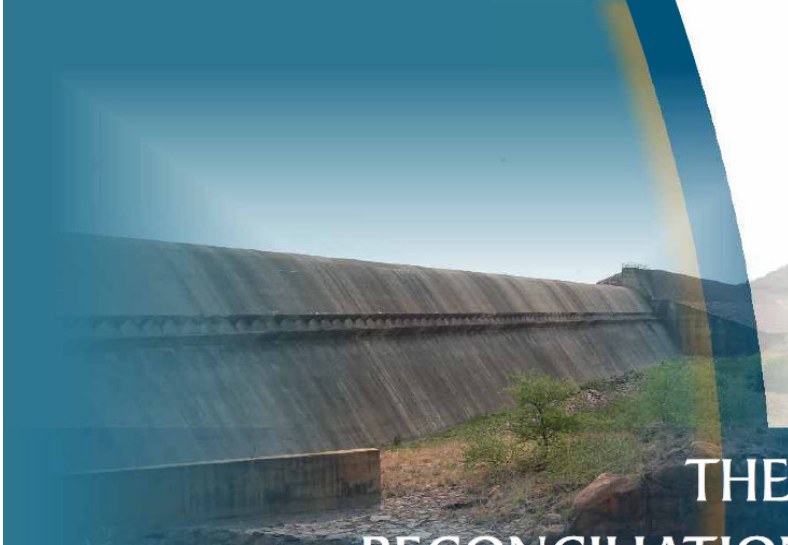

water & forestry
Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

P WMA 03/000/00/3408

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

Summary of Previous and Current Studies

MAY 2008

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LIST OF STUDY REPORTS

THE DEVELOPMENT OF A RECONCILIATION STRATEGY FOR 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	P WMA 03/000/00/3508	H4125-05
Version 1 of the Reconciliation Strategy	P WMA 03/000/00/3608	H4125-06
WRYM and WRPM Analyses	P WMA 03/000/00/3708	H4125-07
Reconciliation Strategy	P WMA 03/000/00/3808	H4125-08
Summary Report	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

This report is to be referred to in bibliographies as:

Department of Water Affairs and Forestry, South Africa, 2008:
The Development of a Reconciliation Strategy for the Crocodile (West) Water Supply System: Summary of Previous and Current Studies

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Report No. P WMA 03/000/00/3408

Title:	***Summary of Previous and Current Studies***
Authors:	*Johanna Boonzaaier (ARCUS GIBB)*
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PROFESSIONAL SERVICE PROVIDER

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

Summary of Previous and Current Studies

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LIST OF ABBREVIATIONS

DWAF	Department of Water Affairs and Forestry
DSL	Dead Storage Level
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	Instream Flow Requirement
ISP	Internal Strategic Perspective
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
NWRS	National Water Resource Strategy
RFS	Crocodile (West) River Return Flow Analysis Study (Report No: P 03/00/00/1004)
SMP	Strategic Management Plan
WCDM	Water Conservation and Demand Management
WMA	Water Management Area
WRSAS	Water Resources Situation Assessment Study (Report No: P 03000/00/0301)
WR90	Water Resources of South Africa, 1990
WRPM	Water Resource Planning Model
WRSM90	Water Resources Simulation Model 1990
WRSM2000	Water Resources Simulation Model 2000
WRYM	Water Resource Yield Model

1 INTRODUCTION AND METHODOLOGY

1.1 Introduction

The objective of this task is to provide a compilation of the most up to date water resource and water quality (salinity) related information for the Crocodile (West) River catchment as part of a bulk water reconciliation study. The study is being conducted for and funded by the Department of Water Affairs and Forestry (DWAF), Directorate National Water Resources Planning.

This task overlaps with the information gathering component of a parallel project that is to deal with the setting up of a hydrological modelling system to assist the DWAF in decision making processes during compulsory water use licensing. The core difference between the information gathering components of these two projects is that the parallel model set up study will provide most of the historical and present day information with emphasis on the input requirements for the calibration of hydrological models. For this study the emphasis shifts towards information gathering for the application of models in planning and the development of integrated, sustainable schemes for bulk water supplies to reconcile imbalances between water resources and water requirements. The focus is in present day and future conditions.

The following information is provided where relevant:

- Present urban, irrigation and afforestation water use, projected future use, and its geographical distribution in the WMA and in affected areas of the adjacent WMAs
- Water utilisation by and removal of invasive alien plants
- Existing water supply infrastructure
- Hydrological information and concerns
- Geohydrological information about the various aquifers
- Water Quality
- The Reserve Requirements
- System modelling and operational management
- Potential impacts of climate change on water usage and scheme yields
- Water Conservation and Demand Management (urban and irrigation)
- Current and potential water reuse
- Trading of existing allocations (especially unutilised allocations)
- Potential surface and groundwater schemes, both local and transfer
- Potential desalination schemes
- Other potential importation schemes.

1.2 Methodology

Previous studies in the Crocodile River (West) Catchment were identified and listed (Appendix A). These studies were reviewed to ascertain the relevance of the information with regards to the latest present day and projected future water requirement and water use information. Emphasis was placed on obtaining the most recent information therefore information from the older studies that were superseded by later studies is not included in this report.

2 STUDY AREA BACKGROUND

The Crocodile River (West) is a major tributary of the Limpopo River. The Limpopo River is an international shared watercourse and originates at the confluence of the Crocodile River (West) and the Marico Rivers. The water resources of the river are shared between Botswana, South Africa, Zimbabwe and Mozambique and it eventually discharges into the Indian Ocean in Mozambique. The major tributaries of the Crocodile River are the Pienaars, Apies, Moretele, Hennops, Jukskei, Magalies and Elands Rivers. Together these Rivers make up the A20 tertiary hydrological catchment with its 40 quaternary catchments. The upper portion of the catchment, south east of Hartbeespoort Dam, is located in the Gauteng Province. The north and north-eastern corners lie in the Limpopo Province while the central/western sections is located within the North West Province

The National Water Resources Strategy (NWRS) divided the Crocodile River (West) Catchment into four sub-areas, namely the Upper Crocodile, Elands River, Apies/Pienaars River and the Lower Crocodile River catchments as shown in **Figure 1.**

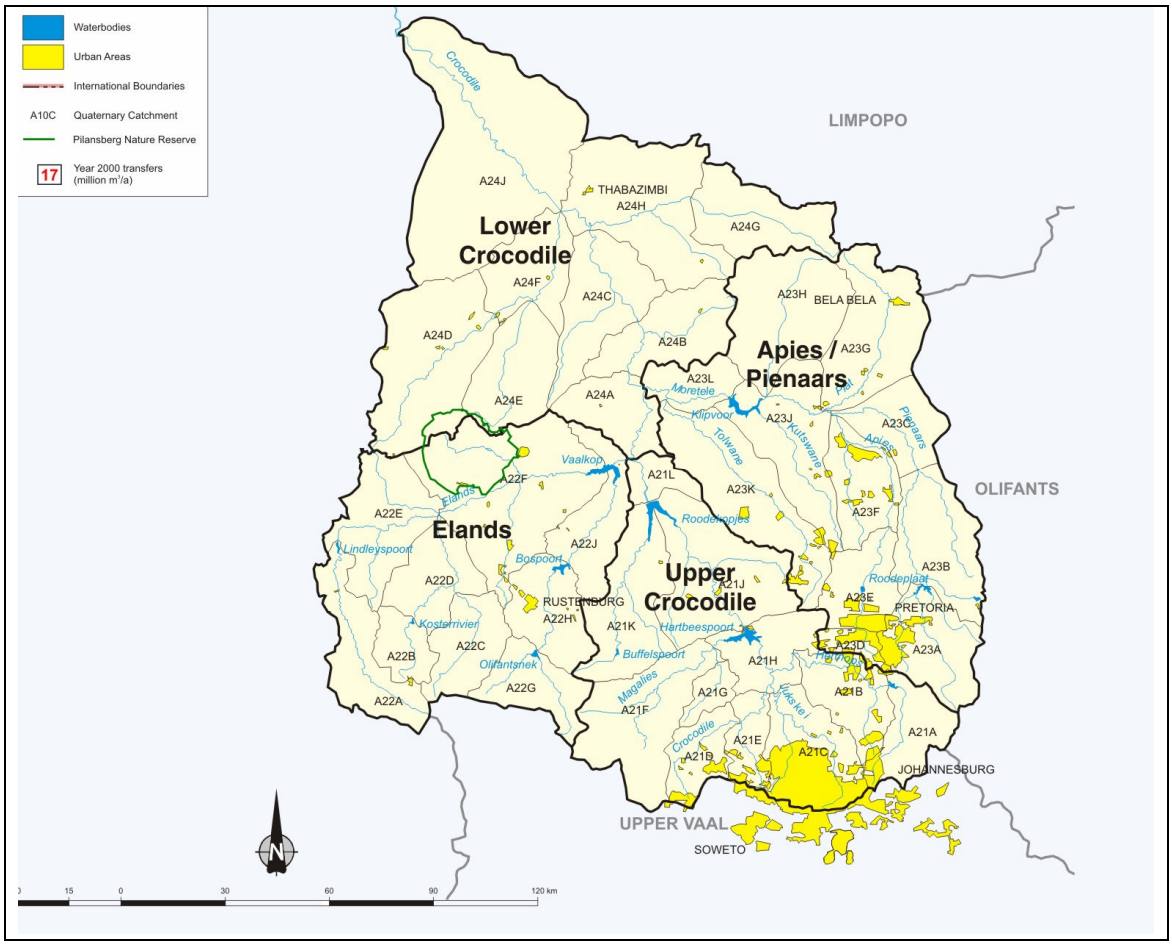

FIGURE 1: STUDY AREA

2.1 Upper Crocodile River Sub-area

The southern portion of the Upper Crocodile Sub-area is highly developed with the large industrial, urban and semi-urban sprawls of northern Johannesburg, Midrand and southern Tshwane. Large volumes of water are transferred from the Vaal River System, via the Rand Water supply system. Significant irrigation and mining activities are present in the area to the north of the Magalies Mountain Range.

2.2 Elands River Sub-area

Large portions of the Elands River Sub-area are owned by State/Tribal Authorities. Rustenburg is the main urban centre and has grown rapidly in recent years due to the expansion of mining activities in the area. Potential for the development of more mines exists, implying a further growth in the water requirements. Water is transferred to this area from the Vaal River System to augment local water resources. Irrigation areas are situated along the northern foothills of the Magalies Mountain Range.

2.3 Apies/Pienaars River Sub-area

A major part of the Apies/Pienaars River Sub-area is densely populated with the City of Tshwane (Pretoria) situated in the higher lying southern portion of the sub-area. The bulk of the water requirements of this area are supplied by Rand Water and is sourced from the Vaal River System, although significant quantities are also supplied from groundwater and from local sources. Irrigation in this sub-area is significant, with an estimated 67 km^2 (6 700 ha) of irrigated crops.

2.4 Lower Crocodile River Sub-area

The Lower Crocodile River Sub-area is characterised by large-scale irrigation activity along the Crocodile River while cattle and game farming are the main activities in the rest of the sub-area. A few mines are also present. Thabazimbi is the main town. The water requirements of the sub-area can be met by return flow for the foreseeable future.

3 PRESENT URBAN, IRRIGATION AND AFFORESTATION WATER USE, PROJECTED FUTURE USE, AND ITS GEOGRAPHICAL DISTRIBUTION IN THE WMA AND IN AFFECTED AREAS OF THE ADJACENT WMAS

3.1 Urban Water Use

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 Vaal River Catchment. 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 (Germiston, Benoni, Edenvale, Modderfontein, Kempton Park, Tembisa) and West Rand District Municipality (Roodepoort, Randfontein, Magaliesburg, 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, Thabazimbi). The primary water suppliers and sources of water are listed in the Water Requirements Report of the Crocodile (West) River Return Flow Analysis Study (P WMA 03/000/00/0904) and are shown in **Table 3-1**. The abstraction patterns and locations of the demands were not discussed and will be obtained as part of the information gathering process of the parallel modelling study. Waste Water Treatment Works are addressed in Section 5.2.

The following issues and strategies were identified in the Internal Strategic Perspective (Report No. P WMA 03/000/00/0303):

Apies/Pienaars River Sub-area: Surplus water will be available in future due to an increase in return flows. The return flows, however, become available in the Apies and Pienaars Rivers and some of it has already been allocated to improve and expand water supply to the areas north of Tshwane. An option to transfer surplus return flow to the western highveld (Olifants WMA) is also being investigated. Riparian irrigators should not be allowed to utilise surplus return flow if the water can be used to supply other water users.

Upper Crocodile Sub-area: A high projected growth in water requirements is estimated. Since most of the water requirements are supplied from the Upper Vaal WMA, the volumes of water transferred and associated return flow will also increase. It must be taken into account that the Vaal River system is augmented from other river basins through Inter Basin Transfers. Water demand management will result in a decrease in usable return flow. A strategy to optimise the use of surplus return flows needs to be developed as an option to delay costly additional transfer schemes. The reuse of return flows will result in an increase in the salinity of the Crocodile (West) River. A cascading re-use is proposed whereby the salts are passed downstream, where it can be stored in slimes dams if mines are the end users. Using return flows for irrigation to establish emerging farmers should also be considered.

Elands River Sub-area: The local water resources, augmented by return flows, in the Elands River catchment are under-utilised, while significant volumes of water are transferred from the Vaal River System. Options to optimise the use of local water resources and return flows, such as Bospoort Dam should be developed.

Lower Crocodile River Sub-area: Water requirements in the Lower Crocodile catchment can be supplied from return flows for the foreseeable future. The NWRS reserved 45 million m^3 per annum for the possible development of mining and a power station in the neighbouring Limpopo WMA. Allocating surplus return flows should therefore be carefully considered.

TABLE 3-1: PRIMARY WATER SUPPLY

SUB-AREA	LOCAL AUTHORITY	TOWNS	WATER SUPPLIER	SOURCES
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 Roodeplaat Dam
		Babelegi		
	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
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
Lower Crocodile	Thabazimbi Municipality	Thabazimbi	Magalies Water	Vaalkop Dam

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

Table 3-2 and **Table 3-3** show the estimated urban and rural water requirement for the year 2000. The estimated rural and urban water requirements for 2025 are listed in **Table 3-4**. These estimates were based on desktop or reconnaissance level assessments of available resources and water requirements that existed in 1995. The data for 2000 and 2025 were estimated using 1995 data.

TABLE 3-2: URBAN WATER REQUIREMENTS FOR THE YEAR 2000

SUB-AREA	URBAN POPULATION	DOMESTIC DIRECT ($10^6m^3/a$)	DOMESTIC INDIRECT ($10^6m^3/a$)	URBAN LOSSES ($10^6m^3/a$)	TOTAL ($10^6m^3/a$)	URBAN PER CAPITA (l/c/d)	URBAN RETURN FLOW (%)
Apies/Pienaars	1877663	106.2	65.8	39.1	211.1	155	50
Upper Crocodile	2167202	141.0	100.8	49.6	291.4	178	54
Elands	180344	11.3	8.0	3.9	23.2	171	41
Lower Crocodile	13687	1.5	1.0	0.6	3.1	299	49
Total	***4238894***	***260.0***	***175.6***	***93.2***	***528.8***	***168***	***52***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

TABLE 3-3: RURAL WATER REQUIREMENTS FOR THE YEAR 2000

SUB-AREA	RURAL POPULATION	DOMESTIC ($10^6m^3/a$)	STOCK WATERING ($10^6m^3/a$)	TOTAL ($10^6m^3/a$)	RURAL PER CAPITA (l/c/d)
Apies/Pienaars	502265	6.4	1.0	7.4	35
Upper Crocodile	218642	2.8	2.2	5.0	35
Elands	219649	2.8	6.9	9.7	35
Lower Crocodile	146524	1.9	1.7	3.6	35
Total	***1087080***	***13.9***	***11.8***	***25.7***	***35***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

TABLE 3-4: ESTIMATED URBAN AND RURAL WATER REQUIREMENTS FOR THE YEAR 2025

SUB-AREA	URBAN WATER REQUIREMENTS ($10^6m^3/a$)	RURAL WATER REQUIREMENTS ($10^6m^3/a$)
Apies/Pienaars	330	8
Upper Crocodile	409	5
Elands	34	10
Lower Crocodile	4	4
Total	***777***	***27***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

3.2 Irrigation

Irrigation requirements constitute 37% of the water requirements in the Crocodile River (West) catchment. In the area to the north west of Johannesburg, south of the Magalies Mountain Range, smallholding and commercial agricultural activities are practised, with limited formal irrigation. Citrus farming activities characterise the area between Rustenburg and Brits on the northern side of the Magalies Mountain Range. Below Hartbeespoort Dam and Brits irrigated cash crop farming are practised. Irrigation also occurs down along the mainstream of the Crocodile River, the most significant areas being just south and north of Thabazimbi.

The irrigation schemes, areas and supply sources for individual irrigators and controlled schemes are shown in **Table 3-5**. Differences exist between the most recent studies. The total irrigation are listed in the RFS is 45966 ha compared to the 30537 ha listed in the WRSAS. The WRSAS did not include the irrigation area of the Crocodile River West Transvaal Irrigation Board.

Potential losses from irrigation canals were not listed in the previous studies. **Table 3-6** shows the irrigation requirements for the year 2000 and **Table 3-7** shows the irrigation water requirement projections for 2025. As can be seen no increase in irrigation water requirements is expected.

TABLE 3-5: IRRIGATION SCHEMES, AREAS AND SUPPLY SOURCES

SUB-AREA	RIVER	RFS	SCHEME	SUPPLY SOURCE	RFS		WRSAS	
		REGISTERED IRRIGATION AREAS FOR INDIVIDUAL USERS (HA)			AREA (HA)	AREA USED FOR MODELLING (HA)	SCHEDULED AREA (HA)	IRRIGATED AREA (HA)
Upper Crocodile	Magalies and Skeerpoort Rivers	4537	Magalies North IB	Magalies River	120	120	188	188
			Magalies South IB	Magalies River	190	190	193	193
			Zeekoeihoek IB	Magalies River	176	176	171	171
			Skeerpoort IB	Skeerpoort River	800	800	*	*
	Crocodile River	2264	Hartbeespoort GWS	Hartbeespoort Dam	14290	14290	16218	16218
	Sterkstroom	2340	Buffelspoort GWS	Buffelspoort Dam	1949	1949	1938	970
			Middelkraal GWS	Middelkraal Dam	103	103	103	25
			Buffelshoek IB	Barnards River	144	144	144	144
			Sterkwater IB	Sterkstroom	104	104	164	164
	Bloubank-spruit	*	Kromdraai IB	Bloubank-spruit	144	Not used	138	138
	TOTAL	***9141***			***18020***	***15927***	***17319***	***18211***
Elands	Elands River	*	LindleysPoort GWS	Lindleyspoort Dam	1587	Not used	1587	1587
	Koster River	*	Koster River IB	Koster River Dam	495	Not used	542	542
	Hex River	*	Olifantsnek IB	Olifantsnek Dam	1600	Not used	1460	1460
		*	Modderfontein IB	Springs	100	Not used	87	87
	Waterkloof-spruit	*	Glyklip IB	Waterkloof-spruit	31	Not used	81	81
	TOTAL				***3 813***	***0***	***3757***	***3757***
Apies/ Pienaars	Pienaars River	*	Pienaars GWS	Roodeplaat Dam	435	Not used	750	750
	Hennops River	2198	Bon Accord IB	Bon Accord Dam	1035	1 035	966	966
		*	Warmbad IB	Bischoffs Dam	243	Not used	231	231
	TOTAL	***2198***			***9339***	***1035***	***9461***	***9461***
Lower Crocodile	Crocodile River (d/s of Roodekopjes, Vaalkop and Klipvoor Dams and u/s of confluence with Bierspruit	3766	Crocodile River W-Tvl IB	Crocodile River	14794	14794	*	*
	Crocodile River (d/s of Bierspruit confluence and u/s of Marico River confluence)	12097	None	N/A	0	0	0	0
	TOTAL	***15863***			***14794***	***14794***	***0***	***0***
TOTAL		**27202**			**45966**	**31756**	**30537**	**31429**

(Sources: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301; Crocodile West River Return flow Analysis Study, Report number P WMA03/000/00/0904)

Note: * No data

TABLE 3-6: IRRIGATION WATER REQUIREMENTS FOR THE YEAR 2000

SUB-AREA	IRRIGATION AREA (HA)		REQUIREMENTS ($10^6m^3/a$)	CONVEYANCE LOSSES (%)	RETURN FLOWS (%)
	GREEN COVER	HARVESTED			
Apies/Pienaars	6734	7752	41.3	9	10
Upper Crocodile	26996	45004	207.7	17	10
Elands	4973	6471	31.8	24	10
Lower Crocodile	13402	20105	136.7	43	10
Total	***52105***	***79332***	***417.5***	***25***	***10***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

TABLE 3-7: ESTIMATED IRRIGATION WATER REQUIREMENTS FOR THE YEAR 2025

SUB-AREA	REQUIREMENTS ($10^6m^3/a$)
Apies/Pienaars	41
Upper Crocodile	208
Elands	32
Lower Crocodile	137
Total	***418***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

The differences between the areas scheduled for irrigation and the actual areas irrigated in the Controlled irrigation schemes are shown in **Table 14-2.**

3.3 Afforestation

No commercial or other forests are present in the Crocodile (West) River catchment.

3.4 Power Generation, Mining and Bulk Industrial

3.4.1 Power Generation

There are three small thermal Power Stations in the catchment, namely the Kelvin Power Station (Kempton Park), Pretoria West Power Station (Tshwane West) and the Rooiwal Power Station (Tshwane North).

3.4.2 Mining

Mining is an important sector of the regional economy. The primary minerals mined at present include platinum and the associated platinum group of minerals as well as gold, iron ore, diamonds, granites and limestone (Report No P WMA 03/000/00/0303, Part I-27). Other minerals mined include: Palladium, chrome, manganese, mineral sands, vanadium and andalusite. Most of the gold mines in the Upper Crocodile River Sub-area are mined out and have been closed. Some of the old mine dumps are now being reworked and the impacts of these reworking operations are not known, but is assumed to be negligible on the rainfall runoff relationship, hence it will not be taken into consideration for the purpose of hydrological modelling. The impact of these mine dumps on the rainfall runoff relationship for the purpose of hydrological modelling is assumed to be negligible. New mines are being developed on the axis between Tshwane, Rustenburg and Sun City. Mines have been approaching Rand Water for the supply of water from the Vaal River System (Report No P WMA 03/000/00/0303, Part I-28). Dewatering of mines, especially between Brits and Rustenburg is causing much concern with local citrus farmers, which believe that the groundwater, their main source of supply, is

being depleted. Environmentalists are concerned about the impact of mining on the natural vegetation.

3.4.3 Bulk Industrial

Very few industries in the Crocodile River (West) catchment receive bulk water supplies, as most industries are connected to the municipal supply systems. Pelindaba and Valindaba, situated just West of Pretoria, meet their water requirements by means of direct abstractions from the Crocodile River upstream of Hartbeespoort Dam. The Pelindaba research facility is no longer fully functional, and their water requirements have declined significantly over the past few years. Magalies Water supplies the Dwaalboom cement factory situated west of Thabazimbi, with water drawn from Vaalkop Dam. Most other industries are situated in the peripheral industrial zones in and around Johannesburg and Tshwane, and purchase water from local authorities.

Table 3-8 list the water requirements for mining, bulk industrial and power generation for the year 2000. Possible return flows from the mining, bulk industrial and power generation will be obtained as part of the information gathering of the parallel modelling study. These water requirements will not change significantly in future (Report No P WMA 03/000/00/0203). The 2000 estimates were based on desktop or reconnaissance level assessments of available resources and water requirements that existed in 1995.

TABLE 3-8: MINING AND BULK INDUSTRIAL WATER REQUIREMENTS FOR THE YEAR 2000

SUB-AREA	POWER GENERATION ($10^6m^3/a$)	MINING AND BULK INDUSTRIAL ($10^6m^3/a$)	TOTAL ($10^6m^3/a$)
Apies/Pienaars	15	6	21
Upper Crocodile	13	38	51
Elands	0	48	48
Lower Crocodile	0	28	28
Total	***28***	***120***	***148***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

4 WATER USE BY AND REMOVAL OF INVASIVE ALIEN PLANTS

A CSIR (Environmentek) team mapped alien vegetation infestations across South Africa using a "best expert knowledge" approach, supplemented by existing detailed localised maps and Geographic Information System data sets obtained from authorities. **Table 4-1** shows the estimated areas of alien vegetation as well as the reduction in runoff and yield due to alien vegetation. According to the CSIR there is only one area in the Crocodile River West catchment where the infestation of alien vegetation is greater than 5% of the area. This is an area of 89 km^2 situated in the Elands River catchment upstream of the Vaalkop Dam (A22F quaternary catchment). The DWAF Working for Water programme has the following projects in the Crocodile West River catchment: Madikwe, Crocodile River, Leeu River, Hartbeespoort, Sterkstroom, Swart River, De Wildt, Tswaing, Karee, Kalbas, Rosespruit, Krugersdorp and Magalies River. Information from these projects as well as the division of alien vegetation into riparian and inland vegetation will be included in the final report.

TABLE 4-1: ALIEN VEGETATION INFORMATION

SUB-AREA	CATCHMENT AREA (KM^2)	ALIEN VEGETATION AREA (KM^2)	REDUCTION IN RUNOFF DUE TO ALIEN VEGETATION (10^6M^3)	REDUCTION IN YIELD DUE TO ALIEN VEGETATION (10^6M^3)
Upper Crocodile	6336	12.63	1	1
Apies/Pienaars	7588	49.20	3	2
Elands	6221	110.09	4	3
Lower Crocodile	9204	39.36	1	0
Total	***29349***	***211.28***	***9***	***6***

(Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

5 EXISTING WATER SUPPLY INFRASTRUCTURE

A complex water infrastructure network exists; with most of the water requirements supplied by two major water boards (Rand Water and Magalies Water) which source water from the Crocodile (West) River catchment and from the Upper Vaal WMA. With the exception of Tshwane and Thabazimbi, the urban water requirements are supplied from surface water. Tshwane and Thabazimbi utilise groundwater in addition to surface water.

Rand Water is the largest water board in South Africa, and supplies purified water to the Greater Johannesburg region, Tshwane, Rustenburg and other smaller consumption centres. The water is drawn from the Upper Vaal catchment, and transferred over the catchment divide to the southern region of the Crocodile River (West) catchment. Return flows from wastewater treatment plants north of the catchment divide contribute significantly to the yield of the Crocodile (West) River system.

Magalies Water covers the central and eastern regions of the Crocodile River (West) catchment. **Table 5-1** list the major water abstractions (source and destination), capacities of the abstraction infrastructure and allocated volumes, where available.

TABLE 5-1: WATER ABSTRACTION

OPERATED BY	NAME OF ABSTRACTION SITE	ABSTRACT FROM	SUPPLY TO	CAPACITY	ALLOCATED VOLUME
Rand Water	Vereeniging & Zuikerbosch	Vaal Dam/ Vaal Barrage	Johannesburg, Midrand, Centurion, Pretoria, Mabopane, Garankuwa and Rustenburg, mines and industries.	5370 Ml/d	*
Tshwane Metro Council	Rietvlei	Rietvlei Dam	Pretoria	40 Ml/d	*
Tshwane Metro Council		Boreholes and Springs	Pretoria	4.9 Ml/d[1]	*
Rand Water	Vereeniging & Zuikerbosch via Barnardsvlei	Vaal Dam/ Vaal Barrage	Rustenburg	19.8 MCM/a[2]	*
Magalies Water	Cullinan Plant	Premier Mine Dam (Olifants WMA)	Rayton, Zonderwater, Cullinan	16 Ml/d	22.2 Ml/d
Magalies Water	Wallmansthall	Pienaars River	Military Base, Baviaanspoort Prison, smallholdings	12 Ml/d	12 Ml/d
Magalies Water	Temba	Leeuwkraal Dam (Apies River)	Moretele Water Supply Scheme	20 Ml/d	30.1 Ml/d
Magalies Water	Klipdrift	Roodeplaat Dam	Pienaarsrivier, Bela Bela, Modimolle (Limpopo WMA)	18 Ml/d	20 Ml/d
Magalies Water	Vaalkop	Vaalkop Dam (supplemented from Roodekopjes and Hartbeespoort)	Thabazimbi, Disake, Mabeskraal, Modikwe, Rustenburg	120 Ml/d	(106.3 Ml/d – before upgrade)

(Source: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301)
Notes: * no data
1. Supply during 1995
2. Estimated supply

5.1 Main Reservoirs

The main reservoirs are listed in **Table 5-2**. An 18.5km long canal with a capacity of $4m^3/s$ can be used to transfer water from Roodekopjes to Vaalkop Dam to augment the yield of Vaalkop Dam.

TABLE 5-2: RESERVOIRS

SUB-AREA	RESERVOIR	NET CAPACITY (10^6m^3)	YIELD (10^6m^3)	WATER USE
Upper Crocodile	Rietvlei	12.5	14.7	Domestic
	Hartbeespoort	198	155	Irrigation, domestic
	Roodekopjes	102.5	26	Irrigation
	Buffelspoort	10	3.2	Irrigation
Elands	Lindleyspoort	14.5	3.0	Irrigation
	Koster	13	1.1	Irrigation, Domestic
	Mankwe	4		Domestic
	Olifantsnek	13.5	2	Irrigation
	Vaalkop	56.1	15.4	Mining, Domestic, Irrigation
	Bospoort	18	1.9	Domestic
Apies/ Pienaars	Roodeplaat	43.5	21.3	Irrigation, Domestic
	Bon Accord	4.5	18	Irrigation
	Leeukraal	0.5		Domestic
	Warmbaths Old	0.5	1.0	Domestic
	Warmbaths New	8		Domestic
	Nooitgedacht	1.5		Recreation
	Klipvoor	47	53.3	Irrigation
Lower Crocodile	Bierspruit	3.5		Irrigation

(Source: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301)

5.2 Wastewater Treatment Works

The main wastewater treatment works are listed in **Table 5-3**. Different capacities were given for some of the Waste Water Treatment Works in the WRSAS and the Integrated Development Plan (IDP) for Tshwane. These differences will be clarified as part of the information gathering for the parallel modelling study. The capacities were not listed in the RFS Reports. Of the Waste Water Treatment Works operated by the Tshwane Metropolitan Council, Zeekoeigat is operated above capacity.

TABLE 5-3: WASTEWATER TREATMENT WORKS

SUB-AREA	QUARTER-NARY CATCHMENT	NAME OF TREATMENT WORKS	WRSAS[1]	IDP[2]		
			CAPACITY (Ml/d)	CAPA-CITY (kl/d)[3]	LOAD (kl/d)	DISCHARGE POINT
Upper Crocodile	A21A	Hartbeesfontein	35			Rietvlei
	A21B	Olifantsfontein	38			Kaalspruit
		Sunderland Ridge	35	45	45	Hennops
	A21C	Esther Park	0.4			Modderfonteinspruit
		Johannesburg Northern	220			Jukskei
		AECI	7			Modderfonteinspruit
		Modderfontein	16			Modderfonteinspruit
		Midrand South	5			Hennops
	A21D	Percy Stewart	25			Rietspruit
	A21E	Driefontein	15			Wilgespruit
	A21H	Schoemansville	1.5			Swartspruit
	A21J	Brits	8.5			Crocodile River
		Lethlabile	2.5			Oxidation ponds
		Mothulung	1.9			Oxidation Ponds
Elands	A22F	Sun City	10			Evaporation Ponds
	A22H	Boitekong	8			Hex River
		Rustenburg	23			Hex River
Apies/ Pienaars	A23A	Zeekoeigat	35	30	38	Pienaars River
		Baviaanspoort	45	58	35	Pienaars River
		Sandspruit		20	3.5	Pienaars River

SUB-AREA	QUARTER-NARY CATCHMENT	NAME OF TREATMENT WORKS	WRSAS[1]	IDP[2]		
			CAPACITY (Ml/d)	CAPA-CITY (kl/d)[3]	LOAD (kl/d)	DISCHARGE POINT
	A23B	Rayton	1			Sterkspruit
		Refilwe	4			Premier Mine slimes dam
	A23E	Rooiwal	150	245	140	Apies River
		Daspoort	45	60	42	Apies River
		Mogwase	4			Apies River
	A23F	Babelegi	8.2	4.7	2.2	Apies River
		Temba	10	12.5	6	Apies River
	A23G	Warmbaths	3.2			Reused for Irrigation
	A23J	Rietgat	5.7	27	9.6	Soutpanspruit
	A23K	Klipgat	40	55	38	Tolwane River
Lower Crocodile		Thabazimbi	2.5			Reused by Iscor

(Sources: 1 - Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301,
2 – Tshwane IDP 2005
3 – Note that the units was given as kilolitre in the IDP – Tshwane Metro was asked to clarify)

5.3 Controlled Irrigation Schemes

The controlled irrigation schemes in the Upper Crocodile sub-area are either government water schemes (GWS) or are controlled by irrigation boards (IB). The Hartbeespoort Government Water Scheme draws water from the Hartbeespoort Dam. Before the dam was built, water was diverted from the Crocodile River via furrows. The furrows are still in existence and are used downstream of the dam to divert water that has been released into the river. There is also a network of concrete-lined canals, and water is released directly from the dam into the canals for distribution to the farmers.

Irrigation water requirements in the Buffelspoort Government Water Scheme are also distributed via a network of canals. The Buffelspoort Dam is over utilised, and irrigation releases from the dam are restricted.

There are a number of controlled irrigation schemes in the Pienaars, Elands and Lower Crocodile River sub-areas. These are either government water schemes (GWS) or irrigation boards. All schemes in this sub-area distribute the water from the dams via canal systems.

Table 5-4 list the scheduled areas, irrigated areas and crops irrigated for the controlled irrigation schemes in the Crocodile (West) River catchment.

TABLE 5-4: CONTROLLED IRRIGATION SCHEMES

SUB-AREA	SCHEME	SUPPLY SOURCE	RFS		WRSAS		
			AREA (HA)	AREA USED FOR MODELLING (HA)	SCHEDULED AREA (HA)	IRRIGATED AREA (HA)	CROPS
Upper Crocodile	Magalies North IB	Magalies River	120	120	188	188	Vegetables
	Magalies South IB	Magalies River	190	190	193	193	Vegetables
	Zeekoeihoek IB	Magalies River	176	176	171	171	Vegetables
	Skeerpoort IB	Skeerpoort River	800	800	-	-	-
	Hartbeespoort GWS	Hartbeespoort Dam	14290	14290	16218	16218	Vegetables
	Buffelspoort GWS	Buffelspoort Dam	1949	1 949	1 938	970	Citrus
	Middelkraal GWS	Middelkraal Dam	103	103	103	25	Citrus
	Kromdraai IB	Bloubank-spruit	144	Not used	138	138	Vegetables
	Sterkwater IB	Sterkstroom	104	104	164	164	Citrus
	Buffelshoek IB	Barnards River	144	144	144	144	Citrus
Elands	LindleysPoort GWS	Lindleyspoort Dam	1587	Not used	1587	1587	Wheat
	Koster River IB	Koster River Dam	495	Not used	542	542	Peppers
	Olifantsnek IB	Olifantsnek Dam	1600	Not used	1460	1460	Citrus, Tobacco
	Modderfontein IB	Springs	100	Not used	87	87	Avocados
	Glyklip IB	Waterkloof-spruit	31	Not used	81	81	Strawberries
Apies/ Pienaars	Pienaars GWS	Roodeplaat Dam	435	Not used	750	750	Cotton
	Bon Accord IB	Bon Accord Dam	1035	1 035	966	966	Vegetables
	Warmbad IB	Bischoffs Dam	243	Not used	231	231	Citrus
Lower Crocodile	Crocodile River W-Tvl IB	Crocodile River	14794	14794	-	-	-

(Sources: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301; Crocodile West River Return flow Analysis Study, Report number P WMA03/000/00/0904)

5.4 Transfers

5.4.1 Inter Water Management Area Water Transfers

Table 5-5 shows the main inter-WMA water transfers. Rand Water imports water from the Upper Vaal WMA to the Crocodile River (West) Catchment for urban, industrial and mining use. Water is also imported to Cullinan from the Olifants River catchment for urban use and for use on the Premier Diamond mine. Magalies Water exports water to supply the requirements of Modimole (Nylstroom) in the Limpopo WMA.

TABLE 5-5: MAIN INTER-WMA WATER TRANSFERS IN 2000

	FROM	TO	VOLUME ($10^6 m^3/a$)	DESCRIPTION
Transfers into the Crocodile (West) River catchment	C22F	Various urban	230.0	Rand Water to Apies/Pienaars sub-area
	C22F	Various urban	352.0	Rand Water to Upper Crocodile sub-area
	C22F	Various urban	19.7	Rand Water to Elands sub-area
	C22F	Various mining	49.4	Rand Water to Elands sub-area
	B20H	Mining	2.7	Bronkhorstspruit Dam to Premier diamond Mine
	B20H	Urban	2.3	Bronkhorstspruit Dam to Cullinan
Transfers out	A23F	A61A	3.0	Magalies water to Nylstroom

(Source: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301)

A number of new water transfer schemes out of the catchment are being considered at present. A regional water supply scheme from Hartbeespoort Dam, using return flows from the Johannesburg and Tshwane urban areas to supply mines between Brits and Rustenburg is considered. A prefeasibility study has been commissioned and the Rustenburg Joint Water Forum is taking the lead in this regard (Anglo Platinum Limited and Lonmin Platinum. Final draft March 2008. Pre-Feasibility Study for the supply of Industrial Grade Water between Hartbeespoort Dam and Lephalale. Report by Bigen Africa Contract No. 930/02/M)

The Department of Water Affairs and Forestry has completed a prefeasibility study regarding the transfer of water from the Crocodile (West) River to the Lephalale area (Department of Water Affairs and Forestry. July 2006. Crocodile West to Mokolo Catchment Water Transfer: Reconnaissance Study Report by Murango Consulting Engineers (Project reference 2005-6) Report No: 14/2/A400/3/2). This will be followed by a feasibility study in order to determine the feasibility of a transfer scheme to supply water to the Lephalale area where it is foreseen that Eskom will develop a number of new power stations, the development of a Coal-to-Liquid facility and for the growth in domestic water requirements by the Lephalale Local Municipality.

5.4.2 Inter-quaternary Transfers

There are several inter-quaternary transfers within the Crocodile (West) River catchment. Most of these transfers forms part of the Magalies Water supply system, supplying water to urban areas, mines and industries. One of the most significant inter-quaternary transfers is the water transfer via a canal, with a design capacity of 4 m^3/s, from Hartbeespoort and Roodekopjes Dams to Vaalkop Dam, from where the water is distributed to the various consumers supplied by Magalies Water. The consumers include Thabazimbi, Rustenburg, Dwaalboom PPC cement factory, many of the platinum mines and numerous rural communities. It is anticipated that the transfer will increase as the demand in the Elands River catchment increases. The demand in the Elands River catchment is driven mainly by mining activity.

A number of effluent transfers within the Crocodile (West) River catchment are also present. Effluent transfers occur when effluent is treated and released to the river in a quaternary other than that in which it was generated. Treated effluent is also used within the catchment. Kelvin Power Station, situated in Kempton Park, is supplied with treated effluent from the Johannesburg Northern sewage works and the Pretoria West and Rooiwal Power Stations, situated in Tshwane, are supplied with treated effluent from the Daspoort and Rooiwal sewage works respectively.

6 HYDROLOGICAL INFORMATION AND CONCERNS

A comprehensive water resources study, the Crocodile River (Western Transvaal) Catchment Study, was completed in 1992. As part of the study four hydrology reports were produced, namely Hydrology of the Upper Crocodile River sub-system (Report No. P A200/00/1492), Hydrology of the Pienaars River sub-system (Report No. P A200/00/1592), Hidrologie van die Elandsriviersubstelsel (Report No. P A200/00/1192) and Hidrologie van die Laer-Krokodilriveir-substelsel (Report No. P A200/00/1692). Results from these reports were used in the Water Resources Situation Assessment Study (Report No. P WMA03000/00/0301), Overview of Water Resources Availability and Utilisation Study (Report number P WMA06000/00/0203) and the Internal Strategic Perspective (Report No. P WMA 03/000/00/0303). The results were also used in the Surface Water Resources of South Africa Study (WR90). The Development of a Strategic Water Management Plan for the Apies-Pienaars River Catchment Study was completed in 2003. The WRSM2000 model was not re-calibrated. It was only used to extend the simulated runoff time series up to 1998.

The hydrological information (catchment area, MAP, MAE, incremental natural MAR and cumulative natural MAR) from the Crocodile River (Western Transvaal) Catchment Study and the Development of a Strategic Water Management Plan for the Apies/Pienaars River Catchment Study is listed in **Table 6-1**

The highest rainfall occurs in the south-eastern upper portion of the Crocodile (West) River Catchment, generating much of the runoff from where it flows north-west to drain into the Limpopo River. Additional to the natural runoff, large volumes of urban return flows are generated, mostly from water imported to the area by Rand Water from the Upper Vaal WMA to Johannesburg and Tshwane. Rietvlei, Hartbeespoort, Roodekopjes, Roodeplaat and Klipvoor Dams harness the natural runoff and return flows in the upper catchment. It was estimated that return flows accounted for about 30% of the available surface water resources within the Crocodile (West) River Catchment in 1995.

There are no natural lakes or large wetlands in the Crocodile River (West) catchment. Land use impacts mainly relate to increases in runoff and return flows from the urban areas as well as reductions in runoff due to infestations by alien vegetation. No commercial or other forests are present.

TABLE 6-1: HYDROLOGICAL INFORMATION

Quaternary catchment	Catchment Area (km^2)	MAP (mm)	MAE (mm)	WRSAS[1]		SMP – Apies/Pienaars[2]	
				Incremental MAR (10^6m^3)	Cumulative MAR (10^6m^3)	Incremental MAR (10^6m^3)	Cumulative MAR (10^6m^3)
A21A	482	684	1700	18.32	18.32		
A21B	527	672	1700	11.35	29.67		
A21C	761	682	1700	42.14	42.14		
A21D	372	714	1700	23.68	23.68		
A21E	290	707	1700	17.90	41.58		
A21F	1001	677	1700	28.31	43.21		
A21G	160	694	1700	14.90	14.90		
A21H	514	668	1700	21.10	177.70		
A21J	1151	637	1700	29.20	206.90		
A21K	865	651	1700	43.40	43.40		
A21L	213	589	1700	2.66	253.00		
A22A	707	604	1750	14.68	14.68		
A22B	284	599	1750	5.70	5.70		
A22C	515	611	1800	8.33	8.33		
A22D	542	582	1850	7.93	21.96		
A22E	813	597	1800	13.22	27.90		
A22F	1690	604	1800	27.59	77.45		
A22G	499	656	1700	11.68	11.68		
A22H	579	658	1750	13.73	25.41		
A22J	592	600	1900	10.11	113.00		
A23A	682	698	1800	28.77	28.77	31.92	31.92
A23B	814	645	1800	15.79	44.56	12.85	44.77
A23C	491	574	1750	4.32	48.88	4.59	49.36
A23D	145	706	1800	16.66	16.66	18.10	18.10
A23E	490	674	1800	14.34	31.00	14.69	32.79
A23F	565	596	1800	5.65	36.65	5.90	38.69
A23G	952	591	1700	16.26	16.26	13.81	13.81
A23H	1058	600	1700	11.86	11.86	9.92	9.92
A23J	931	585	1750	9.09	122.70	8.53	120.31
A23K	1131	606	1750	14.77	14.77	20.91	20.91
A23L	329	604	1800	4.24	141.80	6.08	147.30
A24A	493	599	1800	7.13	514.80		
A24B	709	611	1750	11.73	526.50		
A24C	802	589	1750	7.66	534.20		
A24D	1328	600	1800	15.53	15.53		
A24E	688	592	1750	7.89	7.89		
A24F	591	602	1750	7.39	30.81		
A24G	736	645	1750	20.60	20.60		
A24H	1339	639	1750	45.59	600.40		
A24J	2518	539	1750	13.97	645.20		

(Source: 1: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301; 2:*Development of a Strategic Water Management Plan for the Apies-Pienaars River Catchment)*

7 GEOHYDROLOGICAL INFORMATION ABOUT THE VARIOUS AQUIFERS

The prevailing lithology of an area is a controlling factor with respect to the groundwater occurrence. The groundwater resources of the region are discussed in Annexure A of the Crocodile River (West) and Marico Water Management Area: Internal Strategic Perspective of the Crocodile River (West) catchment report (Report No. P WMA 03/000/00/0303). A summary is given below.

7.1 The south eastern, central, north eastern and far north western areas underlain by granite

Quaternary catchments A21C, A21E, the south western portions of quaternary catchments A21A and A21B, the eastern portion of quaternary catchment A21D around Johannesburg, and portions of quaternary catchments A21J, A21K, A21L, A22F, A22J, A23B, A23E, A23F, A23J, A23K, A23L, A24B, A24C, A24G, A24H and A24J are underlain by granite, forming four distinct geographical areas with differing topography and land use.

7.1.1 The southern outcrops underlying Johannesburg and the northern suburbs

Quaternary catchments A21C, A21E and parts of A21A and A21B are underlain by granite that forms a gently undulating plateau with remnants of the African erosion surface. Widespread aquifers developed within the weathering associated with the African erosion surface. Urban and peri-urban areas exist in the area with widespread groundwater abstraction from boreholes for domestic supply, garden watering and small-scale industrial purposes. Boreholes yield between 0.5 and 5 l/s and the water table vary from shallower than 20m to deeper than 50m. The groundwater quality is generally suitable for potable use but pollution is a growing problem in areas of informal settlements and poor agricultural practices.

The following issues were raised:

- Groundwater pollution from informal settlements and poor agricultural practises is problematic. The polluted base flow in the Jukskei River contributes to the algal blooms occurring in the Hartbeespoort dam.
- Uncontrolled growth of informal settlements can seriously impact on groundwater quality.

7.1.2 The Central East - West Zone

This area comprise of quaternary catchments A21J, A21K, A21L, A22F, A22J, A23B, A23E, A23F, A23J, A23K and A24E. A broad east - west trending band of granite from Hammanskraal in the east to the Pilansberg in the west, and north towards Northam forms an undulating to hilly terrain, with the rugged hills of the Pilansberg Complex in the west. Most of the area is used for farming. The communal land areas of ODI 1, ODI 2 and Mankwe lie within this area and depend on groundwater for water supply. Groundwater availability is limited with sustainable borehole yields varying from less than 0.5 to 2 l/s. The water table lies between 20 and 40 metre below ground level. The groundwater quality is generally good, but zones of elevated TDS (conductivity >150mS/m) are present in quaternary catchments A23J and A23K at depths of 80 to 120 metres. Areas of elevated fluoride levels are present around Moretele and in and around the Pilansberg Complex.

The following issues were raised:

- The availability of water during drought is a concern in the ODI 1, ODI 2, and Mankwe area.
- Groundwater resources are polluted from pit latrines and increasing population in the ODI 1, ODI 2, and Mankwe area (elevated TDS and NO_3 concentrations).
- Boreholes with elevated NO3, TDS and F concentrations are equipped for domestic use.
- Agricultural activities in the valley areas where irrigation is practised and fertiliser application is poorly managed impact negatively on groundwater.
- Any widespread or large scale development will impact on the pristine nature of the resources in the Pilansberg Game Reserve Area.

7.1.3 The north eastern area

Hilly terrain characterise the north-eastern area (quaternary catchments A23H, A23L, A24B, A24G and A24H). The area is sparsely populated and land use consists mostly of farming. Groundwater is used on for homesteads and stock watering. The groundwater quality is generally good and boreholes yield between less than 0.5 and 2 l/s. The depth of the water table varies between 30 and 50 metres.

7.1.4 The far north western area

Quaternary catchment A24J is the downstream quaternary between Thabazimbi and the confluence with the Marico River and is sparsely populated. The area is characterised by poor to marginal groundwater resources with borehole yield below 0.5 l/s.

7.2 The Southern Dolomite Outcrop

This area (parts of quaternary catchments A21A, A21B, A21D, A21F, A21G and A21H) comprises of the hemispherical outcrop of dolomite to the east, north and west of the granite underlying Johannesburg and includes Rietvlei dam and the World Heritage Site centred on Sterkfontein Caves. The dolomite forms mostly flat ground to the east and north east of Johannesburg. Extensive dry land agriculture and some irrigation, especially around Bapsfontein, are practised in the area. The topography to the north and north west of Johannesburg varies from rolling countryside to hills. Extensive irrigation is practise in the Tarlton area. Borehole yields vary between 2 and 10 l/s and the water table varies from 10 metres in vlei areas to 50 metres below ground level. The groundwater use was estimated to amount to 21.9 million m^3 in 1995, with most of the water used for urban supply from the dolomite aquifer in the Centurion area and irrigation abstraction in the Bapsfontein and Tarlton areas. The aquifer also contributes to base flow of the surface drainage flowing into the Hartbeespoort dam.

The following issues were raised:

- The dolomite aquifer crosses the catchment boundary into the Upper Vaal and Olifants Water Management Areas.
- Available information indicates that the groundwater resources are approximately 85% utilised.
- Active management of the dolomite aquifer is necessary to ensure long term sustainability of both quantity and quality
- Artificial recharge of the dolomite aquifer should be considered.
- Abstraction from the dolomite aquifer is reported to have caused sinkholes to develop.

- The effluent discharge from Kempton Park Sewage Works, the growth in settlements, especially in the A21A, and the widespread agricultural use of A21A and A21D in particular could lead to pollution of the dolomite groundwater resources.
- Closure of the gold mines in the southern part of the catchment could have an impact on the quality of the groundwater resources of the dolomite aquifer north of Randfontein.
- The impact of agriculture and agricultural practise on groundwater pollution needs to be addressed.

7.3 The Northern Dolomite Outcrop

A narrow southwest northeast trending outcrop of Malmani dolomite lies to the west of Thabazimbi (parts of quaternary catchments A24D, A24F, A24H and A24J). The topography is gently rolling to hilly and groundwater resources are mostly limited. Groundwater quality is good. Parts of this area are remote, groundwater quality is pristine and the area ecologically sensitive.

The following issues were raised:

- Development will impact on the pristine nature of the groundwater resources.
- In the Thabazimbi area groundwater resources are polluted due to mining effluent and agricultural activities.
- The availability of groundwater in the communal land areas is a problem during periods of drought.
- Groundwater resources are polluted from pit latrines and increasing population (elevated TDS and NO_3 concentrations).

7.4 The Dolomite of the Crocodile River fragment

Parts of quaternary catchments A23K, A24A and A24B are an area of dolomite lying between ridges of quartzite across which the Crocodile River flows. The dolomite forms relatively flat ground with widespread agriculture and irrigation. Borehole yields in this are can be higher than 10 l/s, especially from the primary alluvial aquifer. Aquifers in the dolomite are restricted to structural features and zones of deeper weathering and karst development. Groundwater levels in the alluvial aquifer are between 5 and 10 metres below ground level. The water level of the dolomitic aquifer is up to 20 metres below ground level. The groundwater quality is good but the aquifers are vulnerable to pollution.

The following issue was raised:

- Groundwater quality could be impacted from agricultural activities along the Crocodile River.

7.5 The southern belt underlain by quartzite and shale, with minor andesite in the west, of the Pretoria group

Quartzite and shale underlie a broad east – west trending zone from A23A in the east to A22A and A22E in the west and includes the prominent Magalies Mountain Range. Tshwane and several smaller towns such as Koster and Swartruggens lie in this area. Land use comprise of urban areas, extensive smallholdings, dry land maize farming and cattle ranching. Communal land in the west (quaternary catchment A22E) depends on groundwater for water supply, vegetable gardening and stock watering. Apart from the Magalies Mountain Range the topography is mostly flat to gently undulating. Aquifers developed within these Pretoria Group lithologies are associated with weathering and fracturing of the bedrock. Groundwater

resources are widespread but limited. Borehole yields vary from below 0.5 l/s to 2 l/s. The water table is between 20 and 30 metres below ground level. Groundwater quality is generally good and suitable for domestic, stock watering and irrigation uses. Elevated chlorides downstream of Hartbeespoort Dam pose problems for tobacco farmers.

The following issues were raised:

- The availability of groundwater in the communal land areas (A22E) is a problem during periods of drought.
- Groundwater resources are polluted from pit latrines and increasing population (elevated TDS and NO_3 concentrations).
- Overgrazing impact on groundwater recharge.
- Agricultural practise pose a groundwater pollution threat.
- Surface water with elevated chloride levels recharge the alluvial aquifer and can impact on agricultural activities.

7.6 The south west – north eastern belt underlain by inter-bedded quartzite, shale, andesite and banded ironstone of the Pretoria group

Parts of quaternary catchments A23D, A23F, A23G, A23H, A23L, A24A, A24B, A24C and A24D comprises a strip of hilly and rugged terrain stretching from west of Northam to Thabazimbi and then east towards Bela Bela. Land use includes communal land (Mankwe District in quaternary catchment A24D), cattle and game farming and mining (Thabazimbi iron ore mine and the closed Rooiberg Tin mine in quaternary catchment A24H). Groundwater occurs in zones of deep weathering and structural features such as faults and fracture zones and geological contacts and aquifers are localised. Boreholes yields are between 0.5 and 2 litre per second. The water level depth varies between 15 and 50 metres below ground level.

The following issues were raised:

- Groundwater in the Thabazimbi area is polluted by mining effluent and agricultural activities.
- The availability of groundwater in the communal land areas is a problem during periods of drought
- Groundwater resources are polluted from pit latrines and increasing population (elevated TDS and NO_3 concentrations).

7.7 The south central east - west trending and north western south west – north east trending areas underlain by norite and gabbro of the Bushveld Igneous Complex

Quaternary catchments A23E, A21J, A21K, A22H, A22J, A22F, A22E, A24D, A24E, A24F and A24C are characterised by flat to gently undulating topography. The northern suburbs and industrial urban areas of Tshwane, Brits and Rustenburg and the smaller town of Northam are within these catchments. Land use includes agriculture and platinum and chrome mines. Groundwater is widespread and water tables tend to be shallow, often less than 15 metres below ground level. Borehole yields of between 0.5 and 2 l/s are common.

The following issues were raised:

- Conflict between the demands of the local population and mine dewatering exist.
- Mining, industrial and agricultural activities pose a groundwater pollution threat.

- The availability of groundwater in the communal land areas is a problem during periods of drought.
- Groundwater resources are polluted from pit latrines and increasing population (elevated TDS and NO_3 concentrations).

7.8 The eastern areas underlain by mostly argillaceous strata of Karoo Age

Parts of quaternary catchments A23C, A23F, A23G, A23H, A23J and A23K form the western extent of the Springbok Flats with a gently undulating topography. Most of the area is comprised of the communal lands of Moretele 1 and Odi 1 districts and is heavily populated in the southern areas of A23F, A23J and A23K. The communal land depends on groundwater for domestic supply and stock watering. These catchments are mostly underlain by marls and clays of the Upper Karoo with low groundwater development potential. Sustainable borehole yields <0.5 l/s are the norm. Towards the NE and the basalt the Clarens Formation sandstone outcrops. Here the groundwater development potential is enhanced with sustainable borehole yields of 1 – 2 l/s sometimes feasible. Water levels are generally 20 – 30mbgl. Groundwater quality is variable with DWAF Class 2 or 3 water frequently encountered due to naturally elevated TDS associated with the low permeability marls. As noted above elevated TDS is present in the contact zone with the underlying granite in the south and west. Groundwater quality is, however, good in the Clarens sandstone outcrop areas, with DWAF Class 0 or 1 the norm.

The following issues were raised:
- The availability of groundwater in the communal land areas is a problem during periods of drought.
- Groundwater resources are polluted from pit latrines and increasing population (elevated TDS and NO_3 concentrations).
- Groundwater quality could be locally impacted from agricultural activities

7.9 The north eastern area underlain by basalt of Karoo Age

Basalts of the Karoo Age form the Springbok Flats south of Bela Bela (Parts of quaternary catchments A23C, A23G and A23H). The area is characterised by extensive agriculture with significant irrigation abstraction. Borehole yields of 10 l/s are common from aquifers developed within deep weathering and well developed fracturing. Groundwater quality is often impacted by elevated NO_3 concentrations.

The following issues were raised:
- A study to determine the available groundwater resources is required in order to understand the impact of over abstraction for irrigation.
- The impact of agricultural practice on groundwater quality must be assessed.

7.10 Various relatively small areas underlain by rhyolite/felsite

Parts of quaternary catchments A23B, A23G, A24B and A24G are characterised by rolling countryside with very limited groundwater resources and marginal groundwater development potential. Only agricultural land use is present. Aquifers are associated with local structural features. Sustainable borehole yields are always below 0.5 l/s.

7.11 The northern and north eastern areas underlain by mainly erinaceous strata of Waterberg Age

The area north of Bela Bela and the Waterberg Mountains north and east of Thabazimbi is underlain by a sequence of mainly coarse-grained sandstone and conglomerate and is characterised by a rugged and mountainous terrain with steep sided valleys. Parts of quaternary catchments A23G, A24G and A24H are with this area. Numerous major faults and fracture zones are present. Land use consists of agricultural land and game farms. Groundwater resources are generally limited with sustainable borehole yields often below 0.5 l/s. Much of the area is pristine with good groundwater quality. The Waterberg Mountains are an important recharge area and groundwater provides important base flow to surface drainage.

The following issues were raised:

- Widespread or large-scale development will impact on the pristine nature of the resources.
- Agricultural activities, especially in the valley areas could impact on groundwater quality.
- Uncontrolled growth of informal settlements around the existing settlements could impact on groundwater quality.

7.12 Riverbed Sand Aquifers

Numerous wellpoint schemes are installed along the Crocodile River and its tributaries to obtain water, either directly from the surface flows or from sand abstraction schemes constructed in the riverbed sediments.

8 WATER QUALITY

The Water Resources Situation Assessment Study (Report No P030000/00/0301) described the mineralogical water quality of the surface water resources in the Crocodile (West) River catchment in terms of total dissolved salts (TDS), using data from the water quality database of the DWAF. The analysis did not reveal any severe water quality problems based on TDS. Water quality problems in this catchment; however arise from nutrient enrichment and not from TDS.

The following issues were raised:

- The upper reaches of the Hartbeespoort Dam catchment are densely populated. A large number of the population has been poorly serviced with sanitation in the past resulting in higher than normal concentrations of nutrients in the Hartbeespoort Dam inflow. In addition industries, such as chicken farms and the use of fertilisers on irrigated crops have also contributed to the nutrient load. A phosphate standard was imposed on the effluent discharged from wastewater treatment works within the catchment but eutrophication remains a problem due to the poor level of sanitation within the catchment, especially in areas such as Alexandria and Tembisa. This results in a number of problems:
    - Urban consumers receiving treated water from Hartbeespoort Dam (Schoemansville, Kosmos, Brits) experience taste and odour problems. Advanced treatment processes are necessary to resolve these problems and are mostly successful.
    - Algal scum on the Hartbeespoort Dam has a detrimental affect on recreation.
    - Growth of algae in irrigation canals result in the need to physically clean out the canals annually.
    - Growth of water hyacinth (Biological control measures have successfully brought water hyacinth under control).
- Similar problems also occur at Bospoort Dam, due to nutrients emanating from Rustenburg and the surrounding rural population, as well as in the Pienaars River downstream of Tshwane. Two out of the three treatment plants, which receive water from the Pienaars River, uses advanced processes to cope with the algae as well as the taste and odour problem.
- The Roodekopjes Dam, downstream of Hartbeespoort, is also subject to eutrophication since it receives spills from Hartbeespoort Dam and nutrient enriched return flows from irrigators and Brits.
- The water that is transferred from Roodekopjes to Vaalkop Dam can also cause problems for the Vaalkop Water treatment plant. The recent upgrade, completed in 1999, included the addition of flotation as an option and a powdered activated carbon process for taste and odour control.

. **Table 8-1** list the DWAF monitoring sites for the Upper Crocodile River Sub-area, **Table 8-2** for the Apies/Pienaars River Sub-area, **Table 8-3** for the Elands River Sub-area and **Table 8-4** for the Lower Crocodile River Sub-area.

TABLE 8-1: DWAF WATER QUALITY MONITORING SITES IN THE UPPER CROCODILE RIVER SUB-AREA

MONITORING SITE	DESCRIPTION	LOCATED ON TYPE	DATE FROM	DATE TO	NUMBER OF SAMPLES
A2H008Q01	ELANDSFONTEIN EYE AT ELANDSFONTEIN	Spring/Eye	29/01/1980	17/10/1998	241
A2H009Q01	HENNOPS RIVER AT RIETVLEI/RIETVLEI DAM	Rivers	02/12/1997	02/12/1997	1
A2H010Q01	MALONEY'S EYE AT STEENEKOPPIE	Spring/Eye	09/02/1978	30/03/2005	194
A2H012Q01	AT KALKHEUWEL ON KROKODILRIVIER	Rivers	04/07/1971	11/05/2005	3319
A2H013Q01	MAGALIES RIVER AT SCHEERPOORT	Rivers	04/07/1971	26/04/2005	1505
A2H014Q01	HENNOPS RIVER AT SKURWEBERG	Rivers	27/01/1976	26/04/2005	1433
A2H019Q01	ROODEKOPJES DAM ON CROCODILE RIVER: DOWN STREAM WEIR	Rivers	06/02/1976	18/05/2005	993
A2H023Q01	DWJ26 JUKSKEI RIVER AT NIETGEDACHT	Rivers	02/05/1979	06/06/2005	1278
A2H024Q01	BRANDVLEI RIVER AT BRANDVLEI	Rivers	09/02/1978	21/03/2005	309
A2H033Q01	NOUKLIP EYE AT HARTBEESHOEK	Spring/Eye	03/03/1980	06/09/2004	112
A2H034Q01	SKEERPOORT RIVER AT SCHEERPOORT	Rivers	21/01/1976	11/05/2005	1435
A2H035Q01	SKEERPOORT RIVER AT HARTBEESHOEK	Rivers	03/02/1980	29/01/1999	53
A2H040Q01	DWJ37 JUKSKEI RIVER AT WATERVAL	Rivers	06/12/1971	13/10/1997	877
A2H042Q01	JUKSKEI RIVER AT LONE HILL	Rivers	06/12/1971	13/10/1997	952
A2H043Q01	RIVERSIDE SPRUIT AT DIEPSLOOT	Rivers	06/12/1971	27/12/1971	2
A2H044Q01	JUKSKEI RIVER AT VLAKFONTEIN	Rivers	06/12/1971	11/05/2005	1324
A2H045Q01	DWJ31 CROCODILE RIVER U/S AT VLAKFONTEIN FARM	Rivers	02/05/1979	18/05/2005	1299
A2H047Q01	LITTLE JUKSKEI RIVER AT KLIPFONTEIN/RANDBURG	Rivers	06/12/1971	06/06/2005	477
A2H048Q01	CROCODILE RIVER AT CROCODILE POORT/THABA MOYA	Rivers	19/02/1976	02/05/2005	1414
A2H049Q01	BLOUBANK (RIET) SPRUIT AT ZWARTKOP	Rivers	23/05/1979	06/06/2005	897
A2H050Q01	CROCODILE RIVER AT ZWARTKOP/HOI-HOI	Rivers	02/05/1979	06/06/2005	901
A2H051Q01	CROCODILE RIVER AT VAN WYKS RESTANT	Rivers	02/05/1979	06/06/2005	785
A2H052Q01	CROCODILE RIVER AT CROCODILE DRIFT/BRITS PUMP STA	Rivers	06/02/1976	16/05/1990	674
A2H053Q01	STERKSTROOM AT GROOTFONTEIN	Rivers	07/03/1978	30/04/1996	277
A2H058Q01	SWART SPRUIT AT RIETFONTEIN/SYFERFONTEIN	Rivers	08/09/1982	10/05/2005	310
A2H067Q01	HARTBEESPOORT DAM RIGHT CANAL @ HARTBEESFNT-D/S B	Canal	05/11/1980	05/12/1980	65
A2H068Q01	HARTBEESPOORT DAM RIGHT CANAL AT MAMAGALIESKRAAL	Canal	05/11/1980	05/12/1980	70
A2H069Q01	HARTBEESPOORT DAM RIGHT CANAL AT KLEINFONTEIN	Canal	05/11/1980	04/12/1980	21
A2H081Q01	HARTBEESPOORT DAM ON CROCODILE RIVER: LEFT CANAL	Canal	19/06/1962	02/05/2005	1406
A2H082Q01	HARTBEESPOORT DAM ON CROCODILE RIVER: RIGHT CANAL	Canal	19/06/1962	02/05/2005	237
A2H083Q01	HARTBEESPOORT DAM ON CROCODILE RIV: DOWN STREAM WEIR	Rivers	22/05/1979	02/05/2005	452
A2H090Q01	HENNOPS RIVER AT V RIEBEECK NAT RES UP/S RIETVLEI	Rivers	25/04/1986	17/02/2004	342
A2H092Q01	BUFFELSPOORT DAM ON STERKSTROOM RIVER: LEFT CANAL	Canal	21/02/1983	19/03/1996	11
A2H113Q01	ROODEKOPJES DAM ON CROCODILE RIVER: LEFT CANAL	Canal	20/05/1986	18/05/2005	195

MONITORING SITE	DESCRIPTION	LOCATED ON TYPE	DATE FROM	DATE TO	NUMBER OF SAMPLES
A2H114Q01	ROODEKOPJES DAM ON CROCODILE RIVER: RIGHT CANAL	Canal	28/10/1992	04/05/2005	173
A2R001Q01	HARTBEESPOORT DAM ON CROCODILE RIV: NEAR DAM WALL	Dam / Reservoir	18/03/1968	01/06/2005	7081
A2R004Q01	RIETVLEI DAM ON HENNOPS RIVER: NEAR DAM WALL	Dam / Reservoir	24/06/1968	08/06/2005	1433
A2R005Q01	BUFFELSPOORT DAM ON STERKSTROOM RIV: NEAR DAM WALL	Dam / Reservoir	18/03/1968	08/06/2004	343
A2R015Q01	ROODEKOPJES DAM ON CROCODILE RIVER: NEAR DAM WALL	Dam / Reservoir	15/11/1984	08/06/2004	646

TABLE 8-2: DWAF WATER QUALITY MONITORING SITES IN THE ELANDS RIVER SUB-AREA

MONITORING SITE	DESCRIPTION	LOCATED ON TYPE	DATE FROM	DATE TO	NUMBER OF SAMPLES
A2H032Q01	SELONS RIVER AT MOEDWIL	Rivers	26/05/1977	27/11/2001	133
A2H036Q01	KOSTER RIVER AT STEENBOKFONTEIN	Rivers	24/09/1971	19/04/2005	1369
A2H038Q01	LOWER WATERKLOOF AT RIETVALLEI	Rivers	12/07/1973	28/06/2004	159
A2H039Q01	UPPER WATERKLOOF AT RIETVALLEI	Rivers	12/07/1973	02/10/1982	32
A2H088Q01	OLIFANTSNEK DAM ON HEX RIVER: LEFT CANAL	Canal	03/04/1986	28/02/1991	45
A2H094Q01	BOSPOORT DAM ON HEX RIVER: DOWN STREAM WEIR	Rivers	22/11/1978	02/01/2004	221
A2H096Q01	LINDLEY'S POORT DAM ON ELANDS RIVER: RIGHT CANAL	Canal	08/03/1983	19/04/2005	340
A2H104Q01	KOSTER RIVER DAM ON KOSTER RIVER: DOWN STREAM WEIR	Rivers	15/01/1972	21/09/2004	532
A2H107Q01	SWARTRUGGENS DAM ON ELANDS RIVER: DOWN STREAM WEIR	Rivers	01/02/1985	08/03/2005	106
A2H110Q01	CANAL FROM ROODEKOPJES DAM TO VAALKOP DAM AT BULHOEK	Canal	09/06/1986	04/05/2005	117
A2H111Q01	VAALKOP DAM ON ELANDS RIVER: DOWN STREAM WEIR	Rivers	28/02/1985	18/05/2005	564
A2R003Q01	OLIFANTSNEK DAM ON HEX RIVER: NEAR DAM WALL	Dam / Reservoir	05/03/1975	08/06/2004	104
A2R006Q01	BOSPOORT DAM ON HEX RIVER: NEAR DAM WALL	Dam / Reservoir	06/03/1975	08/06/2004	282
A2R007Q01	LINDLEY'S POORT DAM ON ELANDS RIVER: NEAR DAM WALL	Dam / Reservoir	18/03/1968	31/03/2005	1387
A2R011Q01	KOSTER RIVER DAM ON KOSTER RIVER: NEAR DAM WALL	Dam / Reservoir	30/11/1971	25/02/2005	1332
A2R013Q01	SWARTRUGGENS DAM ON ELANDS RIVER: NEAR DAM WALL	Dam / Reservoir	13/02/1980	04/05/2005	216
A2R014Q01	VAALKOP DAM ON ELANDS RIVER: NEAR DAM WALL	Dam / Reservoir	04/03/1975	08/06/2004	714
A3R005Q01	SEHUJWANE RIVER: SEHUJWANE DAM-NEAR DAM WALL	Dam / Reservoir	28/08/2000	08/11/2004	18

TABLE 8-3: DWAF WATER QUALITY MONITORING SITES IN THE APIES/PIENAARS RIVER SUB-AREA

MONITORING SITE	DESCRIPTION	LOCATED ON TYPE	DATE FROM	DATE TO	NUMBER OF SAMPLES
A2H006Q01	PIENAARS RIVER AT KLIPDRIFT	Rivers	02/02/1976	26/04/2005	1394
A2H011Q01	BON ACCORD	Rivers			0
A2H021Q01	PIENAARS RIVER AT BUFFELSPOORT	Rivers	27/09/1971	17/05/2005	1260
A2H026Q01	APIES RIVER AT HAMMANSKRAAL	Rivers	23/09/1975	06/06/1984	343
A2H027Q01	PIENAARS RIVER AT BAVIAANSPOORT	Rivers	08/02/1967	23/05/2005	4130
A2H028Q01	AT KAMEELDRIFT ON HARTBEESSPRUIT	Rivers	10/05/1967	23/05/2005	3243
A2H029Q01	AT LEEUWFONTEIN ON EDENDALSPRUIT	Rivers	08/02/1967	06/06/2005	1975
A2H030Q01	ROODEPLAAT SPRUIT AT ROODEPLAAT/LOUWSBAKEN SE LOOP	Rivers	15/05/1968	10/05/2005	480
A2H054Q01	AT WOLMARANSPOORT ON HARTBEESSPRUIT	Rivers	16/11/1982	06/06/2005	1059
A2H055Q01	MORETELE SPRUIT AT DERDEPOORT PRETORIA/MORELETTA	Rivers	16/11/1982	06/06/2005	1122
A2H056Q01	STEENOOND SPRUIT AT BELLE OMBRE STATION/APIES CONFLUENCE	Rivers	14/09/1982	26/04/2005	1126
A2H057Q01	SKINNER SPRUIT AT DASPOORT PRETORIA/BANTULE	Rivers	17/11/1982	26/04/2005	1117
A2H061Q01	APIES RIVER AT RONDAVEL	Rivers	04/07/1984	10/05/2005	1046
A2H062Q01	WALKER SPRUIT AT SUNNYSIDE PRETORIA/LOFTUS VERSVELD	Rivers	07/08/1984	09/05/2005	1038
A2H063Q01	WONDERBOOM SPRUIT AT MAYVILLE PRETORIA	Rivers	13/06/1984	26/04/2005	1042
A2H066Q01	APIES RIVER AT ONDERSTEPOORT NATURE RESERVE	Rivers	08/04/1980	15/09/1981	63
A2H070R01	KLIPDRIFT PURIFICATION WORKS RAW EX RDP LEFT CANAL	Water Purification Works	26/06/1979	11/05/2005	418
A2H071R01	WALLMANNSTHAL PURIFICATION WORKS-ROODEPLAAT CANAL	Water Purification Works	02/09/1985	11/05/2005	319
A2H084Q01	BON ACCORD DAM ON APIES RIVER: RIGHT CANAL TO LEFT CANAL	Canal	04/01/1984	16/09/1987	12
A2H085Q01	BON ACCORD DAM ON APIES RIVER: RIGHT CANAL	Canal	04/01/1980	26/04/2005	394
A2H097Q01	WARMBAD DAM ON BUFFELS SPRUIT: LEFT CANAL	Canal	02/01/1983	02/03/1987	17
A2H100Q01	ROODEPLAAT DAM ON PIENAARS RIVER: LEFT CANAL	Canal	07/01/1980	10/05/2005	2569
A2H101Q01	ROODEPLAAT DAM ON PIENAARS RIVER: LEFT CANAL TO RIGHT BANK	Canal	17/09/1975	27/12/1978	65
A2H102Q01	ROODEPLAAT DAM ON PIENAARS RIVER: DOWN STREAM WEIR	Rivers	07/01/1980	10/05/2005	510
A2H106Q01	KLIPVOOR DAM ON PIENAARS RIVER: DOWN STREAM WEIR	Rivers	28/10/1985	03/05/2005	411
A2H122Q01	ROODEPLAAT SEWAGE: SETTLING POND'S OUTFLOW	Sewage Works	27/10/1993	23/05/2005	770
A2H124Q01	ZEEKOEGAT SEWAGE EFFLUENT	Sewage Works	23/01/1995	23/05/2005	758
A2H125Q01	BAVIAANSPOORT SEWAGE EFFLUENT	Sewage Works	23/01/1995	23/05/2005	711
A2H126Q01	AT FRANSPOORT ROAD BRIDGE ON EDENDALSPRUIT	Rivers	24/01/1995	23/05/2005	721
A2H127Q01	PIENAARS RIVER AT BAVIAANSPOORT (MAGALIESBERG)	Rivers	23/01/1995	23/05/2005	711
A2R002Q01	BON ACCORD DAM ON APIES RIVER: NEAR DAM WALL	Dam / Reservoir	27/02/1975	08/06/2005	1589

MONITORING SITE	DESCRIPTION	LOCATED ON TYPE	DATE FROM	DATE TO	NUMBER OF SAMPLES
A2R008Q01	WARMBAD DAM ON BUFFELS SPRUIT: NEAR DAM WALL	Dam / Reservoir	18/02/1976	22/01/2004	221
A2R009Q01	ROODEPLAAT DAM ON PIENAARS RIVER: NEAR DAM WALL	Dam / Reservoir	14/03/1968	30/05/2005	7552
A2R012Q01	KLIPVOOR DAM ON PIENAARS RIVER: NEAR DAM WALL	Dam / Reservoir	05/03/1975	07/06/2005	1208
A2R016Q01	LEEUKRAAL DAM ON APIES RIVER: NEAR DAM WALL	Dam / Reservoir	01/05/1985	10/05/2005	693
D4N783Q01	BOREHOLE NEAR SIHEN USED FOR PURIFICATION WORKS	Borehole			0

TABLE 8-4: DWAF WATER QUALITY MONITORING SITES IN THE LOWER CROCODILE RIVER SUB-AREA

MONITORING SITE	DESCRIPTION	LOCATED ON TYPE	DATE FROM	DATE TO	NUMBER OF SAMPLES
A2H025Q01	CROCODILE RIVER AT HARDEKOOLBULT	Rivers	28/09/1971	04/06/1997	338
A2H037Q01	CROCODILE RIVER AT BUFFELSHOEK	Rivers	24/01/1985	04/04/1991	119
A2H059Q01	CROCODILE RIVER AT VAALKOP/ATLANTA	Rivers	07/02/1985	17/05/2005	775
A2H060Q01	CROCODILE RIVER AT NOOITGEDACHT	Rivers	29/03/1984	17/05/2005	973
A2H116Q01	PAUL HUGO DAM ON CROCODILE RIVER: DOWN STREAM WEIR	Rivers	07/12/1989	18/05/2005	458

9 THE RESERVE REQUIREMENTS

As mentioned in the ISP (Report No. P WMA 03/000/00/0303), it is important to optimise the use of water to stimulate economic growth in the area, and to ensure that the economic growth does not compromise the health of the environment. The National Water Act (Act 36 of 1998) makes specific reference to the importance of natural riverine ecosystems and their role in supporting all forms of life. The need for the Reserve (basic human needs and ecological water requirements) has been promulgated to reflect this importance. As part of the ISP study, a Desktop Reserve Study has been conducted for the whole catchment. This desktop level ecological water requirement flow regime was then used to determine the available yield and the yield balance in the whole Crocodile River (West) Catchment as has been reflected in the NWRS. The preliminary desktop Reserve requirements for the Crocodile (West) River catchment are shown in **Table 9-1**.

TABLE 9-1: DESKTOP RESERVE REQUIREMENTS AS DETERMINED IN 1999

SUB-AREA	NATURAL MAR ($10^6m^3/a$)	RESERVE REQUIREMENTS ($10^6m^3/a$)	RESERVE REQUIREMENTS AS A % OF NATURAL MAR
Apies/Pienaars	142	34	24
Upper Crocodile	253	57	23
Elands	113	15	13
Lower Crocodile	138	25	18
Total	*646*	*131*	*20*

Source: Crocodile West and Marico Water Management Area: Overview of Water Resources Availability and Utilisation, Report number P WMA06000/00/0203)

9.1 Preliminary Reserve Determination Studies completed since October 1999

Table 9-2 show the Reserve determination studies completed in the Crocodile (West) River catchment. The Upper Crocodile River sub-area was used as a testing site to develop Resource Directed Measures (RDM) methodologies in 1999. Three key sites were identified and rapid Reserve determinations for a single recommended ecological category were conducted upstream and downstream of Roodeplaat Dam. A groundwater component as well as a wetland was included. The Directorate National Water Resource Planning and the Regional Office of the North West Province conducted higher Reserve Determination Studies for the Apies/Pienaars River sub-area.

TABLE 9-2: HISTORIC IFR AND RESERVE DETERMINATION STUDIES IN THE CROCODILE (WEST) RIVER CATCHMENT

YEAR COMPLETED	LOCATION OF STUDY SITES	COMPONENT	LEVEL OF CONFIDENCE IN RESULTS
1999	Upstream of Roodeplaat Dam (RPD) Downstream of RPD Wetland Catchment are related to surface water sites Upstream and downstream of RPD	River River Wetland Groundwater River Quality	Rapid level 3 Rapid level 3 Rapid Rapid Rapid
1999	All quaternary catchments	River	Desktop level (WSAM)
2003	Pienaars River Apies River Tolwane River Plat River Kutswane River Rietspruit	River River River River River River	Intermediate Intermediate Intermediate Rapid level 3 Rapid level 3 Rapid level 3

The Resource Directed Measures Directorate of the DWAF conducts ad-hoc Reserve determination studies at a rapid or higher level as part of the licensing process. **Table 9-3** provides a summary of the studies conducted since the implementation of Chapter 3 of the National Water Act in October 1999.

TABLE 9-3: AD HOC PRELIMINARY RESERVE DETERMINATIONS (RAPID LEVEL AND HIGHER) CONDUCTED IN THE CROCODILE RIVER (WEST) CATCHMENT

QUATERNARY CATCHMENT	RESOURCE NAME	COMPONENT	LEVEL OF CONFIDENCE*	DATE OF APPROVAL
A21K	Brakspruit-Sterkstroom	River	Rapid 1	2001
A21K	Sterkstroom	River	Rapid 1	2001
A22A	Elands River	River	Rapid 1	2001
A22B	Koster River	River	Rapid 1	2001
A22F	Elands River	River	Rapid 3	2001
A22H	Hex	River	Rapid 1	2001
A23A	Pienaars	River	Rapid 1	2001
A23A	Pienaars	River	Rapid 1	2001

Note: * Level of confidence of these studies to be confirmed with the RDM Directorate

Preliminary groundwater Reserve studies were conducted in a limited number of quaternary catchments in the Crocodile (West) River catchment.

10 SYSTEM MODELLING AND OPERATIONAL MANAGEMENT

System Analysis studies for the Crocodile (West) River catchment was completed in 1992 as part of the Crocodile River (Western Transvaal) Catchment Study. The following reports were produced: System Analysis of the Upper Crocodile River Sub-system (Report No. PA200/00/1892), Stelselontleding van die Elandsrivier-substelsel (Report No. PA200/00/2092) and System Analysis of the Pienaars River Sub-system (Report No. PA200/00/1992). Results from these studies were used in the Water Resources Situation Assessment Study (Report No. P WMA03000/00/0301), Overview of Water Resources Availability and Utilisation Study (Report number P WMA06000/00/0203) and the Internal Strategic Perspective (Report No. P WMA 03/000/00/0303). The system analysis of the Apies/Pienaars Sub-area was updated in 2003 as part of the Development of a Strategic Water Management Plan for the Apies-Pienaars River Catchment Study.

10.1 Upper Crocodile River Sub-area

The firm yields of Hartbeespoort and Roodekopjes Dams are augmented by urban return flows and were determined to be 155.7 million m^3 and 26.3 million m^3 respectively. The System Analysis of the Upper Crocodile River System study determined the yield of Hartbeespoort Dam, based on the 1987 development level, as 155.7 million m^3. New information on crop patterns resulted in a revision of the irrigation demands upstream of Hartbeespoort Dam with an associated drop in the yield of Hartbeespoort Dam to 146 million m^3.

The firm yields, based on the 1987 development level, of Buffelspoort and Rietvlei Dams were determined to be 32 million m^3 and 14.7 million m^3 respectively. Since 1987 the capacity of the purification works has been increased and the water requirement has increased from 9.8 million m^3 to 15.5 million m^3 per annum.

The firm yields for the dams in the Upper Crocodile River sub-area as well as the operating rules are shown in **Table 10-1**. The seasonal distribution of water requirements is shown in

Table 10-2.

TABLE 10-1: YIELD OF RESERVOIRS IN THE UPPER CROCODILE RIVER SUB-AREA

RESERVOIR	NET CAPACITY (10^6m^3)	YIELD (10^6m^3)	WATER USE	OPERATING RULES
Rietvlei	12.5	14.7	Domestic	Dam can be drawn down to DSL. Compensation releases has higher priority than Tshwane municipal demand
Hartbeespoort	198	146.0*	Irrigation, domestic	Dam can be drawn down to DSL. Priorities: 1 – Irrigators using "Old furrows", 2 – urban users, 3 – irrigators using government channels
Roodekopjes	102.5	26.3	Irrigation	Dam can be drawn down to DSL.
Buffelspoort	10	3.2	Irrigation	Irrigators supplied with full quota if dam spills twice a year otherwise compensation quota is supplied and remaining quota restricted Compensation quota supplied if dam capacity is above 5% of FSC and remaining quota is supplied (in part) if capacity is above 16% of FSC

Note: * Reduced from 155.7 million m^3

(Source: System Analysis of the Upper Crocodile River Sub-system, Report No. PA200/00/1892)

TABLE 10-2: SEASONAL DISTRIBUTION OF WATER REQUIREMENTS IN THE UPPER CROCODILE RIVER SUB-AREA(%)

RESERVOIR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Rietvlei	9.69	7.85	8.20	7.89	6.38	5.78	4.97	9.02	7.39	8.82	11.15	12.86
Hartbeespoort	8.44	11.75	7.62	8.34	17.74	11.19	2.78	0.92	7.85	6.19	7.62	9.56
Roodekopjes	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33	8.33
Buffelspoort	11.70	10.90	9.80	6.70	5.90	5.00	6.00	6.40	7.30	6.90	10.40	13.00

10.2 Elands River Sub-area

The firm yields of the dams in the Elands River Sub-area were determined as part of the Stelselontleding van die Elandsrivier-substelsel and are listed in **Table 10-3**.

TABLE 10-3: YIELD OF RESERVOIRS IN THE ELANDS RIVER SUB-AREA

RESERVOIR	NET CAPACITY (10^6m^3)	YIELD (10^6m^3)	WATER USE	OPERATING RULES
Swartruggens	0.25	0.4	Domestic	
Lindleyspoort	14.5	3.0	Irrigation	
Koster	13	1.1	Irrigation, Domestic	Irrigators can draw dam down to 10% of FSC
Mankwe	4	unknown	Domestic	
Olifantsnek	13.5	2.0	Irrigation	
Vaalkop	56.1	15.4	Mining, Domestic, Irrigation	Irrigators can draw dam down to 10% of FSC
Bospoort	18	1.9	Domestic	

(Source: Stelselontleding van die Elandsrivier-substelsel, Report No. PA200/00/2092)

10.3 Apies/Pienaars River Sub-area

The firm yields of the dams in the Apies/Pienaars River Sub-area were determined as part of the System Analysis of the Pienaars River Sub-system Study and are listed in **Table 10-4**.

The system analysis of the Development of a Strategic Water Management Plan for the Apies-Pienaars River Catchment Study followed an excess yield approach. Excess yield was defined as the additional firm yield that can be abstracted from the Apies-Pienaars River system after giving priority to existing in-basin water requirements and without adversely affecting the water supply to these users and were determined for the Roodeplaat Dam, at gauging site A2H061 in the Apies River and for the Klipvoor Dam. The excess yields were found to be 4.5 million m^3 at Roodeplaat Dam and 7 million m^3 at gauging site A2H061 in the Apies River for 2000 development levels. No excess yield was available at Klipvoor Dam (2000 development levels).

TABLE 10-4: YIELD OF RESERVOIRS IN THE APIES/PIENAARS RIVER SUB-AREA

RESERVOIR	NET CAPACITY (10^6m^3)	YIELD (10^6m^3)	WATER USE
Bospoort	18	1.9	Domestic
Roodeplaat	43.5	21.3	Irrigation, Domestic
Bon Accord	4.5	18	Irrigation
Leeukraal	0.5		Domestic
Warmbaths Old	0.5	1	Domestic
Warmbaths New	8		Domestic
Nooitgedacht	1.5		Recreation
Klipvoor	47	53.3	Irrigation

(Source: System Analysis of the Pienaars River Sub-system, Report No. PA200/00/1992)

10.4 Lower Crocodile River Sub-area

The net capacity of the Bierspruit Dam was obtained from the WRSAS and is given in **Table 10-5**. The firm yield for this dam is unknown.

TABLE 10-5: YIELD OF RESERVOIRS IN THE LOWER CROCODILE RIVER SUB-AREA

RESERVOIR	NET CAPACITY (10^6m^3)	YIELD (10^6m^3)	WATER USE
Bierspruit	3.5	unknown	Irrigation

(Source: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301)

11 POTENTIAL IMPACTS OF CLIMATE CHANGE ON WATER USAGE AND SCHEME YIELDS

Scenarios emanating from earlier studies of climate change have often produced controversial results with different results and trends being produced for the same areas. Results associated with climate change scenarios must be viewed within the context of a rapidly emerging science for which noticeable measurements and amounts of evidence are increasing rapidly. Particularly significant is the increased rate of progress made in the last four years to gather and share more information and research results. This has served to improve climate change models and the calibrations thereof. Confidence in the models has increased but continued research and data collection is essential to refine results and adapt them to accommodate the increasing volume of new information. Discussions with Prof R.E. Schulze, (pers com., 2005) Project leader of a recently completed project titled "Climate Change and Water Resources in South Africa" have served to highlight the most recent findings regarding possible climate change trends in South Africa, some of which may be of relevance to the Crocodile (West) study area. The project was funded by the Water Research Commission (report K5/1430). A consortium representing four Universities, namely the University of KwaZulu Natal, the University of Cape Town, the University of the Witwatersrand and the University of Pretoria conducted the work. Prof Schulze emphasized that while the climate change projections from the various universities differed in terms of magnitude as a result of the range of models and scenarios used, most models, unlike previous studies, now pointed towards similar trends for similar areas of the country. Of particular relevance to the Crocodile (West) study are the regional trends in the Limpopo Province, the local trends in the Crocodile (West) river system and the trends in areas further a field (e.g. Lesotho) from which imported water is obtained.

The most noticeable of the similar trends produced by the various climate change models is that most of the Limpopo Province is likely to experience a decrease in the mean annual runoff. The mean annual rainfall will not necessarily alter significantly but the total number of individual rainfall events could decrease, and of these a relatively larger proportion could have a higher intensity of rainfall compared to the typical events that have been observed in the past. Associated flash flood events could be significantly larger than the previously observed events but the increased time delay between individual events is expected to result in an overall decrease in the amount of natural runoff from the Limpopo Province.

From a design flood studies perspective, the local impacts in the Crocodile (West) catchment will probably be more pronounced in the south in terms of increased design flood expectations for all return periods while the northern part of the catchment will be less affected with a possibility that design flood amounts could even decrease in the extreme north for all return periods. With respect to water resources the yields of small dams (farm dams) can be expected to reduce as a result of the increased spacing between runoff events. The yields of larger dams could also be affected but the long-term impacts will be less significant in comparison to those of the minor dams.

The most noticeable change in terms of water requirements as affected by climate change will be the impact on irrigation needs. In the Crocodile (West) area the effects of the increased number of dry days between rainfall events will not be significantly offset by the fact that the relative number days with large amounts of rainfall will increase. Projected increases for irrigation water requirements as a result of climate change are in the region of ten percent.

The main difficulty in incorporating the above type of projections of climate change into water resource management studies at this stage is that, while consensus appears to be merging regarding the likely local trends in climate change (based on results from several models applied by four different Universities mentioned previously), uncertainty still exists regarding the reliability of the quantitative outputs of projections in local areas.

It is anticipated that the accuracy of regional projections based on climate change models for realistic scenarios will continue to improve with time from a quantitative perspective and that improvements in capability to perform projections for local areas will improve thereafter. The projected trends in the study imply that there is a need to examine the historical rainfall and flow data in an attempt to ascertain whether any of the trends from the climate change models are visible and can be verified at this stage.

Attempts to incorporate scenarios of climate change should be considered in future integrated water resource management efforts, but scenarios should be curtailed to realistic ranges commencing with projections based on detectable (if any) trends in the historical climatic and hydrological records. Developments in climate change modelling should be monitored and projections incorporated into the water resource studies if confidence in the magnitude of the projected trends achieves a level of accuracy that is deemed acceptable.

12 WATER CONSERVATION AND DEMAND MANAGEMENT (URBAN AND IRRIGATION)

The National Water Conservation and Demand Management (WCDM) Strategy is based on the following three principles:

1) Water institutions should strive to supply water efficiently and effectively, minimise water losses, and promote WCDM among their consumers.
2) Users should not waste water, and should strive to use it efficiently.
3) WCDM should be an integral part of water resources and water services planning.

WCDM is a strategy with conflicting results 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 users downstream of the major urban centers (Johannesburg and Tshwane) consist of return flows from these urban centers mainly. Effective WCDM practices will reduce these return flows with an associated reduction in available water resources. Schemes to augment the water transfers are costly and WCDM 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 (WRSAS) and should be addressed.

Table 12-1 summarises the water requirements for the Crocodile (West) River catchment and **Table 12-2** show the water available for use/re-use.

TABLE 12-1: WATER REQUIREMENTS

SUB-AREA	TOTAL LOCAL YIELD (10^6M^3)	WATER REQUIREMENTS (10^6M^3)					TOTAL WATER REQUIRE-MENTS
		IRRIGATION	URBAN	RURAL	MINING/ BULK	POWER GENE-RATION	
Upper Crocodile	336	208	292	5	38	13	556
Apies/Pienaars	186	41	211	7	6	15	280
Elands	86	32	23	10	48	0	113
Lower Crocodile	59	137	3	3	28	0	171
TOTAL	***667***	***418***	***529***	***25***	***120***	***28***	***1120***

(Source: National Water Resources Strategy)

TABLE 12-2: WATER AVAILABLE FOR USE/RE-USE

SUB-AREA	NATURAL MAR (10^6M^3)	YIELD (10^6M^3)		RETURN FLOW (10^6M^3)			TOTAL LOCAL YIELD (10^6M^3)
		SURFACE	GROUND	IRRIGATION	URBAN	MINING/ BULK	
Upper Crocodile	253	111	31	21	158	15	336
Apies/Pienaars	142	38	36	4	106	2	186
Elands	113	30	29	3	10	14	86
Lower Crocodile	138	7	29	14	1	8	59
TOTAL	***464***	***186***	***125***	***42***	***275***	***39***	***667***

(Source: National Water Resources Strategy)

As can be seen from **Table 12-1**, irrigation water requirements constitute 37% of the total water requirements. This sector is known for inefficient use (water losses on the Hartbeespoort Irrigation Scheme are estimated to be in the order of 50%). Addressing these losses will have a significant impact on the irrigation water requirements in the Upper Crocodile River sub-area.

Urban water requirements constitute 47% of the total water requirements and urban return flows contribute 41% of the available yield. Water conservation measures should also be concentrated on return flows from northern Johannesburg and Tshwane.

Bulk industrial and mining activities use a small portion of the total water supply and are considered to be reasonably efficient.

Local water resources in the Rustenburg area are under-utilised due to water quality problems specifically in Bospoort Dam, while water is imported from Vaalkop Dam via the Rand Water supply network. Poorly treated effluent return flows are the main contributor to the poor water quality. Mines in the vicinity of Bospoort Dam have expressed interest in utilising the poorly treated effluent return flows from Bospoort Dam instead of drawing water downstream from Vaalkop Dam. This will reduce the demand on Vaalkop Dam.

12.1 Proposed and implemented WCDM strategies

The Internal Strategic Perspective (Report No. P WMA 03/000/00/0303) identified 25 strategies for the Crocodile River catchment, within nine strategic areas. According to Strategy four (Water Conservation and Demand Management) the "broad Management Objective: is to make more efficient use of the existing available water resources in all water use sectors. This will enable the catchment management to "free up" additional water, which can possibly be put to beneficial use elsewhere in the catchment or can be used to meet the ecological water requirements in the river system". The Internal Strategic Perspective suggested that WCDM strategies should focus on areas/activities where return flows are insignificant, lost or wasted. The impact of WCDM must take cognisance of the dependence of water users on return flows as well as related water quality. The following were proposed:

1) Local resources must be used optimally before using water transferred from other catchments.
2) The Hartbeespoort Irrigation Scheme and urban use in the upper catchment should be targeted as top priorities for WCDM. Water savings are probably also possible in the Lower Crocodile River. The potential savings here need to be better understood.
3) The water use from Bospoort Dam and the Rustenburg area needs to be investigated from a WCDM perspective to strive towards the optimal use of local resources. The water quality aspects of the situation need to be investigated in parallel with the WCDM issue.

Rand Water completed the following studies: Investigative Phase of the Ekurhuleni Water Demand Management Project, Water Cycle Management in the Rand Water/ Gauteng area of supply and the Springs Pressure Management Study. These studies covered Alberton, Edenvale, Germiston, Kempton Park/Tembisa, Springs, Mogale, Mabopane, Ga-Rankuwa and the Winterveld. As part of the studies districts for zone management and pressure management were investigated, flows and pressures were logged, bulk water meters were audited for accuracy, installation, operation and suitability and recommendations were made for the implementation of management zones and pressure management. The recommendations were implemented in Tembisa. Recommendations for the other areas will be implemented in due course.

The water demand Strategy in the city of Tshwane Metropolitan Municipality was also obtained. Their focus is on measuring water use rather than water demand management.

13 CURRENT AND POTENTIAL WATER RE-USE

Water re-use in the Crocodile (West) River catchment consist of direct re-use (i.e. use of treated effluent) and indirect re-use of water (use of return flows). The main component at present is indirect re-use (use of return flows). As can be seen in **Table 13-1** return flows contributes 58%, 60%, 31% and 39% to the local yield in the Upper Crocodile River, Apies/Pienaars River, Elands River and Lower Crocodile River sub-areas respectively. At present the DWAF attempts to reduce discharges. This will have a detrimental effect on the water availability within the Crocodile (West) River catchment. Strategies to use return flow effectively would be more beneficial to water users within the catchment (refer to Section 12). According to the WRSAS such schemes include transferring water from downstream of Hartbeespoort to the Tshwane North/Mabopane area, increasing transfers from the Roodekopjes dam to Vaalkop for use by the mines and rural communities, and transferring water from the Roodeplaat Dam to KwaNdebele.

TABLE 13-1: CONTRIBUTION OF RETURN FLOW TO LOCAL YIELD

SUB-AREA	SURFACE AND GROUNDWATER CONTRIBUTION TO LOCAL YIELD (%)	RETURN FLOW CONTRIBUTION TO LOCAL YIELD (%)			
		IRRIGATION	URBAN	MINING/ BULK	TOTAL (%)
Upper Crocodile	42	6	47	4	58
Apies/Pienaars	40	2	57	1	60
Elands	69	3	12	16	31
Lower Crocodile	61	24	2	14	39

Direct re-use of water in the Crocodile (West) River catchment consist of the use of treated effluent at the power stations within the catchment. Kelvin Power Station uses on average 19 900 m^3 of treated effluent from the Johannesburg Northern Water Treatment Works. The Pretoria West and Rooiwal Power Stations are supplied with treated effluent from the Daspoort and Rooiwal sewage works respectively

Other present and potential water re-uses, including the use of water from mine dewatering at other industries, will be quantified during the information gathering process of the Crocodile (West) River catchment modelling study.

14 TRADING OF EXISTING ALLOCATIONS (ESPECIALLY UNUTILISED ALLOCATIONS)

Government has progressively adopted a more comprehensive and holistic approach to the planning of interventions to resolve problems of inadequate water availability, in line with the objectives of equitable and sustainable social and economic development (Crocodile West and Marico WMA Report). All possible solutions are investigated whenever there is a water shortage including re-allocations of water such as moving water from lower to higher benefit uses by trading water use authorisations.

TABLE 14-1: RECONCILIATION OF WATER REQUIREMENTS AND AVAILABLE WATER FOR 2000 (10^6M^3)

SUB-AREA	LOCAL YIELD	TRANSFERS IN	LOCAL REQUIREMENTS	TRANSFERS OUT	BALANCE
Upper Crocodile	186	182	280	87	1
Apies/Pienaars	336	279	556	17	42
Elands	86	71	113	24	20
Lower Crocodile	59	112	171	0	0
Total	***667***	***644***	***1120***	***128***	***63***

(Source: National Water Resources Strategy)

As can be seen in **Table 14-1**, no shortages existed in the Crocodile (West) River catchment in 2000. Trading of allocations was therefore not considered in any of the previous studies conducted in the Crocodile (West) River catchment. Differences in the allocated abstraction volumes and capacities exist at Cullinan, Temba, Klipdrif and Magalies abstraction points as can be seen in **Table 14-2**. **Table 14-3** shows the differences in allocated and actual irrigated areas.

TABLE 14-2: DIFFERENCES IN ALLOCATIONS AND ABSTRACTION CAPACITY

OPERATED BY	NAME OF ABSTRACTION SITE	ABSTRACT FROM	SUPPLY TO	CAPACITY	ALLOCATED VOLUME
Magalies Water	Cullinan Plant	Premier Mine Dam (Olifants WMA)	Rayton, Zonderwater, Cullinan	16 Ml/d	22.2 Ml/d
Magalies Water	Temba	Leeuwkraal Dam (Apies River)	Moretele Water Supply Scheme	20 Ml/d	30.1 Ml/d
Magalies Water	Klipdrift	Roodeplaat Dam	Pienaarsrivier, Bela Bela, Modimolle (Limpopo WMA)	18 Ml/d	20 Ml/d
Magalies Water	Vaalkop	Vaalkop Dam (supplemented from Roodekopjes and Hartbeespoort)	Thabazimbi, Disake, Mabeskraal, Modikwe, Rustenburg	120 Ml/d	(106.3 Ml/d – before upgrade)

(Source: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301)

TABLE 14-3: DIFFERENCES IN ALLOCATED AND ACTUAL IRRIGATION AREAS

SCHEME	SUPPLY SOURCE	SCHEDULED AREA (HA)	IRRIGATED AREA (HA)
Buffelspoort GWS	Buffelspoort Dam	1 938	970
Middelkraal GWS	Middelkraal Dam	103	25

(Source: Water Resources Situation Assessment Study, Report No. P WMA03000/00/0301)

15 POTENTIAL SURFACE AND GROUNDWATER SCHEMES, BOTH LOCAL AND TRANSFER

According to strategy 7.1 (Infrastructure Development) of the ISP (Report No. P WMA 03/000/00/0303), local surface water resource development in the Crocodile (West) River catchment has reached its maximum potential. No further viable major developments in this regard are expected in future. Local water resources, including natural runoff and return flow, are not fully utilised while large quantities of water is imported from the Upper Vaal catchment. Local and District Municipalities should develop conveyance infrastructure to make use of the local resources. The following potential schemes were identified:

- To optimise the utilisation of the allocation of the Madibeng Local Municipality, a water treatment works should be constructed below Hartbeespoort Dam to supply new and existing mines between Brits and Rustenburg. A major pipeline will have to be installed. The pipeline could also be linked to the groundwater that is pumped out of the mines in their dewatering processes to supply water to settlements such as Majakaneng, Modderspruit/Bapong and the farmers between Brits and Rustenburg.
- Magalies Water should increase the canal capacity between Roodekopjes and Vaalkop dams to purify more water for use at Rustenburg and rural settlements and mines in the Pilansberg area.
- Additional transfers from the Vaal River System should not be considered unless the local resources, including natural runoff and return flows, are used optimal and WCDM measures are successfully implemented.
- The yield of the Klipvoor Dam could be harnessed to supply water to the surrounding rural settlements. Additionally the water could be pumped to Tshwane to augment the urban water supply.
- Water can be transferred from Roodeplaat Dam to the Western Highveld (former KwaNdebele) area in the Olifants WMA.

16 POTENTIAL DESALINATION SCHEMES

At present the DWAF attempts to reduce discharges. Organisations such as the Kelvin Power Station therefore are implementing desalination plants to treat water for re-use in their operations.

The re-use of return flows will also result in an increase in the salt load of the Crocodile (West) River. Desalination should be considered to solve the potential problems. As mentioned in Section 8, there are no severe water quality problems based on TDS in the Crocodile (West) River. Desalination schemes were therefore not addressed in any of the previous studies.

17 OTHER POTENTIAL TRANSFER SCHEMES

Of the utilisable water resources in the Crocodile (West) River catchment, 49% consist of transferred water and 27% is return flow from irrigation, urban mining and bulk industrial water use. As mentioned, Rand Water imports water from the Upper Vaal WMA to the Crocodile River (West) Catchment for urban, industrial and mining use. Water is also imported to Cullinan from the Olifants River catchment for urban use and for use on the Premier Diamond mine. Since a major part of the water used within the catchment are imported already and the local resources are under-utilised, attention should rather be given to optimising the use of local resources (including groundwater) and return flows as discussed in Section 15.

18 CONCLUSIONS

The reconciliation of the water requirements and available water (surface and ground water) for the year 2000 is shown in **Table 18-1**. As can be seen, 42 million m^3 is available in the Upper Crocodile River Sub-area, 1 million m^3 in the Apies/Pienaars Sub-area and 20 million m^3 in the Elands River Sub-area. All available water resources in the Lower Crocodile River Sub-area are fully used. A high growth in water requirements is expected in the Upper Crocodile, Apies/Pienaars and Elands River Sub-areas. WCDM and the optimum use of return flows will therefore become more critical to postpone additional costly water augmentation schemes.

TABLE 18-1: RECONCILIATION OF WATER REQUIREMENTS AND AVAILABLE WATER FOR THE YEAR 2000 ($10^6 m^3$)

SUB-AREA	TOTAL LOCAL YIELD	TRANSFERS IN	TOTAL AVAILABLE	TOTAL WATER REQUIREMENTS	TRANSFERS OUT	BALANCE
Upper Crocodile	336	279	615	556	17	42
Apies/Pienaars	186	182	368	280	87	1
Elands	86	71	157	113	24	20
Lower Crocodile	59	112	171	171	0	0
TOTAL	***667***	***667***	***1311***	***1120***	***128***	***63***

The latest Water Resources Study for the Crocodile River (West) Catchment was completed in 1992. Results from this study were used in the Water Resources Situation Assessment Study (Report No. P WMA03000/00/0301), Overview of Water Resources Availability and Utilisation Study (Report number P WMA06000/00/0203), the Internal Strategic Perspective (Report No. P WMA 03/000/00/0303) as well as in the Surface Water Resources of South Africa Study (WR90). The Development of a Strategic Water Management Plan for the Apies-Pienaars River Catchment Study was completed in 2003. The WRSM2000 model was not re-calibrated. It was only used to extend the simulated runoff time series up to 1998. The water requirements and availability data used in these studies were based on desktop or reconnaissance level assessments of available resources and water requirements that existed in 1995.

The Crocodile (West) River Return Flow Analysis Study was completed in 2004. As part of this study an urban/industrial as well as an irrigation sector return model linking water requirements with return flows were developed. The availability, format and spatial distribution of reliable water requirement and return flow data proved to be a considerable problem for all water use sectors. For the irrigation sector no return flow data exists. The water requirement and return flow data needs to be updated and verified.

Additional information from studies currently being conducted in the Crocodile (West) River Catchment will be included in the final report if it become available towards the end of the study.

Appendix A

LIST OF PREVIOUS STUDIES

APPENDIX A: LIST OF PREVIOUS STUDIES

Anglo Platinum Limited and Lonmin Platinum. Final draft March 2008. Pre-Feasibility Study for the supply of Industrial Grade Water between Hartbeespoort Dam and Lephalale. Report by Bigen Africa Contract No. 930/02/M

Bureau de Recherches Geologiques et Miniere 1977. Groundwater study in the Crocodile River Area. Contract W6018, Department of Water Affairs, RSA.

City Council of Pretoria. 1982. Northern Pretoria areas water supply scheme. Report No: A230/xx/0282

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Departement van Nasionale Gesondheid en Bevolkingsontwikkeling. 1987. Sosio-ekonomiese streekprofiel: Beplanningstreek 24 Noordwes-Transvaal. Report No: A220/xx/0187J-24-1(87)

Department of Water Affairs and Forestry. 1971. Vaalkopdam: Gedenkprogram. Report No: A210/00/0171

Department of Water Affairs and Forestry. 1975. Planning Study Bophutatswana – Summary (Volume 1) & Data Analysis (Volume 2). Report by Stewart, Sviridov & Olivier. Report No: A200/xx/0182 (B73/1/1)

Department of Water Affairs and Forestry. 1975. Temba and environs: water supply. Report No: A230/00/0175

Department of Water Affairs and Forestry. 1976. Temba watersuiweringswerke. Report No: A230/WQ/0076

Department of Water Affairs and Forestry. 1978. Watervoorsiening aan Temba en Babelegi. Report No: A230/00/0178

Department of Water Affairs and Forestry. 1979. Preliminary report on the augmentation of the water supply to the Temba township and the Babelegi industrial area. Report by M.M.Carter & Partners. Report No: A230/xx/0179

Department of Water Affairs and Forestry. 1979. Chemical control of the Water Hyacinth on the Hartbeespoortdam. Report by Scott, Ashton, Steyn. Report No: A210/xx/0179

Department of Water Affairs and Forestry. 1979. Chlorides in Hartbeespoort Dam. Report No: A210/WQ/0079

Department of Water Affairs and Forestry. 1979. Chlorides in Hartbeespoort Dam: follow up. Report No: A210/WQ/0079

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