socio-economic and water use characteristics.

8 SCENARIO RESULTS

8.1 URBAN WATER REQUIREMENTS

The total net urban water requirements projections for the study area for the nine scenarios analysed are summarised in **Table 8.1**.

Table 8.1: Total urban water requirements (million m^3/a) – Includes WC/WDM and population growth

Scenario	2005	2010	2015	2020	2025	2030
Scenario B: High (million m^3/a)	628.29	704.81	782.82	854.29	914.13	978.36
Scenario B: Base (million m^3/a)	618.51	683.82	744.30	799.10	847.99	900.07
Scenario B: Low (million m^3/a)	617.30	660.38	695.70	716.34	727.60	739.24
Scenario C: High (million m^3/a)	628.29	661.44	680.65	713.97	746.81	807.40
Scenario C: Base (million m^3/a)	618.51	641.74	647.16	667.85	692.80	742.84
Scenario C: Low (million m^3/a)	617.30	619.81	605.17	599.22	595.25	611.10
Scenario D: High (million m^3/a)	628.29	656.98	730.57	797.33	852.80	915.83
Scenario D: Base (million m^3/a)	618.51	637.41	694.62	745.83	791.11	842.56
Scenario D: Low (million m^3/a)	617.30	615.63	649.40	668.80	679.09	692.37

The urban water requirements for the various scenarios are displayed below per municipality in **Table 8.2** to **Table 8.10**.

Table 8.2: Scenario B (High) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.30	13.63	15.06	16.39	17.41	18.49
	Johannesburg Northern	178.02	204.23	226.09	249.67	271.28	287.39	304.46
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	170.99	195.15	219.26	241.60	261.72	283.52
	Zeekoegat + Baviaanspoort	45.14	51.16	58.56	65.93	72.74	78.80	85.38
	Sandspruit	1.85	2.09	2.39	2.68	2.96	3.21	3.47
	Babelegi	2.19	2.48	2.83	3.18	3.51	3.80	4.12
	Temba	6.73	7.61	8.69	9.77	10.77	11.67	12.64
	Rietgat	7.38	8.34	9.53	10.71	11.80	12.79	13.86
	Klipgat	16.23	18.36	20.96	23.56	25.97	28.14	30.50
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	22.12	24.96	27.59	29.88	32.02	34.31
	Olifantsfontein	32.71	45.62	51.22	56.60	61.36	65.55	70.02
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	15.25	16.96	18.90	20.40	21.14	21.90
Mogale City LM	Percy Stewart	10.71	12.10	13.64	15.09	16.55	17.93	19.42
Moretele LM	Apies	2.37	2.69	3.08	3.47	3.83	4.16	4.51
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.42	8.41	9.40	10.28	10.90	11.57
Rustenberg LM	Bafokeng and Rustenberg	23.01	29.48	31.49	33.49	35.15	36.21	37.30
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**628.29**	**704.81**	**782.82**	**854.29**	**914.13**	**978.36**

Table 8.3: Scenario B (Base) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.11	13.23	14.32	15.33	16.15	17.01
	Johannesburg Northern	178.02	201.05	219.35	237.37	253.74	266.57	280.05
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	168.33	189.34	208.47	225.98	242.74	260.75
	Zeekoegat + Baviaanspoort	45.14	50.36	56.81	62.68	68.03	73.09	78.52
	Sandspruit	1.85	2.06	2.32	2.55	2.77	2.97	3.20
	Babelegi	2.19	2.44	2.75	3.03	3.28	3.53	3.79
	Temba	6.73	7.49	8.43	9.29	10.07	10.82	11.63
	Rietgat	7.38	8.21	9.24	10.18	11.04	11.86	12.75
	Klipgat	16.23	18.07	20.34	22.40	24.29	26.10	28.05
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	21.77	24.21	26.23	27.95	29.70	31.55
	Olifantsfontein	32.71	44.91	49.69	53.81	57.39	60.79	64.40
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	14.78	15.96	17.08	17.85	18.18	18.53
Mogale City LM	Percy Stewart	10.71	11.91	13.24	14.35	15.48	16.63	17.87
Moretele LM	Apies	2.37	2.65	2.98	3.30	3.58	3.86	4.15
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.31	8.16	8.93	9.62	10.11	10.64
Rustenberg LM	Bafokeng and Rustenberg	23.01	29.02	30.55	31.84	32.87	33.58	34.31
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**618.51**	**683.82**	**744.30**	**799.10**	**847.99**	**900.07**

Table 8.4: Scenario B (Low) Projected Municipal urban water requirements (million m³/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m³/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.08	12.75	13.34	13.68	13.77	13.86
	Johannesburg Northern	178.02	200.56	211.49	221.21	226.43	227.32	228.21
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	167.92	182.53	194.27	201.64	207.01	212.52
	Zeekoegat + Baviaanspoort	45.14	50.24	54.77	58.41	60.71	62.33	64.00
	Sandspruit	1.85	2.05	2.23	2.38	2.47	2.54	2.60
	Babelegi	2.19	2.44	2.65	2.82	2.93	3.01	3.09
	Temba	6.73	7.48	8.13	8.66	8.99	9.23	9.48
	Rietgat	7.38	8.19	8.91	9.49	9.85	10.11	10.39
	Klipgat	16.23	18.03	19.61	20.88	21.67	22.26	22.86
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	21.72	23.35	24.44	24.94	25.33	25.72
	Olifantsfontein	32.71	44.80	47.91	50.15	51.21	51.84	52.48
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	14.98	15.86	16.74	17.03	16.72	16.42
Mogale City LM	Percy Stewart	10.71	11.88	12.76	13.37	13.81	14.18	14.56
Moretele LM	Apies	2.37	2.64	2.88	3.07	3.20	3.29	3.38
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.29	7.87	8.32	8.58	8.62	8.67
Rustenberg LM	Bafokeng and Rustenberg	23.01	28.95	29.46	29.67	29.37	28.74	28.12
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**617.30**	**660.38**	**695.70**	**716.34**	**727.60**	**739.24**

Table 8.5: Scenario C (High) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.30	12.30	12.92	13.35	14.14	15.18
	Johannesburg Northern	178.02	204.23	203.99	214.20	221.03	233.49	249.91
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	170.99	189.83	189.64	201.63	210.60	230.87
	Zeekoegat + Baviaanspoort	45.14	51.16	54.92	52.04	54.57	56.60	62.51
	Sandspruit	1.85	2.09	2.16	2.42	2.67	2.89	3.14
	Babelegi	2.19	2.48	2.74	3.01	3.30	3.57	3.88
	Temba	6.73	7.61	7.86	8.27	9.02	9.69	10.61
	Rietgat	7.38	8.34	9.27	9.97	10.83	11.53	12.56
	Klipgat	16.23	18.36	19.02	19.38	20.78	22.06	24.23
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	22.12	22.75	22.98	22.39	21.74	23.84
	Olifantsfontein	32.71	45.62	46.19	48.14	50.02	51.11	55.35
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	15.25	16.96	18.90	20.40	21.14	21.90
Mogale City LM	Percy Stewart	10.71	12.10	13.64	15.09	16.55	17.93	19.42
Moretele LM	Apies	2.37	2.69	3.08	3.47	3.83	4.16	4.51
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.42	8.04	8.26	8.60	8.65	9.31
Rustenberg LM	Bafokeng and Rustenberg	23.01	29.48	31.49	33.49	35.15	36.21	37.30
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**628.29**	**661.44**	**680.65**	**713.97**	**746.81**	**807.40**

Table 8.6: Scenario C (Base) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.11	11.94	12.28	12.49	13.12	13.96
	Johannesburg Northern	178.02	201.05	197.91	203.65	206.74	216.58	229.88
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	168.33	184.17	180.30	188.60	195.33	212.33
	Zeekoegat + Baviaanspoort	45.14	50.36	53.29	49.48	51.04	52.49	57.49
	Sandspruit	1.85	2.06	2.09	2.30	2.50	2.68	2.89
	Babelegi	2.19	2.44	2.65	2.86	3.09	3.31	3.57
	Temba	6.73	7.49	7.63	7.86	8.44	8.99	9.76
	Rietgat	7.38	8.21	8.99	9.48	10.13	10.69	11.55
	Klipgat	16.23	18.07	18.45	18.43	19.43	20.46	22.28
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	21.77	22.07	21.85	20.94	20.16	21.92
	Olifantsfontein	32.71	44.91	44.81	45.77	46.79	47.41	50.90
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	14.78	15.96	17.08	17.85	18.18	18.53
Mogale City LM	Percy Stewart	10.71	11.91	13.24	14.35	15.48	16.63	17.87
Moretele LM	Apies	2.37	2.65	2.98	3.30	3.58	3.86	4.15
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.31	7.80	7.85	8.05	8.02	8.56
Rustenberg LM	Bafokeng and Rustenberg	23.01	29.02	30.55	31.84	32.87	33.58	34.31
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**618.51**	**641.74**	**647.16**	**667.85**	**692.80**	**742.84**

Table 8.7: Scenario C (Low) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.08	11.51	11.45	11.15	11.19	11.38
	Johannesburg Northern	178.02	200.56	190.82	189.79	184.48	184.68	187.33
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	167.92	177.55	168.02	168.29	166.58	173.05
	Zeekoegat + Baviaanspoort	45.14	50.24	51.37	46.11	45.55	44.77	46.86
	Sandspruit	1.85	2.05	2.02	2.15	2.23	2.29	2.35
	Babelegi	2.19	2.44	2.56	2.67	2.76	2.82	2.91
	Temba	6.73	7.48	7.35	7.32	7.53	7.67	7.95
	Rietgat	7.38	8.19	8.67	8.83	9.03	9.12	9.41
	Klipgat	16.23	18.03	17.79	17.17	17.34	17.45	18.16
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	21.72	21.28	20.36	18.69	17.19	17.87
	Olifantsfontein	32.71	44.80	43.21	42.66	41.75	40.43	41.49
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	14.98	15.86	16.74	17.03	16.72	16.42
Mogale City LM	Percy Stewart	10.71	11.88	12.76	13.37	13.81	14.18	14.56
Moretele LM	Apies	2.37	2.64	2.88	3.07	3.20	3.29	3.38
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.29	7.52	7.32	7.18	6.84	6.97
Rustenberg LM	Bafokeng and Rustenberg	23.01	28.95	29.46	29.67	29.37	28.74	28.12
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**617.30**	**619.81**	**605.17**	**599.22**	**595.25**	**611.10**

Table 8.8: Scenario D (High) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.30	12.40	13.74	14.97	15.92	16.98
	Johannesburg Northern	178.02	204.23	205.68	227.77	247.87	262.74	279.52
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	170.99	187.21	210.39	231.70	250.92	272.39
	Zeekoegat + Baviaanspoort	45.14	51.16	52.92	59.88	66.29	71.88	78.25
	Sandspruit	1.85	2.09	2.04	2.31	2.56	2.78	3.03
	Babelegi	2.19	2.48	2.69	3.03	3.35	3.63	3.95
	Temba	6.73	7.61	7.45	8.46	9.39	10.22	11.15
	Rietgat	7.38	8.34	9.14	10.30	11.37	12.32	13.38
	Klipgat	16.23	18.36	18.07	20.52	22.78	24.79	27.05
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	22.12	22.87	25.25	27.19	28.99	31.22
	Olifantsfontein	32.71	45.62	46.93	51.80	55.83	59.34	63.71
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	15.25	16.96	18.90	20.40	21.14	21.90
Mogale City LM	Percy Stewart	10.71	12.10	12.79	13.80	14.96	15.99	17.47
Moretele LM	Apies	2.37	2.69	3.08	3.47	3.83	4.16	4.51
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.42	8.04	9.00	9.87	10.47	11.13
Rustenberg LM	Bafokeng and Rustenberg	23.01	29.48	31.49	33.49	35.15	36.21	37.30
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**628.29**	**656.98**	**730.57**	**797.33**	**852.80**	**915.83**

Table 8.9: Scenario D (Base) Projected Municipal urban water requirements (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.11	12.03	13.06	14.01	14.76	15.62
	Johannesburg Northern	178.02	201.05	199.54	216.55	231.84	243.71	257.11
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	168.33	181.64	200.04	216.72	232.73	250.52
	Zeekoegat + Baviaanspoort	45.14	50.36	51.35	56.94	62.00	66.67	71.97
		1.85	2.06	1.98	2.20	2.40	2.58	2.79
	Babelegi	2.19	2.44	2.61	2.88	3.13	3.37	3.63
	Temba	6.73	7.49	7.23	8.04	8.79	9.48	10.25
	Rietgat	7.38	8.21	8.87	9.79	10.63	11.43	12.31
	Klipgat	16.23	18.07	17.53	19.51	21.31	22.99	24.88
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	21.77	22.19	24.00	25.43	26.88	28.71
	Olifantsfontein	32.71	44.91	45.53	49.24	52.22	55.04	58.60
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	14.78	15.96	17.08	17.85	18.18	18.53
Mogale City LM	Percy Stewart	10.71	11.91	12.41	13.12	13.99	14.83	16.07
Moretele LM	Apies	2.37	2.65	2.98	3.30	3.58	3.86	4.15
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.31	7.80	8.56	9.23	9.71	10.24
Rustenberg LM	Bafokeng and Rustenberg	23.01	29.02	30.55	31.84	32.87	33.58	34.31
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**618.51**	**637.41**	**694.62**	**745.83**	**791.11**	**842.56**

Table 8.10: Scenario D (Low) Projected Municipal urban water requirements (million m³/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Water Requirements (million m³/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	3.08	3.23	3.37	3.53	3.69	3.86	4.04
City of Johannesburg MM	Roodepoort Driefontein	11.11	12.08	11.60	12.17	12.50	12.59	12.72
	Johannesburg Northern	178.02	200.56	192.39	201.81	206.89	207.83	209.52
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	151.26	167.92	175.11	186.41	193.38	198.47	204.18
	Zeekoegat + Baviaanspoort	45.14	50.24	49.50	53.06	55.32	56.86	58.66
	Sandspruit	1.85	2.05	1.91	2.05	2.14	2.20	2.27
	Babelegi	2.19	2.44	2.51	2.69	2.79	2.87	2.96
	Temba	6.73	7.48	6.97	7.50	7.84	8.08	8.36
	Rietgat	7.38	8.19	8.55	9.12	9.49	9.75	10.03
	Klipgat	16.23	18.03	16.90	18.18	19.02	19.61	20.27
Ekurhuleni MM	Hartebeestfontein + Estherpark	19.88	21.72	21.39	22.37	22.69	22.93	23.40
	Olifantsfontein	32.71	44.80	43.90	45.89	46.60	46.94	47.76
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	1.10	1.21	1.32	1.44	1.57	1.72	1.87
LM of Madibeng	Brits (Madibeng)	13.26	14.98	15.86	16.74	17.03	16.72	16.42
Mogale City LM	Percy Stewart	10.71	11.88	11.96	12.22	12.49	12.65	13.09
Moretele LM	Apies	2.37	2.64	2.88	3.07	3.20	3.29	3.38
Moses Kotane LM	Moses Kotane	7.22	7.89	8.61	9.41	10.28	11.22	12.26
Randfontein LM	Randfontein	6.62	7.29	7.52	7.97	8.23	8.28	8.34
Rustenberg LM	Bafokeng and Rustenberg	23.01	28.95	29.46	29.67	29.37	28.74	28.12
Thabazimbi LM	Thabazimbi	3.55	3.73	3.91	4.10	4.29	4.50	4.72
Totals		**543.44**	**617.30**	**615.63**	**649.40**	**668.80**	**679.09**	**692.37**

8.2 RURAL WATER REQUIREMENTS

Rural water requirements were calculated based on stepped per capita water requirements. Discussions with the Chief Directorate: Water Services indicated that this was more reasonable than an assumption of a constant unit requirement. The increase in per capita rural water requirements to 2010 is in line with the commitment of DWAF to progressively increase the minimum level of water supplied to at least 50 ℓ/capita/day, to clear the sanitation backlog and eradicate the bucket system by that date. The rural water requirements were assumed to increase from 40 ℓ/day in 2001 to 60 ℓ/day in 2010, to 80 ℓ/day in 2020 and to 100 ℓ/day in 2030 to reflect rising levels of service for water services provision. The total rural water requirements projections based only on the population projections are displayed in **Table 8.11**.

Table 8.11: Total rural water requirements (million m^3/a) – Only population growth

Scenario	2005	2010	2015	2020	2025	2030
High	7.87	11.62	10.97	14.55	14.94	22.99
Base	7.81	11.42	10.67	14.01	14.25	21.70
Low	7.79	11.01	9.94	12.50	12.15	17.74

The rural water requirements for the high, base and low population projections per municipality are presented in **Table 8.12**, **Table 8.13** and **Table 8.14** below.

Table 8.12: Rural water requirements (million m^3/a) for High population growth scenario

Municipality	2005	2010	2015	2020	2025	2030
Ekurhuleni Metro	0.01	0.00	0.00	0.00	0.00	0.00
City of Tshwane Metro	1.54	2.07	1.63	2.16	2.40	7.44
City of Johannesburg Metro	0.00	0.00	0.00	0.00	0.00	0.00
Mogale City	0.15	0.25	0.27	0.40	0.43	0.58
Randfontein	0.07	0.11	0.12	0.17	0.19	0.02
Rustenburg	0.90	1.31	1.21	1.54	1.52	1.80
Moretele	2.68	4.19	4.32	5.92	6.05	7.71
Madibeng	0.56	0.57	0.23	0.04	0.00	0.00
Thabazimbi	0.71	1.16	1.23	1.71	1.77	2.26
Bela-Bela	0.22	0.38	0.40	0.56	0.56	0.68
Kgetlengrivier	0.20	0.29	0.27	0.33	0.29	0.29
Moses Kotane	0.85	1.28	1.28	1.71	1.73	2.20
Total	**7.87**	**11.62**	**10.97**	**14.55**	**14.94**	**22.99**

Table 8.13: Rural water requirements (million m^3/a) for Base population growth scenario

Municipality	2005	2010	2015	2020	2025	2030
Ekurhuleni Metro	0.01	0.00	0.00	0.00	0.00	0.00
City of Tshwane Metro	1.53	2.04	1.59	2.08	2.29	7.02
City of Johannesburg Metro	0.00	0.00	0.00	0.00	0.00	0.00
Mogale City	0.15	0.25	0.27	0.38	0.41	0.55
Randfontein	0.07	0.11	0.12	0.17	0.18	0.02
Rustenburg	0.89	1.29	1.18	1.49	1.45	1.70
Moretele	2.65	4.12	4.20	5.70	5.77	7.28
Madibeng	0.55	0.56	0.22	0.04	0.00	0.00
Thabazimbi	0.70	1.14	1.19	1.65	1.69	2.14
Bela-Bela	0.22	0.37	0.39	0.54	0.53	0.64
Kgetlengrivier	0.19	0.29	0.27	0.32	0.27	0.27
Moses Kotane	0.84	1.26	1.25	1.65	1.65	2.07
Total	**7.81**	**11.42**	**10.67**	**14.01**	**14.25**	**21.70**

Table 8.14: Rural water requirements (million m^3/a) for Low population growth scenario

Municipality	2005	2010	2015	2020	2025	2030
Ekurhuleni Metro	0.01	0.00	0.00	0.00	0.00	0.00
City of Tshwane Metro	1.53	1.96	1.48	1.86	1.95	5.74
City of Johannesburg Metro	0.00	0.00	0.00	0.00	0.00	0.00
Mogale City	0.15	0.24	0.25	0.34	0.35	0.45
Randfontein	0.06	0.10	0.11	0.15	0.16	0.02
Rustenburg	0.89	1.24	1.10	1.33	1.23	1.39
Moretele	2.65	3.97	3.92	5.09	4.92	5.95
Madibeng	0.55	0.54	0.20	0.03	0.00	0.00
Thabazimbi	0.70	1.10	1.11	1.47	1.44	1.75
Bela-Bela	0.22	0.36	0.37	0.48	0.46	0.53
Kgetlengrivier	0.19	0.28	0.25	0.29	0.23	0.22
Moses Kotane	0.84	1.22	1.16	1.47	1.40	1.70
Total	**7.79**	**11.01**	**9.94**	**12.50**	**12.15**	**17.74**

8.3 URBAN RETURN FLOWS

The total net urban water return flows projections for the study area for the nine scenarios analysed are summarised in **Table 8.15**.

The urban return flows for the nine scenarios per municipality are provided in **Table 8.16** to **Table 8.24**.

Table 8.15: Total urban water return flows (million m^3/a) – Includes WC/WDM and population growth

Scenario	2005	2010	2015	2020	2025	2030
Scenario B: High (million m^3/a)	324.44	369.61	415.60	457.61	492.62	530.41
Scenario B: Base (million m^3/a)	318.60	357.06	392.56	424.60	453.06	483.53
Scenario B: Low (million m^3/a)	317.89	343.12	363.64	375.32	381.34	387.55
Scenario C: High (million m^3/a)	324.44	347.20	366.87	389.59	414.26	445.28
Scenario C: Base (million m^3/a)	318.60	335.37	346.44	361.34	380.82	405.74
Scenario C: Low (million m^3/a)	317.89	322.28	320.95	319.47	320.64	325.35
Scenario D: High (million m^3/a)	324.44	358.34	401.79	441.51	475.00	510.60
Scenario D: Base (million m^3/a)	318.60	346.15	379.48	409.61	436.79	465.40
Scenario D: Low (million m^3/a)	317.89	332.64	351.52	362.07	367.63	372.99

Table 8.16: Scenario B (High) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.43	7.13	7.88	8.58	9.12	9.70
	Johannesburg Northern	94.23	110.54	123.58	137.62	150.47	160.09	170.32
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	92.86	107.74	122.59	136.35	148.75	162.27
	Zeekoegat + Baviaanspoort	25.22	29.06	33.79	38.50	42.85	46.73	50.96
	Sandspruit	1.40	1.58	1.80	2.03	2.23	2.42	2.62
	Babelegi	1.10	1.24	1.42	1.60	1.76	1.91	2.07
	Temba	3.70	4.18	4.78	5.37	5.92	6.41	6.95
	Rietgat	1.97	2.23	2.54	2.86	3.15	3.42	3.70
	Klipgat	10.18	11.52	13.15	14.78	16.29	17.65	19.13
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.36	11.07	12.66	14.05	15.34	16.74
	Olifantsfontein	19.25	27.23	30.56	33.77	36.62	39.11	41.77
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	10.18	11.32	12.61	13.61	14.10	14.61
Mogale City LM	Percy Stewart	5.94	6.71	7.56	8.37	9.17	9.94	10.77
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.76	4.42	5.08	5.67	6.09	6.53
Rustenberg LM	Bafokeng and Rustenberg	3.02	6.10	7.18	8.25	9.13	9.70	10.30
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**324.44**	**369.61**	**415.60**	**457.61**	**492.62**	**530.41**

Table 8.17: Scenario B (Base) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.33	6.92	7.49	8.02	8.46	8.93
	Johannesburg Northern	94.23	108.64	119.57	130.30	140.03	147.69	155.77
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	91.22	104.16	115.95	126.73	137.06	148.23
	Zeekoegat + Baviaanspoort	25.22	28.55	32.67	36.43	39.85	43.08	46.57
	Sandspruit	1.40	1.55	1.75	1.93	2.09	2.24	2.41
	Babelegi	1.10	1.22	1.38	1.52	1.65	1.77	1.90
	Temba	3.70	4.12	4.63	5.10	5.53	5.95	6.39
	Rietgat	1.97	2.19	2.47	2.72	2.95	3.17	3.40
	Klipgat	10.18	11.34	12.76	14.05	15.24	16.37	17.59
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.15	10.62	11.84	12.88	13.93	15.07
	Olifantsfontein	19.25	26.81	29.65	32.11	34.25	36.27	38.42
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	9.86	10.65	11.40	11.91	12.13	12.36
Mogale City LM	Percy Stewart	5.94	6.60	7.34	7.95	8.58	9.22	9.90
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.68	4.25	4.77	5.23	5.56	5.91
Rustenberg LM	Bafokeng and Rustenberg	3.02	5.86	6.68	7.36	7.92	8.30	8.69
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**318.60**	**357.06**	**392.56**	**424.60**	**453.06**	**483.53**

Table 8.18: Scenario B (Low) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.31	6.67	6.98	7.16	7.22	7.27
	Johannesburg Northern	94.23	108.36	114.89	120.68	123.78	124.33	124.88
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	90.96	99.96	107.19	111.74	115.04	118.44
	Zeekoegat + Baviaanspoort	25.22	28.47	31.37	33.70	35.17	36.21	37.28
	Sandspruit	1.40	1.55	1.69	1.79	1.86	1.91	1.96
	Babelegi	1.10	1.22	1.33	1.41	1.47	1.51	1.55
	Temba	3.70	4.11	4.47	4.76	4.94	5.07	5.21
	Rietgat	1.97	2.19	2.38	2.53	2.63	2.70	2.77
	Klipgat	10.18	11.31	12.30	13.09	13.60	13.96	14.34
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.12	10.10	10.76	11.06	11.29	11.53
	Olifantsfontein	19.25	26.74	28.59	29.93	30.56	30.93	31.31
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	9.99	10.58	11.17	11.36	11.16	10.95
Mogale City LM	Percy Stewart	5.94	6.59	7.07	7.41	7.66	7.86	8.07
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.67	4.06	4.36	4.53	4.56	4.59
Rustenberg LM	Bafokeng and Rustenberg	3.02	5.82	6.09	6.21	6.05	5.72	5.41
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**317.89**	**343.12**	**363.64**	**375.32**	**381.34**	**387.55**

Table 8.19: Scenario C (High) Projected Municipal Return Flows (million m³/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m³/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.43	6.44	6.76	6.99	7.41	7.96
	Johannesburg Northern	94.23	110.54	111.40	114.23	116.87	125.34	133.63
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	92.86	105.59	113.80	124.65	133.58	144.58
	Zeekoegat + Baviaanspoort	25.22	29.06	32.12	33.71	36.68	39.22	42.83
	Sandspruit	1.40	1.58	1.66	1.67	1.75	1.79	1.91
	Babelegi	1.10	1.24	1.38	1.54	1.69	1.83	2.00
	Temba	3.70	4.18	4.34	4.76	5.22	5.63	6.12
	Rietgat	1.97	2.23	2.50	2.76	3.01	3.25	3.53
	Klipgat	10.18	11.52	12.24	13.24	14.41	15.54	16.78
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.36	10.08	10.24	9.95	9.60	9.90
	Olifantsfontein	19.25	27.23	27.56	28.73	29.85	30.50	33.02
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	10.18	11.32	12.61	13.61	14.10	14.61
Mogale City LM	Percy Stewart	5.94	6.71	7.56	8.37	9.17	9.94	10.77
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.76	4.27	4.55	4.85	4.96	5.36
Rustenberg LM	Bafokeng and Rustenberg	3.02	6.10	7.18	8.25	9.13	9.70	10.30
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**324.44**	**347.20**	**366.87**	**389.59**	**414.26**	**445.28**

Table 8.20: Scenario C (Base) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.33	6.24	6.43	6.54	6.88	7.33
	Johannesburg Northern	94.23	108.64	107.78	108.15	108.76	115.64	122.22
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	91.22	102.08	107.63	115.86	123.10	132.08
	Zeekoegat + Baviaanspoort	25.22	28.55	31.07	31.90	34.11	36.16	39.15
	Sandspruit	1.40	1.55	1.61	1.59	1.64	1.66	1.76
	Babelegi	1.10	1.22	1.34	1.46	1.58	1.70	1.84
	Temba	3.70	4.12	4.21	4.53	4.89	5.22	5.63
	Rietgat	1.97	2.19	2.43	2.62	2.82	3.01	3.24
	Klipgat	10.18	11.34	11.88	12.59	13.48	14.41	15.44
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.15	9.67	9.58	9.12	8.72	8.91
	Olifantsfontein	19.25	26.81	26.74	27.31	27.92	28.29	30.37
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	9.86	10.65	11.40	11.91	12.13	12.36
Mogale City LM	Percy Stewart	5.94	6.60	7.34	7.95	8.58	9.22	9.90
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.68	4.11	4.28	4.47	4.53	4.85
Rustenberg LM	Bafokeng and Rustenberg	3.02	5.86	6.68	7.36	7.92	8.30	8.69
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**318.60**	**335.37**	**346.44**	**361.34**	**380.82**	**405.74**

Table 8.21: Scenario C (Low) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.31	6.02	5.99	5.83	5.86	5.97
	Johannesburg Northern	94.23	108.36	103.57	100.17	96.14	97.34	97.98
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	90.96	97.97	99.52	102.17	103.35	105.58
	Zeekoegat + Baviaanspoort	25.22	28.47	29.83	29.51	30.11	30.40	31.34
	Sandspruit	1.40	1.55	1.55	1.48	1.46	1.42	1.43
	Babelegi	1.10	1.22	1.29	1.36	1.41	1.45	1.50
	Temba	3.70	4.11	4.06	4.22	4.36	4.45	4.59
	Rietgat	1.97	2.19	2.34	2.44	2.52	2.57	2.64
	Klipgat	10.18	11.31	11.45	11.73	12.03	12.29	12.58
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.12	9.19	8.71	7.83	7.07	6.82
	Olifantsfontein	19.25	26.74	25.78	25.45	24.92	24.12	24.75
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	9.99	10.58	11.17	11.36	11.16	10.95
Mogale City LM	Percy Stewart	5.94	6.59	7.07	7.41	7.66	7.86	8.07
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.67	3.92	3.91	3.87	3.72	3.77
Rustenberg LM	Bafokeng and Rustenberg	3.02	5.82	6.09	6.21	6.05	5.72	5.41
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**317.89**	**322.28**	**320.95**	**319.47**	**320.64**	**325.35**

Table 8.22: Scenario D (High) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.43	6.48	7.05	7.68	8.21	8.74
	Johannesburg Northern	94.23	110.54	122.09	135.31	147.54	157.07	167.13
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	92.86	105.74	120.40	133.87	145.94	158.94
	Zeekoegat + Baviaanspoort	25.22	29.06	32.31	36.86	41.06	44.77	48.81
	Sandspruit	1.40	1.58	1.66	1.88	2.07	2.24	2.42
	Babelegi	1.10	1.24	1.38	1.55	1.71	1.86	2.02
	Temba	3.70	4.18	4.36	4.93	5.45	5.91	6.41
	Rietgat	1.97	2.23	2.50	2.81	3.10	3.36	3.64
	Klipgat	10.18	11.52	12.28	13.83	15.29	16.62	17.97
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.36	10.14	11.48	12.62	13.70	14.78
	Olifantsfontein	19.25	27.23	27.99	30.64	32.90	34.94	36.87
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	10.18	11.32	12.61	13.61	14.10	14.61
Mogale City LM	Percy Stewart	5.94	6.71	7.08	7.64	8.28	8.85	9.67
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.76	4.26	4.89	5.46	5.87	6.31
Rustenberg LM	Bafokeng and Rustenberg	3.02	6.10	7.18	8.25	9.13	9.70	10.30
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**324.44**	**358.34**	**401.79**	**441.51**	**475.00**	**510.60**

Table 8.23: Scenario D (Base) Projected Municipal Return Flows (million m^3/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m^3/a)						
		2001	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.33	6.29	6.70	7.18	7.62	8.04
	Johannesburg Northern	94.23	108.64	118.12	128.11	137.30	144.91	152.86
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	91.22	102.23	113.87	124.42	134.47	145.19
	Zeekoegat + Baviaanspoort	25.22	28.55	31.24	34.88	38.18	41.27	44.61
		1.40	1.55	1.61	1.79	1.94	2.08	2.22
	Babelegi	1.10	1.22	1.34	1.48	1.60	1.72	1.86
	Temba	3.70	4.12	4.23	4.69	5.09	5.48	5.89
	Rietgat	1.97	2.19	2.43	2.67	2.90	3.12	3.35
	Klipgat	10.18	11.34	11.92	13.15	14.30	15.41	16.53
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.15	9.73	10.74	11.57	12.45	13.31
	Olifantsfontein	19.25	26.81	27.15	29.13	30.77	32.40	33.91
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	9.86	10.65	11.40	11.91	12.13	12.36
Mogale City LM	Percy Stewart	5.94	6.60	6.87	7.26	7.75	8.21	8.90
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.68	4.10	4.60	5.04	5.36	5.71
Rustenberg LM	Bafokeng and Rustenberg	3.02	5.86	6.68	7.36	7.92	8.30	8.69
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**318.60**	**346.15**	**379.48**	**409.61**	**436.79**	**465.40**

Table 8.24: Scenario D (Low) Projected Municipal Return Flows (million m³/a)

Metropolitan Council/ Local Municipality	Model Drainage Area / WWTW	Return Flows (million m³/a)						
		2001	2005	2010	2015	2020	2025	2030
Bela Bela LM	Bela-Bela	0.00	0.00	0.00	0.00	0.00	0.00	0.00
City of Johannesburg MM	Roodepoort Driefontein	5.80	6.31	6.06	6.24	6.41	6.50	6.55
	Johannesburg Northern	94.23	108.36	113.50	118.65	121.36	121.98	122.54
City of Tshwane MM	Sunderland + Rooiwal + Daspoort	80.70	90.96	98.11	105.28	109.71	112.88	116.02
	Zeekoegat + Baviaanspoort	25.22	28.47	30.00	32.27	33.70	34.69	35.71
	Sandspruit	1.40	1.55	1.56	1.66	1.73	1.77	1.81
	Babelegi	1.10	1.22	1.29	1.38	1.43	1.47	1.51
	Temba	3.70	4.11	4.08	4.37	4.55	4.67	4.80
	Rietgat	1.97	2.19	2.34	2.49	2.59	2.66	2.73
	Klipgat	10.18	11.31	11.49	12.26	12.76	13.15	13.47
Ekurhuleni MM	Hartebeestfontein + Estherpark	8.00	9.12	9.25	9.76	9.94	10.09	10.18
	Olifantsfontein	19.25	26.74	26.18	27.14	27.46	27.63	27.64
Kgetlengrivier / Kunqwini	Swartruggens+Koster+Kgetlengrivier	0.33	0.36	0.39	0.43	0.47	0.51	0.56
LM of Madibeng	Brits (Madibeng)	8.85	9.99	10.58	11.17	11.36	11.16	10.95
Mogale City LM	Percy Stewart	5.94	6.59	6.63	6.77	6.91	7.00	7.25
Moretele LM	Apies	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Moses Kotane LM	Moses Kotane	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Randfontein LM	Randfontein	3.22	3.67	3.91	4.20	4.37	4.40	4.43
Rustenberg LM	Bafokeng and Rustenberg	3.02	5.82	6.09	6.21	6.05	5.72	5.41
Thabazimbi LM	Thabazimbi	1.07	1.12	1.17	1.23	1.29	1.35	1.42
Totals		**273.97**	**317.89**	**332.64**	**351.52**	**362.07**	**367.63**	**372.99**

8.4 RURAL RETURN FLOWS

It was assumed that there was no return flow from the rural areas when projections were made.

8.5 WATER REQUIREMENTS FOR STOCK WATERING

Water requirements for stock watering was determined as part of the groundwater survey undertaken. The water requirements for stock watering occur throughout the catchment and the total water requirements are 21.9 million m³/a. In the water balances the water requirements for stock watering were not included with the rural requirements. It was also assumed that no return flow returned to the system from stock watering.

8.6 IRRIGATION WATER REQUIREMENTS AND RETURN FLOWS

Irrigation water requirements were determined from actual irrigation areas as determined from satellite images linked to crop types. A study to validate and verify the existing lawful irrigation areas and linked irrigation water use for licensing purposes is currently being executed for DWAF.

Irrigation areas, as well as the irrigation water requirements, are accepted to remain constant between 2005 and 2030. Distribution losses for irrigation supply between the source of the water and point of application was based on best estimates as provided by representatives from DWAF and the Irrigation Boards. Distribution losses associated with water supply to irrigation in the study area are in some cases accepted to be as high as 50%. These very high distribution losses could lead to mis-conceptions of the water balance situation and result in the mismanagement of the water resources. The effect of reduction in distribution losses on total water requirements, water availability and the water balance should be addressed as one of the reconciliation strategies. The high distribution losses should also be evaluated and investigated in more detail and could probably be addressed in the *Validation and verification of existing lawful use in the Crocodile (West) River Study*.

The irrigation water requirements, including distribution losses, summarised per sub-area, are presented in **Table 8.25**. For the purpose of direct comparison in the water balance calculations all the water requirements were converted to one common 1:50 assurance of supply level. It is accepted that larger quantities may be abstracted in practice for irrigation, but at a lesser assurance of supply. Irrigation return flows are assumed to remain constant over the projected period.

Table 8.25: Irrigation water requirements (million m³/a)

Sub-catchment	Irrigation area	Irrigation requirement	Distribution losses	Total irrigation requirement		Irrigation return flows	
				Volume	1:50 assurance		
Unit	**ha**	**million m³/a**	**million m³/a**	**million m³/a**	**million m³/a**	**%**	**million m³/a**
Upper Crocodile: Rietvlei	454	1.9	0.3	2.2	1.9	8.1	0.2
Upper Crocodile: Hartbeespoort	4 042	21.8	10.9	32.7	28.4	10.9	2.4
Upper Crocodile: Roodekopjes	15 764	91.3	45.7	137.0	116.5	9.4	8.5
Elands: Bospoort	500	2.7	0.6	3.3	2.8	11.8	0.3
Elands: Vaalkop	1 014	5.3	1.3	6.5	5.4	12.2	0.6
Apies-Pienaars: Roodeplaat	374	2.5	0.2	2.7	2.3	11.9	0.3
Apies-Pienaars: Apies	2 389	12.2	1.1	13.3	11.5	11.2	1.4
Apies-Pienaars: Klipvoor	2 536	13.3	1.2	14.5	12.3	9.6	1.3
Apies-Pienaars: Rest	864	4.5	0.4	4.9	4.1	8.0	0.4
Crocodile d/s Roodekopjes to confluence with Pienaars	7 014	36.9	18.5	55.4	45.9	0.0	3.6
Rest of Lower Crocodile to Limpopo River	21 022	116.0	58.0	174.1	144.5	9.2	10.6
TOTAL	**55 974**	**308.4**	**138.2**	**446.6**	**375.5**	**9.6**	**29.5**

8.7 POWER GENERATION

There are three power stations in the Crocodile River catchment: Kelvin in the Upper Crocodile sub-catchment and Pretoria-West and Rooiwal in the Apies-Pienaars sub-catchment. The water requirements of the Kelvin, Pretoria-West and Rooiwal power stations are 11 million m³/a, 6 million m³/a and 17.5 million m³/a respectively and are expected to remain constant for the projected years. The projected return flows were also assumed to remain constant at a total volume of 7.4 million m³/a.

8.8 MINING

Mining water requirements include the mines that are not supplied through the municipal supply systems. Information was collected to distinguish between industrial and potable requirements. It should be noted that the mining requirements currently include a portion of potable water for on-site residential areas.

The water requirements of the mining industry, both the historical data and future projections, were very difficult to obtain. Data gathered by UWP Consulting Engineers for water supply in the Rustenburg area (between Hartbeespoort Dam and Rustenburg as well as the areas beyond Rustenburg to the northern parts of the study area), supplemented by data gathered in the Upper Crocodile and Apies-Pienaars sub-catchments, were assumed to be the best available data for this study. Due to the sensitive nature of the requirements of individual mines, the mining water requirements were lumped together according to geographic sub-areas. Three scenarios of mining water requirements were determined: high, base and low based on the population projections. The total mining requirements projections for the three scenarios are presented in **Table 8.26**.

Table 8.26: Mining water requirements (million m^3/a)

Scenario	2005	2010	2015	2020	2025	2030
High	92.3	128.8	144.6	151.5	151.7	150.6
Base	92.3	126.3	138.7	144.2	144.9	144.8
Low	92.3	124.4	136.3	141.6	142.3	142.3

There is still much uncertainty about the reliability of the projected future mining water requirements. This needs to be further reviewed and verified. The mining water requirements for the high, base and low scenarios for the Upper Crocodile, Elands, Apies-Pienaars and Lower Crocodile sub-catchments are presented in **Table 8.27**, **Table 8.28**, **Table 8.29** and **Table 8.30** respectively.

8.8.1 Upper Crocodile sub-catchment

Table 8.27: Upper Crocodile sub-catchment mining water requirements (million m^3/a)

Scenario	Sub-area	2005	2010	2015	2020	2025	2030
High mining water requirements (million m^3/a)	Upper Crocodile: Rietvlei	0.4	0.4	0.4	0.4	0.4	0.4
	Upper Crocodile: Hartbeespoort	5.0	5.0	5.0	5.0	5.0	5.0
	Upper Crocodile: Roodekopjes	26.9	37.7	42.4	48.4	47.6	47.8
	Total	***32.3***	***43.1***	***47.8***	***53.8***	***53.0***	***53.2***
Base mining water requirements (million m^3/a)	Upper Crocodile: Rietvlei	0.4	0.4	0.4	0.4	0.4	0.4
	Upper Crocodile: Hartbeespoort	5.0	5.0	5.0	5.0	5.0	5.0
	Upper Crocodile: Roodekopjes	26.9	37.5	41.9	47.5	47.6	47.7
	Total	***32.3***	***42.9***	***47.3***	***52.9***	***53.0***	***53.1***
Low mining water requirements (million m^3/a)	Upper Crocodile: Rietvlei	0.4	0.4	0.4	0.4	0.4	0.4
	Upper Crocodile: Hartbeespoort	5.0	5.0	5.0	5.0	5.0	5.0
	Upper Crocodile: Roodekopjes	26.9	36.9	41.2	46.6	46.7	46.9
	Total	***32.3***	***42.3***	***46.6***	***52.0***	***52.1***	***52.3***

8.8.2 Elands sub-catchment

Table 8.28: Elands sub-catchment mining water requirements (million m^3/a)

Scenario	Sub-area	2005	2010	2015	2020	2025	2030
High mining water requirements (million m^3/a)	Elands: Bospoort	18.5	25.4	27.7	28.9	29.2	28.5
	Elands: Vaalkop	20.7	28.8	34.2	33.8	34.1	33.4
	Total	***39.2***	***54.2***	***61.9***	***62.7***	***63.3***	***61.9***
Base mining water requirements (million m^3/a)	Elands: Bospoort	18.5	23.2	23.4	23.5	23.4	23.4
	Elands: Vaalkop	20.7	28.7	34.0	33.8	34.5	34.4
	Total	***39.2***	***51.9***	***57.4***	***57.3***	***57.9***	***57.8***
Low mining water requirements (million m^3/a)	Elands: Bospoort	18.5	22.8	23.0	23.1	23.0	22.9
	Elands: Vaalkop	20.7	28.1	33.4	33.2	33.9	33.7
	Total	***39.2***	***50.9***	***56.4***	***56.3***	***56.9***	***56.6***

8.8.3 Apies-Pienaars sub-catchment

Table 8.29: Apies-Pienaars sub-catchment mining water requirements (million m^3/a)

Scenario	Sub-area	2005	2010	2015	2020	2025	2030
High mining water requirements (million m^3/a)	Apies-Pienaars: Roodeplaat	0.6	0.6	0.6	0.6	0.6	0.6
	Apies-Pienaars: Apies	0.2	0.2	0.2	0.2	0.2	0.2
	Total	***0.8***	***0.8***	***0.8***	***0.8***	***0.8***	***0.8***
Base mining water requirements (million m^3/a)	Apies-Pienaars: Roodeplaat	0.6	0.6	0.6	0.6	0.6	0.6
	Apies-Pienaars: Apies	0.2	0.2	0.2	0.2	0.2	0.2
	Total	***0.8***	***0.8***	***0.8***	***0.8***	***0.8***	***0.8***
Low mining water requirements (million m^3/a)	Apies-Pienaars: Roodeplaat	0.6	0.6	0.6	0.6	0.6	0.6
	Apies-Pienaars: Apies	0.2	0.2	0.2	0.2	0.2	0.2
	Total	***0.8***	***0.8***	***0.8***	***0.8***	***0.8***	***0.8***

8.8.4 Lower Crocodile sub-catchment

Table 8.30: Lower Crocodile sub-catchment mining water requirements (million m^3/a)

Scenario	Sub-area	2005	2010	2015	2020	2025	2030
High mining water requirements (million m^3/a)	Rest of Lower Crocodile to Limpopo River	19.9	30.7	34.0	34.3	34.5	34.8
	Total	***19.9***	***30.7***	***34.0***	***34.3***	***34.5***	***34.8***
Base mining water requirements (million m^3/a)	Rest of Lower Crocodile to Limpopo River	19.9	30.7	33.1	33.1	33.1	33.1
	Total	***19.9***	***30.7***	***33.1***	***33.1***	***33.1***	***33.1***
Low mining water requirements (million m^3/a)	Rest of Lower Crocodile to Limpopo River	19.9	30.4	32.5	32.5	32.5	32.5
	Total	***19.9***	***30.4***	***32.5***	***32.5***	***32.5***	***32.5***

8.9 TOTAL WATER REQUIREMENTS AND URBAN RETURN FLOWS

A summary of the total water requirements and urban return flows for the study area are provided in **Table 8.31** and **Table 8.32** respectively.

Table 8.31: Total water requirements for the study area (million m^3/a) for all scenarios

Scenario	User/Sector	2005	2010	2015	2020	2025	2030
Scenario B: High (million m^3/a)	Urban	628.3	704.8	782.8	854.3	914.1	978.4
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	128.8	144.6	151.5	151.7	150.6
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1160.4**	**1277.1**	**1370.3**	**1452.2**	**1512.7**	**1583.9**
Scenario B: Base (million m^3/a)	Urban	618.5	683.8	744.3	799.1	848.0	900.1
	Rural	7.8	11.4	10.7	14.0	14.3	21.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	126.3	138.7	144.2	144.9	144.8
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1150.5**	**1253.4**	**1325.6**	**1389.2**	**1439.0**	**1498.5**
Scenario B: Low (million m^3/a)	Urban	617.3	660.4	695.7	716.3	727.6	739.2
	Rural	7.8	11.0	9.9	12.5	12.2	17.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	124.4	136.3	141.6	142.3	142.3
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1149.3**	**1227.7**	**1273.8**	**1302.3**	**1313.9**	**1331.2**
Scenario C: High (million m^3/a)	Urban	628.3	661.4	680.7	714.0	746.8	807.4
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	128.8	144.6	151.5	151.7	150.6
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1160.4**	**1233.8**	**1268.1**	**1311.9**	**1345.3**	**1412.9**
Scenario C: Base (million m^3/a)	Urban	618.5	641.7	647.2	667.8	692.8	742.8
	Rural	7.8	11.4	10.7	14.0	14.3	21.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	126.3	138.7	144.2	144.9	144.8
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1150.5**	**1211.4**	**1228.4**	**1258.0**	**1283.8**	**1341.2**
Scenario C: Low (million m^3/a)	Urban	617.3	619.8	605.2	599.2	595.3	611.1
	Rural	7.8	11.0	9.9	12.5	12.2	17.7
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	124.4	136.3	141.6	142.3	142.3
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1149.3**	**1187.1**	**1183.3**	**1185.2**	**1181.6**	**1203.0**
Scenario D: High (million m^3/a)	Urban	628.3	657.0	730.6	797.3	852.8	915.8
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	128.8	144.6	151.5	151.7	150.6
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1160.4**	**1229.3**	**1318.0**	**1395.3**	**1451.3**	**1521.3**
Scenario D: Base (million m^3/a)	Urban	618.5	637.4	694.6	745.8	791.1	842.6
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	126.3	138.7	144.2	144.9	144.8
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1150.6**	**1207.2**	**1276.2**	**1336.5**	**1382.8**	**1442.3**
Scenario D: Low (million m^3/a)	Urban	617.3	615.6	649.4	668.8	679.1	692.4
	Rural	7.9	11.6	11.0	14.6	14.9	23.0
	Irrigation	375.5	375.5	375.5	375.5	375.5	375.5
	Mining	92.3	124.4	136.3	141.6	142.3	142.3
	Power generation	34.5	34.5	34.5	34.5	34.5	34.5
	Stock watering	21.9	21.9	21.9	21.9	21.9	21.9
	Total	**1149.4**	**1183.6**	**1228.6**	**1256.9**	**1268.2**	**1289.6**

Table 8.32: Total return flows for the study area (million m^3/a)

Scenario	User/Sector	2005	2010	2015	2020	2025	2030
Scenario B: High (million m^3/a)	Urban	324.4	369.6	415.6	457.6	492.6	530.4
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	20.2	22.7	23.8	23.8	23.6
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**375.8**	**426.7**	**475.2**	**518.3**	**553.3**	**591.0**
Scenario B: Base (million m^3/a)	Urban	318.6	357.1	392.6	424.6	453.1	483.5
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.8	21.8	22.6	22.7	22.7
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**370.0**	**413.8**	**451.2**	**484.1**	**512.7**	**543.2**
Scenario B: Low (million m^3/a)	Urban	317.9	343.1	363.6	375.3	381.3	387.5
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.5	21.4	22.2	22.3	22.3
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**369.3**	**399.5**	**421.9**	**434.4**	**440.6**	**446.8**
Scenario C: High (million m^3/a)	Urban	324.4	347.2	366.9	389.6	414.3	445.3
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	20.2	22.7	23.8	23.8	23.6
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**375.8**	**404.3**	**426.5**	**450.3**	**475.0**	**505.8**
Scenario C: Base (million m^3/a)	Urban	318.6	335.4	346.4	361.3	380.8	405.7
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.8	21.8	22.6	22.7	22.7
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**370.0**	**392.1**	**405.1**	**420.9**	**440.5**	**465.4**
Scenario C: Low (million m^3/a)	Urban	317.9	322.3	320.9	319.5	320.6	325.3
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.5	21.4	22.2	22.3	22.3
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**369.3**	**378.7**	**379.2**	**378.6**	**379.9**	**384.6**
Scenario D: High (million m^3/a)	Urban	324.4	358.3	401.8	441.5	475.0	510.6
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	20.2	22.7	23.8	23.8	23.6
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**375.8**	**415.5**	**461.4**	**502.2**	**535.7**	**571.1**
Scenario D: Base (million m^3/a)	Urban	318.6	346.2	379.5	409.6	436.8	465.4
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.8	21.8	22.6	22.7	22.7
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**370.0**	**402.9**	**438.2**	**469.1**	**496.4**	**525.0**
Scenario D: Low (million m^3/a)	Urban	317.9	332.6	351.5	362.1	367.6	373.0
	Rural	0.0	0.0	0.0	0.0	0.0	0.0
	Irrigation	29.5	29.5	29.5	29.5	29.5	29.5
	Mining	14.5	19.5	21.4	22.2	22.3	22.3
	Power generation	7.4	7.4	7.4	7.4	7.4	7.4
	Stock watering	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**369.3**	**389.1**	**409.8**	**421.2**	**426.9**	**432.2**

8.10 RAND WATER: SUMMARY

All the water transfers into the Crocodile River catchment are from the Vaal River system by Rand Water to urban, industrial and mining water users. It was assumed that existing water users that are currently supplied by Rand Water will in future also be supplied with water from Rand Water. However, the options remain that the Rand Water supply area could be increased or decreased in future. It was further assumed that the supply area of Rand Water will not be extended to other areas, but that local water sources (including return flows) will be used to supply the growing water requirements in those areas. The transfer capacity of the Rand Water pipelines into the study area was assumed to be upgraded over time to make provision for the growing water requirements. The only exception being the Rand Water pipeline to Rustenburg, where it was assumed that Rand Water will supply water to the Rustenburg area to the maximum capacity of the existing Rand Water pipeline, and that water in excess of this capacity will be supplied from other sources. The total water transfers via the Rand Water system into the study area for the high, base and low scenarios are summarised in **Table 8.33**.

Table 8.33: Total Rand Water transfers into the Crocodile River catchment (million m^3/a)

Scenario	2005	2010	2015	2020	2025	2030
Scenario D: High	512	535	594	654	705	762
Scenario D: Base	504	519	564	611	654	701
Scenario D: Low	503	501	528	548	561	576
Scenario C: High	512	538	553	585	617	671

8.11 MAGALIES WATER SUMMARY

The following tables provide a summary of the water purification works and water requirements for Magalies Water. All information was a result of discussions with Mr Roelf le Roux held on the 22 July 2008. From these discussions there were indications of future plans for water supply in the Crocodile (West) River catchment, but these were subject to approval of increased allocations (licenses) by DWAF.

The water supply to all users in the catchment had been categorized between "Rand Water" and "own sources". It was assumed that users (areas) that are currently supplied from Rand Water will also be supplied from "Rand Water" in future (growth of existing users will be supplied from Rand Water). All other users will be supplied from "own sources". Users supplied by Magalies Water are thus supplied in the category from "own sources".

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The information below is the results from the discussion as <u>no projected water use</u> could be provided.

Table 8.34: Klipdrift water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
Bela-Bela	19	1.7	Bela-Bela
CTMM	48	4.3	Temba & Babelegi
Moretele	8	0.7	No WWTW
Nokeng tsa Taemane	2	0.2	No WWTW
Modimolle	23	2.0	N/A
TOTAL	***100***	***8.9***	***-***

Table 8.35: Wallmannsthal water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
Nokeng tsa Taemane	100	3.5	Baviaanspoort & Zeekoegat
TOTAL	**100**	**3.5**	**-**

Table 8.36: Roodeplaat water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
CTMM	100	0.0	Rooiwal
TOTAL	**100**	**0.0**	**-**

Table 8.37: Temba water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
CTMM	80	8.8	Mainly Temba WWTW
Moretele (Rural)	20	2.2	No WWTW
TOTAL	**100**	**11.0**	**-**

Table 8.38: Cullinan water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
Nokeng tsa Taemane	100	-	-
TOTAL	**100**	**0.0**	**-**

Table 8.39: Bospoort water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
Rustenburg - Mines	100	0.0	-
TOTAL	**100**	**0.0**	**-**

Table 8.40: Vaalkop water purification works

Local municipality	%	2003 (million m^3/a)	WWTW
Madibeng (very small amount - negligible)	0	0.0	-
Moses Kotane	28	14.0	Mogwase/Bodirelo
Rustenburg	35	17.9	Boitekong & Rustenburg/Thlabane
Thabazimbi	37	18.6	Thabazimbi & Northam
TOTAL	**100**	**50.5**	**-**

9 ELECTRONIC DATA

The suite of reports compiled for the *Vaal River System: Large Bulk Water Supply Reconciliation Strategies* used in this study was distributed and is available on the CD attached. The CD also contains the nine different scenario files for the study used in the Urban Water Requirements and Return Flows Model.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 CONCLUSIONS

- Future growth in water requirements in the Crocodile (West) catchment will largely be driven by population and economic growth in the existing urban/metropolitan areas as well as mining developments in the northern/western part of the catchment.
- Little growth in rural water requirements is foreseen while no growth in irrigation water requirements is foreseen.
- Water requirements in urban areas and for irrigation can be significantly influenced by WC/WDM.
- The year 2005 was selected as a base year for demand projections since it was used to calibrate the Urban Return Flow model. Projected demands were provided for 2010, 2015, 2020, 2025 and 2030. The implementation of WC/WDM can provide a significant reduction in the water demands in the area if the measures are implemented properly and maintained indefinitely. The initial cost of implementing WC/WDM measures is often less than that of the related maintenance costs, which are often overlooked, with the result that the WC/WDM interventions fail within a year or two of being implemented. It is evident that return flows from urban areas, which are a major source of water for users in the downstream parts of the sub-catchments of the Crocodile (West) River catchment, are strongly dependent on water use upstream as well as the degree of success with the implementation of WC/WDM measures.
- The greatest uncertainties are with respect to the following:
  - Future population and economic growth
  - Growth in mining water requirements (quantum and timing)
  - Actual water use by irrigation sector
  - The actual savings to be achieved through WC/WDM, and the resultant impacts on return flows.

10.2 RECOMMENDATIONS

- The value of good quality data should never be underestimated. This study agrees with previous studies where it was stated that good records of water usage and return flows are necessary for future planning. It is strongly emphasised that all water users should submit water usage, return flow and quality data on regular intervals to a central point (DWAF) where this data should be readily available. Measuring/monitoring of respective variables should be undertaken on a regular basis. A standard format in which this data should be provided to DWAF should be developed and maintained which will also support the data required to analyse water requirements and return flows from sewerage drainage areas. The establishment of a comprehensive data base by DWAF is proposed where the processing, co-ordination and regular updating of the data will be managed and controlled. The evaluation of the data, in particular to identify informative trends should also be undertaken by DWAF.

- The validation and verification of existing water use in the whole catchment should be undertaken.
- Local authorities are obliged to develop Water Service Development Plans (WSDPs), which are received and reviewed by the Chief Directorate: Water Services. At present the WSDPs do not consistently provide all the necessary water requirement and return flow information required for water resource planning, but an initiative to promote cooperation between the Directorate of National Water Resource Planning and the relevant Directorates in Water Services in this regard could provide a solution in the medium term.
- Continuous identification and consultation with all stakeholders in various capacities can result in an integrated strategic planning. An integrated approach involving data sharing and a document tracking register could assist planning initiatives in speeding up the data gathering processes. The cooperation between the Office of the State President, DWAF and Statistics South Africa in developing a population projection to support planning is one such step towards a more coordinated planning approach.
- It is recommended that growth in future population and water use be monitored and compared to the estimates collated in this report, so that further investigations or additional WC/WDM interventions can be launched well ahead of requirements outstripping supply.
- Based on the experiences obtained during the study the following recommendations are made:
  - Feedback and comments on study results from all major municipalities should be obtained through the Study Steering Committee and, if necessary, adjustments to projections should be made. This is very important as decisions on the new augmentation schemes will be based on these assumptions/projections;
  - Special attention should be given to establishing and maintaining official communication links between DWAF and all major water users (especially major municipalities). It is highly recommended that information sessions be conducted on annual basis, which would allow regular updates of the urban return flow model. Its results could then be used in the envisaged annual Crocodile (West) River System analysis;
  - Data on other land use in the Northern Sewage Drainage Areas should be obtained from related municipalities and fed into the model so demands and return flows could be assessed more accurately in future updates;
  - To streamline time-consuming data collection exercises and to avoid or limit costly repetition of previously undertaken data collection work, it is recommended that an “easy-accessible and user-friendly” central data base be established at DWAF with the specific purpose of providing accurate, consistent and reliable information pertaining to primary water requirements and return flows in the urban context. The Water Services

Division has partly started this initiative but it needs to be popularized within DWAF and communicated to all project managers and leaders of DWAF water resources and services projects;

- Planning of water supply and sewage treatment infrastructure at Local Authority level is mostly undertaken by separate divisions within the organization. For meaningful water resource planning in the Crocodile (West) River catchment it is important to establish the linkage between water supply, sewage generation and return flows within defined measurable units (such as sewage drainage areas). It is, therefore, recommended that future guidelines on compilation of Water Services Development Plans should include prescriptions to this effect as well as license conditions in order to create awareness with the appropriate municipal decision-makers and managers of their water and sewerage systems; and
- It is further recommended that a proper monitoring system for quantifying return flows (quantity and quality) in the catchment be designed and implemented. This should also be included in future guidelines on compilation of Water Services Development Plans.

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DOCUMENT CONTROL

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PROJECT NAME : Development of a reconciliation strategy for the Crocodile West Water Supply System

PROJECT No. : J25111

TITLE OF DOCUMENT : Current and Future Water Requirements and Return Flows

ELECTRONIC LOCATION : **P:\J25111A Crocodile West Recon Strategy\Reports\Current & Future Water Req WCWDM\FINAL\Current and Future Water Requirements FINAL.doc**

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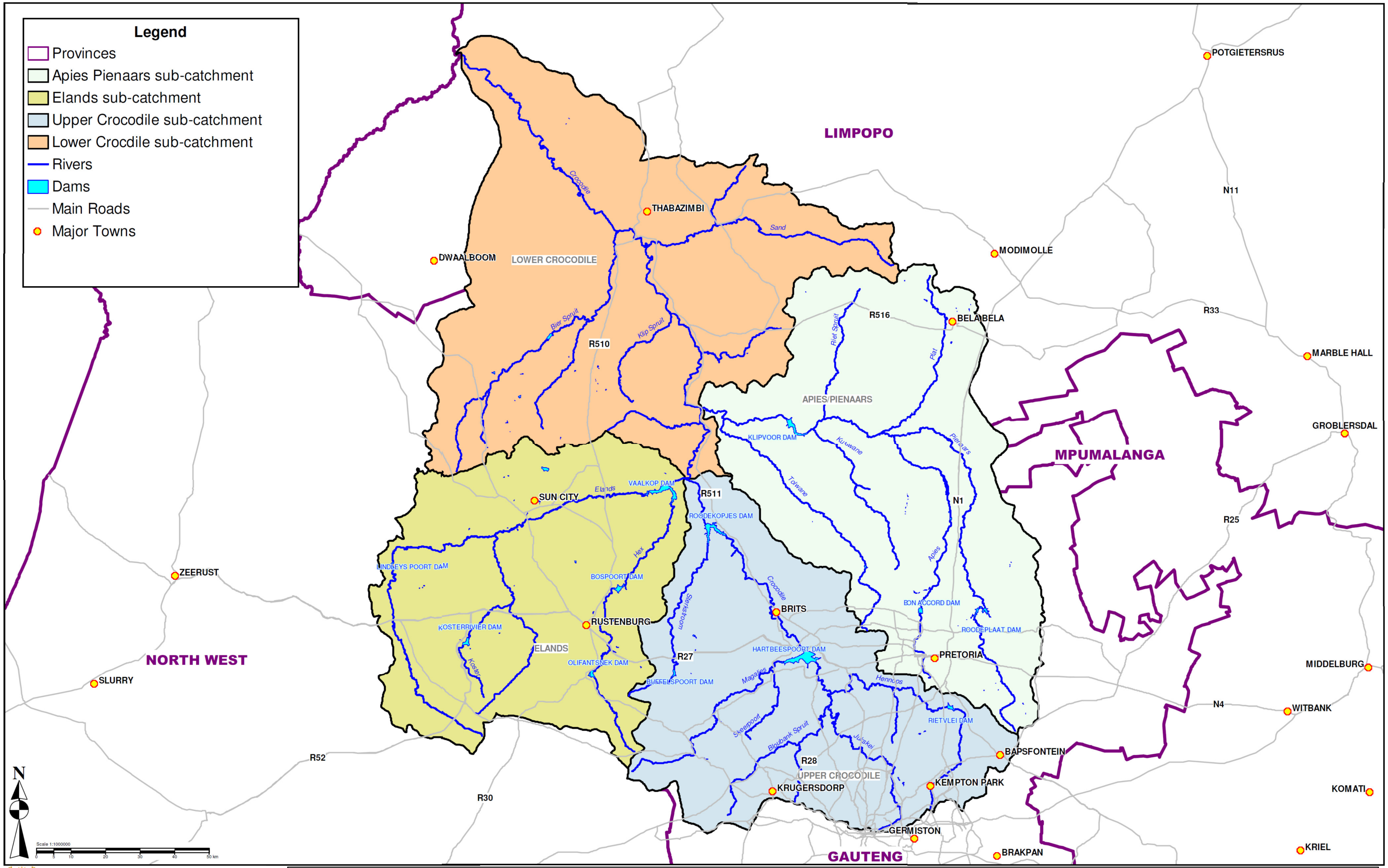

THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE CROCODILE (WEST) WATER SUPPLY SYSTEM

LOCALITY MAP

APPENDIX A

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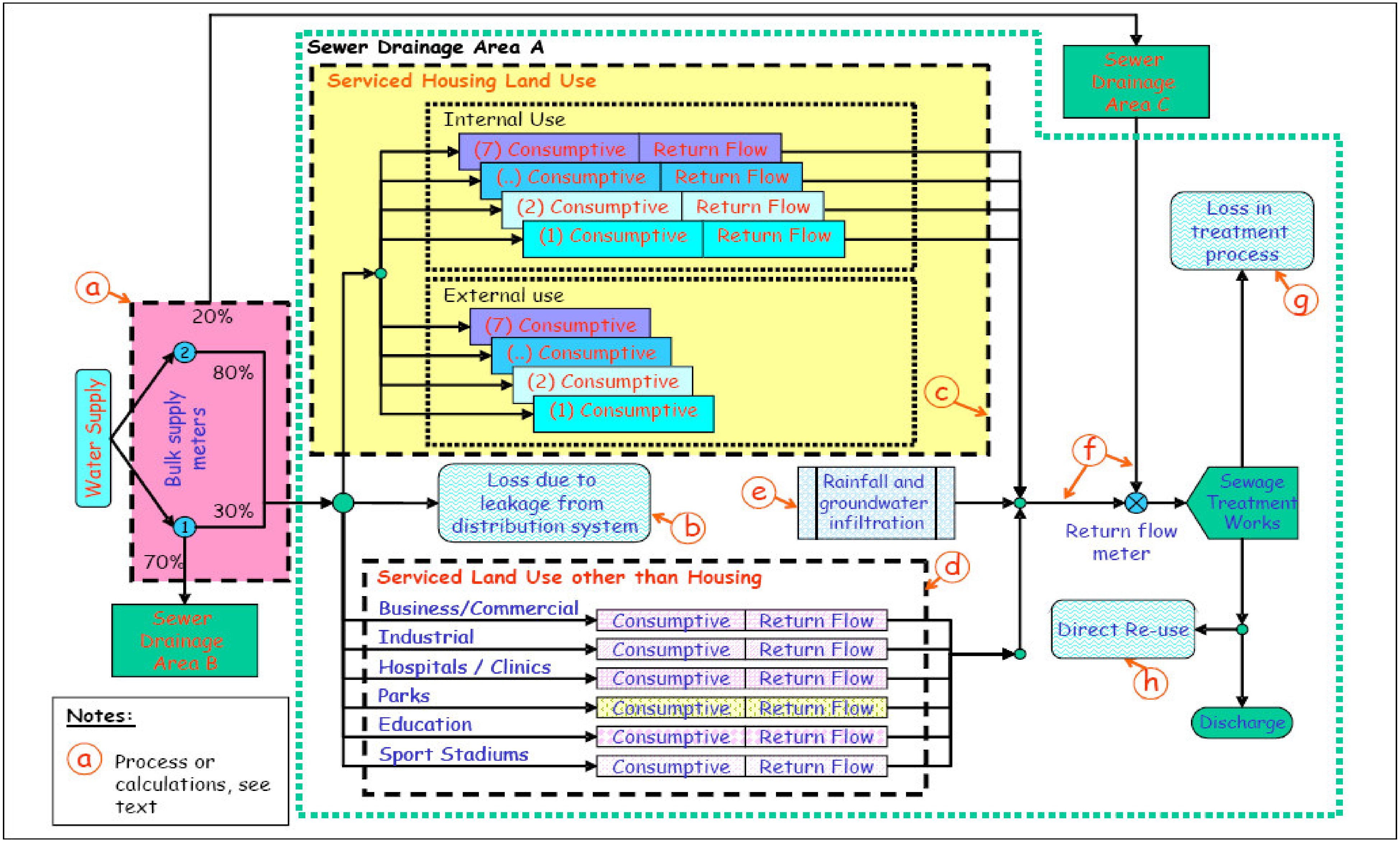
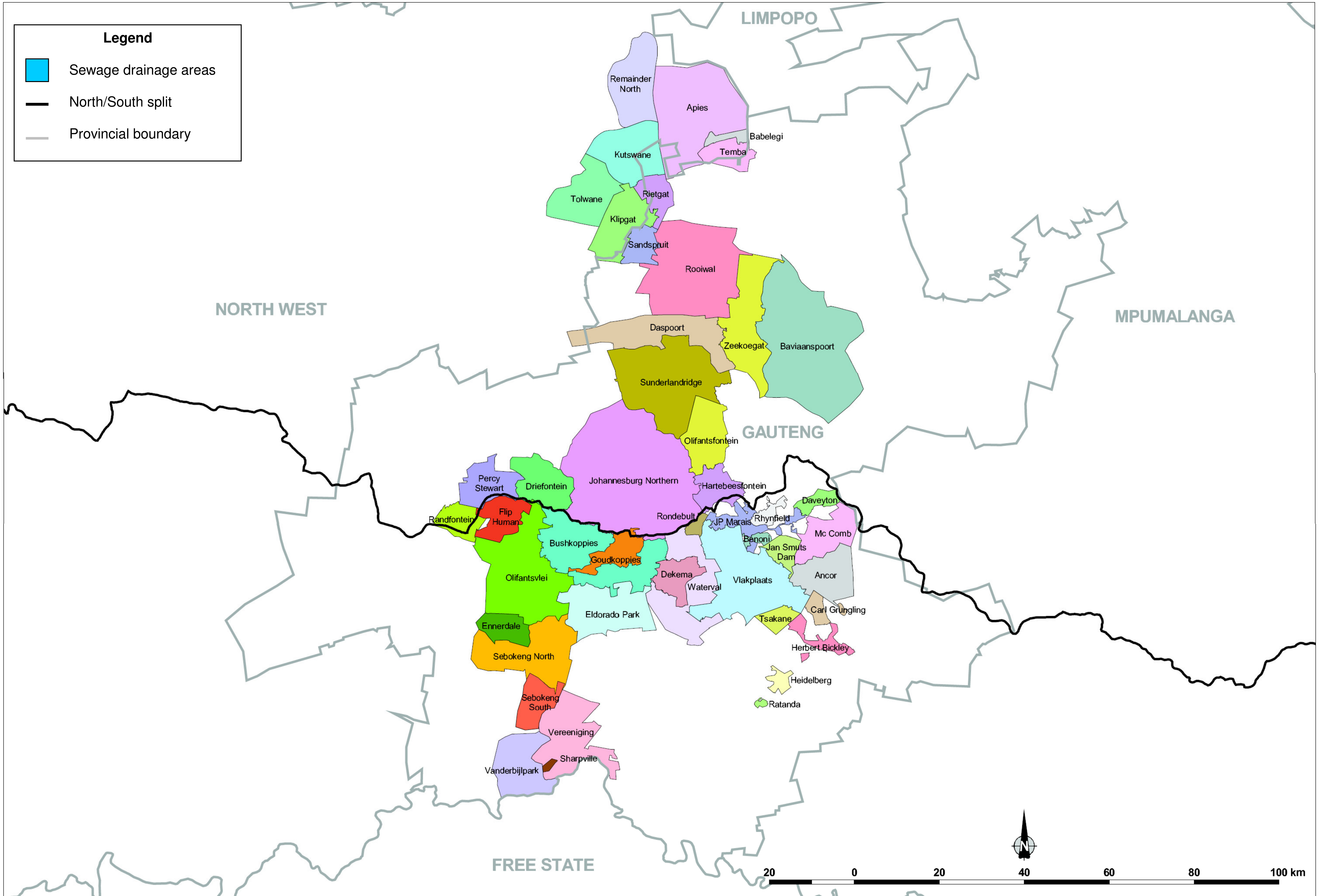


THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE CROCODILE (WEST) WATER SUPPLY SYSTEM

SCHEMATIC OF THE WATER REQUIREMENTS AND RETURN FLOWS MODEL

APPENDIX B

(As used in Vaal River System: Large Bulk Water Supply Reconciliation Strategies and Water Conservation and Demand Management Studies)



THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR THE CROCODILE (WEST) WATER SUPPLY SYSTEM

SEWAGE DRAINAGE AREAS

APPENDIX C

(As used in Vaal River System: Large Bulk Water Supply Reconciliation Strategies and Water Conservation and Demand Management Studies)