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DEPARTMENT: WATER AFFAIRS AND FORESTRY

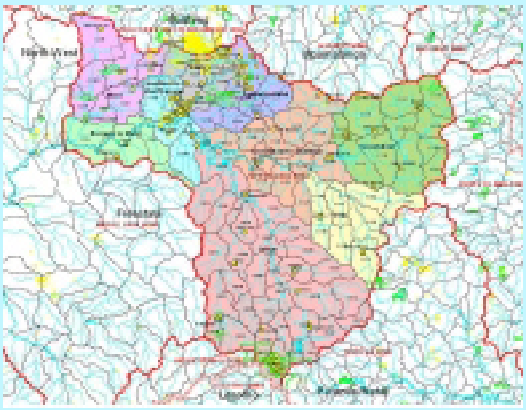
Directorate: Water Resources Planning

UPPER VAAL WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT
FINAL: JULY 2002

VAAL DAM



STERKFONTEIN DAM OUTLET WITH CRUMP WEIR

COMPILED BY:

STEWART SCOTT

Title:	**Upper Vaal Water Management Area: Water Resources Situation Assessment – Main Report – Volume 1 of 3**
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UPPER VAAL WATER MANAGEMENT AREA

WATER RESOURCES SITUATION ASSESSMENT

MAIN REPORT

OVERVIEW

The water resources of South Africa are vital to the health and prosperity of its people, the sustenance of its natural heritage and to its economic development. Water is a national resource that belongs to all the people who should therefore have equal access to it, and although the resource is renewable, it is finite and distributed unevenly both spatially and temporally. The water also occurs in many forms that are all part of a unitary and inter-dependent cycle.

The National Government has overall responsibility for and authority over the nation's water resources and their use, including the equitable allocation of water for beneficial and sustainable use, the redistribution of water and international water matters. The protection of the quality of water resources is also necessary to ensure sustainability of the nation's water resources in the interests of all water users. This requires integrated management of all aspects of water resources and, where appropriate, the delegation of management functions to a regional or catchment level where all persons can have representative participation.

This report is based on a desktop or reconnaissance level assessment of the available water resources and quality and also patterns of water requirements that existed during 1995 in the Upper Vaal Water Management Area, which occupies portions of the Gauteng, Free State, Mpumalanga and North-West Provinces. The report does not address the water requirements beyond 1995 but does provide estimates of the utilisable potential of the water resources after so-called full development of these resources, as this can be envisaged at present. A separate national study has been conducted to consider future scenarios of land use and water requirements and the effects of water conservation and demand measures on these requirements and to identify alternative water resource developments and water transfers that will reconcile these requirements with the supplies.

The main purpose of this report is to highlight the principal water related issues, to identify existing water shortages, to provide information that is necessary to formulate future strategies such as the national water resources strategy and catchment management strategies and to stimulate initial actions to ensure the best overall sustainable utilisation of the water, with minimal waste and harm to the aquatic ecosystems.

The National Water Act, 1998 (Act No. 36 of 1998), requires that a national water resources strategy (NWRS) be established that sets out the policies, strategies, objectives, plans, guidelines and procedures and the institutional arrangements for the protection, use, development, conservation, management and control of water resources for the country as a whole, and establish and define the boundaries of water management areas taking into account catchment boundaries, socio-economic development patterns, efficiency considerations and communal interests. This strategy is binding on all authorities and institutions exercising powers or performing duties under the National Water Act.

The national water resources strategy will, *inter alia*, provide for at least the requirements of the Reserve, international rights and obligations, actions required to meet projected future water needs and water use of strategic importance. Furthermore, it will contain estimates of present and future water requirements, set out principles relating to water conservation and demand management, give the total quantity of water available within each water management area, state the surpluses or deficits, provide for inter-catchment water transfers required to balance the supply with the requirements and state the objectives in respect of water quality to be achieved through the classification system to be provided for the water resources.

A catchment management agency established in terms of the National Water Act, 1998 (Act No. 36 of 1998), must progressively develop a catchment management strategy, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of water resources within its water management area. Such a strategy must not be in conflict with the national water resources strategy, must take into account the class of water resource and resource quality objectives, the requirements of the Reserve and any applicable international obligations, the geology, land use, climate, vegetation and waterworks within its water management area. The strategy shall contain water allocation plans, take account of any relevant national or regional plans prepared in terms of any other law; enable public participation and take into account the needs and expectations of existing and potential water users. This report provides the initial baseline data that can be used by the catchment management agency to develop its catchment management strategy, objectives, plans, guidelines and procedures for the protection, use, development, conservation, management and control of the water resources in its area of responsibility.

The national water resources strategy will be reviewed and published at five-yearly intervals, with Addenda being issued in the interim, when required. The strategy will give guidance to the Department of Water Affairs and Forestry in respect of the protection, use, development, conservation, management and control of water resources and will also serve as a very important means of communication with all the stakeholders. The overall responsibility for the compilation of the national water resources strategy rests with the Directorate: Strategic Planning of the Department of Water Affairs and Forestry, while the Directorate: Water Resources Planning is responsible for:

- Identification of water resources to meet particular requirements.
- Identification of international rights and obligations.
- Identification of water use of strategic importance.
- Calculating water balances.
- Developing plans to reconcile water requirements and resources.

A number of inter-related studies have therefore been included by the Directorate: Water Resources Planning of the Department of Water Affairs and Forestry in the national future scenario study that will supply the information required for formulating the strategies, as given above.

The main objective of this water resources situation assessment has been to determine the water requirements of all the user sectors (including those of the riverine and estuarine ecosystems) and the ability of the available water resources to supply these requirements. However, other aspects such as water quality, legal and institutional aspects, macro-economics and existing infrastructure have also been addressed. This report outlines the 1995 water resources situation, using information obtained from previous study reports to identify the main water related issues of concern. The large body of information available in the Department of Water Affairs and Forestry and from other sources has also been collated and presented in this assessment. This has been collected on a catchment basis at the quaternary catchment level of resolution. The levels of confidence that can be attached to the data on land use, water requirements and surface water and groundwater resources have however, been found to vary considerably because of the desktop nature of the study. This has therefore also provided a basis for identifying where improvements need to be made to the data in future and to prioritise such studies. It is also important to note that where information on land and water use and sensitive ecosystems is not given, this could be due to the fact that it does not exist or because it has not been documented in a format or source that is readily accessible.

The larger inter-related studies that have supported this water resources situation assessment have been the following:

- Development of a computerised database

  Data collected in this water resources situation assessment has been used to populate the database of the Chief Directorate: Planning of the Department of Water Affairs and Forestry. The database design has mainly been based on the requirements of a water balance model that has been developed to compare the water requirements with the available water resources.

- Demographic study.

  An important part in the development of the national water resources strategy is the future scenarios. Since water use is mainly driven by the requirements of the various socio-economic groupings of the population, a national demographic study was initiated. An important part of the study was an estimate of the base year (1995) population. The study has also associated the population with defined water user categories to facilitate estimating existing and future water requirements. These categories have *inter alia* been defined on the basis of reports on urban water supplies and questionnaires completed by local authorities.

- Macro-economic study

  Economic activity and its effects on the spatial distribution of the population and vice versa is an important determinant of water use. With the ever-increasing need for water for domestic use and protection of the water resources, water availability is already becoming a limiting factor in various regions of the country. The economic viability of continuing to supply water for existing sectors, such as irrigation and also of expanding such activities to satisfy socio-economic aspirations will need careful consideration. A national macro-economic study has therefore been undertaken to provide basic economic data for use in the demographic study and to provide macro-economic overviews for each water management area.

- Formulation and development of a water situation assessment model

  The primary function of the water situation assessment model is to reconcile water supply and water requirements by quantifying the surplus or deficit per catchment area. Water balances are compiled from the quaternary catchment level of resolution of the data, which can then be aggregated to suite any desired predetermined catchment boundaries. The water situation assessment model is nevertheless only a coarse planning tool and does not replace the detailed hydrological studies that are required for basin studies or project investigations.

- Water requirements for the ecological component of the Reserve

  The National Water Act, 1998 (Act No. 36 of 1998) requires that water be provided for the Reserve, which is the quantity and quality of water required to satisfy basic human needs and to protect the aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant resource. The ecological sensitivity and importance of the rivers in South Africa and the present ecological status class was therefore established at the quaternary catchment level of resolution, using available data and local knowledge. At the same time the results of previous field assessments of the water requirements of the aquatic ecosystems at selected sites in South Africa were used in a separate study to develop a model for estimating the water required for the ecological component of the Reserve for various ecological management classes that correspond to those determined previously for the rivers throughout the country.

PREFACE

The Orange/Vaal River Basin extends over four countries, covering an area of 964 000 km². Almost 600 000 km² of the basin falls within South Africa, mainly covering the central part, and which represents nearly half of the surface area of the country. It incorporates the whole of Lesotho (where the main river is known as the Senqu), reaches to the southern part of Botswana, and drains most of the southern half of Namibia. From its origin in the highlands of Lesotho, the Orange River passes through different landscapes and highly varied climatic regions on its 2 300 km journey to the Atlantic Ocean. As a consequence, runoff from the different sub-catchments in the basin is disproportionate to the size of the catchment areas, as illustrated by the fact that approximately 40% of the MAR of the Orange River Basin is contributed by catchments in Lesotho which cover only 4% of the land area of the basin. This is in contrast to the downstream desert reaches of the Orange River where evaporation losses are in excess of the runoff from local tributaries.

The Vaal River forms the main tributary to the Orange River. It originates on the plateau west of the Drakensberg escarpment and drains much of the central highveld of South Africa.

Within South Africa, the Orange/Vaal River Basin includes five of the 19 Water Management Areas (WMA). These are the Upper Vaal, Middle Vaal, Lower Vaal, Upper Orange and Lower Orange WMAs. The small portion of the Crocodile West and Marico WMA that falls within the Orange/Vaal River Basin has no significant effect on the water resources situation of the basin. Great differences occur with respect to the hydro-meteorological characteristics as well as nature and level of development in these WMAs. The Vaal River is probably the most developed and regulated river in Southern Africa, while some of the largest dams in Africa have been built in Lesotho and on the main stem of the Orange River. Although linked together by the natural watercourses, a particular characteristic of the Orange/Vaal WMAs is the extensive intercatchment transfer of water within WMAs as well as interbasin transfers between these and other adjoining WMAs. The relative location of the Orange/Vaal WMAs together with a schematic representation of the main transfers of water, are given in **Diagram 1**.

An additional five WMAs are directly linked to the Orange River Basin (and the Orange/Vaal WMAs) through interbasin transfers, while the impacts of water resource management within the basin also indirectly extend to other WMAs and to the neighbouring countries of South Africa outside the basin (Zimbabwe, Swaziland and Mozambique). The main interdependencies among the Orange/Vaal (and other interlinked) WMAs relate to flow volume, flow regime and water quality.

A summarised description of the main features of each of the Orange/Vaal WMAs, effecting other WMAs and countries, follows:

Diagram 1: Layout of Orange/Vaal River Basin

Upper Vaal WMA

This is the most developed, industrialised and populous of the Orange/Vaal WMAs. From a water resource management perspective it is a pivotal WMA in the country. Large quantities of water are transferred into the WMA from the Usutu to Mhlatuze and the Thukela WMAs as well as from the Senqu (Orange) River in Lesotho. Similarly large quantities of water are released along the Vaal River to the Middle Vaal and Lower Vaal WMAs and are also transferred to the Crocodile West and Marico, and the Olifants WMAs.

Middle Vaal WMA

The Middle Vaal WMA is dependant on water releases from the Upper Vaal WMA for meeting the bulk of the water requirements by the urban, mining and industrial sectors within its area of jurisdiction, with local resources mainly used for irrigation and smaller towns. Water is also transferred via the Vaal River through this WMA, from the Upper Vaal WMA to the Lower Vaal WMA. Water quality in the Vaal River is strongly influenced by usage and management practices in the Upper Vaal WMA.

Lower Vaal WMA

Over 90% of the water used in the Lower Vaal WMA is sourced through releases from the Upper Vaal WMA and from Bloemhof Dam on the Vaal River, on the border with the Middle Vaal WMA. About 80% of the water use in this WMA is for irrigation (mainly at the Vaalharts irrigation scheme). Essentially only irrigation return flows, which are of high salinity, and unregulated flood flows from the Vaal River, reach the confluence with the Orange River.

Upper Orange WMA

Close to 60% of the water resources generally associated with the Upper Orange WMA, originate from the Senqu River in Lesotho. Developments in Lesotho can therefore have a significant impact on the Upper Orange WMA. The two largest storage reservoirs in South Africa, created by the Gariep and Vanderkloof Dams, are located in this WMA. Two thirds of the total yield realised by the dams in Lesotho and in the Upper Orange WMA together, is transferred to the Upper Vaal and Fish to Tsitsikamma WMAs, and released to the Lower Orange WMA as well as for use by Namibia.

Lower Orange WMA

Water requirements in the Lower Orange WMA are far in excess of the yield available from resources within the WMA, and about 95% are supplied by water released from the Upper Orange WMA. High evaporation losses from the Orange River, which are of the same order, as the water requirements in the WMA, are characteristic of the region. Namibia also abstracts water from the Orange River.

Summarising remarks

From a national point of view, the Orange/Vaal River system can be regarded as the most important river system in South Africa, not only because of its size and strategic central location, but because it sustains about half the economic production and a large proportion of the population of the country. It is evident that water resource management in the Orange/Vaal WMAs should be well co-ordinated and be viewed in an integrated systems context. Therefore none of the water resources situation assessment reports for the five WMAs in the Orange/Vaal River Basin should be interpreted in isolation, but rather as part of a suite of reports. Management of water resources in the basin should also be within the framework of the Orange-Senqu River Commission (ORASECOM) recently established by South Africa, Lesotho, Botswana and Namibia. Furthermore, impacts on water resources in other WMAs as well as in the neighbouring countries (other than the Orange co-basin countries), as a result of interbasin transfers, should also be of primary consideration in the management of the Orange/Vaal River Basin and river system.

The reader of this report is requested to take cognisance of the inter-relationships between the three Vaal WMA's, as set out in their respective WMA reports. The surplus yields passing from the Upper Vaal WMA has considerable bearing on the passage of water flowing through the Middle and Lower Vaal WMA's and further downstream to the Lower Orange WMA and influence the calculation of surplus yields that could be used for future development.

The report numbers for the four water management areas are as follows:

- Upper Vaal WMA: 08000/00/0101 (Stewart Scott).
- Middle Vaal WMA: 09000/00/0101 (Stewart Scott).
- Lower Vaal WMA: 10000/00/0101 (BKS).
- Lower Orange WMA: 14000/00/0101 (V3).

SYNOPSIS

1. Introduction

The National Water Act, 1998 (Act No. 36 of 1998) requires the Minister of the Department of Water Affairs and Forestry (DWAF) to establish a national water resource strategy for the protection, use, development, conservation, management and control of water resources. To enable the strategy to be established, information on the present and probable future situations regarding water requirements and water availability is required, that is, a national water resources situation assessment providing information on all the individual drainage basins in the country.

As a component of the National Water Resource Strategy, the Minister of DWAF has established water management areas and determined their boundaries. The National Water Act, 1998 (Act No. 36 of 1998) provides for the delegation of water resource management from central government to the regional or catchment level by establishing catchment management agencies. It is intended that the documents produced in this study and the national database should, in addition to contributing to the establishment of the National Water Resources Strategy, provide a tool for collaborative planning of water resources development and utilisation by the central government and the future catchment management agencies.

The study was carried out as a desktop exercise using data from reports, electronic databases (WR90) and data supplied by associated studies, local authorities and DWAF. The study considers conditions as they were in 1995.

2. Physical Features

The Upper Vaal Management Area (Upper Vaal WMA) is located upstream of the confluence of the Vaal and the Mooi rivers and extends to the headwaters of the Vaal, Klip, Wilge and Liebenbergsvlei rivers. It covers a catchment area of 55 565 km^2. This WMA includes the very important dams Vaal Dam, Grootdraai Dam and Sterkfontein Dam. It includes parts of Gauteng, Mpumalanga, Free State and North-West provinces.

The following table describes the key areas.

LOCATION OF KEY POINT			DESCRIPTION
PRIMARY CATCHMENT		QUATERNARY CATCHMENT NO.	
NO.	KEY AREA NAME AND POINT		
C	Wilge – C83M outlet	C81A-M, C82A-H,C83A-M	C8 Secondary catchment
	Klip – C13H outlet	C13A-H	C13 Tertiary catchment
	Grootdraai – C11L outlet	C11A-L	Grootdraai Dam
	Grootdraai to Vaal Dam – C12L outlet	C11M, C12A-L	Vaal Dam (together with C8)
	Suikerbosrand – C21G outlet	C21A-G	C21 Tertiary catchment
	Klip – C22E outlet	C22A-E	Klip River catchment
	Mooi – C23K outlet	C23D-K	Mooi River catchment
	Vaal Dam to Vaal Barrage – C22K outlet	C22F-K	Barrage catchment
	Barrage to Mooi	C23A-C, C23L	Remaining Vaal River catchment in the Upper Vaal WMA

The Vaal catchment slopes gently from an elevation of about 1 800 m in the east to 1 450 m in the west in the vicinity of the Vaal Barrage, with some steep areas in the headwaters of the Wilge tributary on the south-eastern border with the Free State province. The topography is flatter in the west than in the east.

Climatic conditions can vary considerably from west to east across the Upper Vaal WMA. The mean annual temperature ranges between 16 °C in the west to 12 °C in the east, with an average of about 15 °C for the catchment as a whole. Maximum temperatures are experienced in January and minimum temperatures usually occur in July. Rainfall is strongly seasonal with most rain occurring in the summer period (October to April). The peak rainfall months are December and January. Rainfall occurs generally as convective thunderstorms and is sometimes accompanied by hail. The overall feature of mean annual rainfall over the Upper Vaal WMA is that it decreases fairly uniformly westwards across the central plateau area. The MAP for the watershed ranges from a high of 1 000 mm in the east to a low of 500 mm in the west with an average of about 700 mm. In accordance with the rainfall pattern the relative humidity is higher in summer than in winter.

Humidity is generally highest in February (the daily mean ranges from 65 % in the west to 70 % in the east) and lowest in August (the daily mean ranges from of 55 % in the west to 62 % in the east).

Average potential gross mean annual evaporation (as measured by Class A-pan) ranges from 1 600mm in the east to a high of 2 200 mm in the dry western parts. The highest gross Class A-pan evaporation is in January (range 180 to 260 mm) and the lowest evaporation is in June (80 to 110 mm).

The area to the south of the Vaal River is underlain by fine sedimentary rocks of the Karoo system, as is the area to the north of the Vaal River situated to the east of longitude 28° E. The total area covered by the Karoo system represents about 80 % of the Vaal River basin. To the north of the Vaal River igneous and metamorphic rocks predominate but there are extensive dolomitic exposures in the central areas (mainly in the catchment of the Mooi River tributary).

Soil depths are generally moderate to deep with undulating relief over the entire Vaal River WMA. There are three main soil types that predominate and these are distributed across the catchment as follows.

- Sandy Loam: In upper reaches of the Vaal and Wilge River catchments and to north of the Vaal River along its central reaches.
- Clay Loam: In the Klip (Gauteng) and Suikerbosrand catchments and to the south of the Vaal River along its central reaches.
- Clay Soil: In the middle and lower catchments of the Wilge and Vaal River catchments upstream of Vaal Dam.

In this WMA the predominant veld type is "pure grassveld". In the upper Wilge River catchment and along the escarpment there is a bit of "temperate and transitional forest and scrub" while grassveld predominates to the north of the Vaal River in its central reaches, particularly in the Mooi River catchment.

3. Development Status

The total urban and rural population in this WMA is over 5,6 million (1995 figures) with the urban population being just over 5 million. The Klip key area in Gauteng is almost 50% of the urban total. The Wilge key area has just over 50% of the total rural population.

The establishment of the Upper Vaal Catchment Management Agency is relatively well advanced with setting up structures, procedures and objectives for the various forums.

Rand Water is the largest water board in the country and provides the vast majority of potable water in this WMA. Sedibeng Water provides a few towns in the Free State in this WMA.

Urbanisation accounts for about 60% of the total land use of about 1 700 km^2. Irrigation accounts for about 17% and alien vegetation covers about 20%. Just over 1 % is afforested.

The following table shows land use per key area as well as population.

CATCHMENT				Irrigation (field area) (km²)	Afforestation (km²)	Alien vegetation (km²)	Urban (km²)	Other [1,2] (km²)	Total (km²)	Population
SECONDARY		TERTIARY								
No	Description	No.	Key Area Description							
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	46,0	14,6	137,4	171,0	17 801,0	18 170	523 879
C1	Klip – C13	C13	Klip (C13A-H)	0	0	17,9	0	5 164,1	5 182	35 295
	Grootdraai	C11	Grootdraai (C11A-L)	40,7	2,1	47,3	28,0	7 876,9	7 995	156 254
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	26,6	0	15,6	33,0	7 218,8	7 294	259 784
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	25,4	0	10,3	132,4	3 372,9	3541	885 576
	Klip	C22	Klip (C22A-E)	21,3	0	26,6	395,9	1 838,2	2 282	2 375 989
	Mooi	C23	Mooi (C23D-K)	45,1	0	15,8	155,0	4 818,1	5 034	532 131
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	29,2	0	72,4	119,9	2 606,5	2 828	797 152
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	25,1	0	6,0	0	3 207,9	3 239	83 271
Total in Gauteng				**63,8**	**0**	**74,7**	**731,2**	**7 332,3**	**8 202**	**4 589 707**
Total in Free State				**77,3**	**14,6**	**191,6**	**210,1**	**26 354,4**	**26 848**	**746 004**
Total in Mpumalanga				**62,7**	**2,1**	**63,1**	**69,3**	**15 370,8**	**15 568**	**427 214**
Total in North-West				**55,6**	**0**	**19,9**	**24,6**	**4 846,9**	**4 947**	**197 256**
TOTAL IN WMA				**259,4**	**16,7**	**349,3**	**1 035,2**	**53 904,4**	**55 565**	**5 649 331**

Note : Dryland sugar cane and indigenous afforestation all zero. For Dryland crops, Nature Reserves and Rural Settlements, data was not readily available.

4. Existing Water Related Infrastructure

There are numerous industries, power stations and mines and together with a growing urban population have very high requirements for an assured water supply. Accordingly there has been a great deal of infrastructure developed over the years to supply these needs. Rand Water is the major supplier of water and has two major offtakes from the Vaal River, one at Zuikerbosch and the other at Vereeniging. There is also a canal from Vaal Dam which can supply water directly to the Zuikerbosch and Vereeniging water purification works. The Zuikerbosch water purification works mainly supplies the East Rand and Pretoria and the Vereeniging works supplies the greater Johannesburg and Vereeniging areas. Lethabo power station has an offtake below Vaal Dam and also has a link to Vereeniging water purification works.

The most important dam in this area is the Vaal Dam fed by the Lesotho Highlands Scheme, the Drakensberg Pumped Storage Scheme with Sterkfontein Dam and Grootdraai Dam. Grootdraai Dam also supplies Tutuka power station and the Sasol II and III plants. There are numerous other large dams in the catchment. Details of weirs, reservoirs, pipelines, pumpstations, sewage treatment works, canals, tunnels, boreholes and hazardous waste sites have been included in the appendices.

The following table shows the combined capacities of individual town and regional potable water supply schemes by key area.

CATCHMENT				**TOWN AND REGIONAL WATER SUPPLY SCHEMES**			
SECONDARY		**TERTIARY**		**Number of People Supplied**	**% of Key Area Population**	**CAPACITY**	
No.	**Description**	**No.**	**Key Area Description**			**($10^6 m^3/a$) (1)**	**(ℓ/capita/d)#**
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	181 000	34,0		293
C1	Klip - C13	C13	Klip (C13A-H)	17 400	49,3		163
	Grootdraai	C11	Grootdraai (C11A-L)	116 300	74,4		170
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	198 009	76,2		264
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	852 674	96,3		309
	Klip	C22	Klip (C22A-E)	2 358 430	99,3		355
	Mooi	C23	Mooi (C23D-K)	489 450	92,0		141
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	749 173	94,0		224
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	57 300	68,8		192
Total in Gauteng				**4 196 177**	**98,1**		**(1)**
Total in Free State				**348 250**	**46,7**		**(1)**
Total in Mpumalanga				**321 859**	**75,3**		**(1)**
Total in North-West				**153 450**	**77,8**		**(1)**
TOTAL IN WMA				**5 019 736**	**88,9**		**294**

Note: (1) This information is not readily available due to the fact that Rand Water supplies most of this water and there is an extremely complex network of pumpstations, reservoirs etc.

Daily urban consumption calculated from urban usage data.

5. Water Requirements

The various water user sectors in this WMA are as follows:

- Ecological Reserve (environmental - in-stream flow requirements). This water is not consumed apart from river losses.
- Domestic (urban and rural).
- Bulk industrial (including thermal power stations) and mining.
- Water transfers.
- Agriculture (including livestock and game).
- Afforestation.
- Alien vegetation.

The vast majority of quaternary catchments analysed generated C management classes, i.e moderately modified aquatic ecosystems that will require 20-40% MAR. Bearing in mind that the assessments were only done at quaternary catchment outlets, there are no A class rivers and only about 10% were designated as B class. This points to the relatively poor state of aquatic ecosystems.

The C2 secondary catchment in this WMA is relatively heavily urbanised. The large urban users are heavily dependent on water imported into this WMA. The bulk supplier of potable water is Rand Water (apart from Qwaqwa which is supplied by Sedibeng Water).

Rural usage can be categorised into domestic rural use, livestock watering and subsistence irrigation. There is no significant rural infrastructure in the Upper Vaal WMA with the exception of QwaQwa (in the Wilge key area), which is supplied by Sedibeng Water (51 ℓ/capita/d).

Strategic bulk water users only apply to Eskom thermal power stations which require a high assurance – 99,5% of supply. There are a number of thermal power stations in the Upper Vaal WMA. The Sasol I, II and III refineries require about 113 x $10^6 m^3$/a of water. Iscor is also a significant user.

Mining activity requires a level of assurance of 98 to 99%. The Klip, Suikerbosch, Mooi and Vaal Dam to Barrage key areas have the highest concentration of domestic and industrial users in South Africa. The Barrage area is characterised by a large number of mining activities ranging from gold mining to quarrying. There are significant impacts on the hydrology and water quality of the Vaal system and water requirements are significant. The economic impact of the mining sector in this area has diminished and is no longer significant (<1% of GGP, UrbanEcon, 1998). Mining operations abstracted 4,6 x $10^6 m^3/a$ of water directly from the Upper Vaal WMA out of total abstractions of 401 x $10^6 m^3$ (BKS et al, 1998d). Although the mining industry appears to be a minor abstractor of water from the catchment, all abstractions are from tributaries of the Vaal and therefore impact on the hydrology of these smaller systems. Mining operations decanted some 28,74 x $10^6 m^3$ of water directly into the catchment river systems out of total discharge of 285,55 x $10^6 m^3/a$ (BKS et al, 1998d). This represents some 10 % of discharges and an estimated increase in salt load of 55 800 t/a (DWAF, 1995). In general it can be stated that mining activities impact significantly on the hydrology of the catchment upstream of the Vaal Barrage and downstream of the Vaal Dam and that the impacts in terms of quality are generally negative for downstream users.

Other bulk users include large industries such as Sasol and Iscor, certain mothballed powerstations (water required for maintenance), small Rand Water consumers, small industrial users and small users from the Vaal Barrage. Other bulk users require a level of assurance from 95% to 99% .

Most of the irrigation in this WMA is concentrated on the Mooi River – Mooi Government Water Scheme, Klipdrift and Vyfhoek Schemes and downstream of the Barrage – Rietpoort and Koppieskraal Irrigation Boards and the Vaal Government Water Control Area. There is also some irrigation upstream and downstream of the Grootdraai Dam and adjoining the Wilge River.

There is no hydro power and afforestation is negligible. There is a small amount of alien vegetation (about 20% of land use).

Based on experience elsewhere in South Africa an overall sustainable reduction in water use of up to 25% could be achieved without having a detrimental effect on users. Return flows could be reduced by up to 10% of total water use. In Soweto in 1994 it was roughly estimated that of the 250 Mℓ/day of water feeding Greater Soweto, as much as 50 % (125 Mℓ/day) is unaccounted for water. Approximately 40 Mℓ/day is thought to be lost to the sewer system, mainly via leaking domestic fittings and 30 Mℓ/day is attributable to leakage from water mains, whilst the remainder can not be accounted for because of faulty meters.

There are a number of water transfers into the Vaal as follows:

- Thukela-Vaal Transfer Scheme. Water from the Thukela River is pumped to Kilburn Dam and onto Sterkfontein Dam from where it is available to augment Vaal Dam.

The Usutu- Vaal Transfer Scheme. Westoe, Jericho and Morgenstond Dams pumpstations to Camden, Kriel, Matla and Kendal power stations. Most of this water (except for the use at Camden) is then transferred out of this WMA into the Komati and Olifants WMA's.

The Heyshope Scheme. Supports Usutu and Grootdraai Dam sub-systems. The water is pumped into the upper reaches of the Little Vaal River to supply Sasol and Eskom power stations.

The Zaaihoek Scheme. Zaaihoek Dam pumpstation supplies to Majuba, Volksrust, Wakkerstroom and Chelmsford Dam. It also supplies deficits in the Grootdraai Dam sub-system.

The Vaal – Olifants Scheme (transfer link). From Grootdraai Dam in Vaal River catchment to Trichardtsfontein Dam in the Olifants River catchment.

Grootdraai Dam sub-system. Supplying Sasol and Eskom power station. The Grootdraai Dam is supplemented by water transferred from Heyshope Dam via the Little Vaal River.

The following table shows the water requirements per user group in 1995.

USER GROUP	ESTIMATED WATER REQUIREMENT (10^6 m^3/a)	REQUIREMENT/USE AT 1:50 YEAR ASSURANCE (10^6 m^3/ a)
Ecological reserve [(5)]	299,4[N1]	48,2
Domestic [(1)]	549,5[(1)][N2]	550,7
Bulk water use [(4)]	246,4[N3]	242,1
Neighbouring States	0	0
Agriculture	193,6[(2)][N4]	157,8
Afforestation	0,6	0,2
Alien vegetation	29,7	15,5
Water transfers [(3)]	507,7[N5]	508,0
Hydropower	0	0
TOTALS	**1 829,9**	**1 522,5**

Notes:

(1) Includes urban domestic, commercial, institutional and municipal requirements (539,1 x 10^6 m^3/a) and rural domestic requirements (10,4 x 10^6 m^3/a).

(2) Includes requirements for irrigation (149,5 x 10^6 m^3/a) and livestock and game (44,1 x 10^6 m^3/a).

(3) Only transfers out of the WMA are included.

(4) Includes thermal powerstations (72,9 x 10^6 m^3/a), major industries (164,2 x 10^6 m^3/a) and mines (9,3 x 10^6 m^3/a).

(5) At outlet of WMA. From Table 5.2.4.1.

The following table shows the urban and rural domestic water requirements in 1995:

CATCHMENT				URBAN (10^6 m^3/a)	RURAL (10^6 m^3/a)	COMBINED URBAN AND RURAL (10^6 m^3/a)	REQUIREMENTS AT 1:50 YEAR ASSURANCE (10^6 m^3/a)	HUMAN RESERVE (AT 1:50) (10^6 m^3/a)
SECONDARY		TERTIARY						
No.	Description	No.	Key Area Description					
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M	19,3	7,1	26,9	26,4	3,1
C1	Klip - C13	C13	Klip (C13A-H)	1,0	0,2	1,2	1,4	0,3
	Grootdraai	C11	Grootdraai (C11A-L)	7,2	0,5	7,7	7,8	1,4
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L) – Total	19,2	0,7	19,9	20,0	2,8
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	96,2	0,4	96,6	96,9	8,1
	Klip	C22	Klip (C22A-E) – Gauteng	305,8	0,2	306,0	306,4	21,7
	Mooi	C23	Mooi (C23D-K)	25,2	0,5	25,7	25,8	5,7
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	61,2	0,5	61,7	61,6	7,3
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	4,0	0,3	4,3	4,4	0,8
Total in Mpumalanga				**26,8**	**1,1**	**27,9**	**28,2**	**2,6**
Total in Free State				**45,9**	**7,9**	**53,8**	**54,0**	**5,2**
Total in Gauteng				**457,2**	**0,7**	**457,9**	**458,5**	**42,8**
Total in North-West				**9,2**	**0,7**	**9,9**	**10,0**	**1,0**
TOTAL IN WMA				**539,1**	**10,4**	**549,5**[A6]	**550,7**	**51,6**

Note : The values in this table include water losses as shown in Table 5.3.2.1 and 5.3.2.2

Regarding losses, the distribution losses include losses due to leaking pipes and reservoirs as well as unaccounted for or unmetered water. The distribution losses can range from 5% of urban water supplied too as high as 35% of urban water supplied in urban centres where proper maintenance is not done and where there is unmetered water supplied. Generally losses due to the distribution system are of the order of 10%.

In semi-arid areas wastewater is regarded as a supplementary source of water. The return flows generated from this WMA supplement the base flow of the Vaal river, thus benefiting all downstream users.

Return flows from urban areas can be divided into three categories:

- The return flows from urban water systems can manifest in two distinct ways:

As wastewater (effluent) concentrated by means of waterborne sewage that is treated and released into the surface river network.

As wastewater diffused locally by means of pit toilets (eg. Loflos, aquaprivies, etc), septic tanks / french drains, or more complex methods such as soil bucket systems or disposal via evaporation from oxidation ponds.

- Return flow due to leakage of clean water

  This is generally 10% for Johannesburg (South), Vereeniging and East Rand areas.

- Stormwater returns

  Return flow due to impervious urban areas (into storm water system). The urban areas in this WMA total 1 035 km^2 and the return flow generated from these areas is 111,4 $x10^6m^3/a$.

  The total urban effluent return flow to the river system is 295,5 $x10^6m^3/a$ and the total urban return flow is 406,9 $x10^6m^3/a$.

  The return flow generated by rural consumers is negligible and in most cases can be taken as zero with the exception of Witsieshoek which is about 2,2 $x10^6m^3/a$. Return flows generated by bulk users are directly proportional to the type of industry. Some mines in this WMA pump out large amounts of groundwater.

  Bulk return flows total 146,1 $x10^6m^3/a$. Irrigation return flow totals 11,4 $x10^6m^3/a$.

The following table summarises water requirements per key area at 1:50 year assurance:

CATCHMENT				STREAMFLOW REDUCTION ACTIVITIES $(10^6 m^3/a)$		WATER USE $(10^6 m^3/a)$		WATER REQUIREMENT $(10^6 m^3/a)$						ECOLOGICAL RESERVE* $(10^6 m^3/a)$	TOTAL $(10^6 m^3/a)$
SECONDARY		TERTIARY													
No.	Description	No.	Key Area Description	AFFOREST-ATION	DRYLAND SUGAR CANE	ALIEN VEG.	RIVER LOSSES(4)	BULK	IRRI-GATION	RURAL	URBAN	WATER TRANSFERS OUT(1)	NEIGH-BOURING STATES		
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	0,2	0	7,2	0,0	0	17,8	22,5	18,7	0,0	0	15,5	1089
C1	Klip	C13	Klip (C13A-H)	0,0	0	0,9	0,0	2,4	0,0	3,2	1,2	0,3	0	2,1	10,1
	Grootdraai	C11	Grootdraai (C11A-L)	0,0	0	2,3	0,0	39,1	21,7	11,1	7,3	125,9	0	13,5	247
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	0,0	0	0,7	0,0	97,4	6,9	6,6	19,2	0,0	0	0*	1568
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0,0	0	0,3	9,8	3,7	7,2	2,3	96,5	0,0	0	1,2	148,0
	Klip	C22	Klip (C22A-E)	0,0	0	1,1	0,0	1,0	10,3	0,6	306,4	3,7	0	3,3	348
	Mooi	C23	Mooi (C23D-K)	0,0	0	0,5	11,9	3,9	40,3	3,4	25,3	0,0	0	11,4	130
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	0,0	0	2,3	0,0	94,6	1,5	2,6	61,0	906,8	0	1,2	10970
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, L)	0,0	0	0,2	15,5	0,0	8,0	2,8	4,1	0,0	0	0*	456
Total (Mpumalanga)				**0,0**	**0**	**3,1**	**0,0**	**133,6**	**28,4**	**17,8**	**26,8**	**126,2**	**0**	**14,1**	**350,0**
Total (Free State)				**0,2**	**0**	**9,2**	**7,7**	**69,2**	**29,7**	**28,4**	**45,8**	**453,4**	**0**	**17,0**	**660,6**
Total (Gauteng)				**0,0**	**0**	**2,8**	**9,9**	**38,4**	**28,3**	**6,7**	**457,8**	**457,1**	**0**	**8,5**	**1 009,5**
Total (North-West)				**0,0**	**0**	**0,4**	**19,6**	**0,9**	**27,3**	**2,2**	**9,3**	**0,0**	**0**	**8,6**	**68,3**
TOTAL IN WMA				**0,2**	**0**	**15,5**	**37,2**	**242,1**	**113,7**	**55,1**	**539,7**	**1 036,7(2)**	**0**	**48,2**	**2 088,4(3)**

Notes: * Negative values for ecological reserve taken as zero.

(1) Only potable water transfers considered.

(2) Total transfers (including those between key areas) = 1 036,7 x 10^6 m^3/a, transfers out of WMA are: 472 x 10^6 m^3/a to Crocodile West and Marico WMA (by Rand Water), 35,4 x 10^6 m^3 to Eskom in Olifants WMA and 0,3 MCM to Volksrust in the Thukela WMA (total of 507,7 x 10^6 m^3/a). The remainder are transfers within the WMA between key areas = 529 x 10^6 m^3/a.

(3) Total requirement in 1995 at 1:50 assurance: 2 088,4 x 10^6 m^3/a – 529 x 10^6 m^3/a = 1 559,4 x 10^6 m^3/a because the internal transfers are accounted for in the water requirements of key areas.

(4) Evaporation losses from dams and wetlands not included. These losses including Wilge River losses are included in the yield determinations (Mallory, 2001).

6. Surface Water Resources

Natural mean annual runoff (MAR) from the total Vaal River catchment is approximately 4 000 x $10^6m^3/a$. For the Upper Vaal WMA, the MAR totals 2 422,8 x $10^6m^3/a$. When expressed as an equivalent unit runoff from the 196 000 km^2 Vaal River catchment, the MAR averages out at about 20 mm. However, the pattern of runoff over the catchment is one of a fairly gradual decline from east to west, in accordance with the east to west decline of rainfall associated with an increase in evaporation rates. Unit runoff varies from over 100 mm in the upper reaches of the Wilge and Elands River tributaries to as little as 23 mm in the upper reaches of the Renoster and Vals rivers. Equivalent figures for mean annual rainfall (MAP) are about 800 mm (east) and about 550 mm (west) and, for gross mean annual Symons Pan evaporation (MAE) – 1 300 mm (east) and 2 300 mm (west).

The developed yield from surface water in the absence of any water use in 1995 totals 2 562,3 x 10^6m^3 and the total potential surface water yield is the same due to the fact that the Upper Vaal WMA as part of the total Vaal system is fully developed. The developed yield from groundwater in 1995 is 33,8 x 10^6m^3 and the potential yield is 593,4 x 10^6m^3. If the relationship between surface water and groundwater is taken into account, the total developed yield in 1995 is 2 596,1 x 10^6m^3 . Surface water yields have not had the ecological Reserve deducted from them i.e the yield is calculated as if the ecological Reserve is zero and there is no development in the catchments.

The following table shows the water resources per key area.

CATCHMENT				SURFACE WATER RESOURCES ($10^6m^{3}/a$)			SUSTAINABLE GROUNDWATER EXPLOITATION POTENTIAL NOT LINKED TO SURFACE WATER ($10^6m^{3}/a$)		TOTAL WATER RESOURCE ($10^6m^{3}/a$)
SECONDARY		TERTIARY		NATURAL MAR	1:50 YEAR DEVELOPED YIELD IN 1995	1:50 YEAR TOTAL POTENTIAL YIELD	DEVELOPED IN 1995	TOTAL POTENTIAL	1:50 YEAR DEVELOPED IN 1995
No.	Description	No.	Key Area Description						
C8	Wilge	C81-C83	Wilge (C81A-M, C82A-H, C83A-M	868,3	64,1	64,1	4,0	84,6	68,1
C1	Klip	C13	Klip (C13A-H)	291,1	7,6	7,6	0,7	22,1	8,3
	Grootdraai	C11	Grootdraai (C11A-L)	457,7	288,6	288,6	5,0	70,6	293,6
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11, C12A-L)	360,0	109,0	109,0	2,2	50,1	111,2
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	92,4	99,8	99,8	1,3	42,7	101,1
	Klip	C22	Klip (C22A-E) – Gauteng	96,2	293,2	293,2	3,7	13,1	296,9
	Mooi	C23	Mooi (C23D-K)	113,0	16,3	16,3	9,0	25,1	25,3
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	68,5	1 691,7	1 691,7	3,4	44,8	1 695,1
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	75,6	-8	-8	4,5	32,4	-3,5
Total in Mpumalanga				**855,6**	**&**	**&**	**7,4**	**120,6**	**&**
Total in Gauteng				**240,1**	**&**	**&**	**7,1**	**236,7**	**&**
Total in Free State				**1 208,6**	**&**	**&**	**8,6**	**111,6**	**&**
Total in North-West				**118,5**	**&**	**&**	**10,7**	**16,5**	**&**
TOTAL IN WMA				**2 422,8**	**2 562,3**	**2 562,3**	**33,8**	**385,4**	**2 596,1**

7. Water Balance

The following is a summary of the water balance for each key area :

- **WILGE KEY AREA**

In 1995 this area had a small surplus of of about 10 x 10^6m^3. The available yield determined for this area does not include the Thukela Vaal Transfer (included in Vaal Dam to Vaal Barrage key area) or any river losses along the Wilge River but includes dam evaporation losses. This key area is rural in nature and rural requirements are relatively significant. Domestic rural and irrigation water requirements make about 50 % of total requirements. Non-consumptive requirements by alien vegetation and the ecological Reserve are about a ¼ of total requirements. Phuthaditjhaba, Harrismith and Bethlehem are the most significant urban centres in the area. Re-usable returns, from urban, rural and agricultural users are relatively significant and add to the baseflow of the river system.

- **KLIP (C13) KEY AREA**

In 1995 this area was basically in balance (about 1 x 10^6m^3). This key area is rural in nature and rural requirements are relatively significant (about 33 % of total requirements). Non-consumptive requirements by alien vegetation and the ecological reserve are also relatively significant (about a third of total requirements).

- **GROOTDRAAI KEY AREA**

In 1995 the Grootdraai area had a surplus of about 82 x 10^6m^3. The available yield determined for this area does include the impact of the Heyshope and Zaaihoek Transfer Schemes and river and dam evaporation losses. This key area is a major importer and exporter of surface water. About 115 x $10^6m^3/a$ is imported from the Usutu to Mhlathuze WMA (Heyshope transfer) and the Thukula WMA (Zaaihoek transfer). About 126 x $10^6m^3/a$ is exported from Grootdraai dam to the Sasol II / III complex (Grootdraai to Vaal Dam key area) and for Eskom power stations in the Olifants WMA. The largest water user within the key area is the Tutuka power station, its associated colliery and 3rd party users. Agricultural and rural domestic requirements are significant, using about 15 % of the total requirement. Ermelo and Bethal TLCs are the main urban centres in this key area.

- **GROOTDRAAI TO VAAL DAM KEY AREA**

In 1995 the Grootdraai to Vaal Dam key area had a surplus of about 82 x $10^6 m^3$. This area is a significant importer of water from Grootdraai and Vaal Dams. The major water user is the Sasol II/III industrial complex. The Highveld Ridge TLC, gold and coal mines receive water from Vaal Dam via the Rand Water water supply infrastructure. The Highveld Ridge and Standerton TLCs are the main urban centres in this area.

- **SUIKERBOSRANT KEY AREA**

In 1995 the Suikerbosrant key area had a surplus of about 183 x $10^6 m^3$. This area is urban in nature and is a significant importer of water from Vaal Dam (via the Rand Water network). The main towns are the East Rand centres of Benoni, Brakpan, Springs, Nigel and Heidelburg. Urban requirements are significant and make up 80 % of total requirements. Urban and industrial users in this area generate significants amounts of return flow (effluent, stormwater and clean returns) that contribute significantly (increases flow by 100 %) to the base flow of the system. Effluent returns in this area are dominated by pumpage from Grootvlei mine (45 x $10^6 m^3$ in 1995) into the system.

- **KLIP (C22) KEY AREA**

In 1995 the Klip key area had a large surplus of about 550 x $10^6 m^3$. This area is highly urbanised and is a significant importer of water from Vaal Dam (via the Rand Water network). The requirements of the area are dominated by urban requirements (94 % of total requirements). The requirement of Johannesburg South MLC is the single largest consumptive requirement in the WMA. Germiston, Boksburg and Alberton MLCs also have significant requirements. Urban centres and to a lesser extent mines in this area generate significant amounts of return flows (effluent, groundwater discharges, stormwater and clean returns) that contribute significantly (increases flow by almost 100 %) to the base flow of the key area.

- **MOOI KEY AREA**

In 1995 the Mooi key area had a small surplus of about 20 x $10^6 m^3$. This area imports water from Vaal Dam and the Zuurbekom Wellfield (via the Rand Water network) for the West Rand towns of Westonaria, Carltonville and Fochville. Urban requirements account for a quarter of total requirements. The major user of water in this area is agricultural for irrigation (40 % of total requirements). Re-usable returns mainly from the gold mines in the area are significant and treble the base flow of the system. Most irrigation schemes appear dependent on these returns.

- **VAAL DAM TO VAAL BARRAGE KEY AREA**

In 1995 this key area had a surplus of about 691 x $10^6 m^3$. The available yield in this area is estimated by the DWAF to be 1 695,1 x $10^6 m^3$ (1995) which included the impact of water from the Thukela Vaal Transfer (754 x $10^6 m^3$ in 1995), surplus water from the upstream catchments of Grootdraai, Wilge, Suikerbosrand and Klip (about 925 x $10^6 m^3$ in 1995) and river and dam evaporation losses on the water resources of the key area. The requirements of this area are dominated by the transfer of potable water from the Vaal Dam (about 907 x $10^6 m^3$ in 1995). Most transfers are by Rand Water, to urban and industrial users in the Crocodile WMA, to Heilbron TLC in the Middle Vaal WMA, to urban and industrial users in the Klip, Suikerbosrand, Mooi, Grootdraai to Vaal Dam and Grootdraai key areas. Bulk requirements by industries such as Eskom, Sasol I and Iscor are also significant and emphasise the highly industrialised nature of this key area. The main urban centres are Vereeniging, Vanderbijlpark and Sasolburg who also receive bulk water from the Rand Water network.

- **BARRAGE TO MOOI CONFLUENCE KEY AREA**

In 1995 this key area had a surplus of about 678 x $10^6 m^3$. The key area is rural in nature and rural and agricultural (irrigation) requirements (35 %) are relatively significant. Non-consumptive requirements of river losses and alien vegetation account for over 50 % of total requirements. The main urban centre is Parys.

The following table shows the water balance per key area

CATCHMENT				AVAILABLE 1:50 YEAR YIELD IN 1995 ($10^6 m^3/a$)(1)			WATER TRANSFERS AT 1:50 YEAR ASSURANCE ($10^6 m^3/a$)		RETURN FLOWS AT 1:50 YEAR	WATER REQUIRE-MENTS AT 1:50 YEAR ASSURANCE(3) ($10^6 m^3/a$)	WATER BALANCE AT 1:50 YEAR ASSURANCE ($10^6 m^3/a$)
SECONDARY		TERTIARY									
No.	Description	No.	Key Area Description	SURFACE WATER	GROUND-WATER USE IN 1995	TOTAL YIELD(5)	IMPORTS(2)	EXPORTS(2)	RE-USABLE		
C8	Wilge	C81, 82,83	Wilge (C81A-M, C82A-H, C83A-M)	64,1	4,0	(+) 68,1	0	0	(+) 23,4	(-) 81,9	[(+) 9,6]
C1	Klip	C13	Klip (C13A-H)	7,6	0,7	(+) 8,3	(+) 2,4	(-) 0,3	(+) 0,0	(-) 9,7	[(+) 0,7]
	Grootdraai	C11	Grootdraai (C11A-L)	288,6	5,0	(+) 293,6(1)	(+) 0,8 / 115,8(1)	(-) 125,9	(+) 8,6	(-) 95,0	[(+) 82,1]
	Grootdraai to Vaal Dam	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	109,0	2,2	(+) 111,2	(+) 102,5	0,0	(+) 16,9	(-)130,8	[(+) 99,8]
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	99,8	1,3	(+) 101,1	(+) 95,5	0,0	(+) 107,1	(-) 121,0	[(+) 182,7]
	Klip	C22	Klip (C22A-E)	293,2	3,7	(+) 296,9	(+) 311,1	(-) 3,7	(+) 268,0	(-) 322,7	[(+) 549,6]
	Mooi	C23	Mooi (C23D-K)	16,3	9,0	(+) 25,3	(+) 16,4	0,0	(+) 73,9	(-) 96,7	(+) 18,9
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	1 691,7	3,4	(+) 1 695,1(1)	(+) 0,0/ 754,0(1)	(-) 906,8	(+) 66,3	(-)163,2	**(+)** 691,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	-8,0	4,5	-3,5	(+) 0,0	0,0	(+) 2,4	(-) 30,7	(+) 678,5(4)
Total (Mpumalanga)				**&**	**7,4**	**&**	**105,7**	**126,2**	**25,5**	**(-) 223,8**	**&**
Total (Free State)				**&**	**7,1**	**&**	**0,0**	**453,4**	**45,8**	**(-) 207,2**	**&**
Total (Gauteng)				**&**	**8,6**	**&**	**419,6**	**457,1**	**444,4**	**(-) 552,4**	**&**
Total (North-West)				**&**	**10,7**	**&**	**3,4**	**0,0**	**50,9**	**(-) 68,3**	**&**
TOTAL in WMA				**2 562,3**	**33,8**	**(+) 2 596,1**	**(+) 1 398,5**(1)	**(-) 1 036,7**(2)	**(+) 566,6**	**(-) 1 051,7**(3)	
Surplus yield to Middle Vaal WMA											**(+) 678,5**

Notes: (1) Available yield provided by the DWAF and includes interbasin transfers from Thukela, Hesyhope and Zaaihoek transfer schemes and evaporation losses from dams.
(2) Only potable water transfers. Totals for transfers out of or into WMA and total for all transfers given (including between key areas).
(3) Water requirements, refer to **Table 7.2.2** less any transfers out of the key area (2 088,4 x $10^6 m^3/a$ – 1 036,7 x $10^6 m^3/a$).
(4) Surplus yield to Middle Vaal includes surplus from Mooi and Vaal Dam to Vaal Barrage key areas.
[ ] These balances - if positive (surplus) are included in “Surface Water” for the Vaal Dam to Vaal Barrage key area. .
(&) Provincial split not readily available.

8. Costs of Water Resource Development

The Upper Vaal WMA has been very highly developed and there is no potential for developing it further. The only possibility is a dam on the Klip River (C13 tertiary catchment), however, this will not increase the yield balance only re-distribute it to a certain degree.

There are no known potential wellfields that could be developed.

9. Conclusions and Recommendations

The Upper Vaal WMA is a highly developed and therefore extremely complex catchment. While local water resources may still be developed, on a macro scale the surface water of the total Vaal River system is fully utilised. A number of transfer schemes are in operation to provide for the increasing urban, rural, industrial, mining, ecological and irrigation requirements. At the 1:50 year level of assurance as at 1995, the Upper Vaal WMA passed about $678 \times 10^6 m^3$ to the Middle Vaal WMA. This surplus should, however, not be viewed in isolation but be considered along with the Middle Vaal and Lower Vaal WMA's.

Although surface water in the total Vaal River system has been fully developed, exploitation of groundwater in the key areas is low and ranges from about 5% to 20%. Pollution of groundwater by mines may hinder potential development.

Return flows are extremely significant in some of the key areas but also carry pollution effects.

The following table summarises available yield and water requirements. It should be noted that because this report is based on the 1995 situation, the Lesotho Highlands scheme has not been included (1998). It does, however, add very significantly ($396 \times 10^6 m^3$ in 1998) to the surplus of $678 \times 10^6 m^3$.

CATCHMENT – SECONDARY No.	CATCHMENT – SECONDARY Description	CATCHMENT – TERTIARY No.	CATCHMENT – TERTIARY Key Area Description	AVAILABLE 1:50 YEAR YIELD IN 1995 ($10^6m^3/a$) (1) – TOTAL YIELD (5)	WATER TRANSFERS AT 1:50 YEAR ASSURANCE ($10^6m^3/a$) – IMPORTS (2)	WATER TRANSFERS AT 1:50 YEAR ASSURANCE ($10^6m^3/a$) – EXPORTS (2)	RETURN FLOWS AT 1:50 YEAR ASSURANCE ($10^6m^3/a$) – RE-USABLE	WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE (3) ($10^6m^3/a$)	WATER BALANCE AT 1:50 YEAR ASSURANCE ($10^6m^3/a$)
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	(+) 68,1	0	0	(+) 23,4	(-) 81,9	[(+) 9,6]
C1	Klip	C13	Klip (C13A-H)	(+) 8,3	(+) 2,4	(-) 0,3	(+) 0,0	(-) 9,7	[(+) 0,7]
	Grootdraai	C11	Grootdraai (C11A-L)	(+) 293,6 (1)	(+) 0,8 / [115,8] (1)	(-) 125,9	(+) 8,6	(-) 95,0	[(+) 82,1]
	Grootdraai to Vaal Dam	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	(+) 111,2	(+) 102,5	0,0	(+) 16,9	(-)130,8	[(+) 99,8]
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	(+) 101,1	(+) 95,5	0,0	(+) 107,1	(-) 121,0	[(+) 182,7]
	Klip	C22	Klip (C22A-E)	(+) 296,9	(+) 311,1	(-) 3,7	(+) 268,0	(-) 322,7	[(+) 549,6]
	Mooi	C23	Mooi (C23D-K)	(+) 25,3	(+) 16,4	0,0	(+) 73,9	(-) 96,7	(+) 18,9
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	(+) 1 695,1 (1)	(+) 0,0/ [754,0] (1)	(-) 906,8	(+) 66,3	(-)163,2	**(+)** 691,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	-3,5	(+) 0,0	0,0	(+) 2,4	(-) 30,7	(+) 678,5 (4)
TOTAL in WMA				**(+) 2 596,1**	**(+) 1 398,5 (1)**	**(-) 1 036,7 (2)**	**(+) 566,6**	**(-) 1 051,7**	
Surplus yield to Middle Vaal WMA									**(+) 678,5**

Notes:

(1) Available yield provided by the DWAF and includes interbasin transfers from Thukela, Heyshope and Zaaihoek transfer schemes and evaporation losses from dams.
(2) Only potable water transfers. Totals for transfers out of or into WMA and total for all transfers given (including between key areas).
(3) Water requirements, refer to **Table 7.2.2** less any transfers out of the key area (2 088,4 x $10^6m^3/a$ – 1 036,7 x $10^6m^3/a$).
(4) Surplus yield to Middle Vaal includes surplus from Mooi and Vaal Dam to Vaal Barrage key areas.
[ ] These balances - if positive (surplus) are included in "Surface Water" for the Vaal Dam to Vaal Barrage key area.

Although every effort has been spent in obtaining accurate data, manipulation of this data and checking and verification thereof, the information presented in this report is dependent on the accuracy and quality of the numerous reports and documentation previously compiled by other organisations. It is therefore likely that some information may have to be revised in the future.

The following recommendations were made:

- While overall irrigation data can be considered reliable, this data is not available on a quaternary catchment basis and therefore quaternary catchment irrigation data represents an estimate only and must be considered to be of poor quality. In order to improve the accuracy of the disaggregated information it is therefore recommended that a study is undertaken to determine the areal distribution and crop types at quaternary catchment scale.

- The urban area data from WR90 represents the 1990 situation and is probably underestimated in the catchments above Vaal Dam and in the Mooi River catchment. It is therefore recommended that the WR90 study be updated.

- The available information on livestock and game was for 1988 and 1990. In addition this data was only available at Magisterial district level and like irrigation the data at quaternary catchment level must be considered approximate.

- A survey of a number of TLC's was undertaken to try and determine urban water requirements. This exercise was fairly successful and should be extended to the remaining TLC's. Most small TLCs were not surveyed and their water requirements were estimated using estimated water requirements. It is considered that the estimated water requirements are too high for most small towns and as a consequence the water requirements have been inflated.

- The situation assessment consultant did review river losses, however this data appears to have been ignored. This is possibly a result of problems with the river losses sub-model of WSAM.

- Information on water allocations, authorisations and permits needs to be centralised and reviewed by an organisation (persons) skilled in the interpretation of these allocations, thus allowing the assessment of the available resources and the volumes allocated.

- Information concerning conveyance losses (most kinds) were generally not readily available. While estimates were provided and these were used extensively, a study of this crucial 'use' is recommended.

- Regarding the ecological water requirements, negative values (that were taken as zero) should be investigated

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DIAGRAMS

ABBREVIATIONS AND ACRONYMS

CCWR	Computing Centre for Water Research
CMA	Catchment Management Agency
DWAF	Department of Water Affairs and Forestry
ELSU	Equivalent Large Stock Units
GIS	Geographic Information System
GJTMC	Greater Johannesburg Transitional Metropolitan Council
GWS	Government Water Scheme
IRP	Integrated Resource Planning
MAE	Mean Annual Evaporation
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MD	Magisterial District
MLC	Metropolitan Local Council
NWA	National Water Act
NWSR	National Water Supply Regulation
SABS	South African Bureau of Standards
TLC	Transitional Local Council
TRC	Transitional Regional Council
WMA	Water Management Area
WR90	Water Resources 1990
WSA	Water Services Act
WSAM	Water Situation Assessment Model

GLOSSARY OF TERMS

AEMC

Attainable Ecological Management Class (A-D). A class indicating the management objectives of an area which could be attained within 5 years. Values range from Class A (largely natural) to Class D (largely modified).

ANASTOMOSED

A river made up of multiple channels with stable islands, usually with a bedrock substrate.

BIOTA

A collective term for all the organisms (plants, animals, fungi. bacteria) in an ecosystem.

CONDENSED AREA

The area considered in the alien vegetation component whereby alien vegetation which sparsely occurs in a large area, is redefined as a smaller area with a maximum concentration/density

CAIRN

Mound of rough stones as a monument or landmark.

CAUCASION

Of the White race.

DEMC

Default Ecological Management Class (A-D). A class indicating the ecological importance and sensitivity of an area, as it is likely to have been under natural (undeveloped) conditions, and the risks of disturbance that should be tolerated. Values range from Class A (highly sensitive, no risks allowed) to Class D (resilient systems, large risk allowed).

DESC

Default Ecological Status Class.

DIURNAL

During the day.

ENVIRONMENTALLY SENSITIVE AREA

A fragile ecosystem which will be maintained only by conscious attempts to protect it [Concise Oxford Dictionary (COD) of Geography].

ECOSYSTEM HEALTH

An ecosystem is considered healthy if it is active and maintains its organisation and autonomy over time, and is resilient to stress. Ecosystem health is closely related to the idea of sustainability.

ECOLOGICAL IMPORTANCE

A measure of the extent to which a particular species, population or process contributes towards the healthy functioning of an ecosystem. Important aspects include habitat diversity, biodiversity, the presence of unique, rare or endangered biota or landscapes, connectivity, sensitivity and resilience. The functioning of the ecosystem refers to natural processes. (a measure of a river for conservation, including natural, socio-economic and cultural aspects).

EDAPHIC

1. Pertaining to the influence of soil on organisms.

2. Resulting from or influenced by factors inherent in soil rather than by climatic factors.

EISC

Ecological importance and sensitivity class.

EPHEMERAL RIVERS

Rivers where no flow occurs for long periods of time.

ENDANGERED

Species in danger of extinction and whose survival is unlikely if the causal factors bringing about its endangered status continue operating. Included are species whose numbers have been reduced to a critically low level or whose habitat has been so drastically diminished and/or degraded that they are deemed to be in immediate danger of extinction.

ENDEMIC

Occurring within a specified locality; not introduced (Concise Oxford Dictionary of Geography.)

ENDOREIC

Portion of a hydrological catchment that does not contribute towards river flow in its own catchment (local) or to river flow in downstream catchments (global).

HETROGENEOUS

Not uniform. Disparate. Consisting of dissimilar parts or ingredients.

INVERTEBRATE

An animal without a backbone - includes insects, snails, sponges, worms, crabs and shrimps.

LOTIC

Flow water.

PESC

Present Ecological Status Class (A-F). A class indicating the degree to which present conditions of an area have been modified from natural (undeveloped) conditions. Factors that are considered in the classification include the extent of flow modification, inundation, water quality, stream bed condition, riparian condition and proportion of exotic biota. Values range from Class A (largely natural) to Class F (critically modified).

PETROGLYPH

A carving or inscription on a rock.

RARE

Species with small or restricted populations, which are not at present endangered or vulnerable, but which are at risk. These species are usually localised within restricted geographical areas or habitats, or are thinly scattered over a more extensive range. These may be species, which are seldom recorded but may be more common than supposed, although there is evidence that their numbers are low.

RED DATA BOOK

A book that lists species that are threatened with extinction. The concept was initiated by the International Union for the Conservation of Nature, and has since become adopted by many countries. The "Red" stands for "Danger". The categories reflect the status of the species only within the area under review, and it is sometimes the case that species, which are threatened in one region may have secure populations in other areas.

RESERVE

The quantity and quality of water required (a) to satisfy basic human needs by securing a basic water supply, as prescribed under the Water Services Act, 1997 (Act 108 of 1997) for people, who are now or who will, in the reasonably near future, be (i) relying upon; (ii) taking water from; or (iii) being supplied from, the relevant water resource; and (b) to protect aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource as indicated in NWA, 1998.

RESILIENCE

The ability of an ecosystem to maintain structure and patterns of behaviour in the face of disturbance (Holling 1986, in Costanza et al 1992), or the ability to recover following disturbance.

RESOURCE QUALITY

The quality of all the aspects of a water resource including:

(a) the quantity, pattern, timing, water level and assurance of instream flow;

(b) the water quality, including the physical, chemical and biological characteristics of the water;

(c) the character and condition of the instream and riparian habitat; and

(d) the characteristics, condition and distribution of the aquatic biota.

RESOURCE QUALITY OBJECTIVE

Quantitative and auditable statements about water quantity, water quality, habitat integrity and biotic integrity that specify the requirements (goals) needed to ensure a particular level of resource protection.

SPATIO — TEMPORARY ROBUST

Does not change significantly with time in relation to spatial distribution.

STROMATOLITE

A rocky cushion-like growth formed by the growth of lime-secreting blue-green algae, thought to be abundant 200 million years ago, when blue-green algae were the most advanced form of life on earth.

SWALES

A small earth wall guiding surface runoff away from the stream back onto the fields.

TAXON (plural: TAXA)

General term for a taxonomic group in a formal system of nomenclature, whatever its rank. A taxonomic group refers to the systematic ordering and naming of plants and animals according to their presumed natural relationships. For example, the taxa Simuliidae, Diptera, Insecta and Arthropoda are examples of a family, order, class and phylum respectively.

TROPHIC

Pertaining to nutrition.

VADOSE ZONE

Relating to or resulting from water or solutions that are above the permanent groundwater level.

VULNERABLE

Species believed likely to move into the endangered category in the near future if the causal factors continue operating. Included are species of which all or most of the population are decreasing because of overexploitation, extensive destruction of habitat, or other environmental disturbance. Species with populations which have been seriously depleted and whose ultimate security is not yet assured, and species with populations that are still abundant but are under threat from serious adverse factors throughout their range.

CHAPTER 1: INTRODUCTION

1.1 PURPOSE OF THE STUDY

The National Water Act, 1998 (Act No. 36 of 1998) requires the Minister of Water Affairs and Forestry to establish a national water resource strategy for the protection, use, development, conservation, management and control of water resources. To enable the strategy to be established, information on the present and probable future situations regarding water requirements and water availability is required, that is, a national water resources situation assessment providing information on all the individual drainage basins in the country.

The Department of Water Affairs and Forestry (DWAF) has appointed consulting engineers to undertake Water Resources Situation Assessments for the purpose of gathering information and using it to reconcile the present water requirements of all the user sectors with the presently available water resources. The information produced by all the studies will be consolidated by DWAF into a national database which will be used to establish the National Water Resource Strategy. Scenarios of future water requirements and water availability are being dealt with in a separate study. These scenarios will be taken up in the National Water Resource Strategy and will be reported on separately for each water management area.

As a component of the National Water Resource Strategy, the Minister of Water Affairs and Forestry has established water management areas and determined their boundaries. The National Water Act provides for the delegation of water resource management from central government to the regional or catchment level by establishing catchment management agencies. It is intended that the documents produced in this study as well as in the subsequent scenario studies referred to above should, in addition to contributing to the establishment of the National Water Resource Strategy, provide information for collaborative planning of water resources development and utilisation by the central government and the future catchment management agencies.

In order to facilitate use by future catchment management agencies, the information has been presented in the form of a separate report on each water management area. This report is in respect of the Upper Vaal Water Management Area (Upper Vaal WMA), which occupies portions of the Mpumalanga, Free State, Gauteng and North-West provinces. A provincial water resources situation assessment can be derived by assembling the provincial data from each of those reports that describe the water management areas that occupy the province.

1.2 APPROACH TO THE STUDY

The study was carried out as a desktop investigation using data from reports and electronic databases, or supplied by associated studies, local authorities and DWAF. The study considered conditions as they were in the year 1995 and did not make projections of future conditions. Data at reconnaissance level of detail was collected on land-use, water requirements, water use, water related infrastructure, water resources and previous investigations of water supply development possibilities. Relevant data was used in a computerised water balance model, developed in a separate study (DWAF, February 2000) to calculate the yield of the water resources at development levels as they were in 1995, and the maximum yield that could be obtained from future development of these resources. The water balance (the relationship between water requirements and water availability) at selected points in each water management area was also calculated

The basic hydrological data used was that contained in the report, The Surface Water Resources of South Africa, 1990, which was published by the Water Research Commission (Stewart Scott, 1990). The data was modified to take account of the Vaal River System Analysis Update Study (BKS et al, 1997). Land-use data was obtained from reports on the Vaal River System Analysis Update Study, from the report on the Surface Water Resources of South Africa, 1990, from the Vaal River Irrigation Study (Loxton et al, 1999b) and a number of other reports as indicated in the **References section**.

Information on urban water use and water related infrastructure was obtained from reports on urban water supplies and from questionnaires filled in by local authorities. The collected data on urban water use was supplied to consultants appointed to carry out a separate national demographic study, in relation to water requirements.

In that study, data from the 1996 census, and other sources, was used to derive demographic information for the whole country for the year 1995. In addition, the information on urban water use, that was supplied by the water resources situation assessment studies, was analysed in the demographic study to derive typical unit water requirements. These were used, in conjunction with the demographic data, to estimate water requirements in 1995 for urban areas for which no recorded data was available.

Both the demographic data and the estimated water requirements in 1995, as supplied for the Upper Vaal WMA by the national demographic study (DWAF, March 2000), are presented in this report. In addition to the separate studies on the water balance model and demography referred to above, separate studies were carried out to provide information on a national basis on:

- Macro-economic aspects.
- Legal aspects of water resource management.
- Institutional arrangements for water supply.

- Effects of alien vegetation on runoff.
- Groundwater resources.
- Bacteriological contamination of water resources.
- Water requirements for irrigation.
- Ecological classification of rivers.
- Water requirements for ecological component of Reserve.
- Effects of afforestation on runoff.
- Storage-yield characteristics of rivers.

Information from all the above studies, that is relevant to the Upper Vaal Water Management Area, is included in the appropriate sections of this report.

1.3 REPORT LAYOUT AND CONTENT

The findings of the study in respect of the Upper Vaal WMA are presented in the nine chapters that make up the main body of this report, and a number of appendices containing mainly statistics for the quaternary hydrological sub-catchments that make up the water management area. (The system used to divide the area into hydrological sub-catchments is explained in **Section 2.1** of the report).

The chapter headings are:

Chapter 1: Introduction
Chapter 2: Physical Features
Chapter 3: Development Status
Chapter 4: Water Related Infrastructure
Chapter 5: Water Requirements
Chapter 6: Water Resources
Chapter 7: Water Balance
Chapter 8: Costs of Water Resources Development
Chapter 9: Conclusions and Recommendations

Chapters 2, 3 and 4 describe climatic and physical features, and land-uses that affect water resources or water supply. **Chapter 5** describes the various water user sectors and their requirements. It includes information on water allocations, water conservation and demand management, and water losses and return flows. **Chapter 6** describes the groundwater and surface water resources of the water management area, and **Chapter 7** compares water requirements with the available resource. In **Chapter 8**, rough estimates are given of the cost of developing the portion of the total water resource that was not developed by 1995, and the conclusions and recommendations arising from the study are presented in **Chapter 9**.

CHAPTER 2: PHYSICAL FEATURES

2.1 THE STUDY AREA

The Upper Vaal WMA covers 55 565 km^2 and is part of the Orange River watercourse as shown in **Figure 2.1.1**.

The study area is shown in **Figure 2.1.2**.

The Upper Vaal WMA is located upstream of the confluence of the Vaal and the Mooi Rivers and extends to the headwaters of the Vaal, Klip, Wilge and Liebenbergsvlei rivers. This WMA includes the very important dams Vaal Dam, Grootdraai Dam and Sterkfontein Dam. It includes parts of Gauteng, Mpumalanga, Free State and North-West provinces.

The northern side of this WMA cuts through Johannesburg, Soweto and outlying areas. Further south are Vereeniging, Vanderbijlpark, Sasolberg, Sebokeng and Meyerton in relatively close proximity. Potchefstroom is situated to the east. Standerton is situated near to Grootdraai Dam. In the southern tip of this WMA, Phuthaditjhaba is situated in the vicinity of Sterkfontein Dam. Other urban areas are Bethlehem, Harrismith, Kestell, Warden, Reitz, Memel, Tweeling, Vrede, Frankfort, Amersfort, Ermelo, Morgenzon, Greylingstad, Denysville, Villiers, Bethal, Evander, Balfour, Parys, Carletonville and surrounding mining areas and the Sasol - Secunda area.

The topography and secondary river catchments are shown in **Figure 2.1.3**.

For purposes of reporting and analysing the water balance at relevant key points such as major reservoirs, WMA boundaries etc., the catchment was divided into nine key areas.

The hydrological sub-catchments showing numbered quaternary sub-catchments, key area boundaries, rivers, dams and main towns are shown in **Figure 2.1.4**.

The Upper Vaal River catchment is fed by a number of tributaries, of which the most significant are (in downstream order) Wilge, Liebensbergvlei, Klip (upstream of Grootdraai Dam), Waterval, Suikerbos, Klip and Mooi. From a water resources point of view the most important is the Wilge and in the future Liebensbergvlei (Lesotho Highlands Water Project).

The Upper Vaal WMA consists of the C11, C12, C13, C21, C22, C23, C81, C82 and C83 tertiary catchments and is shown in **Figure 2.1.4**. The figure also shows the main rivers and towns, the WMA boundary, secondary catchments, provincial boundaries where applicable, and names of adjacent Water Management areas.

The Vaal catchment slopes gently from about 1 800 m in the east to 1 450 m in the west in the vicinity of the Vaal Barrage, with some steep areas in the headwaters of the Wilge tributary on the south-eastern border with the Orange. The topography is flatter in the west than in the east. **Figure 2.1.3** shows the topography and river catchments and **Figure 2.1.4** shows the 88 quaternary catchments and other main features.

2.2 CLIMATE

Climatic conditions can vary considerably from east to west across the Upper Vaal WMA.

Temperature

The mean annual temperature ranges between 16 °C in the west to 12 °C in the east, with an average of about 15 °C for the catchment as a whole. Maximum temperatures are experienced in January and minimum temperatures usually occur in July. The following table summarises temperature data for these two months (Schulze et al, 1997).

TABLE 2.2.1: TEMPERATURE DATA

Month	Temperature (°C)	Average	Range
January	Mean temperature	20	18 – 22
	Maximum temperature	27	24 – 30
	Minimum temperature	14	10 – 16
	Diurnal range	13	12 – 15
July	**Mean temperature**	8	6 – 10
	Maximum temperature	16	14 – 19
	Minimum temperature	0	-2 – 2
	Diurnal range	16	14 - >18

Frost occurs throughout the Upper Vaal WMA in winter, typically over the period mid-May to late August. The average number of frost days per year for the ranges from 30 in the northern and eastern parts up to 50 in the central plateau areas of the Free State.

Rainfall

Rainfall is strongly seasonal with most rain occurring in the summer period (October to April). The peak rainfall months are December and January. Rainfall occurs generally as convective thunderstorms and is sometimes accompanied by hail. The average hail day frequency is four per annum (at any single location) and the mean lightning flash density is 6-9 per km^2 per annum.

The overall feature of mean annual rainfall over the Upper Vaal WMA is that it decreases fairly uniformly westwards from the eastern escarpment regions across the central plateau area. The MAP for the watershed ranges from a high of 1 000 mm in the east to a low of 500 mm in the west with an average of about 700 mm. The average coefficient of variation (CV) ranges from 25% to 35%.

For the driest year in five (80% exceedance probability) the annual rainfall for the eastern half of the Upper Vaal WMA is about 650 mm and for the western half the annual rainfall is about 450 mm. It can be as low as about 300 mm in some places. For the wettest year in five (20% exceedance probability) the annual rainfall in the eastern half is about 750 mm and can be as high as 1 800 mm in the escarpment areas. For the western half the annual rainfall is about 700 mm and can be as high as 900 mm in places.

Figure 2.2.1 shows the study area and distribution of MAP with an inset of a histogram showing the monthly distribution of rainfall.

Humidity and evaporation

In accordance with the rainfall pattern the relative humidity is higher in summer than in winter. Humidity is generally highest in February (the daily mean ranges from 65 % in the west to 70 % in the east) and lowest in August (the daily mean ranges from of 55 % in the west to 62 % in the east).

Average potential mean annual gross evaporation (as measured by Class A-pan) ranges from 1 600mm in the east to a high of 2 200 mm in the dry western parts. The highest Class A-pan evaporation is in January (range 180 to 260 mm) and the lowest evaporation is in June (80 to 110 mm).

The gross irrigation requirement (based on rainfall and A-pan evaporation) ranges from 1 600 mm/a in the dry western parts to 900 mm/a in the eastern escarpment areas. The minimum monthly requirement is in June (ranges from 70 to 110 mm) and the maximum monthly requirement is in September (ranges from 130 to 200 mm).

Figure 2.2.2 shows the study area and distribution of mean annual gross evaporation with an inset showing the monthly distribution.

2.3 GEOLOGY

The area to the south of the Vaal River is underlain by fine sedimentary rocks of the Karoo system (compact arenaceous and argillaceous strata – refer to Figure 2.3.1), as is the area to the north of the Vaal River, situated east of longitude 28° E. The Karoo system covers about 80 % of the Upper Vaal WMA. To the north of the Vaal River, west of longitude 28° E, igneous and metamorphic rocks predominate (compact sedimentary strata and compact sedimentary extrusive and intrusive rocks – refer to **Figure 2.3.1**) but there are extensive dolomitic exposures in the central areas which are mainly in the catchment of the Mooi tributary (dolomite, chert and subordinate limestone – refer to **Figure 2.3.1**).

Dolomitic exposures can alter the normal flow of water in a catchment in that apparent losses occur in the areas where there are dolomites but this water invariably reappears in another area via springs.

The predominant minerals are gold, uranium, base metals, semi-precious stones, industrial minerals and dimension stone. Gold mining, in particular is of particular economic importance. Also of importance are uranium and coal mining.

The geology of the WMA showing the main rock types is given in **Figure 2.3.1**.

2.4 SOILS

Figure 2.4.1 shows a generalised soil map of this WMA using some 16 broad soil groupings (obtained from the WR90 study). The 16 groupings were derived by the Department of Agricultural Engineering of the University of Natal using a national base map, which was divided into 82 soil types. These soil types were then analysed according to features most likely to influence hydrological response, viz. depth, texture and slope.

Soil depths are generally moderate to deep with an undulating relief over the entire Upper Vaal WMA. There are three main soil types that predominate and these are distributed across the catchment as follows.

- Sandy Loam: In upper reaches of the Vaal and Wilge catchments and to north of the Vaal River along its central reaches.
- Clay Loam: In the Klip (Gauteng) and Suikerbosrand catchments and to the south of the Vaal River along its central reaches.
- Clay Soil: In the middle and lower catchments of the Wilge and Vaal catchments upstream of Vaal Dam. It also occurs to the west of the Vaal

It should be noted that the base information for the above work is quite old and that much more detailed and reliable information exists today which can be used for more detailed planning purposes. The interpretation of this data for a particular purpose, such as runoff response or irrigation potential will however involve considerable work and was therefore not deemed warranted for the purpose of this study.

2.5 NATURAL VEGETATION

2.5.1 Introduction

Some 20 000 different plant species occur throughout South Africa. These are however not randomly distributed within the region but are organised into distinct communities, largely dependent on the prevailing climatic (especially rainfall) and edaphic (soil) conditions. For the purposes of identifying and managing the heterogeneous range of vegetation within South Africa, we need to be able to recognise relatively homogenous vegetation groups or types. Furthermore, for the recognised groups to be meaningful, it is essential that they are readily apparent and spatio-temporally robust.

Acocks (1988) introduced the concept of "Veld type", which he defined as "a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming potentialities". Acocks (1988) identified a total of 70 veld types in South Africa (see **Table 2.5.1.1**), including 75 variations. These 70 veld types fall into 11 broad categories, ranging from various forest types to sclerophyllous (Fynbos) types (**Table 2.5.1.1**). These "simplified" Acocks veld type categories are used for the purposes of this report, and accordingly the description of the natural vegetation types occurring within the WMA is rather broad.

TABLE 2.5.1.1: A LIST OF THE DETAILED AND SIMPLIFIED ACOCKS VELD TYPES (Acocks, 1988).

DETAILED VELD TYPES	NO.	SIMPLIFIED VELD TYPE
Coastal Forest and Thornveld	1	**Coastal Tropical Forest**
Alexandria Forest	2	
Pondoland Coastal Plateau Sourveld	3	
Knysna Forest	4	
'Ngongoni Veld	5	
Zululand Thornveld	6	
Eastern Province Thornveld	7	
North-eastern Mountain Sourveld	8	**Inland Tropical Forest**
Lowveld Sour Bushveld	9	
Lowveld	10	**Tropical Bush and Savanna**
Arid Lowveld	11	
Springbok Flats Turf Thornveld	12	
Other Turf Thornveld	13	
Arid Sweet Bushveld	14	
Mopani Veld	15	
Kalahari Thornveld	16	
Kalahari Thornveld invaded by Karoo	17	
Mixed Bushveld	18	
Sourish Mixed Bushveld	19	
Sour Bushveld	20	
False Thornveld of Eastern Cape	21	**False Bushveld**
Invasion of Grassveld by Acacia karoo	22	
Valley Bushveld	23	**Karoo and Karroid**
Noorsveld	24	

DETAILED VELD TYPES	NO.	SIMPLIFIED VELD TYPE
Succulent Mountain Scrub	25	
Karroid Broken Veld	26	
Central Upper Karoo	27	
Western Mountain Karoo	28	
Arid Karoo	29	
Central Lower Karoo	30	
Succulent Karoo	31	
Orange River Broken Veld	32	
Namaqualand Broken Veld	33	
Strandveld	34	
False Arid karoo	35	**False Karoo**
False Upper Karoo	36	
False Karroid Broken Veld	37	
False Central Lower Karoo	38	
False Succulent Karoo	39	
False Orange River Broken Karoo	40	
Pan Turf Veld invaded by Karoo	41	
Karroid Merxmuellera Mountain Veld replaced by Karoo	42	
Mountain Renosterveld	43	
Highveld Sourveld and Dohne Sourveld	44	**Temperate and Transitional Forest and Scrub**
Natal Mist Belt 'Ngongoni Veld	45	
Coastal Renosterveld	46	
Coastal Fynbos	47	
Cymbopogon – Themeda Veld	48	**Pure Grassveld**
Transitional Cymbopogon – Themeda Veld	49	
Dry Cymbopogon – Themeda Veld	50	
Pan Turf Veld	51	
Themeda Veld or Turf Highveld	52	
Patchy Highveld to Cymbopogon – Themeda Veld Transition	53	
Turf Highveld to Highland Sourveld Transition	54	
Bakenveld to Turf Highveld Transition	55	
Highland Sourveld to Cymbopogon – Themeda Veld Transition	56	
North-eastern Sandy Highveld	57	
Themeda – Festuca Alpine Veld	58	
Stormberg Plateau Sweetveld	59	
Karroid Merxmuellera Mountain veld	60	
Bankenveld	61	**False Grassveld**
Bankenveld to Sour Sandveld Transition	62	
Piet Retief Sourveld	63	
Northern Tall Grassveld	64	
Southern Tall Grassveld	65	
Natal Sour Sandveld	66	
Pietersburg Plateau False Grassveld	67	
Eastern Province Grassveld	68	
Fynbos	69	**Sclerophyllous Bush**
False Fynbos	70	**False Sclerophyllous Bush**

2.5.2 Natural vegetation types

In this WMA the predominant veld type is "pure grassveld". In the upper Wilge catchment and along the escarpment where the rainfall increases from about 700 mm to up to 1 000 mm there are areas of "temperate and transitional forest and scrub" while "false grassveld" predominates to the north of the Vaal River in its central reaches, particularly in the Mooi catchment. The Acock's veld types are shown in **Figure 2.5.2.1**.

2.6 ECOLOGICALLY SENSITIVE SITES

2.6.1 Sensitive Ecosystems

The conservation of living resources is essential for sustaining development, by maintaining the essential ecological processes and life support systems, preserving genetic diversity and ensuring that utilisation of species and ecosystems is sustainable. However, for conservation to succeed it should be underpinned by two basic principles, namely the need to plan resource management (including exploitation) on the basis of an accurate inventory and the need to implement proactive protective measures to ensure that resources do not become exhausted. Accordingly, a vital component of ensuring sustainable conservation practices is the identification of conservation worthy habitats or sensitive ecosystems.

In terms of Section 2 (1) of the Environment Conservation Act, 1989 (Act No. 73 of 1989), South Africa's schedule of protected areas was published in the Government Gazette 15726 in May 1994 (Notice 449 of 1994). This classification identifies the following sensitive or protected areas:
Scientific and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas and Protected Land/Seascapes, based on their location and the functions they fulfil.

South Africa has also recognised the importance of its wetlands as sensitive ecosystems that require conservation, and accordingly has become a signatory to the international Convention on Wetlands of International Importance especially as Waterfowl Habitat or RAMSAR Convention. In terms of this convention, signatories undertake to include wetland conservation considerations in their national land-use planning, and as far as possible to ensure the wise use of wetlands within their territory.

The most sensitive ecological area in the Upper Vaal WMA is the Blesbokspruit wetland in the catchment of Suikerbosrand River.

Before moving on to discuss ecosystems of concern to the study area it would be prudent to give some consideration to the definition of aquatic ecosystems, especially with respect to the National Water Act, 1998 (Act No. 36 of 1998). In general terms an ecosystem may be defined as a community of organisms and their physical environment interacting as an ecological unit. Hence, aquatic ecosystems encompass the aquatic community and water resources necessary to sustain its ecological integrity. Within the National Water Act the water resource requirements of aquatic ecosystems are recognised and protected by the introduction of the concept of an ecological reserve, viz. the water required to protect the aquatic ecosystem of the water resources. The Reserve refers to both the quantity and quality of the resource. Accordingly, development must take cognisance not only of the sensitivity of the receiving ecosystem but also of the resource requirements or ecological reserve of the aquatic communities it supports.

2.6.2 River Classification

The water resources of South Africa are to be protected in terms of the National Water Act, 1998 (Act No. 36 of 1998). This will be accomplished by classifying each water resource, setting the resource quality objectives and determining the Reserve. This process had not yet been completed and therefore it was necessary to determine the present condition or present ecological status class (PESC) of the water resources so as to estimate the quantities of water required to maintain them in this condition for the purpose of the 1995 water resources situation assessment

The water resources situation assessment has been performed at the quaternary catchment scale of resolution as described in **Section 2.1**. However, the delineation of these quaternary catchments was not based on ecological principles. In order to provide some ecological basis for the estimates of water requirements to maintain a particular class of river it was decided to base estimates of water requirements on an index of the ecological importance and sensitivity class (EISC) of the rivers in the quaternary catchment of concern. The ecological importance and sensitivity class of the rivers was used to derive the default ecological management class (DEMC), which relates to a default ecological status class (DESC). The default ecological status class and the present ecological status class (PESC) have been used to arrive at a suggested future ecological management class (AEMC) to be considered for the water resources. The default ecological status class would normally be assigned to a water resource on the basis of ecological sensitivity and importance. This methodology is based on the assumption that the ecological importance and sensitivity of a river would generally be closely associated with its default ecological management class and that its current ecological status and potential to recover from past ecological damage will determine the possibility of restoring it to a particular ecological management class.

This section describes the procedures and methods adopted to estimate the various status and management classes of the rivers that will be used to estimate the corresponding quantities of water required for that component of the Reserve that is necessary to protect the aquatic ecosystems according to the designated class.

The procedure that has been followed to determine the various classifications is illustrated in **Diagram 2.6.2.1**. The descriptions of the various ecological importance and sensitivity classes (EISC), default ecological management classes (DEMC), default ecological status classes (DESC), present ecological status classes (PESC) and the suggested future ecological management class (AEMC) are given in **Diagram 2.6.2.2**.

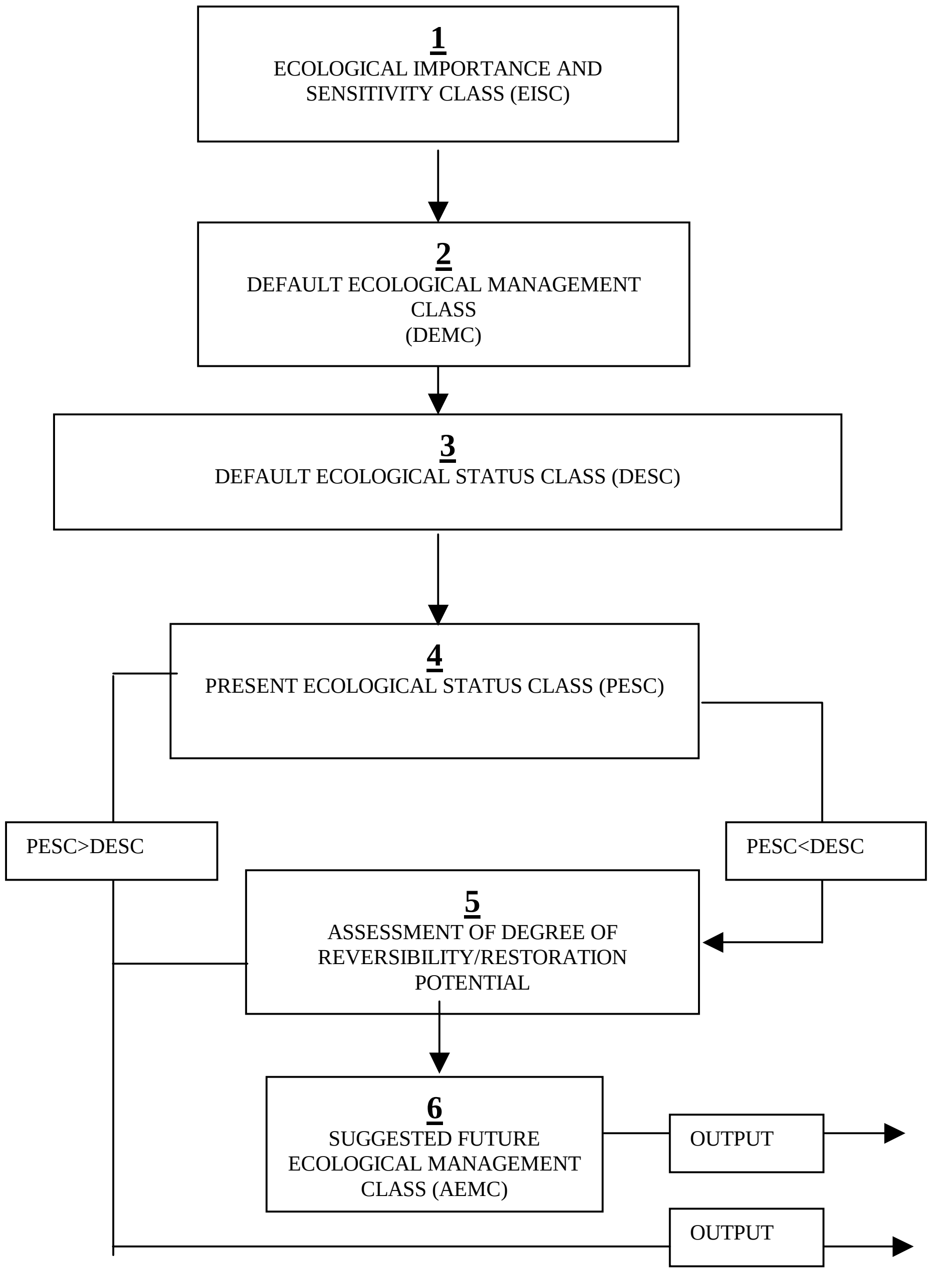


Diagram 2.6.2.1: Procedure followed to determine the river classifications

EISC | DEMC and DESC

Very high → No human induced hazards → Class A: Unmodified natural

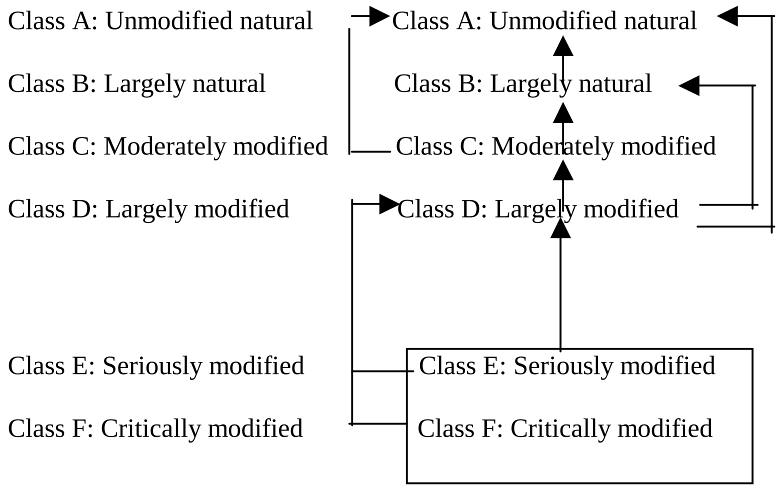
High → Small risk allowed → Class B: Largely natural

Moderate → Moderate risk allowed → Class C: Moderately modified

Low/marginal → Large risk allowed → Class D: Largely modified

PESC | PESC: SUGGESTED ATTAINABLE IMPROVEMENT

Acceptable range of AEMC:



→: indicates relationship.

──►: indicates possible direction of desirable change.

Diagram 2.6.2.2: Descriptions of EISC, DEMC, DESC, PESC and AEMC.

Individual assessors familiar with the ecology of a particular area or a comparable area were engaged in discussions and workshops during which a number of biotic and habitat determinants considered important for the determination of ecological importance and sensitivity were quantified or scored. The procedure that was followed was considered to be suitable for the situation where the delineation of the quaternary catchment units was not based on ecological considerations. The approach may however, have a low ecological sensitivity because of the absence of an ecological typing framework. The median of the scores assigned by the assessors was calculated to derive the ecological importance and sensitivity class. The assessors were then required to compare this with their overall estimation of the ecological importance and sensitivity class of the main stem river of the quaternary catchment of concern near its outlet.

The assessors were required to record and be able to substantiate their assessments to a reasonable degree for possible review in future.

The ecological importance and sensitivity classes were assessed during meetings or a workshop held during 1998. This was followed by a second workshop during 1999 that was primarily concerned with the assessment of the present ecological status class, the potential to improve the ecological status class and the suggested future management class. The second workshop however, also involved an overall review of the ecological importance and sensitivity assessments determined during the original workshop.

The procedure that was adopted to classify the rivers was qualified in the following respects:

- Only lotic systems (i.e. streams and rivers and associated habitats such as lotic wetlands) can be classified and the procedure is not meant to be applied to lakes, pans, impoundments or estuaries. Although several of the components considered in this assessment may be generally applicable, the application of the procedure to systems other than rivers and streams was not attempted.

- Where a quaternary catchment contained an estuary, this procedure was only applied to the riverine part of the catchment.

- Only the main stem river in a quaternary catchment was considered in the assessment and therefore the management class must not be applied to any tributary streams in the quaternary catchment. These tributaries and their associated water requirements do however, become relevant when a water resources situation assessment is conducted at a sub-quaternary level.

- In cases where a dam wall was present at or relatively close to the outlet of a quaternary catchment, the assessments for that quaternary catchment were based on the river upstream of the dam (i.e. upstream of the backwater effect of the dam).

- In cases where degradation has occurred along certain sections of the mainstem of a quaternary catchment, but where there are still substantial less disturbed sections, the classification was based on those less disturbed areas. The intention of this was to ensure that the ecological component of the Reserve would provide for these less disturbed sections as if they were situated at the outlet of the quaternary catchment, where the ecological component of the Reserve will be estimated for the water resources situation assessments.

- The classifications were fundamentally considered from an instream and riparian zone perspective. Although the catchment in itself plays a major role in the condition and functioning of the rivers and streams in the catchment, the purpose of this procedure was not to provide an overall assessment of the condition of each catchment.

- The riparian zone was broadly regarded as that part of the river bordering on the river channel. Usually characteristic plant species and/or vegetation structure provided an indication of the extent of the riparian zone.

The specific aspects that were considered when classifying the rivers are described below.

Ecological Importance and Sensitivity Class (EISC)

The following ecological aspects were considered for the estimation of the ecological importance and sensitivity class:

- The presence of rare and endangered species, unique species (i.e. endemic or isolated populations) and communities, species intolerant to changes in flow regime or water quality and species diversity was taken into account for both the instream and riparian components of the river.

- Habitat diversity was also considered. This included specific habitats and river reaches with a high diversity of habitat types such as pools, riffles, runs, rapids, waterfalls and riparian forests.

- The importance of the Particular river or stretch of river in providing connectivity between different sections of the river, i.e. whether it provides a migration route or corridor for species.

- The presence of conservation or relatively natural areas along the river section serving as an indication of ecological importance and sensitivity.

- The ecological sensitivity (or fragility) of the system to environmental changes. Both the biotic and abiotic components were included.

The ecological importance of a river is an expression of its importance to the maintenance of ecological diversity and functioning on local and broader scales. Ecological sensitivity (or fragility) refers to the system’s ability to resist disturbance and its resilience or capability to recover from a disturbance that has occurred.

The present ecological status was not considered when determining the ecological importance and sensitivity per se. The ecological importance and sensitivity that has been established for the water resources situation assessments is a general and unrefined estimate. It is strongly biased towards the potential importance and sensitivity of the main stem river of the quaternary catchment under close to unimpaired conditions.

Present Ecological Status Class (PESC)

Habitat integrity i.e. ecological integrity, condition and change from the natural condition, was regarded as a broad preliminary indicator of present ecological status for the purpose of the water resources situation assessments.

Each of the above attributes that were used to estimate the present ecological status, were scored, from which the mean was calculated. This mean was used to assign a present ecological status class to the main stem river in the vicinity of the outlet of the quaternary catchment.

Suggested Future Ecological Management Class (AEMC)

The potential to improve the ecological conditions was assessed only in terms of the present flow regime. Degradation of the system purely because of non-flow related change was ignored.

The practicality of improving an existing modified ecological system to arrive at the suggested future ecological management class was assessed on the basis of the changes that have occurred, by comparing the difference between the present ecological status class and the default ecological status. For the purpose of these water resources situation assessments restoration was accepted to be the "…re-establishment of the structure and function of an ecosystem, including its natural diversity". Generally, structure is the native or natural species diversity of the ecosystem, while function is its productivity in terms of growth of plant biomass as the basis for food webs and the functions of hydrology, trophic structure and transport. Restoration is to reverse the decline of the health of a degraded ecosystem towards its historic structure. In contrast, reclamation and rehabilitation are usually more local and site-specific, while habitat creation refers to the establishment of new habitat, without regard to historical conditions.

The water resources situation assessment is, inter alia, concerned with the quantity of water, and therefore particular emphasis was placed on flow modification. Where the impact on the biota and the habitats of the estimated present flow modification was less than can be inferred from the present ecological status, this was taken into account and specifically highlighted (emphasised or flagged). It is obvious that such a state of affairs needs more specific attention. This situation arose only in a limited number of cases and has been indicated in the assessment of both the present ecological status class and the suggested future ecological management class, but needs more specific attention in future.

2.6.3 Aquatic Ecosystems of Concern to the Study

It is important to recognise that within the context of the current report sensitive ecosystems refer specifically to ecosystems, which are sensitive with respect to possible changes in water quantity and quality. Other sensitive ecosystems, specifically protected areas, are discussed in **Section 2.6.4**.

The ecological significance/conservation importance of the river systems falling within the Upper Vaal WMA, as exemplified by their Ecological Importance and Sensitivity Classes (EISC), are summarised in **Figures 2.6.3.1 to 2.6.3.3.** These show, respectively for each quaternary catchment, the default ecological management class, the present ecological status class, and the suggested future ecological management class. Definitions of these EISC are given in the glossary of terms at the front of this report. The EISC of a river, as reflected in the DESC, is an expression of its importance to the maintenance of ecological diversity and functioning on a local and wider scale, as well as the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred.

The default ecological management class (**Figure 2.6.3.1**) showed that the majority of the catchment could be tolerated as class C (moderately modified) with seven quaternary catchments even being of class D (largely modified). Interspersed were quaternary catchments where a class B (largely natural) could be tolerated. The present ecological status class (**Figure 2.6.3.2**) showed no class A (unmodified, natural) in quaternary catchments and only three in class B in the C13 tertiary catchment. The largest portion of the WMA showed class C with the remainder being Class D and ten quaternary catchments of class E-F (seriously/critically modified) along parts of the Liebenbersvlei, Klip River and upstream of Grootdraai Dam. The suggested future management class (**Figure 2.6.3.3)** showed the worst class as being class D. Portions of classes D and C from **Figure 2.6.3.2** showed improvement to class B, mainly in the eastern part and the north-west corner of the WMA.

2.6.4 Natural Heritage Sites, Proclaimed Game and Nature Reserves and Wilderness Areas.

As previously alluded to, the sensitive ecosystems outlined above only include those relevant to aquatic ecosystems. However, in addition to these ecosystems the Upper Vaal WMA contains other protected areas which may be impacted directly or indirectly upon by development activities associated with water resources. These protected areas include Natural Heritage Sites as well as Scientific and Wilderness Areas, National Parks and Reserves, Monuments and Areas of Cultural Significance, Habitat and Wildlife Management Areas, Protected Land/Seascapes.

Table 2.6.4.1 contains a list of the protected areas within the Upper Vaal WMA. All water resource development should take cognisance of these sites and it is the developer's responsibility to identify the exact proximity of activities to any of these sites, and to ensure that activities do not threaten the integrity of these sites. This consideration is particularly pertinent where water resource development activities impact on the supply of water resources to these areas and hence their long-term ecological sustainability.

TABLE 2.6.4.1: PROTECTED NATURAL AREAS AND NATURAL HERITAGE SITES WITHIN THE UPPER VAAL WMA.

AREA NAME	CATEGORY	Quaternary catchment and Province
Holkranse	Habitat and Wildlife Management Area	C11A (Mpumalanga)
Douglas Dam Nature Reserve	Habitat and Wildlife Management Area	C11F (Mpumalanga)
Vaal Dam Nature Reserve	Habitat and Wildlife Management Area	C12L (Mpumalanga)
Zeekoeivlei Nature Reserve	Habitat and Wildlife Management Area	C13C (Free State)
Marievale Bird Sanctuary	Habitat and Wildlife Management Area	C21E (Gauteng)
Heidelberg Army Gymnasium	Habitat and Wildlife Management Area	C21F (Gauteng)
Suikerbosrand Nature Reserve	Habitat and Wildlife Management Area	C21F (Gauteng)
Rondebult Bird Sanctuary	Habitat and Wildlife Management Area	C22B (Gauteng)
Abe Bailey Nature Reserve	Habitat and Wildlife Management Area	C23E (Gauteng)
Boskop Dam Nature Reserve	Habitat and Wildlife Management Area	C23G/H (North West)

Notes:
(1) Information from (Readers Digest, 1990)

This list should only be viewed as a guide to the protected areas, since as the status of protected areas is constantly changing and new areas are receiving protection, the list cannot be comprehensive. It is the developer's responsibility to ascertain the location of any protected areas adjacent to the development and to ensure that activities do not impact on these areas
Details of Nature Reserves are as follows:

Holkranse is a conservation area situated in the headwaters of the Vaal River in Mpumalanga. It has an area of 732 ha and has endangered animals such as oribi, aardvark and veldlikkewaan.

Douglas Dam Nature Reserve surrounds Douglas Dam, 6 km from Ermelo. The 540 ha reserve is home to eland, zebra, blesbok and springbok.

Vaal Dam Nature Reserve is located 3 km from the dam wall on the north shore. The 350 ha reserve is characterised by highveld grassland broken by clumps of Karoo thorn and acacia. Barbel, carp and yellowfish are found in the dam and the main bird species include duck, coot, egret, geese and fish eagle.

Zeekoeivlei Nature Reserve is located on the Klip River near Memel. The vleis in the 379 ha reserve are important breeding grounds for thousands of waterfowl.

Marievale Bird Sanctuary is situated in a large vlei on the Blesbokspruit, close to Nigel. The 500 ha reserve is a RAMSAR site and owes its existence to the discharge of treated effluent upstream of the vlei. Over 125 bird species (mainly waterfowl) have been observed, including flamingos, spoonbill, ducks, geese and waders, some of which are rare migrants gallinule.

Heidelberg Army Gymnasium is a military training base, which is situated on the outskirts of the town. It covers an area of 131 ha and has endangered animals such as aardvark.

Suikerbosrand Nature Reserve is located in the hills of the Suikerbosrand near Heidelberg. The 13 337 ha reserve is covered by grassland with pockets of acacia woodland. The main mammal species are blesbok, black wildebeest, eland, red hartebeest, springbok, oribi, zebra, mountain reedbuck, duiker, grey rhebok, steenbok, kudu, brown hyena and cheetah.

Rondebult Bird Sanctuary is located on the outskirts of Germiston and comprises vlei and marshland fed by discharge of treated effluent from Rondebult Sewage Treatment Works. The reserve is home to over 156 bird species (mainly waterfowl), including avocet, flamingos, herons, spoonbill, ibis and purple gallinule.

Abe Bailey Nature Reserve is situated 5 km north of Carletonville in flat terrain and is covered by grassland and by bush. The 3 000 ha reserve includes a 400 ha vlei, sustained by mine pumpage. Mammal species include springbok, black wildebeest and red hartebeest. The vlei attracts a variety of waterfowl as well as fish eagle and flamingo.

Boskop Dam Nature Reserve is situated around Boskop Dam, 20 km north east of Potchefstroom. Vegetation in the 372 ha reserve includes an endangered succulent *Lithops lesliei*. Mammals include black wildebeest, eland, red hartebeest, zebra and blesbok. The dam is home to bass, carp, barbel, yellowfish and mud-fish, as well as a variety of birds such as ducks, crakes, avocets, goliath heron and fish eagle.

Other conservation areas which have endangered animals and plant species are Alice Glockner, Rolfes Pan, Qwaqwa and Vaalbank (in quaternary catchments C21F, C22B, C81F/G and C83B respectively).

Figure 2.6.3.2 shows ecologically sensitive sites, nature reserves, etc.

2.7 CULTURAL AND HISTORICAL SITES

Development of water supplies and services can have a negative impact on the archaeological and cultural heritage by way of development of dams, pipelines, canals, water services infrastructure and enterprises following on the provisions of water.

The National Monuments Act, 1969 (Act No. 28 of 1969) provides for the protection and conservation of cultural resources including all archaeological sites. In addition, the Environment Conservation Act, 1973 (Act No. 73 of 1989) provides for the integration of cultural resources into environmental management processes.

Any given development may have an impact on archaeological or cultural heritage sites. It is essential therefore that potential impacts of any water supply and services related development should be assessed at the earliest possible phase of project planning.

Permission for the development to proceed is granted by the National Monuments Council once it is satisfied that steps have been taken to safeguard archaeological or cultural heritage sites, or that they have been adequately recorded and/or sampled.

No general listing of the sites of palaeontological, archaeological and historical significance within the Upper Vaal WMA is available. Some information was, however, obtained from the "Morris and National Monuments Council" brochure. The National Monuments Council does possess a database of National Monuments within each province, but this is only of limited use since it only lists National Monuments (as declared within the Government Gazette), and the vast majority of these occur within urban areas which are unlikely to be impacted upon by water resources projects. Accordingly, it is the responsibility of the developer to liase with the National Monuments Council and South African Museum to establish whether they are aware of any sites of cultural/historical/archaeological interest within any area earmarked for development.

Moreover, it is the developer's responsibility to ensure that the development area is surveyed for archaeological sites or artefacts, and that necessary steps are taken to conserve them if they are present. To this end, the developer should be familiar with the relevant sections of the National Monuments Act and any other relevant legislation (e.g. National Parks Act, 1975 (Act No. 57 of 1975)), and should consult with the National Monuments Council on discovering sites or artefacts of palaeontological, archaeological or historical significance.

Also, developers should take cognisance of the fact that the National Heritage Act is likely to supersede the National Monuments Act in April 2000, and should undertake to familiarise themselves with the contents of the new Act.

CHAPTER 3: DEVELOPMENT STATUS

3.1 HISTORICAL DEVELOPMENT OF WATER RELATED INFRASTRUCTURE

Being the principal source of water supply to Gauteng, the Vaal River is perhaps South Africa's most important river – certainly the most overutilised.

The Vaal River basin boasts South Africa's earliest major multi-purpose scheme, which is also the first major inter-basin transfer scheme, viz. the Vaal River Development scheme, of which the main storage unit is Vaal Dam which is in the Upper Vaal WMA. Constructed during the mid-nineteen thirties, Vaal Dam was designed to serve both the Reef Complex and the Vaal-Harts Irrigation Scheme in the Lower Vaal WMA (involving diversion of water from the Vaal River into the Harts River valley). Although for many years most of the water from the Vaal River went to Vaal-Harts, the major share now goes to Rand Water (in the Upper Vaal WMA) for distribution throughout its 17 000 km^2 supply area.

Bloemhof Dam (in the Middle Vaal WMA), built in 1970, helped to relieve Vaal Dam of part of the downstream load. Upstream of Bloemhof, Sedibeng Water and MidVaal Water (previously the Western Transvaal Regional Water Supply Company) in the Middle Vaal WMA withdraw water from the Vaal River.

The Vaal River also provides water to the Lower Vaal WMA, to Kimberley and other riparian towns and to the Gamagara pipeline (serving the Kalahari (Hotazel-Postmasburg) mineral complex). The Sasol II and III complex is supplied from Grootdraai Dam in the Upper Vaal WMA. Considerable quantities of water are exported beyond the boundaries of the Vaal River basin – to Pretoria, Rustenburg and the northern parts of Rand Water's supply area and to Eskom power stations.

To meet spiralling water demands within the basin, various water importation schemes have been implemented. The most important of these are the Tugela-Vaal, Usutu-Vaal, Zaaihoek and the recently completed Phase 1A of the Lesotho Highlands Water Scheme (all entering the Upper Vaal WMA). Other waters brought into the Vaal River basin are those from the Caledon River to augment the supply to Bloemfontein (covered in the Upper Orange WMA report). Most of the major tributaries of the Vaal River support irrigation schemes.

3.2 DEMOGRAPHY

3.2.1 Introduction

A national study (Schlemmer et al, 2001) to develop water use projections to the year 2025 was undertaken for the Department of Water Affairs and Forestry by a team of specialists, in order to support the development of the National Water Resource Strategy. This included the development of baseline 1995 population estimates. The work commenced well before the results of the 1996 census became available, and a number of sources were used to develop the baseline data set. The database developed was subsequently reconciled with the results of the census in areas where the census had provided superior information.

The study focussed on so-called functional urban centres having or likely to have reticulated water supply systems in the future. In a number of instances areas on the fringe of urban centres and classified as rural in the 1996 census were incorporated with the functional urban centres defined in the study, and urban populations identified in this study therefore differed from the urban populations enumerated in the census. The regional weighting of census counts to compensate for undercounts was also identified as a factor distorting some urban populations in smaller centres reported in the census.

3.2.2 Methodology

Functional urban areas were identified within magisterial districts. Estimates were made of the 1995 population in these centres, while the populations outside of these urban areas were grouped together as a so-called rural remainder. The urban populations were further categorised in order to provide a basis for developing estimates of urban water use for the entire country (see **Section 5.3**).

A number of sources and approaches were used to obtain baseline population data for the year 1995. These included projections and estimates made by the following institutions:

- The Development Bank of Southern Africa.
- The Demographic Information Bureau.
- The Bureau for Market Research.
- Local authority estimates, where available.

The data from the above sources were compared with extrapolations and estimates based on the following:

- Household counts from the sampling database held by one of the participating consultants.
- Previous census results from 1970 onwards, including former homeland censuses.
- Estimates obtained from very large surveys such as that of the SAARF.

- The database of villages of the Directorate: Water Services of the Department of Water affairs and Forestry.

Discrepancies were reconciled on the basis of local knowledge and special enquiries directed at local authorities. The results of the 1996 census became available after this had been completed, and was used as an additional check on the database. Where discrepancies were significant these were investigated, and the database was revised where the 1996 census provided improved information.

As an overall check the population distribution database for 1995 that was developed as part of this study was projected for one year on the basis of a ruling population growth rate of 1,9%. An effective population of 42 379 000 persons in 1996 was arrived at in this way, which is only 1% above the 1996 census population of 41 945 000 persons.

A reasonable estimate of the distribution of the rural population was made, using the census results for the rural population as a guideline, to develop a spatially distributed database.

3.2.3 Historical Population Growth Rate

Information on historical growth trends is not readily available. Migration to urban areas is a significant trend in SA because of the perception that job opportunities are greater and services are better. Refugees and migrants (including illegal migrants) from neighbouring states are not a significant portion of the population (estimated at 68 000).

3.2.4 Population Size and Distribution in 1995

Quaternary catchment urban and rural population data was obtained from the National Demographic Study (Markdata and Schlemmer, 2000*)*. This data has been reproduced in **Figure 3.2.4.1** (shown as pie diagrams) and in **Appendices A.1** (urban data) **and A.2** (rural data). The quaternary catchment data has been summarised in **Table 3.2.4.1** into key area and provincial, urban and rural population data. A high proportion of the population in this WMA is urbanised (89 %).

The Klip Key area (C22A – E) is the most urbanised key area (99 %) and the Gauteng Province has the largest urbanised population (91 %). The Wilge catchment is the least urbanised (35 %).

The Wilge catchment (C8) has the largest rural population (65 %). This area is dominated by the rural population of Witsieshoek (former Qwa Qwa homeland) and makes up 76 % of the total rural population in the Wilge catchment.

The population distribution is shown in **Figure 3.2.4.1**: Population Distribution. It shows quaternary catchments with the urban and rural population in each quaternary catchment shown by a pie diagram with the diameter related to the population.

TABLE 3.2.4.1: POPULATION IN 1995

CATCHMENT				POPULATION IN 1995		
SECONDARY		TERTIARY		URBAN	RURAL	TOTAL
No	Description	No.	Key Area Description			
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	181 000	342 879	523 879
C1	Klip - C13	C13	Klip (C13A-H)	17 400	17 895	35 295
	Grootdraai	C11	Grootdraai (C11A-L)	116 300	39 954	156 254
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	198 009	61 775	259 784
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	852 674	32 902	885 576
	Klip	C22	Klip (C22A-E)	2 358 430	17 559	2 375 989
	Mooi	C23	Mooi (C23D-K)	489 450	42 681	532 131
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	749 173	47 979	797 152
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	57 300	25 971	83 271
Total in Gauteng				**4 196 177**	**82 680**	**4 589 707**
Total in Free State				**348 250**	**397 754**	**746 004**
Total in Mpumalanga				**321 859**	**105 355**	**427 214**
Total in North-West				**153 450**	**43 806**	**197 256**
TOTAL IN WMA				**5 019 736**	**629 595**	**5 649 331**

3.3 MACRO-ECONOMICS

3.3.1 Introduction

The purpose of this section is to provide an economic overview of the salient features of the Upper Vaal WMA in terms of the following aspects:

- The present economic development of the Upper Vaal WMA on a sectoral basis, taking into account the context of economic development in South Africa.
- The comparative advantages of the Upper Vaal WMA.

Selected graphs are included to illustrate the text and additional supporting information is given in **Appendix B.1**.

3.3.2 Data sources

The information presented has been derived from a database of macroeconomic indicators that was prepared by Urban-Econ: Development Economists from a number of sources, including the Development Bank of Southern Africa. **Appendix B.2** contextualises each WMA economy in terms of its significance to the national economy, as derived from the national economic database. Only gross geographic product (GGP) and labour data are analysed. A brief description of the database of macro-economic indicators and associated economic information system is given in **Appendix B4.**

Gross geographic product is the total value of all final goods and services produced within the economy in a geographic area for a given period. GGP is the most commonly used measure of total domestic activity in an area and is also the basis for the national account. Changes in the local economy can therefore be expressed as an increase in GGP. Base GGP data for 1972, 1975, 1978, 1981, 1984, 1988, 1991, 1993 and 1994 were obtained from Statistics South Africa. Data for unknown years between 1972 and 1994 were interpolated applying a compound growth formula. The interpolated data was balanced with national account figures. Data for 1995 to 1997 is based on weighted least squares estimates of the long-term trend, taking into account the change in electricity consumed. The projected data was balanced with national account figures. The major limitation of GGP figures is that activities in the informal sector are largely unmeasured.

The **labour** distribution provides information on the sectoral distribution of formal economic activities, as do the GGP figures, but in addition, information is provided on the extent of informal activities, as well as dependency. Dependency may be assessed from unemployment figures, as well as by determining the proportion of the total population that is economically active. *Total economically active* population consists of those employed in the formal and informal sectors, and the unemployed. *Formally employed* includes employers, employees and self-employed who are registered taxpayers. *Unemployment figures* include people who are actively looking for work, but are not in any type of paid employment, either formal or informal. *Active in informal sector* includes people who are employers, employees or self-employed in unregistered economic activities, i.e. businesses not registered as such. The labour data was obtained directly from the Development Bank of Southern Africa (DBSA). The DBSA has utilised the 1980 and 1991 population censuses as the basis but has also updated the figures utilising the 1995 October Household Surveys of Statistics South Africa (Central Statistical Services statistical release P0317 for South Africa as a whole and P3017.1 to P0317.9 for the nine provinces).

The GGP and labour statistics are disaggregated into the following major economic sectors:

- Agriculture.
- Mining.
- Manufacturing.
- Electricity.
- Construction.
- Trade.
- Transportation.

- Finance.
- Government and Social Services (Community Services).

The nature and composition of each sector are described in **Appendix B.3**.

3.3.3 Methodology

Each sector of the economy was dealt with in an appropriate way to reflect a reasonable approximation of the spatial distribution of production and labour:

- **Agriculture**

The digitised geographic layer of WMAs was merged with the Magisterial District (MD) boundaries, and the surface area for each of the newly generated polygons was determined. The proportion of the surface area of each of the MD, which falls within each WMA, was calculated, and that proportion was used to allocate the part of a GGP figure that falls on each side of a WMA-boundary.

- **Trade and Community Services**

To take account of the subdivision of local authority areas by MD or WMA boundaries, the number of enumerator areas (EAs) falling within each subdivision of a local authority area, as a proportion of the total number of EAs in a local authority area, was determined. This proportion was applied to the latest population figure (1996 census) of each local authority area. As EAs are of approximately equal population size, these proportions were used to calculate the approximate population for that part of a local authority area which falls within each MD, as they are subdivided by WMA boundaries. The population of each MD segment, as a proportion of the total MD population, was used to calculate the proportion of a GGP figure which should be allocated to each segment of a MD, so that theses figures could be totalled up within the WMA boundaries.

- **Other Sectors**

Historical factors such as the relocation of certain segments of the population to non-productive areas, and the immigration of mainly Mozambicans, especially to Mpumalanga and the Northern Province, had to be taken into account when allocating the GGP figure to the WMAs. Subsequently, for all the sectors apart from those discussed above, only the Caucasian population was used to perform the calculations as described above. Economic activities in these sectors are less dependent on population *per se*, but are dependent on the same factors which affect the kind of population distribution that is not distorted by government intervention or other external factors. The Caucasian population has typically not been influenced by the latter factors, and its distribution is therefore a better guide for determining the distribution of economic activities in these sectors.

3.3.4 Status of economic development

The GGP of the Upper Vaal WMA was R104,7 billion in 1997, making the second largest contribution amongst WMAs to the national economy. The most important magisterial districts in terms of contribution to GGP in this WMA are shown below:

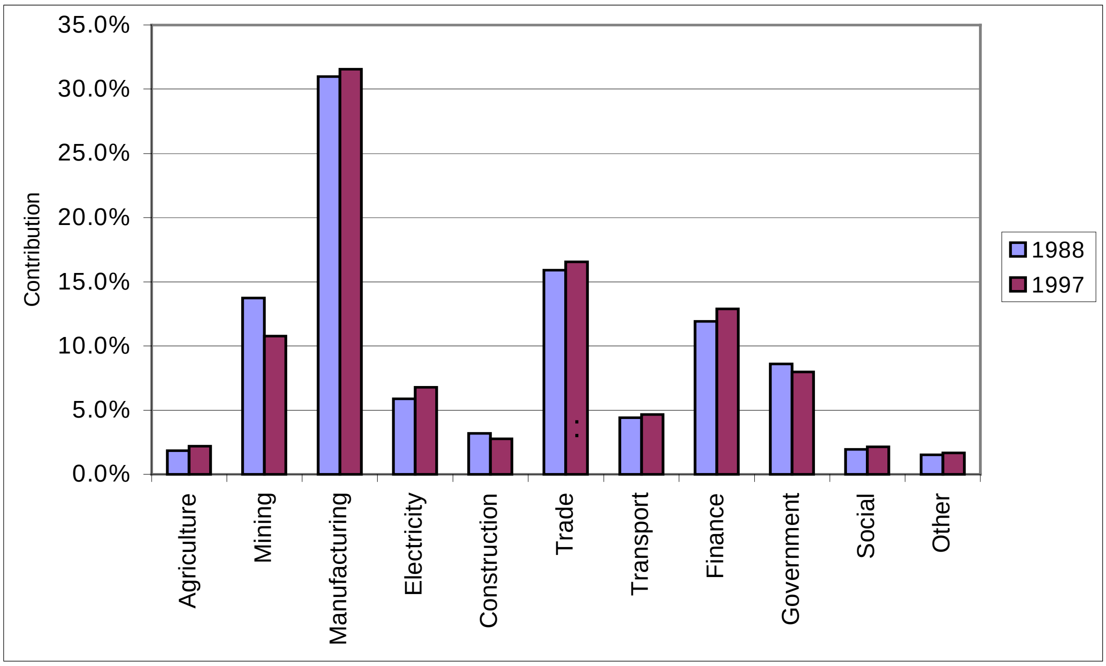
- Johannesburg 28,6%.
- Germiston 8,9%.
- Highveld Ridge 7,4%.
- Oberholzer 6,2%.
- Vereeniging 6,1%.
- Other 42,8%.

Economic Profile

The composition of the Upper Vaal WMA economy is shown in Diagram 3.3.1. The most important sectors in terms of contribution to GGP are shown below:

- Manufacturing 31,6%.
- Trade 16,6%.
- Financial Services 12,9%.
- Mining 10,8%.
- Other 28,1%.

Diagram 3.3.1: Contribution by Sector to Economy of Upper Vaal Water Management Area, 1988 and 1997 (%)



The importance of the mining sector can be attributed to the Vereeniging-Sasolburg coal fields which rank third in South Africa in terms of importance. Other mines include the New Vaal Colliery and Sigma Mines, which together produce approximately 18 million tons per annum. Mining activities in the East Rand consist mainly of gold mining. However, weak international gold trading conditions, coupled with the present depth of gold reserves and extraction costs of gold on the East Rand do not render gold mining on the East Rand economically viable. Other mining activities can also be identified in the Vaal area and include clay, sand pits and dolomite. Gold is by far the most important mineral found in the West Rand area, with the largest unmined gold reserve in South Africa in Westonaria. Significant gold deposits are also found in Carletonville and Randfontein.

The manufacturing sector in the WMA shows strong linkages with primary sector activities, namely agriculture and mining. In the Northern Free State and southern Mpumalanga, manufacturing is largely concentrated on petro-chemical products. These products include ammonia, waxes, phennolic products and plastics. The Sasol plants in Sasolburg contribute to the importance of the manufacturing sector in the Upper Vaal WMA. An important manufacturing activity in the Eastvaal area is the Alpha-Olefin project near Secunda. The most dominant manufacturing activities in the East Rand area relate to basic metal industries and the manufacturing of chemical, plastic and pharmaceutical products. The dominance of these industries can be attributed to the presence of large national keypoint industries such as AECI and Iscor.

The importance of the trade sector can be attributed to the fact that Gauteng is the major trade centre in South Africa and is in line for numerous new trade related developments.

Due to the presence of large numbers of financial and business service institutions and head offices in Gauteng, this sector plays an important role in the Upper Vaal Region.

Economic Growth

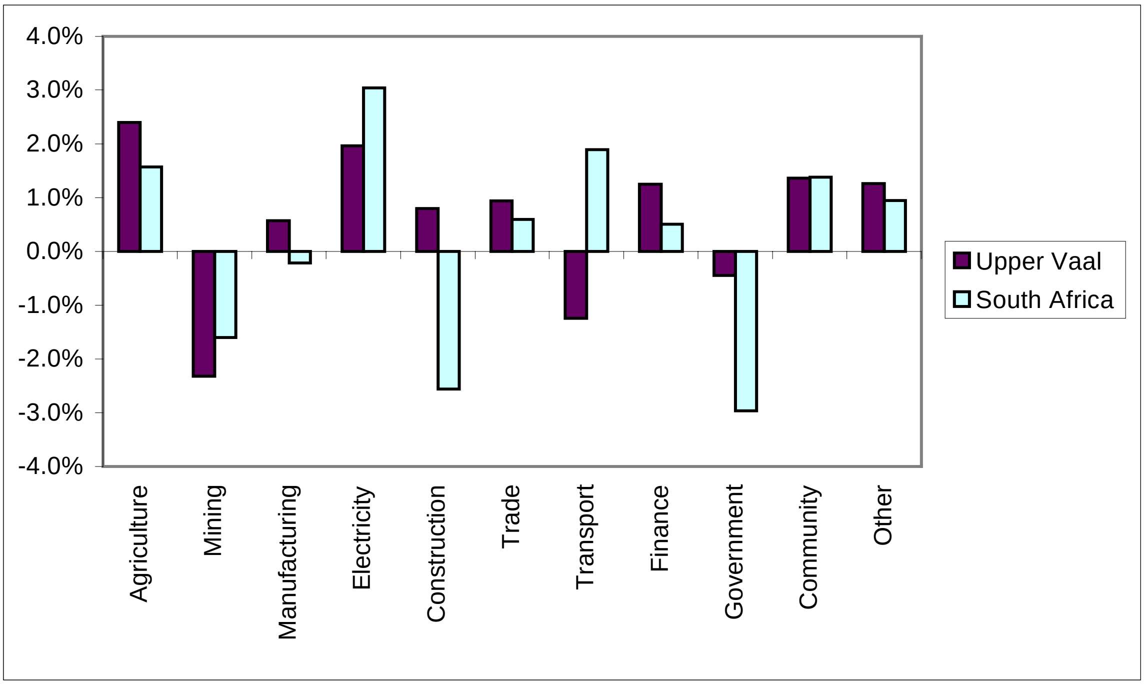
The average annual economic growth by sector is shown in Diagram 3.3.2. Between 1987 and 1997, the highest average growth rates were recorded in the following sectors:

- Agriculture : 2,4%
- Electricity : 2,0%

An industry with growth potential is leather tanning and finishing. Other industries identified with growth potential are floriculture at Harrismith and fruits and vegetables at Bethlehem.

The provision of services and facilities to address basic needs in accordance with RDP standards will stimulate growth in the electricity sector

Diagram 3.3.2: Average Annual Economic Growth by Sector of Upper Vaal Water Management Area and South Africa, 1988-1997



Labour

Of the total labour force of 2,2 million in 1994, 30,6% were unemployed, which is higher than the national average of 29,3%. Fifty six percent (55,6%) were active in the formal economy. Twenty eight percent (27,5%) of the formally employed labour force worked for government, while 23,3%, were involved in manufacturing activities and 13,7% in trade.

Employment growth was only recorded in the financial services sector (3.3% per annum).

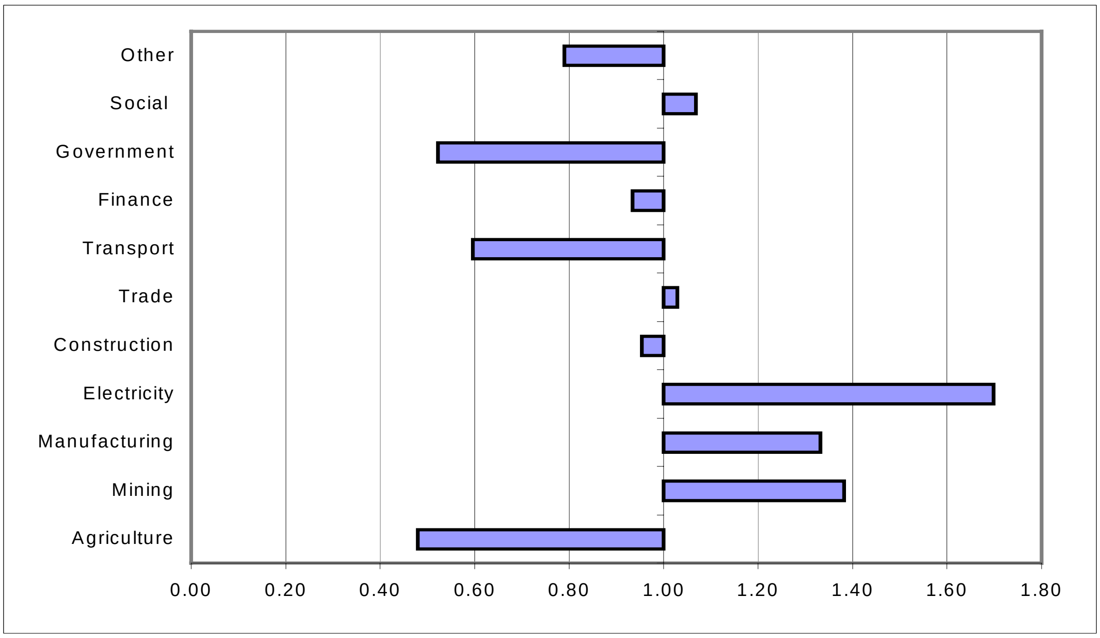
3.3.5 Comparative advantages

A geographic area is said to have a comparative advantage in the production of certain goods and services if it can produce them at a lower cost per unit than another region while maintaining the same quality. When this is the case, production of such goods tend to become relatively more concentrated in the region which has the comparative advantage. The location quotient is a measure of the relative concentration of economic activities in a region as compared with another region, or as compared with a larger region of which it forms part. A location quotient for an economic sector with a value of more than one implies that the sector contributes a larger percentage to a sub-region's GGP than that sector contributes to the larger area of which the sub-region forms part. The location quotient can, however, not be equated with comparative advantage, and provides only an indication.

Diagram 3.3.3 shows the location quotients for the Upper Vaal WMA. The Diagram shows that, based on the location quotients for 1997, the Upper Vaal WMA economy is relatively more competitive than the remainder of South Africa in the following economic activities:

- Electricity : 1,70.
- Manufacturing : 1,33.
- Mining : 1,39.

Diagram 3.3.3: Upper Vaal Gross Geographic Product Location Quotient by Sector, 1997



The manufacturing activities in Gauteng, Vereeniging and Sasolburg make significant contributions to the comparative advantage of the manufacturing sector.

The high concentration of gold mining activities also contribute to the comparative advantage recorded by the mining sector.

3.4 LEGAL ASPECTS AND INSTITUTIONAL ARRANGEMENTS FOR WATER SUPPLY

3.4.1 Past history

The history of settlement in southern Africa is linked to the availability and supply of fresh water. From early times South African water law was based on the needs of white settlers who in colonizing the land promulgated a water law in which domestic and agriculture needs and later industrial needs played the major role (*res publica)* and the government had the function to regulate the use of water (*dominus fluminis*).

Initially Roman and Roman Dutch law had a strong influence in the shaping of South African water law and water running in rivers was regarded as common property. This changed in the latter half of the 19th century, after the occupation of the Cape by the British. The judges trained by the British introduced the principle that owners of property riparian to a river became entitled to water from that river.

The first codification of water law in South Africa was in the Irrigation and Conservation of Waters Act of 1912. The emphasis was still on irrigation and carried down the riparian principle. This Act was repealed by the Water Act of 1956, which also placed a major emphasis on the use of water for irrigation, although other water uses, such as domestic, urban and industrial, also received recognition.

This remained the situation until the National Water Act, 1998 (Act No. 36 of 1998) (NWA) was assented to by the President on 20 August 1998. As from 1 October 1999 the whole of the NWA came into full effect and is now the only Act dealing with water law.

3.4.2 National Water Act

The NWA does away with and introduces some far-reaching concepts. These concepts have both economic and social features. The former to address water management by conservation and pricing strategy and the latter by ensuring that past discriminatory principles are not continued in the NWA. The most important of these can be summarised as follows:

- The riparian principle is done away with. The nation's water resources become common property, belonging to the nation as a whole. Therefore the previous concept of private ownership in water is done away with;
- The national government, through the Minister of Water Affairs and Forestry, becomes responsible as the public trustee of all water resources to ensure that water resources are protected and water allocated equitably and used beneficially in the public interest. Therefore the NWA reflects the constitutional right of access to sufficient water (Section 27 of the Constitution);
- All right to use water derives from the NWA;
- Water must be available for the Reserve. The Reserve is a new concept and consists of two legs, namely the quantity and quality of water required to satisfy basic human needs as prescribed by the Water Services Act, 1997 (Act No 108 of 1997) for people who now or will in future require water and to protect the aquatic ecosystems in order to secure ecologically sustainable development and use of the relevant water resource. Thus environmental considerations are anchored in the NWA;
- Setting out in the purposes of the Act is that institutions which have appropriate community, racial and gender representation must be developed to give effect to the NWA;
- Shifts the emphasis from the traditional "supply management" approach towards "demand management", that is conservation of the nation's water resources by lessening the demand and providing for an innovative pricing system.
- Providing for extensive public participation. Virtually no decision can be made without public participation;

- The abolishment of the Water Courts and introducing a Water Tribunal where administrative final decisions can be appealed to; and
- Recognition of international obligations.

3.4.3 Strategies

The NWA makes provision for establishment of two water management strategies. These are the National Water Resource Strategy and the Catchment Management Strategy. The National Water Resource Strategy is binding on the Minister of the Department of Water Affairs and Forestry, other organs of State and all water management institutions for anything contained therein, while the catchment management strategy is binding on the relevant catchment management agency and is more on a local level.

Water resource management will in future be based on the management strategies and the classification system for the protection of water resources provided for in the NWA. The contents of the National Water Resource Strategy are wide and included therein are the principles relating to water conservation and water demand management; the objectives in respect of water quality to be achieved through the classification system, as well as having to establish the future water needs. The National Water Resource Strategy will also provide for international rights and obligations.

3.4.4 Environmental Protection

Chapter 3 of the NWA deals with protection of the water resources.

The Minister must classify the nation's water resources and then determine the class and resource quality objectives for each class. This will establish clear goals for resource protection and at the same time provide for a balance between the need to protect and sustain one's water resources and the need to develop and use them on the other hand.

An important function is for the Minister to determine the Reserve, which as stated above, is closely linked to the Water Services Act, 1997 (Act No. 108 of 1997).

Section 19 of the NWA provides *inter alia* that any person who is in control of land over which pollution is taking place or who causes pollution or potential pollution to take place, must take the necessary steps to prevent this from continuing. Should this not be done, the Minister shall have the right to take the necessary steps to recover the cost from the responsible person.

3.4.5 Recognition of Entitlements

The NWA abolishes the historical distinction between public and private water. There is no ownership in water and all water is subject to a licensing system, except for the following:

- Water use that is set out under Schedule 1 of the NWA;
- General authorisations issued under section 39 of the NWA; and
- Existing lawful use recognised under the NWA until such time as the person is required to apply for a licence.

The statutory difference between water resources within an area proclaimed as a government water control area in terms of the Water Act of 1956 and areas outside a government water control area has now been done away with. In actual fact the whole of the country is a government water control area.

3.4.6 Licensing

Whereas the Water Act of 1956 divided water into different categories, in the NWA all water has the same status. Section 21 of the NWA sets out what is regarded as water use. These include, amongst other uses, taking water from a water resource, storage of water, diverting water, discharging waste into a watercourse, disposing of waste in a manner that may detrimentally impact on a water resource and recreational use.

Two new concepts of water use are created. The first is that the Minister can declare any activity to be a stream flow reduction activity, if that activity reduces the availability of water. Afforestation has already been declared a stream flow reduction activity. The second new concept is that the Minister can declare any activity to be a controlled activity if that activity impacts on a water resource. Activities such as irrigation on any land with waste, recharging of an aquifer are examples of activities that are already controlled activities.

All water use requires a licence unless it falls into a Schedule 1 use (this deals with the *de minimus* use, such as water for reasonable domestic use, small gardening and animal watering (excluding feedlots); or was permissible as an existing lawful use (water use permitted under previous laws and which were exercised during the period of two years before the date that section 32 came into effect; namely 1 October 1998); and under a general authorisation.

An important innovation is that a licence can only be for a maximum period of 40 years and is subject to a review period, which may not be at intervals of more than five years. A licence can be increased at each review period but not for more than the review period. This is known as the “revolving licence”.

If a person who has an existing lawful use applies for a licence under section 43 of the NWA (compulsory licensing), and the application has been refused or has been granted for a lesser amount which results in severe economic prejudice, the applicant may claim compensation. Compensation cannot be claimed if the reduction is to provide for the Reserve, rectify a previous over-allocation or a previous unfair allocation.

Compensation must be claimed from the Water Tribunal.

The Minister has the right to attach conditions to any licence as well as to make regulations on various topics set out in section 26 of the NWA.

It is important to note that although the Water Services Act, 1997 (Act No. 108 of 1997) deals with water services; the actual water use is controlled under the NWA.

3.4.7 Other legislation

The NWA is aligned with other laws in order to prevent, for example, duplication of applications, unnecessary expenses and where possible, a “one stop” can be issued. Specific examples are as follows:

- Environment assessments in terms of the Environmental Conservation Act of 1989 can be taken into account by the responsible authority when issuing a licence;
- If a licence is issued under other acts that meet the purpose of the NWA, the responsible authority can dispense with the issuing of a licence for water under the NWA; and
- Provisions in the Constitution of the Republic of South Africa must be complied with.

Further, there is a close connection between the Water Services Act, 1997 (Act No. 108 of 1997) and the NWA.

The Abolition of Racially Based Land Measures Act repealed laws that previously restricted black persons from owning or occupying land. These acts had the effect of preventing black persons from having any water rights or under certain circumstances, limited water entitlements.

Notwithstanding the NWA there are other acts to which a water user and indeed the State must comply.

These Acts are the following:

Physical Planning Act, 1991 (Act No. 125 of 1991)
Under this act no land use, development or subdivision may be permitted unless in accordance with an approved plan.

Development Facilitation Act, 1995 (Act No. 67 of 1995)
This act prescribes the set of principles with which all development projects and all land use and land use planning should comply, and which will serve as guidelines for the administration of land use and development schemes.

Restitution of Land Rights Act, 1994 (Act No. 22 of 1994)
This act is aimed at the restitution of land to those who have been deprived thereof in terms of discriminatory laws. Claims are lodged with the Land Claims Commission. It is because of this act that when a transfer of water entitlements is approved in terms of the NWA an indemnity is required from

the transferor that a claim was not lodged against the land in terms of the Restitution of Land Rights Act.

Environmental Conservation Act, 1989 (Act No. 73 of 1989)
This act provides for the effective protection and control of the environment. It makes provision for the declaration of an environmental conservation policy.

In terms of this act the state has a responsibility to act as trustee of the natural environment and to consider all activities which may have an influence on the environment.

Activities, which may have a detrimental effect on the environment, have been published in terms of section 21 of this act. To undertake any of these activities, authorisation is required, which can only be obtained from the Minister of Environmental Affairs and Tourism after the prescribed procedure has been complied with. The construction of various forms of water works (dams, water diversions, water transfer schemes, etc.) are subject to the new process.

Through a consultative process a White Paper for Sustainable Coastal Development in South Africa was prepared. In terms thereof it is the joint responsibility of the Departments of Water Affairs and Forestry and of Environmental Affairs and Tourism to protect the in-shore marine environment.

In terms of this act the Department of Environmental Affairs and Tourism is responsible for issuing waste permits under this act and has published a Government Notice 1986 of 24 August 1990 relating to the identification of waste. This government notice needs drastic amendment to bring it in line with the NWA.

In May 2000 the Department of Environmental Affairs and Tourism published a White Paper on Integrated Pollution and Waste Management for South Africa. Aspects included water pollution; diffuse water pollution, marine pollution; and land pollution.

National Environmental Management Act, 1998 (Act No. 107 of 1998)
This act lays a new foundation for environmental management. The act includes 20 principles that serve as a general framework within which environmental management and implementation plans must be formulated and guide any other law concerned with the protection or management of the environment. Environment is defined as the natural environment and the physical chemical, aesthetic and cultural properties of it that influence human well being.

To give effect to these principles this act creates the National Environmental Forum and the Committee for Environmental Co-ordination and defines the procedure for the establishment of a Coastal Management Subcommittee of the Committee for Environmental Co-ordination in order to achieve better inter-governmental co-ordination of coastal management.

This act provides for the drawing up of environmental implementation plans by certain scheduled national Government Departments and the Provinces. In addition, environmental management plans are to drawn up by certain national Departments. The two sets of plans do not have to be drawn up by the private sector and may be consolidated. The purpose of the plans is set out in detail and must co-ordinate and harmonise environmental policies, plans, decisions of the three spheres to prevent duplication; give effect to co-operative governance and enable monitoring the achievement.

Chapter 7 of this act relates to environmental damage, duty of care, emergencies and remediation.

Conservation of Agriculture Resources Act, 1983 (Act No. 43 of 1983)
This act is to provide for control over the utilisation of the natural agricultural resources in order to promote the conservation of the soil; the water resources and vegetation and the combating of weeds and invader plants. Except for weeds and invader plants, this act does not apply to land in an urban area.

3.4.8 Institutions Created Under the National Water Act

The NWA creates various institutions, some of which are listed below.

The first are Catchment Management Agencies (CMA), one of which will be established in each of the Water Management Areas that have been promulgated by Government Notice 1160 of 1 October 1999 (19 in total). These will have various functions either delegated or assigned to them, thus bringing the management of water resources to the regional or catchment level. A CMA will operate via a board along the lines set out in Schedule 4 to the NWA. The composition of the board is recommended by an Advisory Committee that is established by the Minister and has the important task to recommend to the Minister proposed members who are racially, gender and community representative.

A second institution, is that of Water User Associations (WUA) that will operate on a restricted local level and are in effect cooperative associations of individual water uses who wish to undertake related water activities for a mutual benefit. Irrigation Boards established under the Water Act of 1956 had until 29 February 2000 to transform into a WUA. All WUA's must have a constitution based on the lines set out in Schedule 5 to the NWA, which must be approved by the Minister. The policy of the Department of Water Affairs and Forestry is that these must also as far as possible be racially, gender and community representative.

A third institution is bodies to implement international agreements. This can only be established by the Minister in consultation with the Cabinet.

A fourth body that the Minister can establish is Advisory Committees. These committees may be established for a particular purpose but can also have powers delegated to it by the Minister.

Lastly the NWA establishes a Water Tribunal where appeals against administrative decisions by the Department of Water Affairs and Forestry and CMA's can be heard. The question of compensation for loss of entitlements to use water is also to be heard in this Tribunal. Appeals on questions of law from the Tribunal are heard in the High Court.

3.4.9 Institutions

The main bulk supplier of potable water is Rand Water (apart from Qwaqwa which is supplied by Sedibeng Water).

Refer to **Appendix A.1** for a list of TLC's as at 1995.

Figure 3.4.8.1 shows the magisterial district and district council boundaries in 1995.

The following district councils exist in this WMA:

- Eastern.
- Eastern Free State.
- East Vaal.
- Island DP.
- Northern District Council.
- Northern Free State.
- Southern.

The following irrigation schemes, boards and controlled areas exist:

- Mooi Government Water Scheme.
- Klipdrift Management Board.
- Vyfhoek Management Board.
- Vaal Government Water Controlled Area.
- Rietpoort Irrigation Board.
- Koppieskraal Irrigation Board.

Figure 3.4.8.2 shows the water board boundaries, and TLC/TRC boundaries in 1995.

3.5 LAND USE

3.5.1 Introduction

The main agricultural activities in this WMA are maize, wheat and livestock farming. While most of this agricultural activity is dryland cultivation, there is significant irrigation along the main river reaches. Refer to **Section 2.6.4** for a summary of known nature reserves.

Small pockets of natural veld occur mainly along the eastern boundary, in the mountainous areas. Other natural areas are situated adjacent to the Vaal River, near Parys, and to the north east of Vaal Dam. Afforestation is negligible and there is no sugarcane in this WMA.

Extensive urban, industrial and mining development occurs to the north of the Vaal River, between Grootdraai Dam and the Mooi River catchment. This urbanised area is situated mostly in the province of Gauteng and extends beyond the WMA boundary. Three operating Eskom power stations are also located in the WMA.

Figure 3.5.1.1 shows secondary catchment boundaries, rivers and dams, urban complexes and towns, mines, large industries, power stations and irrigated and afforested areas. **Table 3.5.1.1** shows areas of irrigation, afforestation, alien vegetation infestation and urbanisation for key areas and provinces.

TABLE 3.5.1.1: LAND USE PER KEY AREA

CATCHMENT				Irrigation (field area) (km^2)	Afforestation (km^2)	Alien vegetation (km^2)	Urban (km^2)	Other [1,2] (km^2)	Total (km^2)
SECONDARY		TERTIARY							
No	Description	No.	Key Area Description						
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	46,0	14,6	137,4	171,0	17 801,0	18 170
C1	Klip – C13	C13	Klip (C13A-H)	0	0	17,9	0	5 164,1	5 182
	Grootdraai	C11	Grootdraai (C11A-L)	40,7	2,1	47,3	28,0	7 876,9	7 995
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	26,6	0	15,6	33,0	7 218,8	7 294
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	25,4	0	10,3	132,4	3 372,9	3541
	Klip	C22	Klip (C22A-E)	21,3	0	26,6	395,9	1 838,2	2 282
	Mooi	C23	Mooi (C23D-K)	45,1	0	15,8	155,0	4 818,1	5 034
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	29,2	0	72,4	119,9	2 606,5	2 828
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	25,1	0	6,0	0	3 207,9	3 239
Total in Gauteng				**63,8**	**0**	**74,7**	**731,2**	**7 332,3**	**8 202**
Total in Free State				**77,3**	**14,6**	**191,6**	**210,1**	**26 354,4**	**26 848**
Total in Mpumalanga				**62,7**	**2,1**	**63,1**	**69,3**	**15 370,8**	**15 568**
Total in North-West				**55,6**	**0**	**19,9**	**24,6**	**4 846,9**	**4 947**
TOTAL IN WMA				**259,4**	**16,7**	**349,3**	**1 035,2**	**53 904,4**	**55 565**

Note : (1) No dryland sugar cane and indigenous afforestation is negligible.
(2) Other landuse includes dryland crops, Nature Reserves and Rural Settlements for which information was not readily available.

3.5.2 Irrigation

Irrigated Areas

The total irrigated area and various crop category areas for each key area are shown in **Table 3.5.2.1**. Both harvested area (which includes re-use of irrigable areas for different seasons) and field area (physical maximum crop area under irrigation at any one time) have been shown. A map depicting the extent of the existing irrigation (harvested area) is shown in **Figure 3.5.1.1** and **Appendix D.1** lists harvested crop area data.

The harvested irrigated area is defined as the maximum area under irrigation during any stage of the year. Due to the regionalised distribution of the prescribed crop factors given in the report (Loxton et al., 1999a), it was found unrealistic to simply determine the maximum irrigated area on the basis of the month with maximum crop area. To solve this problem in a realistic fashion the irrigated area was accepted as the maximum of the mid-summer crop area and the mid-winter crop area. Considering the given full range of crop factors available, mid-summer was defined as January/February while mid-winter was defined as July/August. Using this approach it was ensured that maximum but realistic allowance was made for double cropping, where appropriate.

Harvested irrigation area data for this WMA was extrapolated from the Vaal River Irrigation Study (Loxton et al., 1999b). This study represents the irrigation situation in the Vaal River catchment in 1995.

The report (Loxton et al., 1999b) presents harvested irrigated crop area for defined river reaches. This data had to be disaggregated into quaternary catchment data. The disaggregation represents an estimate and was undertaken as follows:

- Each river reach area was reviewed and the irrigated harvested crop area were noted. Refer to **Table 7.2** (Loxton et al., 1999b).
- The main river channel quaternary catchments in each river reach area were noted (the assumption being that most irrigation is from the main river channel) and where applicable, maps of the irrigation areas were reviewed. Refer to **Figure 11.11** (Loxton et al., 1999b).

For example the irrigation area in the Grootdraai key area known as “Vaal Dam Catchment GWCA - upstream Grootdraai Dam” (Loxton et al., 1999b) has a harvested crop area of 42,89 km^2. The main river channel quaternary catchments in which irrigation is most likely to occur are C11B, C11D, C11E, C11J and C11L. No information on the physical location of the irrigation in this irrigation area was known. As a result the harvested area per quaternary catchment was estimated equally for each quaternary catchment to be 8,58 km^2. This means that key area harvested irrigation data can be considered reliable but quaternary catchment irrigation data represents an estimate only and must be considered to be of poor quality.

Irrigated Crops

In this WMA the crops are predominantly low value crops (maize, wheat and pastures). The only area with significant medium and high value crops is within the Wilge key area, in the area known as Liebensbergvlei River (Saulspoort Dam to Wilge confluence). The information on crops irrigated in the study area was obtained from the report (Loxton et al., 1999b).

The main summer crops that are irrigated are maize and kikuyu pastures, there is some soyabeans, groundnuts, summer vegetables and flowers irrigated. The main winter crop irrigated is wheat. The main perennial crop irrigated is lucerne with some minor areas of deciduous and soft fruits.

Irrigation Methods

The most common irrigation methods used in this WMA are mechanical (centre pivot) and sprinkler systems. In general the irrigation methods used for a specific crop type do not vary significantly between different catchments.

The information on the irrigation methods used in the study area was obtained from the report (Loxton et al., 1999b). **Table 3.5.2.1** highlights the irrigation methods for key areas.

TABLE 3.5.2.1: IRRIGATION LAND USE

CATCHMENT				IRRIGATED AREA BY CROP CATEGORY[1] (km^2)				
SECONDARY		TERTIARY						
No.	Description	No.	Key Area Description	Perennial	Summer	Winter	Total harvested area [2]	Total field area [3]
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	7,2	38,8	10,2	56,3	46,0 (M/S)
C1	Klip - C13	C13	Klip (C13A-H)	0	0	0	0	0
	Grootdraai	C11	Grootdraai (C11A-L)	23,2	17,5	2,2	42,9	40,7 (S)
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	5,6	21,0	12,3	38,9	26,6 (M)
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0	25,4	0	25,4	25,4 (M)
	Klip	C22	Klip (C22A-E)	0	21,3	10,7	32,0	21,3 (M)
	Mooi	C23	Mooi (C23D-K)	25,9	19,2	1,0	46,1	45,1 (F/S)
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	2,3	26,9	8,8	38,0	29,2 (M)
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	14,2	10,9	0,5	25,7	25,1 (M/S/F)
Total in Gauteng				**2,6**	**59,0**	**15,6**	**77,2**	**63,8**
Total in Free State				**13,8**	**57,7**	**18,0**	**79,8**	**77,3**
Total in Mpumalanga				**27,1**	**38,6**	**10,8**	**76,6**	**62,7**
Total in North-West				**34,9**	**26,0**	**1,3**	**71,7**	**55,6**
TOTAL IN WMA				**78,4**	**181,3**	**45,7**	**305,3**	**259,4**

Note :
(1) There are no undifferentiated crops in this area. Crop area data was obtained from Tables 7.2 and 8.2 of the report (Loxton et al., 1999b).
(2) Total crop area irrigated in 1995.
(3) Physical area (summer + perennial crop area) under irrigation in 1995.
(M/S/F) Mechanical, sprinkler and flood irrigation systems.

Enterprise Returns

It is generally recognised that future growth in irrigation will be severely limited by the availability of water. In more water-scarce areas it may even become necessary to curtail some irrigation to meet the growing demands of domestic and urban water use. In order to do this it will be necessary to base such decisions on sound economic principles such as the economic return per unit of water. Although acknowledged to be fairly generalised, only three economic categories of irrigated crops have been used for the purpose of this study. These categories also represent an appropriate grouping for the purpose of assurance of irrigation water supply. **Table 3.5.2.2** shows typical crops within each category that are grown within this WMA.

TABLE 3.5.2.2: ASSURANCE CATEGORIES FOR IRRIGATED CROPS.

Category	Crop Examples
Low	Maize, wheat, soya beans, dry beans, groundnuts and pastures for livestock.
Medium	Vegetables, potatoes, seed production and pastures for dairying.
High	Citrus, deciduous fruit and nuts, dates and speciality vegetables.

The above categories include for double cropping of the different crop types where appropriate.

The economic value of crops is shown for each quaternary catchment in **Appendix D.1**.

The economic value of crop does not appear to be a consideration when determining quotas for so called scheduled irrigation areas and does not appear to be the driving motivation for why irrigation water is supplied.

3.5.3 Dryland Farming

The main dryland crops that are cultivated are maize, wheat and fodder pastures (kikuyu and rye). There is no dry land sugar cane being produced in the study area and the extent of dryland cultivation is not known.

3.5.4 Livestock and game farming

Introduction

The livestock species reviewed, included cattle (beef and milk), sheep, goats, pigs, horses, donkeys and mules. While game species reviewed, ranged from black wildebeest to zebra. This data was available from several sources at magisterial district scale. All livestock and game species had to be converted to “equivalent large stock units” (ELSUs), before disaggregation to quaternary catchment scale.

Sources of information

Livestock and game data was obtained from 2 main sources, namely the:

- Department of Agriculture (DOA), 1990 Food Survey, digital data provided by Glen Agricultural Station. This data is available on a primary catchment basis per magisterial district.
- Central Statistical Services (CSS), produced a "Census of Agriculture, 1988" on a magisterial district basis and is similar to that provided by the DOA. Data on pigs, horses, mules and donkeys is available from this survey. The main disadvantages of this data are that unlike the "Glen" data it is not presented per primary catchment and game is not broken down into species.

It was assumed that livestock and game data for 1988 and 1990 can be used to represent 1995 figures as the general consensus is that agriculture has reached a threshold and numbers are unlikely to change significantly. Furthermore the 1988 and 1990 data represents both mature and immature livestock and game numbers, therefore these numbers can be extrapolated to represent the mature livestock and game numbers for 1995. The CSS livestock data was used if the Food Survey data looked suspect or if data was missing. For example the Food Survey database did not provide any data on pig numbers while the CSS survey did.

Conversion of data

The first step involved converting the different livestock and game species into Equivalent Large Stock Units (ELSUs). The ELSU conversion factors for various species of livestock and game is provided in **Appendix F3**. This conversion table was provided by the DWAF. Unconverted magisterial district data for livestock and game species is also provided in **Appendix F.3**.

The disaggregation of ELSUs from Magisterial District (MD) to quaternary catchment resolution was based on a uniform spatial distribution of ELSUs within a MD. The actual disaggregation was carried out pro-rata to the areas of the quaternary catchments within the MD. Judgement was, however, exercised where there was additional information.

Appendix F.3 lists equivalent large stock numbers at quaternary catchment scale. The average water use by ELSUs is taken at 45 ℓ/ELSU/day. The overall ELSUs for key areas and provinces for 1995 are given in **Table 3.5.4.1** and **Figure 3.5.4.1**. **Section 5.3.3** provides information on the water requirements of livestock in the WMA.

The Wilge key area and the area upstream of Grootdraai Dam have over 50% of the ELSU (33% and 23% respectively). Cattle farming is the main type of stock farming in the WMA.

TABLE 3.5.4.1: 1995 LIVESTOCK AND GAME POPULATIONS.

CATCHMENT				NUMBER OF ELSU
SECONDARY		TERTIARY		
No	Description	No.	Key Area Description	
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	742 293
C1	Klip - C13	C13	Klip (C13A-H)	143 377
	Grootdraai	C11	Grootdraai (C11A-L)	518 219
	Grootdraai	C11- C12	Grootdraai to Vaal Dam (C11M, C12A-L)	284 455
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	92 703
	Klip	C22	Klip (C22A-E)	18 132
	Mooi	C23	Mooi (C23D-K)	139 467
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	96 355
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	124 276
Total in Gauteng				**161 685**
Total in Free State				**1 029 664**
Total in Mpumalanga				**810 930**
Total in North-West				**156 998**
TOTAL IN WMA				**2 159 277**

3.5.5 Afforestation and Indigenous Forests

The climate is unsuitable for commercial forestry with the exception of a narrow strip along the eastern escarpment, where mean annual rainfall exceeds 800 mm. The total area under afforestation is about 17 km^2, most of which is planted to Wattle. Approximately 2 km^2 occurs in the Grootdraai headwater catchment of the Vaal and the remainder occurs in the upper Wilge River catchment.

There is no appreciable indigenous afforestation.

TABLE 3.5.5.1: AREAS OF AFFORESTATION AND INDIGENOUS FOREST.

CATCHMENT				AFFORESTATION				INDIGENOUS FOREST (km²)
SECONDARY		TERTIARY		Eucalyptus (km²)	Pine (km²)	Wattle (km²)	Total (km²)	
No	Description	No.	Key Area Description					
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	1,1	0	13,5	14,6	0
C1	Klip - C13	C13	Klip (C13A-H)	0	0	0	0	0
	Grootdraai	C11	Grootdraai (C11A-L)	0	0	2,1	2,1	0
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	0	0	0	0	0
C2	Suikerbos-rand	C21	Suikerbosrand (C21A-G)	0	0	0	0	0
	Klip	C22	Klip (C22 A-E)	0	0	0	0	0
	Mooi	C23	Mooi (C23D-K)	0	0	0	0	0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	0	0	0	0	0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	0	0	0	0	0
Total in Gauteng				**0**	**0**	**0**	**0**	**0**
Total in Free State				**1,1**	**0**	**13,5**	**14,6**	**0**
Total in Mpumalanga				**0**	**0**	**2,1**	**2,1**	**0**
Total in North-West				**0**	**0**	**0**	**0**	**0**
TOTAL IN WMA				**1,1**	**0**	**15,6**	**16,7**	**0**

3.5.6 Alien Vegetation

The impacts of the widespread infestations by alien plants in South Africa are increasingly recognised. The total incremental water use of invading alien plants was estimated at 3 300 million m³/a by Le Matre (Le Matre et al, 1999) but this estimate is not widely recognised by the water resources planning community. This estimate is almost twice as high as the estimate for stream flow reduction resulting from commercial afforestation. Le Matre estimated that the impact will increase significantly in the next 5 to 10 years, resulting in the loss of much, or possibly even all, of the available water in certain catchment areas. Again, this is a debatable point requiring more research to verify these statements.

Much of the infested areas occur in the riparian zones where the degree of infestation is largely independent of the rainfall in the surrounding areas. The acacias, pines, eucalyptus, and prosopis species and melia azedarachs are among the top ten invading aliens, which account for about 80% of the water use.

Commercial afforestation has been one of the major sources of alien vegetation in South Africa, largely as a result of poor past forestry management practices. The results of a recent national scale study (Nel et al., 1999) showed that about 44% of the area invaded by plantation trees (pine, eucalyptus and black wattle) overlaps with areas affected by commercial afforestation practices. The new commercial afforestation plantations generally tend to be well-managed, maximising benefits of forestry and minimising environmental impacts.

Alien vegetation infestations across South Africa were mapped under supervision of a CSIR (Environmentek) team using a “best expert knowledge” approach, supplemented by existing detailed localised maps and Geographic Information System (GIS) data sets obtained from certain specific authorities. The expert knowledge was gathered through workshops in different regions and the expert information was mapped directly onto overlays on 1:250 000 scale topographic maps. Data capture procedures were designed to standardise the approach and terminology and to ensure consistency and comparability in the inputs made by the wide range of people involved.

Areas invaded by alien vegetation were mapped as independent polygons with each polygon accompanied by attribute data regarding species and density. All polygons and attribute data were captured in a GIS (Arc/Info).

The following shortcomings and limitations of the CSIR data base on alien vegetation infestation have been highlighted by Görgens (1998):

- The quality of data gathered is known to be variable as it depended on the level of expert knowledge available, the nature of the terrain and the extent and complexity of the actual invasion.
- Mapping of alien vegetation ending very abruptly (and artificially) along some or other administrative boundary.
- Mapping of riparian infestations along rivers at the coarse scale of the available GIS coverages (generally, 1:500 000 with 1:250 000 for some areas) could have led to significant under-estimates of river lengths and, therefore, of infested riparian areas. For example, a pilot comparison by the CSIR of 1:50 000 scale (a suitable scale) and 1:500 000 scale maps yielded a river length ratio of 3,0 and greater.
- Riparian infestation identification in a particular catchment with the simple statement: “all rivers are invaded”. In these cases, all the river lengths appearing in the particular coverages were assigned a uniform infested “buffer” strip of specific width, say 20m.
- Small rivers not reflected on the smaller scale mapping, were not accounted for and therefore infestation along these particular rivers was not mapped or quantified.

Data on alien vegetation eradication schemes throughout the country was not readily available from the Working for Water Programme Co-ordinator.

Infestation by alien vegetation is given in **Table 3.5.6.1**.

TABLE 3.5.6.1: INFESTATION BY ALIEN VEGETATION.

CATCHMENT				CONDENSED AREA OF ALIEN VEGETATION (km^2)
SECONDARY		TERTIARY		
No	Description	No.	Key Area Description	
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	137,4
C1	Klip - C13	C13	Klip (C13A-H	17,9
	Grootdraai	C11	Grootdraai (C11A-L)	47,3
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	15,6
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	10,3
	Klip	C22	Klip (C22A-E)	26,6
	Mooi	C23	Mooi (C23D-K)	15,8
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	72,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	6,0
Total in Gauteng				**74,7**
Total in Free State				**191,6**
Total in Mpumalanga				**63,1**
Total in North-West				**19,9**
TOTAL IN WMA				**349,3**

3.5.7 Urban areas

Assurance of water supply for urban users ranges from 95 % to 99%. The human Reserve for this WMA is set at 25 ℓ/capita/day and has an assurance of 99,9%.

The largest urban area in South Africa and the largest urban water user within the WMA, namely the Greater Johannesburg Metropolitan Council, straddles part of the northern catchment divide between the Klip key area in this Upper Vaal WMA and the Crocodile (West) and Marico WMA. For modeling purposes this area under the jurisdiction of the Greater Johannesburg Metropolitian Council has been split into Johannesburg South (in the Upper Vaal WMA) and Johannesburg North (in the Crocodile (West) and Marico WMA). Other large metropolitan areas in the WMA include:

- Germiston, Boksburg, Alberton, Benoni, Brakpan, Springs and Nigel on the East Rand.
- Vereeniging, Vanderbijlpark and Sasolburg.
- Westonaria, Carltonville on the West Rand.

These areas also represent the most heavily populated areas in the WMA and all of these towns and cities are supplied with bulk water from the Vaal Dam via the Rand Water bulk water network.

Other significant urban centres are Bethlehem and Phuthaditjhaba in the Wilge River catchment, Highveld complex, Standerton and Ermelo in the Vaal River catchment upstream of Vaal Dam and Potchefstroom in the Mooi River catchment.

All urban areas are listed in Appendix A.1 and are shown **Figure 3.5.1.1**. An estimate of total urban area of 1 035 km^2 was made from WR90 and VRSAU data. The data from WR90 represent the 1990 situation and the urban area is probably underestimated in the catchment above Vaal Dam and in the Mooi River catchment.

3.6 MAJOR INDUSTRIES AND POWER STATIONS

3.6.1 Introduction

Due to different levels of assurance of water supply, so-called Bulk Users have been divided into three categories:

- Strategic users (power stations).
- Mining.
- Other Bulk users (includes major industries).

Mining is treated as a separate category (**Section 3.7**) because return flows from mines can be significant (quantitatively and qualitatively) and have been divided into treated effluent returns and groundwater pumped into the system for operational reasons.

3.6.2 Strategic Bulk Users

For the purpose of this study, strategic bulk users apply only to power stations, which require a high assurance of water supply which range from 98 to 99 % (refer to **Appendix F.9**). This means that power stations have preferential access to water after allowing for the Reserve.

There are three operational thermal power stations (Eskom owned) in the WMA, namely Tutuka, Majuba and Lethabo Power Stations. For locations and other details of these power stations refer to **Figure 3.5.1.1**, to **Section 5.4.2** and to **Appendices F.5 and F.7**. Hydro power stations are described in greater detail in **Section 4.4**.

3.6.3 Major Industries

Major industries in this WMA include Sasol I, Iscor, Sappi, AECI and Sasol II and III. For locations and other details about major industries refer to **Figure 3.5.1.1 and to Section 5.4.4**. **Appendix F.5** lists these major industries along with smaller bulk users. The assurance of water supply for these bulk users ranges from 95 % to 99% with the majority being at 98% (refer to **Appendix F.9**).

Sasol I is located in the Free State province near Sasolburg and abstracts water from the Vaal Barrage. The production of petro-chemicals is the main activity. Sasol I is an economically important industry and a large employer.

Iscor is located in Gauteng Province near Vanderbijlpark and abstracts raw and purified water from the Vaal Barrage. The production of iron and steel products is the main activity. Iscor is an economically important industry and a significant employer.

Sasol II and III are located in Mpumalanga Province near the Highveld (Secunda etc) urban area. Water for Sasol II and III is supplied by pipeline from Grootdraai Dam. The requirement of this bulk user is the largest in the WMA. The production of petro-chemicals products is the main activity. Sasol II and III is an economically important industry and a significant employer.

Other important industries such as Sappi and AECI receive water from the urban centres where they are located. For example AECI receives its water from the Sasolburg TLC water distribution system.

3.7 MINES

Introduction

Mining operations in South Africa encompass a wide range of activities, which include the extraction, dressing and beneficiation of naturally occurring minerals to render the material marketable or to enhance the market value of the material. Mining operations include underground and surface mines and quarries. Assurance of water supply for mines ranges from 98 % to 99 % (**Appendix F.9**).

Figure 3.7.1 shows the location of operating mines.

Mining operations

Products of the mining industry in the Upper Vaal WMA include precious metals (gold, uranium, etc.), base metals, semi-precious stones, industrial minerals and dimension stone. **Appendix F.6** lists all known operating mines in the WMA with special reference to mines that impact on the hydrology and or water quality of the WMA.

Data about mines was obtained from a number of sources including:

- Council of Geoscience, SAMINDABA database (SA Mining Database).
- Reports on the "Vaal River Systems Analysis Update" Study (BKS et al, 1998d,e,f)

It should be noted that the names of many mines have changed in the past 5 years and that the names provided in **Appendix F.6** are possibly out of date.

Quantitative information is given in **Section 5.4.3**. **Appendix G.4** provides quaternary water quality and quantity information for mines that discharge effluent or pump (including seepage) groundwater into the surface water system.

In the area upstream of the Vaal Dam, mining operations in the Mpumalanga Province do not impact significantly on the hydrology of the Upper Vaal River system. In 1995 the total pumpage or seepage from coal and gold mines in this area was estimated at about 1,85 x $10^6 m^3$.

There is some concern about the quality of groundwater seepage from coal mining activities in the Bethal to Secunda area (C11 and C12 tertiary catchments). These seepages do present water quality challenges locally regarding salinity, acidity, fluoride and metals. Similar problems can be expected from gold mining activities in the upper Waterval catchment (Secunda area). These mining operations can also produce elevated nutrient levels (ammonia and nitrate) that are associated with slurry explosive residues.

The impact in particular of coal mining on the economy of this area is significant, as it is one of the more important industries in Mpumalanga Province.

The area downstream of the Vaal Dam has the highest concentration of domestic and industrial users in South Africa. This area is characterised by a large number of mining activities ranging from gold mining to quarrying. These activities have significant impacts on the hydrology and water quality of the Vaal system and their water requirements are significant.

In particular gold mining development has resulted in large pollutant loads in this area. In 1995 the total pumpage, effluent return or seepage from mainly gold mines in this area was estimated at about 121 x $10^6 m^3$.

Much of the mining pollutant load (point and diffuse) emanates from the Klipspruit, Suikerbosrand, Vaal Dam to Vaal Barrage and Mooi key areas.

In the Suikerbosrand key area Grootvlei Mine pumps groundwater of poor quality and this source contributes about 45 x $10^6 m^3$/a of saline (about 4 000 mg/ℓ TDS) water to the Blesbokspruit and its RAMSAR wetland. This area is also impacted by seepage from old abandoned coal mine workings located adjacent to the Blesbokspruit.

Durban Roodepoort Deep and ERPM in the Klipspruit key area decant about 13,7 x $10^6 m^3$/a of poor quality groundwater (about 4 000 mg/ℓ TDS) into the Upper Klip River and Elsburgspruit respectively.

In the Vaal Dam to Vaal Barrage key area, the Western Areas Gold Mine discharges about 13,4 x 10^6 m^3/a of fissure water to the Groot Rietspruit catchment. The TDS concentration (about 900 mg/ℓ TDS) of this effluent is significantly lower than that of the Central and Eastern Witwatersrand gold mines. Operating collieries that are located in the Vereeniging-Vanderbijlpark-Sasolburg area adjacent to the Vaal River, give rise to diffuse salinity problems.

Gold mining operations on the West Rand (e.g. Libanon, West Rand Consolidated, West Driefontein, Blyvooruitzicht, Deelkraal, Kloof, Anglo Gold and Leeudoorn Gold Mines) has led to significant contamination of the Mooirivierloop (Wonderfonteinspruit) and Loopspruit. As a result the extensive underlying dolomitic compartments also appear to be significantly contaminated.

The economic impact of the mining sector in this area has diminished and is no longer significant (< 1% of GGP, **Section 3.3.4**).

3.8 WATER RELATED INFRASTRUCTURE

Due to the fact that the Upper Vaal WMA's water resources were fully utilised many years ago and the fact that it is heavily industrialised and urbanised, a number of dams have been constructed and transfer schemes have been developed which transfer water from other basins to the Vaal River. The Vaal Dam is the largest dam in this WMA but several other important dams are listed in **Table 4.3.1**. The two most important transfer schemes are the Lesotho Highlands Scheme, which supplies the Vaal Dam and the Drakensberg Pumped Storage Scheme, which also supplies Vaal Dam from Sterkfontein Dam. **Section 4.4** provides details about Pump Storage Schemes in the WMA.

Rand Water has a significant network of reservoirs; pump stations, pipelines and purification works. A summary of the five major supply routes has been given in **Section 4.2.1**. Other important schemes are the Usutu – Vaal scheme, the Zaaihoek Scheme and the Vaal – Olifants Scheme (exports water out of the WMA).

There are a number of power stations with associated water distribution networks that supply water to the power station and in some cases to the coal mine associated with the power station and to third party users living along the network.

There are also numerous water treatment works outside the Rand Water supply area that provide purified water to cities and towns like Potchefstroom, Standerton, Ermelo, etc. The supply of bulk water to Phuthadjhaba and the Witsieshoek rural area is managed by Sedibeng Water, for the DWAF.

There are numerous sewage treatment works, many of which return purified effluent to the various rivers in the WMA. Many of the smaller towns return sewage water to oxidation (or evaporation) ponds. While some re-use of treated sewage water occurs not much information is available.

Major infrastructure in the WMA is shown in **Figure 4.1.1** and a schematic diagram, **Figure 4.1.2**, also shows major infrastructure. More detailed information is provided in **Chapter 4**.

CHAPTER 4: WATER RELATED INFRASTRUCTURE

4.1 OVERVIEW

The Upper Vaal WMA is the main focus of economic activity in South Africa. There are several major industries, some of the country's power stations and a number of large mines in the area. These industries, power stations and mines together with a growing urban population have very high requirements for an assured water supply. Rand Water is the major supplier of water and has two major offtakes from the Vaal River, one at Zuikerbosch and the other at Vereeniging. The Zuikerbosch water purification works mainly supplies the East Rand and Pretoria and the Vereeniging works supplies the greater Johannesburg, Vereeniging – Sasol area and the West Rand.

Figures 4.1.1 and 4.1.2 show water related infrastructure such as dams, water treatment works, reservoirs, sewage treatment works, pipelines, irrigation schemes, etc. Due to the fact that there is so much water related infrastructure in the Upper Vaal WMA, the Rand Water supply network being an example, some of the infrastructure has been shown schematically on the GIS map in **Figure 4.1.1**. A full schematic diagram has been given in **Figure 4.1.2.**

Table 4.1.1 provides a summary of potable water supply schemes per key area and for the provinces. Per capita urban consumption ranges from 141 ℓ/capita/day (Mooi key area) to 355 ℓ/capita/day (Klip key area). This information is not readily available for District Councils.

There are a number of water transfers into this WMA (refer to **Sections 4.2 and 5.14**)

There are numerous large dams in the catchment and their details have been recorded in **Table 4.3.1**. Details of weirs have been included in **Appendix E.1**. There is a large network of reservoirs, pumpstations and pipelines, details of which have been provided in **Appendices E.2, E.3 and E.6**. Those managed by Rand Water have been indicated. Sewage treatment works have been included in **Appendix E.4**. Details of canals and tunnels have been provided in **Appendix E.7**. Details of boreholes and hazardous waste sites have been included in **Appendices E.5 and E.8** respectively.

TABLE 4.1.1: COMBINED CAPACITIES OF INDIVIDUAL TOWN AND REGIONAL POTABLE WATER SUPPLY SCHEMES BY KEY AREA.

CATCHMENT				TOWN AND REGIONAL WATER SUPPLY SCHEMES			
SECONDARY		TERTIARY		Number of People Supplied	% of Key Area Population	CAPACITY	
No.	Description	No.	Key Area Description			($10^6m^3/a$) (1)	(ℓ/capita/d)#
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	181 000	34,0		293
C1	Klip - C13	C13	Klip (C13A-H)	17 400	49,3		163
	Grootdraai	C11	Grootdraai (C11A-L)	116 300	74,4		170
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	198 009	76,2		264
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	852 674	96,3		309
	Klip	C22	Klip (C22A-E)	2 358 430	99,3		355
	Mooi	C23	Mooi (C23D-K)	489 450	92,0		141
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	749 173	94,0		224
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	57 300	68,8		192
Total in Gauteng				**4 196 177**	**98,1**		**(1)**
Total in Free State				**348 250**	**46,7**		**(1)**
Total in Mpumalanga				**321 859**	**75,3**		**(1)**
Total in North-West				**153 450**	**77,8**		**(1)**
TOTAL IN WMA				**5 019 736**	**88,9**		**294**

Note: (1) This information is not readily available due to the fact that Rand Water supplies most of this water and there is an extremely complex network of pumpstations, reservoirs etc.

Daily urban consumption calculated from urban usage data.

4.2 MAJOR WATER SUPPLY SCHEMES AND WATER SUPPLIERS

4.2.1 Rand Water Supplier

Rand Water is a major supplier of water in this management area and has a vast network of pipelines. There are two intakes from the Vaal River as follows:

- Zuikerbosch pumping station receives water from the Vaal River, via a canal from Vaal Dam and from the Lethabo intake station.
- Vereeniging pumping station receives water from the Vaal Barrage.

Water supply from Vereeniging and Suikerbosch pumping stations meet at the Daleside reservoir and continue to Zwartkoppies pumpstation where there are quite a number of pipelines branching off in different directions. Areas supplied along this route include Vereeniging and the Vaal Magisterial District (MD), Meyerton and De Deur, Walkerville and Randvaal MD's. Discussion was held with Lourens Human of Rand Water regarding the information required on pipelines, reservoirs and pumpstations. He explained that Rand Water has a very complex and dynamic system and that tabulating reservoir and pipeline capacities, heads etc, would not be of much use. Their network is very much a managed system which is operated in different ways to meet demands which may vary depending on a number of factors. Some reservoirs are not fully utilised, pipelines can be pressurised to supply more water, water can be diverted to meet emergency demands if certain infrastructure is out of commission etc. They are busy completing a very comprehensive GIS system of their infrastructure. It was therefore decided to list their reservoir and pipeline infrastructure components in the relevant tables but not to provide further details. For the pipelines it was decided to limit description of the supply network to the five major routes as follows:

- Vereeniging pumpstation to Heilbron (pumping main) supplying areas Vanderbijlpark, Sasolburg and Heilbron

- Vereeniging and Zuikerbosch pumpstations to Zwartkoppies and Zuurbekom pumpstations to Libanon and Blyvooruitzicht reservoirs to Khutsong (gravity main). Included are boreholes at Zuurbekom, which are also managed by Rand Water.
  Supplying areas of southern Johannesburg, Soweto, the Westonaria and Carletonville MD's and Khutsong.

- Vereeniging and Zuikerbosch pumpstations to Zwartkoppies pumpstation through Pretoria to the Hartebeespoort area and Mamelodi (gravity main).
  Supplying areas in the Alberton, Germiston, Kyalami and Pretoria MD's, Mamelodi, Atteridgeville, Soshanguve and the Hartebeespoort area.

- Vereeniging and Zuikerbosch pumpstations to Zwartkoppies and Bloemendal pumpstations to Wildebeesfontein (gravity main).
  Supplying areas in the Alberton, Germiston, Boksburg, Benoni, Brakpan, Springs, Nigel and Heidelberg MD's and to Devon, Leandra and Evander.

- Vereeniging and Zuikerbosch pumpstations to Zwartkoppies to Rustenburg (gravity main)
  Supplying areas of Greater Johannesburg and the Randfontein, Krugersdorp and Magaliesburg MD's and Rustenburg.

  Appendix's E.2, E.3, E5 and E6 provide details of Rand Water reservoirs, pumpstations, boreholes and pipelines.

4.2.2 Sedibeng Water Supplier

Although Sedibeng Water operates mainly in the Middle Vaal WMA, it does operate the DWAF water supply infrastructure in the Witsieshoek area in the Upper Wilge Catchment. This network supplies water from the Metsi Matso and Fika Patso Dams to the towns of Phuthaditjhaba and Kestell and to the large rural community in this area.

4.2.3 Lesotho-Highlands Scheme

The largest transfer to the Upper Vaal WMA is the Lesotho Highlands Scheme (which started operating in 1998.) Water is pumped from Katse Dam (Lesotho) in the Upper Orange WMA and flows into the Liebenbergsvlei River via Saulspoort Dam (which acts as a weir), which flows into the Wilge River which flows into the Vaal Dam.

4.2.4 Thukela-Vaal Transfer Scheme

Also feeding the Vaal Dam via the Wilge River is Sterkfontein Dam (Drakensberg pumped storage scheme). Water is pumped from Driel Barrage to Driekloof Dam which spills into Sterkfontein Dam in the Thukela WMA.

4.2.5 The Usutu- Vaal Transfer Scheme

The Westoe, Jericho and Morgenstond Dams in the Usutu WMA supply water to Camden, Kriel, Matla and Kendal power stations. Most of this water (except for the use at Camden Power Station) is transferred by pipeline out of this WMA into the Komati and Olifants WMA's.

4.2.6 The Heyshope Scheme

This scheme supports the Usutu and Grootdraai Dam sub-systems. The water is pumped into the upper reaches of the Little Vaal River and flows into

Grootdraai Dam where it is used supply Sasol 2 and 3 and Eskom power stations.

4.2.7 The Zaaihoek Scheme

The Zaaihoek scheme supplies water from the Thukela WMA to Majuba Power Station, Volksrust, Wakkerstroom and Chelmsford Dam. It also supplies deficits in the Grootdraai Dam sub-system.

4.2.8 The Vaal – Olifants Scheme (transfer link)

From Grootdraai Dam in Vaal River catchment to Trichardtsfontein Dam in the Olifants WMA to supply Eskom Power stations in the area.

4.3 MAJOR WATER SUPPLY SCHEMES PER KEY AREA

4.3.1 The Wilge key area

The Thukela – Vaal Transfer Scheme (**Section 4.2.4**) and the Lesotho Highlands Scheme (**Section 4.2.3**) deliver water to the Wilge and Liebensbergvlei Rivers respectively. Both these schemes ultimately supply water to Vaal Dam at the outlet of this key area.

There is a large rural population in this key area of about 342 880 the majority of which are supplied by Sedibeng Water from the Metsi Matso and Fika Patso Dams. Phuthadijhaba and Kestell are also supplied by Sedibeng Water from these sources. The remaining urban centres abstract water from mainly surface water resources. For example Harrismith abstracts water from the Wilge River, while Bethlehem obtains its water from the Saulspoort Dam on the Ash River.

4.3.2 The Klip (C13) key area

The Zaaihoek Scheme delivers water to Majuba Power station in this key area (refer to **Section 4.2.7**).

The urban and rural populations are small (about 17 400 and 17 895 respectively). The urban populations of Vrede and Memel obtain water from the Klip River and its tributaries. The rural population is likely to obtain their water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.3 The Grootdraai (C11) key area

The Usutu-Vaal Transfer Scheme (**Section 4.2.5**) supplies Eskom power stations within the key area (Tutuka Power Station) and Olifants WMA and Grootdraai Dam is supplemented by water transferred from Heyshope Dam (Usutu WMA) and Zaaihoek Dam (Thukela WMA).

The urban populations obtain their water from various sources. For example Bethal receives water from Rand Water (Vaal Dam), Ermelo, Standerton and

Breyten from surface water resources in the area, while the smaller towns like Paardekop and Morgenzon abstract water from groundwater sources. The rural population is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.4 The Grootdraai to Vaal Dam key area

Sasol II and III receive water from Grootdraai Dam (Usutu-Vaal Transfer Scheme).

The urban populations obtain their water from various sources. For example the Highveld Ridge TLC (Secunda, Kinross, Evander and Trichardt) receives water from Rand Water (Vaal Dam). Villiers abstracts water directly from Vaal Dam, while smaller towns like Greylingstad, Cornelia and Charl Cilliers are likely to obtain water from both surface (municipal dams) and groundwater (boreholes) sources. The rural population (about 61 775) is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.5 The Suikerbosrand key area

There is a large urban population of about 852 670 in this area and with the exception of Balfour (dam in Suikerbosrand catchment), the urban water requirements of Benoni, Brakpan, Springs, Nigel and Heidelberg are supplied by Rand Water from Vaal Dam. The rural population is relatively insignificant (about 32 900) and is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.6 The Klip key area

This area has the largest urban population (about 2 358 430) and the urban centres of Johannesburg (Vaal catchment), Germiston, Boksburg and Alberton are supplied by Rand Water from Vaal Dam. The rural population is insignificant (about 17 560) and is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.7 The Mooi key area

The urban population of about 489 450 is supplied from various sources. The urban centres of Westonaria, Carltonville, Fochville and Wedela are supplied by Rand Water from the Vaal Dam and Zuurbekom boreholes while Potchefstroom abstracts water from the Mooi River. The rural population of about 42 680 and is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.8 The Vaal Dam to Vaal Barrage key area

The urban population of about 749 170 is mainly supplied by Rand Water from the Vaal Dam. Urban centres include Western (Vanderbijlpark) and Eastern

(Vereeniging) Vaal Metro's and Sasolburg. Randwater also transfers water for urban usage to Heilbron in the Middle Vaal WMA via the Sasolburg network. Deneysville receives water from Vaal Dam via a DWAF operated canal. The rural population of about 47 980 is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

4.3.9 The Barrage to Mooi key area

The urban population of about 57 300 obtains water from the Vaal River in the case of Parys and from the Vaal River and boreholes in the case of Vredefort. The rural population of about 25 970 is likely to obtain water from both surface (farm dams) and groundwater (boreholes) sources.

The most important dam in the Upper Vaal WMA is the Vaal Dam, which is augmented by transfers from the Lesotho Highlands Scheme, the Drakensberg Pumped Storage Scheme and Grootdraai Dam.

Grootdraai Dam also supplies Tutuka power station and the Sasol II and III plants and transfers water for power stations in the Crocodile WMA.

Table 4.3.1 provides details of all major dams in the Upper Vaal WMA. Details of Water supply schemes are given in **Table 4.3.2**.

TABLE 4.3.1: MAIN DAMS IN THE UPPER VAAL WMA

NAME	LIVE STORAGE CAPACITY (10^6m^3)	DOMESTIC SUPPLY ($10^6m^3/a$)	IRRIGATION SUPPLY ($10^6m^3/a$)	OTHER SUPPLY ($10^6m^3/a$)	OWNER	1:50 YEAR YIELD ($10^6m^3/a$)
Saulspoort	16,866	7,253		50,367	DWAF	6,6
Klipdrift	13,492		3,423	58,426	DWAF	5,0
Boskop	20,854 (gross)		38,092	32,117	DWAF	38,5
Klerkskraal	8,163		13,218	43,351	DWAF	24,0
Driekloof	32,226				DWAF	$
Sterkfontein	2 616,951				DWAF	$
Grootdraai	362,525	42,386			DWAF	151,0
Vaal	2 603,413	731,572			DWAF	831,0

Note : 1. Domestic, irrigation and other supply from reservoir records for the 1995 hydrological year. Live storage also taken from reservoir records (where available) otherwise "List of Hydrological Gauging Stations (Volume 2) July 1990"

2. $ There is a transfer from the Thukela River into Driekloof and on to Sterkfontein. This system has been estimated at yielding 736 x 10^6 m^3/a.

Using WR90 data, storages in this WMA have been shown graphically for selected areas in Diagram 4.3.1. Dams on the Vaal River and major tributaries have been designated as major dams and others as minor dams.

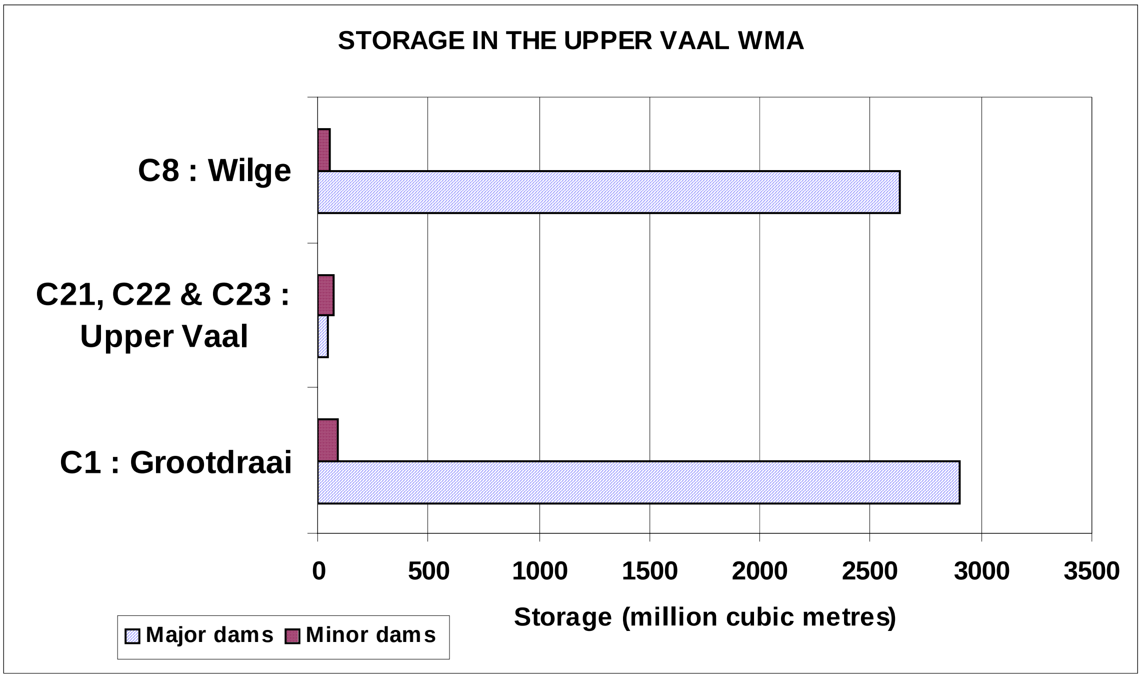


Diagram 4.3.1: Storage in the Upper Vaal WMA

TABLE 4.3.2: REGIONAL WATER SUPPLY SCHEMES: BULK WATER SUPPLY INFRASTRUCTURE

WATER TREATMENT WORKS			RAW WATER SOURCE				
NAME	CAPACITY (Ml / d)	OWNER/ OPERATOR	NAME	CAPACITY/SUPPLY (10^6 m^3/a)	CAPACITY/SUPPLY (Mℓ/d)	ADDITIONAL YIELD ALLOCATED TO OTHER USERS (10^6 m^3)	OWNER AND OPERATOR
Balfour			Balfour Dam		Y 1,9		
Bethlehem	D 40,0	Municipality	Saulspoort Dam	O 11,0 Y 2,2	O 30,1 Y 5,9	0	Municipality
Camden Power Station (mothballed)			Jericho Dam				
Cornelia (Frankfort WTW)	O 9,0	Municipality (Frankfort)	Wilge River	Y 1,2	Y 3,3	0	Municipality
Deneysville	Unknown	Municipality	Vaal Dam	Unknown	Unknown		Municipality
Ermelo			Dams	Y 2,8	Y 7,8		
Eskom Lethabo Power Station			Vaal Barrage				
Frankfort	Unknown	Municipality	Wilge River	Y 1,2	Y 3,3		Municipality
Grootvlei Power Station (mothballed			Vaal dam				
Harrismith	D 10,0 O 5,0	Harrismith TLC	Sterkfontein Dam Gibson Dam Wilge River	Y 0,7	Y 2,0		Harrismith TLC
Iscor Klip Works			Vaal Barrage				

WATER TREATMENT WORKS			RAW WATER SOURCE				
NAME	CAPACITY (Ml / d)	OWNER/ OPERATOR	NAME	CAPACITY/SUPPLY (10^6 m^3/a)	CAPACITY/SUPPLY (Mℓ/d)	ADDITIONAL YIELD ALLOCATED TO OTHER USERS (10^6 m^3)	OWNER AND OPERATOR
Iscor Vaal Works			Vaal Barrage				
Iscor Vanderbijl Works			Vaal Barrage				
Kestell		Sedibeng Water	Boreholes	O 0,1 Y 3,2	O 0,3 Y 8,8	0	Sedibeng Water
Majuba Power Station			Zaaihoek dam				
Memel	Unknown	Municipality	Boreholes	O 0,0004	O 0,001		Municipality
Parys	D 12,5 O 11,5	Municipality	Vaal River	Y 2,5	Y 6,84		Municipality
Potchefstroom		Municipality	Mooi River	Y 10,6	Y 29,1		Municipality
Sasolburg	Unknown	Rand Water	Vaal Dam	Y 16,98	Y 46,5		Rand Water
Reitz	O 80,0	Municipality	Geluk Dam De Mollen Reward Dam Gryp Dam	Y 0,54	Y 1,49	0	Municipality
Sasol I			Vaal Barrage				
Sasol II and III			Grootdraai Dam				
Standerton			Vaal River	Y 4,92	Y 13,46		
Tutuka Power Station			Grootdraai Dam				
Tweeling	D 0,96 O 0,75	Municipality	Unknown	Unknown	Unknown		Municipality
Tubemakers, Stuart and Lloyd			Vaal Barrage				
Villiers	D 3,5 O 1,8	Municipality	Vaal River	O 0,3	O 0,86	0	Municipality
Vrede	Unknown	Municipality	Vrede Dam New Dam on the Spruitsonderdrf	Unknown	Unknown	0	Municipality
Warden	D 2,59 O 1,2	Municipality	Warden	O 0,20 Y 0,13	O 0,55 Y 0,35	0	Municipality

Note : D denotes design
O denotes Operating yield
Y denotes Municipal Yearbook 1995 and is the average daily consumption
Where the source of water is unknown, it is usually local rivers

Major water supply schemes have been summarised in **Table 4.3.3**.

TABLE 4.3.3: POTABLE WATER SUPPLY SCHEMES IN THE UPPER VAAL WMA.

Scheme Name	Raw water source	Population supplied	Scheme Capacity		
			(10^6 m^3/a)	(Mℓ/day)	Limiting factor
Zuikerbosch and Vereeniging purification works	Vaal Barrage Vaal Dam Sterkfontein Dam	10 000 000 within an area of 17 000 km^2 (Rand Water Supply area – includes Crocodile WMA)	*	3 001 (maximum day in 1995/1996)	In rural areas and certain township developments, infrastructure is the limiting factor. The main limiting factor, however, is yield. Rand Water's primary infrastructure is more than sufficient for current needs.
Zuurbekom wells (groundwater)	Groundwater	#	9,13	25 (max day)#	Quality of water ? Susceptible to pollution from mining.
Sasol II and III; Eskom p/s	Grootdraai Dam	For power generation and industrial use.	±200,0	#	#
Qwa Qwa Region: Witsieshoek and Phuthadjhaba	Metsi Matso Dam Fika Patso Dam	310 000	±14,4	40	Not much information available.

Notes to Table 4.3.3:

1. The Zuikerbosch and Vereeniging works supply numerous areas. These areas have been summarised into five major areas (refer to the schematic diagram – Figure 4.1.2) as follows:

- Vereeniging and Vanderbijl area
- West Rand area
- South-western JHB to Carletonville
- North JHB to Pretoria and Hartbeespoort
- East Rand

Most of these supply areas can have a mixture of Zuikerbosch and Vereeniging Treatment Works water.

2. * The Scheme capacity cannot simply be explained with a figure in this column.

The Rand Water raw water sources have the following maximum storages (Rand Water Annual Report, 1996, for the period April 1995 to March 1996):

	Storage (x $10^6 m^3$)
Barrage Reservoir	54,21
Sterkfontein Reservoir	2 617,00
Vaal Dam	2 580,49
Total	5 251,70

Of the Vaal Dam storage, 234,362 x $10^6 m^3$ is reserved for Rand Water.

Capacities of water purification works are not readily available in any report, however, the following maximum reservoir storages are known.

	Capacity (x $10^6 m^3$)
Station reservoirs (potable water)	1,537
Service reservoirs (potable water)	3,908
Total	4,062

In 1995/96 Rand Water customers consumed on average 2,469 x $10^6 m^3$/day.

Not readily available

The major irrigation schemes have been summarised in **Table 4.3.4**.

TABLE 4.3.4: CONTROLLED IRRIGATION SCHEMES IN THE UPPER VAAL WMA.

SCHEME/ BOARD OR CONTROL AREA NAME	SCHEDULED AREA(1) (ha)	IRRIGATED FIELD AREA(1) (ha)	PRODUCE	WATER SOURCE	GUIDELINE QUOTA(1) (m^3/ha/a)	AVAILABLE YIELD (2) (10^6 m^3 /a)	PRESENT AVERAGE ANNUAL USE(3) (10^6 m^3 /a)	THEORETICAL REQUIREMENT OF CURRENT IRRIGATED AREA (4) (10^6 m^3 /a)
Vaal GWCA (u/s Vaal Dam)	0	6 538	Maize, fodder	Vaal River	6 100		37,57	39,88
Vaal GWCA (d/s Vaal Dam)	0	712	Maize, fodder	Vaal River	6 100		4,62	4,34
Mooi GWS	4 760	4 760	Fodder, maize	Mooi River	7 700		36,81	36,65
Rietpoort IB	193	100	Fodder, maize	Vaal River	6 100		0,78	1,18
Koppieskraal IB	170	170	Fodder	Vaal River	6 100		1,58	1,04
Klipdrift	1 027	1 027	Fodder, maize	Loopspruit	5 875		8,91	6,03
Vyfhoek	114	104	Fodder	Loopspruit	7 700		0,93	0,88
TOTALS	**6 264**	**7 229**			**5 875 to 7 700**		**91,2**	**90,0**

Notes:

(1) From Tables 7.2 and 8.2 of report (Loxton et al, 1999b)

(2) No readily available information.

(3) Calculated by multiplying schedules area by the known crop water use / ha for an area. Crop water use from Table 8.2, (Loxton et al, 1999b).

(4) Calculated by multiplying schedules area by the guideline quota / ha for an area. Guideline quota is not the official quota, refer to Table 8.2 of the report (Loxton et al., 1999b).

4.4 HYDRO-POWER AND PUMPED STORAGE

There are no hydro-power stations in the Upper Vaal WMA and only one pumped storage scheme.

Details of the Drakensberg pumped storage scheme have been provided in **Table 4.4.1** . Operated by Eskom, water is pumped from the Driel Barrage in the upper reaches of the Thukela River over the Drakensberg up to Driekloof Dam which adjoins Sterkfontein Dam. Some of the water in Driekloof Dam spills into Sterkfontein Dam over the weekend when the demand for power is low. The water retained in Driekloof Dam is used to generate power during periods of peak demand.

The maximum pumping capacity (from Jagersrust in the Thukela WMA) is 20 m^3/s. From historical flow records a maximum transfer of 530 $x10^6$ m^3 /a (on average) is possible.

TABLE 4.4.1: PUMPED STORAGE SCHEMES

Description	**Drakensberg (Sterkfontein Dam)**
Location: Latitude Longitude	29º05’00” S 28º33’54” E
Rated capacity	1 000 MW
Peak capacity (generator limitation)	1 080 MW
Rated head	411 m
Load factor	20 %

CHAPTER 5: WATER REQUIREMENTS

5.1 SUMMARY OF WATER REQUIREMENTS

The various water user sectors in the Upper Vaal WMA are as follows:

- Ecological Reserve (environmental - in-stream flow requirements. This water is not consumed apart from river losses).
- Domestic (urban and rural).
- Bulk water use (including thermal power stations and mine users).
- Agriculture (including livestock and game).
- Afforestation.
- Alien vegetation.
- Water transfers.

Table 5.1.1 summarises the 1995 water requirements and the equivalent requirement at 1:50 year assurance.

Distribution losses and conveyance losses are included in the values given for water requirements, including water transfers, but return flows have not been subtracted. Water requirements for aquatic ecosystems are given as the requirement at the outlet to the WMA.

Not all water is required at the same assurance, for example, water for urban demand must be provided at a much higher assurance than water for irrigation. Refer to **Appendix F.9** for the assurance of supply for various users. Assurance is, however, taken into account when determining the equivalent 1:50 year requirement.

Figure 5.1.2 shows water requirements at 1:50 year assurance for the user groups per key area. Pie diagrams showing all the water requirements in the key areas have been included. The most significant water requirements are domestic users (urban and rural) and exports out of the WMA to the Crocodile River catchment. **Table 5.1.2** summarises water requirements of the user groups for the key areas and for provinces.

TABLE 5.1.1: WATER REQUIREMENTS PER USER GROUP

USER GROUP	ESTIMATED WATER REQUIREMENT ($10^6 m^3/a$)	REQUIREMENT/USE AT 1:50 YEAR ASSURANCE ($10^6 m^3/a$)
Ecological reserve (5)	299,4[N1]	48,2
Domestic (1)	549,5(1)[N2]	550,7
Bulk industrial use (4)	246,4[N3]	242,1
Neighbouring States	0	0
Agriculture	193,6(2)[N4]	157,8
Afforestation	0,6	0,2
Alien vegetation	29,7	15,5
Water transfers (3)	507,7[N5]	508,0
Hydropower	0	0
TOTALS	**1 829,9**	**1 522,5**

Note:

(1) Includes urban domestic, commercial, institutional and municipal requirements (539,1 x $10^6 m^3/a$) and rural domestic requirements (10,4 x $10^6 m^3/a$).

(2) Includes requirements for irrigation (149,5 x $10^6 m^3/a$), dryland sugar cane (0 x $10^6 m^3/a$) and livestock and game (44,1 x $10^6 m^3/a$).

(3) Only potable transfers out of the WMA, RW transfers to Crocodile WMA (472 x $10^6 m^3/a$), Eskom transfer for powerstations in Olifants WMA (35,4 x $10^6 m^3/a$) and transfer to Volkrust from supply dams.

(4) Includes thermal powerstations (72,9 x $10^6 m^3/a$), major industries (164,2 x $10^6 m^3/a$ and mines (9,3 x $10^6 m^3/a$).

(5) At outlet of WMA. Totals from Table 5.2.4.1

TABLE 5.1.2: WATER REQUIREMENTS PER USER GROUP FOR KEY AREAS AND PROVINCES AT 1:50 YEAR ASSURANCE.

CATCHMENT				USERS[(3)]								
SECONDARY		TERTIARY		DOMESTIC USERS[(1)] ($10^6m^3/a$)		BULK USERS[(2)] ($10^6m^3/a$)	AGRICULTURAL USERS ($10^6m^3/a$)		AFFOREST-ATION ($10^6m^3/a$)	ALIEN VEGETATION ($10^6m^3/a$)	WATER TRANSFERS[(4)] ($10^6m^3/a$)	HYDRO-POWER ($10^6m^3/a$)
No	Description	No.	Key area	Urban	Rural		Irrigation	Livestock and game				
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	18,7	7,5	0,0	17,8	15,0	0,18	7,2	0	0
C1	Klip	C13	Klip (C13A-H)	1,2	0,2	2,4	0	3,0	0,00	0,9	0,3	0
	Grootdraai	C11	Grootdraai (C11A-L)	7,3	0,5	39,1	21,7	10,6	0,02	2,3	125,9	0
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	19,2	0,8	97,4	6,9	5,8	0,00	0,7	0,0	0
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	96,5	0,4	3,7	7,2	1,9	0,00	0,3	0,0	0
	Klip	C22	Klip (C22A-E) - Gauteng	306,4	0,2	1,0	10,3	0,4	0,00	1,1	3,7	0
	Mooi	C23	Mooi (C23D-K)	25,3	0,5	3,9	40,3	2,9	0,00	0,5	0,0	0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	61,0	0,6	94,6	1,5	2,0	0,00	2,3	906,8	0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	4,1	0,3	0,0	8,0	2,5	0,00	0,2	0,0	0
Total in Mpumalanga				**26,8**	**1,4**	**133,6**	**28,4**	**16,4**	**0,02**	**3,1**	**126,2**	**0**
Total in Free State				**45,8**	**8,2**	**69,2**	**29,7**	**20,2**	**0,18**	**9,2**	**453,4**	**0**
Total in Gauteng				**457,8**	**0,7**	**38,4**	**28,3**	**6,0**	**0,00**	**2,8**	**457,1**	**0**
Total in North-West				**9,3**	**0,7**	**0,9**	**27,3**	**1,5**	**0,00**	**0,4**	**0,0**	**0**
TOTAL IN WMA				**539,7**	**11,0**	**242,1**	**113,7**	**44,1**	**0,20**	**15,5**	**1 036,7**	**0**

Notes: [A6]

(1) Includes urban and rural domestic requirements and indirect urban requirements.
(2) Includes thermal power stations, major industries, other bulk industrial users and mines.
(3) Assurance data provided by the DWAF.
(4) Only potable water transfers out of key areas or provinces given. Where rivers are boundaries between provinces 50 % of known transfer assigned to each province.

5.2 ECOLOGICAL COMPONENT OF RESERVE

5.2.1 Introduction

The classification of the main stem rivers in the vicinity of the outlets of the quaternary catchments is described in **Section 2.6.2**. On the basis of this classification, a so-called desktop method has been developed (Hughes and Münster, 1999) to provide a low-confidence estimate of the quantity of water required for the ecological component of the Reserve, which is suitable for use in this water resources situation assessment.

The method involves the extrapolation of high confidence results of previous instream flow requirement (IFR) workshops, the use of a reference time series of monthly runoff at the outlet of the quaternary catchment and a number of hydrological indices or parameters that have been defined for 21 desktop Reserve parameter regions in South Africa. These desktop Reserve parameter regions are described and shown in **Figure 5.2.1.1**. The instream flow requirements that were determined previously were mostly based on the use of the Building Block Method (King and Louw, 1998). The monthly time series of natural flow that has been used is described in **Section 6.3**. The following are the two main hydrological parameters:

- a measure of the longer term variability, which is a combination of the coefficients of variation of winter and summer volumes (CV); and
- an estimate of the proportion of the total flow that occurs as base flow (BFI), which can be considered to be a measure of short-term variability.

The ratio of the above two indices (CV/BFI) has been used as an overall hydrological index of flow variability or reliability. Rivers with low variability and a high base flow response have very low hydrological indices of flow variability and vice versa.

A relationship has been found between the hydrological index of flow variability, the ecological status and the annual requirements for low and high flows for the so-called maintenance and drought periods of the modified flow regime for the river. The essence of the relationship is that for a particular ecological status or class, the water required for the ecological component of the Reserve will increase as the hydrological index of flow variability decreases, and vice versa. Furthermore, the water requirement will decrease as the ecological status is decreased.

The method that has been used is based on a series of assumptions, many of which have not yet been verified due to either a lack of information or of time since the method was developed. The following is a summary of the main limitations in order to provide an indication of the level of accuracy that can be expected:

- The extrapolations from past IFR workshops are based on a very limited data set, which does not cover the whole of the country. While some development work has been completed to try and extend the extrapolations and has improved the high flow estimations for dry and variable rivers, this has been limited.

- The extrapolations are based on a hydrological index and no allowance (in the desktop method adopted for this water resources situation assessment) has been made for regional, or site specific ecological factors. It is unlikely that an index based purely on hydrological characteristics can be considered satisfactory but it represents a pragmatic solution in the absence of sufficient ecological data.
- The method assumes that the monthly time series of natural flows are representative of real natural flow regimes and many of the algorithms rely upon the flow characteristics being accurately represented. Should the data indicate more extended base flows than actually occur, the hydrological index of flow variability would be under-estimated and the water requirements for the ecological component of the Reserve would be over-estimated.

5.2.2 Quantifying the Water Requirements

A simulation model has been developed to simulate the relationships that were found to exist between the hydrological index of flow variability, the ecological status and the annual requirements for low and high flows and for so-called maintenance and drought flow periods (Hughes and Münster, 1999).

The simulation model provides annual maintenance and drought low flows and maintenance high flows (expressed as a proportion of the mean annual runoff). The model also provides for the seasonal distribution and assurances associated with the monthly flows on the basis of a set of default parameters that has been developed for each of the 21 desktop Reserve parameter regions of South Africa referred to in **Section 5.2.1**. The quaternary catchments in the Upper Vaal WMA all fall within the Vaal desktop Reserve parameter regions (number 20) except for quaternary catchments C23D to C23H which fall within the Southern Cape wet desktop Reserve parameter region (number 7).

The monthly time series of natural flows at the outlets of the quaternary catchments have been used to generate an equivalent time series of water requirements for the ecological component of the Reserve. This has been accomplished by relating the assurances of the natural flows in a particular month to the assurances of the flow required for the ecological component of the Reserve during the same month.

In the water balance model it is necessary to express the water requirements for the ecological component of the Reserve in terms of annual requirements that are directly comparable to those of any other sector. It therefore becomes necessary to reduce these water requirements to a common assurance and more specifically the effect that these requirements will have on the capacity of the river system to supply water at a specific assurance i.e. the effect on the yield of the river system.

The effects on the yield of the river system of the water required for the ecological component of the Reserve have been based on an analysis of the monthly time series of these water requirements for the same 70-year period as for the natural time series of flows, that is described in **Section 6.3**. This has been estimated by establishing the average annual quantity of water required for the ecological component of the Reserve during the most severe or so-called critical drought that has determined the yield of the river system at a recurrence interval of 50 years. The duration of the critical drought can be approximated by the (inverse of) marginal rate of increase of the yield of the river system per unit increase in storage capacity i.e. the slope of the storage-yield curve at the storage capacity under consideration. The periods of high and low flows in the monthly time series of water requirements for the ecological component of the Reserve also mimic the periods of high and low flows in the monthly time series of natural flows used to establish the yield of the river system. Therefore, the portion of the yield of the system that is required for the ecological component of the Reserve can be estimated by finding the lowest average flow for all periods in the monthly time series of water requirements for the ecological component of the Reserve that are as long as the critical drought period.

The monthly time series of water requirements for the ecological component of the Reserve has been determined at the outlet of each quaternary catchment for each of the ecological status Classes A to D. These time series have been analysed for various lengths of the critical drought to establish the system yield required for the ecological component of the Reserve. This has been done for a range of system capacities, from which the appropriate value corresponding to the storage capacity being considered has then been selected for use in the water balance.

The method that has been used to quantify the water requirements is based on a series of assumptions, many of which have not yet been verified due to either a lack of information or of time since the method was developed. The following is a summary of the main limitations in order to provide an indication of the level of accuracy that can be expected:

- The seasonal distributions of the annual estimates of water requirements are based on analyses of the base flow characteristics of some 70 rivers using daily data, the results of which were then regionalised. Some individual quaternary catchments that have been allocated to a specific region may however, have somewhat different characteristics.

- Similarly, the regional parameters for the assurance rule curves have been based on the duration curve characteristics of the natural flow regimes represented by the monthly time series of flow described in **Section 6.3** and some experience of setting assurance rules used at past IFR workshops. Regionalising was done by investigating a representative sample of quaternary catchments and it is therefore possible that some have been assigned to the wrong regions.

- The estimates of water required for the ecological component of the Reserve are the best estimates that can be given at this stage, but must be regarded as low confidence estimates. As more detailed estimates are made for a wider range of rivers, the estimates will be improved through modifications made to the delineation of the regions and the regional parameters that have been assigned. It is also anticipated that a better way of accounting for regional or site specific ecological considerations will be added in due course.

5.2.3 Comments on the results

Indications are that the management classes produced, given the limitations of this procedure, represent a relatively accurate picture of the ecological state of the analysed rivers.

The vast majority of quaternary catchments analysed generated C management classes, i.e moderately modified aquatic ecosystems that will require 20-40% MAR. Bearing in mind that assessments were only done at quaternary catchment outlets, there are no A class rivers and only about 10% were designated as B class. This points to the relatively poor state of aquatic ecosystems.

5.2.4 Presentation of results

Table 5.2.4.1 shows the water requirements for certain key points. Note that the key points considered coincide with catchment or sub-catchment outlets, or with the other specific criteria adopted for the WMA and that the key points (outlets of key areas) shown are those given in **Table 7.2.1**. Note also that there can be intra-quaternary catchment variation in class and state, so there may be intra-tertiary or intra-key point variation. The quaternary information for present ecological status class is contained in **Appendix F.1.**

The water requirements for the Ecological Component of the Reserve are summarised for the quaternary catchments in **Figure 5.2.4.1**.

TABLE 5.2.4.1: WATER REQUIREMENT FOR ECOLOGICAL COMPONENT OF THE RESERVE.

KEY POINT	PRESENT ECOLOGICAL STATUS CLASS (PESC)	RIVERINE ECOLOGICAL WATER REQUIREMENTS FOR PESC		
		% VIRGIN MAR	VOLUME ($10^6 m^3/a$)	IMPACT ON EXISTING YIELD AS 1:50 YEAR YIELD * ($10^6 m^3/a$)
Wilge (C83M)	C	13,4	116,4	15,5
Klip River (C13H)	C	13,4	39,0	2,1
Grootdraai (C11L)	E-F (use default D)	8,9	40,7	13,5
Grootdraai to Vaal Dam (C12L)	C	12,8	46,1	0,0 (-12,3)
Suikerbosrand (C21G)	D	9,4	8,7	1,2
Klipspruit (C22E)	E-F (use default D)	9,7	9,3	3,3
Mooi (C23K)	D	22,6	25,5	11,4
Vaal Dam to Vaal Barrage (C22K)	D	9,4	6,4	1,2
Barrage to Mooi (C23L)	D	9,7	7,3	0,0 (-2,2)

Note : * Negative values taken as zero

5.2.5 Discussion and Conclusions

With regard to limitations of the results, Kleynhans (Kleynhans, 1999) has provided the following comments:

- An aspect that has become glaringly obvious is the paucity of knowledge on many of South Africa’s rivers. While the regional experts were able to supply useful input on many river systems, there were also many systems that had little or no published ecological data and were not familiar to the relevant regional experts. There is a need therefore, to provide some sort of forum for the continual updating of the information and data.

- The database and its data need to be modified as and when additional (research) information becomes available. An allowance, to a certain extent, is made for this by Kleynhans’ (Kleynhans, 1999) assertion that “...it can be expected and considered mandatory that the information required for the determination of the ecological Reserve under these situations should improve in confidence and detail compared to that of the desktop estimate, e.g. in all probability information beyond desktop level will be required.”

- Related to the above point, it would be useful if there could be some sort of linkage between quaternary confidence ratings and the generation of the various indices. It became apparent, during the regional workshops that the difference in assessment expertise and experience between the regional experts needed to be leveled. Confidence ratings perhaps need to play a greater role in determining a particular management class. At present they are merely recorded in the EcoInfo Programme, and their relative importance have perhaps been understated. A role for confidence ratings within the algorithmic sequences of means and medians that Kleynhans (Kleynhans, 1999) developed to determine the quaternary management classes should be investigated, particularly for any future versions of this procedure.

This procedure for the determination of the ecological Reserve constitutes a solid, workable foundation that may provide a springboard for the development of other procedures, for instance for the rapid determination method. Although general and conservative in nature, it does provide a synthesis of flow related (ecological) data and a means for providing a general estimate of ecological flow requirements.

5.3 URBAN AND RURAL

5.3.1 Introduction

Since political change occurred in 1994 and with the new National Water Act, 1998 (Act No. 36 of 1998) in place, new considerations emerged in urban and rural water supply and return flows. About 1200 new water service systems have been augmented based on the Reconstruction and Development Program (RDP). Although some of these new trends have not actually been implemented yet, it can be stated that the demand for water in urbanised areas is generated mainly by the following criteria:

- Population growth.
- Price of water development and services.
- Technological choices based on the socio-economic situation of various water users.
- Climate.

There are many other variables such as mandatory restrictions, water use legislation, subsidies etc., which can significantly influence the demand for water. However, all these factors are of a secondary nature

The reconciliation of water requirements generated primarily by the growth in population, urbanisation and technology changes against available water resources is an essential component of any planning of any planning process.

In general the development and management of regional water resources in the Upper Vaal WMA over the last four decades were influenced by political decisions with the result that the industrial and mining sectors tended to receive priority. The result is well developed water supply infrastructure in certain areas that are managed by large public and private water providers e.g. municipalities, water boards, etc. In the rural areas the only real development is related to farming. As a result, the development of rural, semi-urban and even some small urban community water supply was lacking. This situation in the 1990's has been aggravated with the influx of the rural population into the vicinity of formal urban settlements resulting in numerous informal settlements without water supply and sanitation facilities. In 1996 the number of informal settlements in Gauteng alone numbered 174 (Urban Dynamics, Cape and Regional Planners on behalf of Rand Water).

Table 5.3.1 summarises the urban and rural domestic water requirements for key areas.

TABLE 5.3.1: 1995 URBAN AND RURAL DOMESTIC WATER REQUIREMENTS.

CATCHMENT				URBAN (1)	RURAL (1)	TOTAL	1:50 YEAR ASSURANCE	HUMAN RESERVE (AT 1:50 YEAR ASSURANCE) (2)
SECONDARY		TERTIARY						
No.	Description	No.	Key Area Description	(10^6 m^3/a)	(10^6 m^3/a)	(10^6 m^3/a)	(10^6 m^3/a)	(10^6 m^3/a)
C8	Wilge	C81, 82,83	Wilge (C81A-M, C82A-H, C83A-M)	19,3	7,1	26,4	26,4	3,1
C1	Klip	C13	Klip (C13A-H)	1,0	0,2	1,2	1,4	0,3
	Grootdraai	C11	Grootdraai (C11A-L)	7,2	0,5	7,7	7,8	1,4
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	19,2	0,7	19,9	20,0	2,8
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	96,2	0,4	96,6	96,9	8,1
	Klip	C22	Klip (C22A-E)	305,8	0,2	306,0	306,4	21,7
	Mooi	C23	Mooi (C23D-K)	25,2	0,5	25,7	25,8	5,7
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	61,2	0,5	61,7	61,6	7,3
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	4,0	0,3	4,3	4,4	0,8
Total in Mpumalanga				**26,8**	**1,1**	**27,9**	**28,2**	**2,6**
Total in Free State				**45,9**	**7,9**	**53,8**	**54,0**	**5,2**
Total in Gauteng				**457,2**	**0,7**	**457,9**	**458,5**	**42,8**
Total in North-West				**9,2**	**0,7**	**9,9**	**10,0**	**1,0**
TOTAL IN WMA				**539,1**	**10,4**	**549,5**	**550,7**	**51,6**

Note: (1) Includes conveyance and distribution losses.
(2) Human Reserve is the minimum water requirement of the population, estimated at 25 ℓ/capita/day (DWAF criterion).

5.3.2 Urban

Introduction

In the Upper Vaal WMA extensive urbanisation has taken place in three main areas. Located around Johannesburg from Soweto and eastwards to Springs and in the vicinity of Vereeniging and Vanderbijlpark and westwards to

Carltonville. These areas represent some of the most heavily urbanised and industrialised areas in South Africa.

Most of the large urban users are heavily dependent on water imported into this WMA. The bulk of potable water in these areas is delivered by Rand Water and is sold to local councils and subsequently to the end users for residential, industrial, municipal and commercial purposes. The end users vary significantly in size of water use and technological level of water utilisation.

Water requirements

A study by Schlemmer (Schlemmer et al, 2001) in support of the development of the National Water Resource Strategy developed a methodology to provide a framework for estimation of both direct and indirect water requirements for the entire South Africa, as well as for the development of long-term projections. A framework methodology was developed on the basis of available information. Information collected in the field as part of the Water Resources Situation Assessments was used to refine the analysis, identify default values and where available update the default database figures.

Methodology

Urban water requirements were classified into direct use by the population and indirect use by the commercial, industrial, institutional and municipal sectors that relate to the direct use.

Direct Water Use: The following criteria were considered significant in identifying categories of direct water use:

- Economic strata.
- Types of housing.
- Levels of service provided.
- Extent of local authority records.

It was recognised that a critical factor to be considered was the dependence on data that was required from Local and Water Service Authorities. Generally many authorities have records of water supplied to different users, individual households, and at times to flats and multi-household complexes. Further detail is not common.

Categories of direct water use were identified in order to develop profiles of use per urban centre. The populations of the urban centres that had been determined were allocated to these categories by Schlemmer (Schlemmeret al., 2001), on the basis of socio-economic category characteristics of each centre. Refer to **Section 3.2** and **Appendix A.1** for details of urban demographic data.

The study then proceeded to derive per capita water use for each of these categories using information from the South African Local Government

Handbook, and the data collected as part of the Water Resources Situation Assessments from local authorities at the time. Where detailed data was not available, an estimation procedure was followed. The categories defined were associated with default unit water uses to generate overall water use estimates where hard data was not available. These categories and default unit water uses are listed in **Table 5.3.2.1**.

TABLE 5.3.2.1: DIRECT WATER USE: CATEGORIES AND ESTIMATED UNIT WATER USE.

CATEGORY		WATER USE (ℓ/capita/day)
1.	Full service : Houses on large erven > 500m^2	320
2.	Full service: Flats, Town Houses, Cluster Houses	320
3.	Full service : Houses on small erven <500m^2	160
4.	Small houses, RDP houses and shanties with water connection but minimal or no sewerage service	90
5.	Informal houses and shanties with service by communal tap only	10
6.	No service from any water distribution system	6
7.	Other/Miscellaneous	90

These default categories of estimated unit water use were reviewed by the situation assessment consultants and adjusted if reliable information for 1995 was available. Generally data of total urban usage (excluding losses) was available. This urban usage data was used to override the default data.

Table 5.3.2.2 summarises the direct water use 'pattern' for the different residential categories within key areas and **Appendix F.8** lists per capita water use for all TLC's. The water use pattern for the WMA is within 90 % of the national default water pattern.

TABLE 5.3.2.2: DIRECT WATER USE: ESTIMATED UNIT WATER USE FOR RESIDENTIAL CATEGORIES FOR KEY AREAS.

Key area	Res_Cat 1 Water use (ℓ / c / d)	Res_Cat 2 Water use (ℓ / c / d)	Res_Cat 3 Water use (ℓ / c / d)	Res_Cat 4 Water use (ℓ / c / d)	Res_Cat 5 Water use (ℓ / c / d)	Res_Cat 6 Water use (ℓ / c / d)	Res_Cat 7 Water use (ℓ / c / d)
Wilge	326	326	163	91	10	6	91
Klip (C13)	286	286	143	81	9	6	81
Grootdraai	264	264	132	74	8	5	74
Grootdraai to Vaal Dam	304	304	152	86	10	6	86
Suikerbosrant	285	285	143	80	9	5	80
Klip (C22)	284	284	142	80	10	6	80
Mooi	248	248	124	70	8	4	70
Vaal Dam to Vaal Barrage	262	262	131	74	8	5	74
Vaal Barrage to Mooi	328	328	164	92	10	6	92
Upper Vaal usage	**290**	**290**	**145**	**81**	**9**	**5**	**81**
Default usage	**320**	**320**	**160**	**90**	**10**	**6**	**90**

Indirect Water Use: Indirect water use was considered in terms of four categories, viz. commercial, industrial, institutional and municipal. Again, available information was complemented by data collected as part of the Water Resources Situation Assessments from local authorities at the time. Limited hard data was obtained at the level of detail sought.

In order to develop a comprehensive set of estimates, a standard table relating the components of indirect water use to the total direct water use of an urban centre was developed. The urban centres were first classified according to shared characteristics related to water use. The classification used is shown in **Table 5.3.2.3**.

TABLE 5.3.2.3: CLASSIFICATION OF URBAN CENTRES RELATED TO INDIRECT WATER USE.

CLASSIFICATION	TYPE OF CENTRE	PERCEPTION
1.	Long established Metropolitan centres (M)	Large conurbation of a number of largely independent local authorities generally functioning as an entity.
2.	City (C)	Substantial authority functioning as a single entity isolated or part of a regional conurbation.
3.	Town: Industrial (Ti)	A town serving as a centre for predominantly industrial activity.
4.	Town: Isolated (Tis)	A town functioning generally as a regional centre of essentially minor regional activities.
5.	Town: Special (Ts)	A town having significant regular variations of population consequent on special functions. (Universities, holiday resorts, etc.).
6.	Town: Country (Tc)	A small town serving essentially as a local centre supporting only limited local activities.
New Centres		
7.	Contiguous (Nc)	A separate statutory authority, or number of authorities adjacent to, or close to, a metropolis or city and functioning as a component part of the whole conurbation.
8.	Isolated (Nis)	A substantial authority or group of contiguous authorities not adjacent to an established metropolis or city.
9.	Minor (Nm)	Smaller centres with identifiable new or older established centres not constituting centres of significant commercial or industrial activity.
10.	Rural (Nr)	All other areas not having significant centres.

Default profiles of indirect water use in relation to total water use were developed by the DWAF on the basis of available information for these classes, and are given in **Table 5.3.2.4**. Water use information for the various categories of indirect use was generally not available. The recommended ‘pattern’ of indirect water use was not adjusted in the urban sub-model.

TABLE 5.3.2.4: INDIRECT WATER USE AS A COMPONENT OF TOTAL DIRECT WATER USE.

URBAN CENTRE CLASSIFICATION	COMMERCIAL	INDUSTRIAL	INSTITUTIONAL	MUNICIPAL
Metropolitan	0,2	0,3	0,15	0,08
Cities	0,2	0,3	0,15	0,08
Towns Industrial	0,2	0,3	0,15	0,08
Towns Isolated	0,2	0,3	0,15	0,08
Towns Special	0,30	0,15	0,08	0,03
Towns Country	0,10	0,15	0,03	0,10
New Centres	0,15	0,08	0,08	0,08

However for most urban centres there was generally information about total indirect water use. Where applicable this total figure over-rides the default indirect total calculated by the Urban sub-model, but the pattern of usage by the various indirect categories remained as given in **Table 5.3.2.4**.

The ratio of direct to indirect water usage is different depending on classification of the urban centre. Generally large TLCs and MLCs have a ratio of 58 % direct usage to 42 % indirect usage. Smaller TLC's have a ratio of 72% direct usage to 28 % indirect usage.

This ratio was adjusted if more detailed information was available. For example, for Sasolburg TLC the ratio of direct to indirect usage was adjusted to 37 % direct usage and 63 % indirect usage. This is considered acceptable as there are some large industrial users (e.g. Polyfin) that are supplied by the municipality and the adjustment did not affect the residential water use pattern adversely. **Appendix F.8** provides direct – indirect ratio details for all urban centres. **Table 5.3.2.7** summarises the total direct and indirect requirements for key areas within the WMA.

Unaccounted for Water Use: In most urban water systems the total bulk water supplied is generally well documented and is often the more reliable measurement of water used by a TLC. The difference between metered water and bulk water supplied is generally referred to as unaccounted-for-water (UAW) and is made up of physical leakages within the water distribution system and in some situations also of un-metered or under-metered water. UAW is therefore a component of direct and indirect urban water requirements.

In the Upper Vaal WMA unaccounted for water can be significant in the larger TLCs and MLCs. UAW is estimated to range from 15 % to 25 %. In Johannesburg unaccounted for water is estimated to range from 25 % to 35 % (Barta, 2000).

Water losses

The water losses in urban areas can be divided into two components:

- Bulk conveyance losses.
- Distribution system losses within urban centre.

Bulk conveyance losses

Bulk conveyance losses are losses that occur during the transfer of urban water from the water source (dam, river, borehole) to the urban area. Bulk supply losses consist of purification and transmission losses. Purification losses are generally of the order of 1% to 3%, although losses can be as high as 10% in the case of turbidities caused by the silt content in the water. Transmission losses can be in the order of 1% to 7% of bulk water supplied.

In the Upper Vaal WMA the main bulk water supplier is Rand Water and the confirmed water loss within the supply system is 3%. **Table 5.3.2.5** gives details of transmission and purification losses experienced by Rand Water from 1994 to 1998. For towns that supply their own bulk water little information is available. These losses are estimated to be 5 % in the case of urban centres without water treatment works and 8 % in the case of urban centres with water treatment works, which have purification losses of about 3 % and transmission losses of about 5 %. **Table 5.3.2.7** summarises the bulk losses for key areas within the WMA.

TABLE 5.3.2.5: BULK CONVEYANCE LOSSES EXPERIENCED BY THE RAND WATER DISTRIBUTION SYSTEMS.

YEAR	WATER ABSTRACTION (Ml/Day)	WATER PRODUCTION (Ml/Day)	TREATMENT LOSSES (%)	TRANSPORT AND LEAKAGE (%)	OVERALL LOSS (%)
Rand Water					
1994	2 726,1	2 684,6	1,52	1,36	2,88
1995	2 953,5	2 881,8	2,43	1,70	4,13
1996	2 560,7	2 483,8	3,00	0,59	3,59
1997	2 739,2	2 668,2	2,59	0,45	3,04
1998	2 891,7	2 852,7	1,35	1,60	2,95
Averages			2,18	1,14*	3,32

Note: The sludge removal process consumes about 1,0% of the 3,3%.

Losses in the water distribution system of an urban area.

Within the water distribution system of an urban area, there are losses associated with the distribution of water (unavoidable, estimated at 10 %) and losses that are caused by the maintenance of the distribution infrastructure (pipes and reservoirs). In many cases the poor maintenance of infrastructure results in significant losses.

Information about distribution losses is not readily available and in many instances the DWAF recommended that a default of 20 % had to be applied. In the Upper Vaal WMA the distribution losses can range from 8% (Frankfort

TLC) to 25% (Benoni and Brakpan) of urban water supplied. **Table 5.3.2.7** summarises distribution losses for the key areas.

Return flow

The evaluation of urban return flows to determine net consumptive use is a critical component of the urban water cycle. The return flows from urban areas have been divided into three categories:

- Effluent return flows from direct users (residential) and indirect users (municipal, industrial etc).
- Return flows due to leakage of clean water.
- Stormwater returns.

Effluent return flows

The return flows from urban water systems can be manifested in two distinct ways:

- As wastewater (effluent) concentrated by means of waterborne sewage that is treated and released into the surface river network. Effluent generated from residential and industrial areas is directly proportional to the water used. The water returned is further dependent on the standard of living of an area (level of sewage service) and the type of industries.
- As wastewater diffused locally by means of pit toilets (e.g. Loflos, aquaprivies, etc), septic tanks / french drains, or more complex methods such as soil bucket systems.

In South Africa wastewater is often regarded as a supplementary source of water. The return flows generated from the urban water service systems of the Upper Vaal WMA supplement the base flow of the Vaal River, thus benefiting all downstream users.

Although concentrated treated waterborne sewage is gradually increasing, vast amounts of diffuse untreated effluent are still released locally. Previous research has shown that some 16 % of total urban water supply is diffused locally on an annual basis (Barta, 1993). This water is generally untreated and is polluting to a large extent the local groundwater and surface water resources.

The return flows generated in the operated urban water services systems (i.e. most urban centres in this WMA) are commonly metered by the water services authorities for its quality and quantity. The actual return flows metered after treatment can (in summer) include an amount of stormwater ingress.

The proportion of urban water that does not contribute to effluent returns is a function of the sewage infrastructure within the various urban categories as well socia-economic factors (for example in more affluent areas water for gardening can be signficant, thus increasing consumption).

Default consumption factors for urban usage were defined by the DWAF and are listed in **Table 5.3.2.6**. These factors were used to estimate the annual returns by urban centres.

These factors had to adjusted (calibrated) in the following circumstances:

- For urban centres with no known returns the consumption factors for all categories were increased to 1 reflecting that consumption or usage is 100 %. The smaller TLC's generally fell into this category. Many of these TLC's have some sewage infrastructure but effluent is returned to evaporation ponds and in some cases re-used as irrigation for sports fields and parks.

TABLE 5.3.2.6: DWAF DEFAULT CONSUMPTION FACTORS FOR URBAN WATER USERS.

CATEGORY		CONSUMPTION FACTOR
Direct : 1	Full service : Houses on large erven > 500m^2	0,45
Direct : 2	Full service: Flats, Town Houses, Cluster Houses	0,2
Direct : 3	Full service : Houses on small erven <500m^2	0,35
Direct : 4	Small houses, RDP houses and shanties with water connection but minimal or no sewage service	0,8
Direct : 5	Informal houses and shanties with service by communal tap only, no sewage service	1,0
Direct : 6	No service from any water distribution system	1,0
Direct : 7	Other/Miscellaneous	0,5
Industrial	Full service	0,15
Commercial	Full service; sewage service dependent on toxicity of returns	0,4
Institutional	Full service	0,1
Municipal	No sewage service	1,0

- For a number of the urban centres the 1995 sewage returns were known. The sewage generated using the default consumption factors was reviewed against the known sewerage returns. If the generated figure was within about 10 % of the known figure the consumption factors were not adjusted. If adjustment was required the following calibration procedure was followed:

  1. The consumption factor for residential category 4 (RDP housing) was adjusted. This category is defined as having no to minimal sewerage infrastructure. For Benoni, Brakpan, Standerton, Bethlehem, Parys and Highveld Ridge TLC's this factor was adjusted from 0,8 to 1,0 (indicating no or limited sewerage system). For Johannesburg (South), Westonaria, Potchefstroom and Harrismith TLC's this factor was reduced indicating the presence of more adequate sewage systems. **Appendix F.8** lists the consumption factors for all urban centres.

  2. If further adjustments were required the industrial consumption factor was adjusted. This adjustment was considered acceptable because some industries do not return water to the system but rather to evaporation ponds. For Harrismith, Benoni and Brakpan TLC's the industrial consumption factor was increased.

3. Only two urban centres required adjustments to other consumption factors, namely Johannesburg (south) and Potchefstroom. In both cases the consumption factors had to be reduced significantly to generate the known returns. The Greater Johannesburg (south) urban area possibly processes effluent from Greater Johannesburg (north).

Appendix F.8 lists the consumption factors for all urban centres.

Table 5.3.2.7 summarises effluent return flows for the key areas of this WMA. Total urban effluent returns for 1995 are estimated at about 296 x 10^6m^3. Consumptive use ranges from 100 % in the Klip (C13) key area to as low as 22 % in Klip (C22A-E) key area. For the WMA as a whole consumptive use is about 33 % of urban requirements (excluding losses).

Return flow due to leakage of clean water

Some of the potable water that leaks from the water distribution system can flow into the river system. This was estimated in 1995 in the Gauteng area to be as high as 30 % because of poor infrastructure maintenance (Johnson, 2000.). However without accurate data the DWAF default of 10% was applied to the following urban areas:

Johannesburg (South), Germiston, Boksburg, Alberton, Vereeniging, Springs, Benoni, Brakpan and Nigel.

Total clean returns for the WMA are estimated in 1995 at 19,3 x 10^6m^3 .

Stormwater returns

Additional rainfall runoff is created due to the impervious areas created in urban areas. On average one eighth of the urban areas in the WMA is effectively paved and it is assumed 84% of rain falling on these areas runs off into the river system. (WR90 values). **Appendix D.2** lists the urbanised centres and the area urbanised (km^2). The impervious area in the WMA is about 1 035 km^2 and the return flow generated from these areas is 111,4 x10^6m^3/a.

It should be noted that most sewage works are designed to receive 115 % of known returns (BKS, 1999). This over design is to accommodate the ingress of storm water into the sewage system during the rainy season.

Table 5.3.2.7 gives the urban water requirements, losses and return flow information per key area.

Sources of data

In order to calculate urban water use to the required level of detail, it was necessary to obtain information from the relevant water supply authorities, e.g. Transitional Local Councils (TLC's), Water Boards etc. A number of TLC's were selected by Markdata and were surveyed by the Situation Assessment Consultant. The survey was done by means of a questionnaire and supplemented by personal communication via telephone and telefax.

Some TLC's straddle the WMA boundaries, however, only Greater Johannesburg MLC was split into Johannesburg South (55 % in Upper Vaal WMA) and Johannesburg North (45 % in Crocodile (West) and Marico WMA). All other TLC's were taken to be totally within whichever WMA the majority of the TLC is located.

Other sources of information were also investigated such as municipal yearbooks and existing reports. Various problems were experienced with all the sources of information. It was difficult to obtain the level of detail required, it was difficult to compare information from different sources due to different dates of records and other conceptual differences and there was also a lack of co-operation from some information sources. About 70% of the questionnaires were eventually returned and of these 20% were of no practical use. The Gauteng TLC's were not surveyed because Rand Water carried out a similar exercise except that return flows were not included. Only six of the relevant 12 TLC's in Gauteng were reviewed as Rand Water also had difficulty in obtaining useful information. Waterborne influent and effluent were obtained directly from the TLC's.

Additional information was obtained from the Vaal River System Analysis (BKS et al, 1998d,e,f) reports and situation assessment reports for the Blesbokspruit (Stewart Scott, 1999) and Mooi River catchments (Pulles et al., 1998).

From the information obtained from the various sources, data for parameters related to water use and return flow were estimated for all the quaternary catchments in this WMA.

TABLE 5.3.2.7: 1995 URBAN WATER REQUIREMENTS BY KEY AREA AND PROVINCE.

CATCHMENT				URBAN WATER REQUIREMENTS		LOSSES			TOTALS		RETURN FLOWS			
SECONDARY		TERTIARY												
No.	Description	No.	Key Area Description	DIRECT (10^6 m^3/a)	INDIRECT (10^6 m^3/a)	BULK CONVEY-ANCE LOSSES (%)	DISTRI-BUTION LOSSES (%)	TOTAL LOSSES (10^6 m^3/a)	TOTAL (10^6 m^3/a)	TOTAL AT 1:50 YEAR ASSURANCE(1) (10^6 m^3/a)	EFFLUENT(2) (10^6 m^3/a)	IMPERVIOUS URBAN AREA (10^6 m^3/a)	TOTAL RETURN FLOW (10^6 m^3/a)	RETURN FLOW AT 1:50 YEAR ASSURANCE(1) (10^6 m^3/a)
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	9,4	5,5	5-10	10-20	4,4	19,3	18,7	6,7	12,7	19,4	19,4
C1	Klip	C13	Klip (C13A-H)	0,5	0,2	8	20-23	0,3	1,0	1,2	0,0	0,0	0,0	0,0
	Grootdraai	C11	Grootdraai (C11A-L)	3,9	1,7	3-8	15-20	1,6	7,2	7,3	2,9	1,9	4,8	4,8
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	9,1	6,4	3-8	10-20	3,7	19,2	19,2	7,2	2,0	9,2	9,2
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	44,1	31,2	3-8	10-25	20,9	96,2	96,5	45,4 (2)	15,4	60,8	60,8
	Klip	C22	Klip (C22A-E)	144,9	108,7	3	12-18	52,2	305,8	306,4	196,6 (2)	55,4	252,0	252,0
	Mooi	C23	Mooi (C23D-K)	14,3	6,1	3-8	12-20	4,8	25,2	25,3	12,6	10,2	22,8	22,8
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K	26,2	25,3	3-8	12-20	9,7	61,2	61,0	22,5 (2)	13,8	36,3	36,3
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	2,4	0,9	5-8	10-20	0,7	4,0	4,1	1,6	0,0	1,6	1,6
Total in Mpumalanga				**12,7**	**9,3**	**3 % to 8 %**	**10 % to 23 %**	**4,9**	**26,8**	**26,5**	**10,1**	**3,9**	**14,0**	**14,0**
Total in Free State				**21,7**	**15,8**	**3 % to 10 %**	**10 % to 20 %**	**8,4**	**45,9**	**46,0**	**17,7**	**16,5**	**34,2**	**34,2**
Total in Gauteng				**216,6**	**158,1**	**3 % to 8 %**	**10 % to 25 %**	**83,5**	**457,2**	**458,0**	**263,1**	**89,3**	**352,4**	**352,4**
Total in North-West				**3,8**	**2,8**	**3 % to 8 %**	**12 % to 20 %**	**1,5**	**9,2**	**9,2**	**4,6**	**1,7**	**6,3**	**6,3**
TOTAL IN WMA				**254,8**	**186,0**	**3% to 10%**	**10 % to 25%**	**98,3**	**539,1**	**539,7**	**295,5**	**111,4**	**406,9**	**406,9**

Note: (1) Assurance data provided the DWAF [A7]
(2) Effluent returns include clean returns.
(3) Returns from impervious area provided by DWAF.

5.3.3 Rural

Rural usage can be categorised into domestic rural use, livestock watering and subsistence irrigation. The main requirements in this WMA are domestic rural use and livestock use. There is no known subsistence irrigation in this WMA.

Water requirements

Domestic rural water requirements

There was little information available on the 1995 rural domestic requirements in this WMA. There is no significant rural infrastructure in the WMA with the exception of the Qwa Qwa area (upper Wilge River catchment). This area has a large rural population that receives water from the Fika Patso and Metsi Matso Dams. Sedibeng Water operates the bulk water supply to the area for the DWAF. The daily usage per capita is estimated to be 51 litres. This is significantly higher then the usage of 25 ℓ/capita/day allowed for the rest of the WMA. **Section 3.2.4** has information on the rural population in the WMA.

Table 5.3.3.1 summarises the daily rural domestic usage for the various rural categories. There was no information in this WMA about usage by the commercial farming and developing urban categories. These categories are treated the same as the rural category. **Table 5.3.3.2** summarises the rural domestic usage for key areas for 1995 and at 1: 50 year assurance.

TABLE 5.3.3.1: 1995 PER CAPITA WATER REQUIREMENTS IN RURAL AREAS.

USER CATEGORY	UNIT WATER REQUIREMENTS			
	Direct use (ℓ/capita/d)	Distribution losses		Total (ℓ/capita/d)
		(%)	(ℓ/capita/d)	
Rural	25	20	6,2	31,2
Advanced rural (Witsieshoek)	51	30*	22,0	73,0
Developing urban	25	20	6,2	31,2
Commercial farming	25	20	6,2	31,2

Note: * Bulk purification and conveyance losses estimated at 10 % and 20 % distribution losses (DWAF default) of direct use.

Livestock and game requirements

Livestock and game farming is a relatively small activity within the Upper Vaal WMA. The source of water for this activity is expected to derive mainly from boreholes (groundwater) and from small farm dams. **Table 5.3.3.2** summarises the livestock requirements. The rural Wilge River catchment has the most significant stockwater requirements.

Refer to **Section 3.5.4** and **Appendix F.3** for details about livestock and game species, sources of data and the conversion of livestock species to Equivalent Large Stock Units (ELSU).

The average water use by an ELSU was estimated at 45 ℓ/ELSU/day.

Water losses

Information on rural distribution losses for 1995 was not readily available. The recommended default of 20 % (DWAF) was applied with the exception of the Qwa Qwa area (Witsieshoek), which has estimated conveyance losses of 10 % and network distribution losses of 20 % (Sedibeng Water, 1999). **Tables 5.3.3.1 and 5.3.3.2** summarise rural losses.

Return flows

The return flow generated by rural consumers is negligible and in most cases can be taken as zero. The exception is the Qwa Qwa area, which returned about 2,2 $x10^6m^3/a$ to the Elands River system of the Wilge catchment.

TABLE 5.3.3.2: 1995 RURAL WATER REQUIREMENTS BY KEY AREA.

CATCHMENT				RURAL DOMESTIC WATER REQUIREMENTS					LOSSES		TOTALS		RETURN FLOW	
SECONDARY		TERTIARY		DOMESTIC (10^6 m^3/a)		SUBSIST. IRRIG. (10^6 m^3/a)	LIVE-STOCK (10^6 m^3/a)	TOTAL (10^6 m^3/a)	(%)	(10^6 m^3/a)	TOTAL ($10^6 m^3/a$)	TOTAL AT 1:50 YR ASSURANCE ($10^6 m^3/a$)(1)	RETURN FLOW (10^6 m^3/a)	RETURN FLOW AT 1:50 YEAR ASSURANCE (10^6 m^3/a)(1)
No.	Description	No.	Key Area Description	(l/c/d)	(10^6 m^3/a)									
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	45	5,6	0,0	12,2	17,8	20-30	4,5	22,3	22,5	2,2	2,2
C1	Klip	C13	Klip (C13A-H)	25	0,2	0,0	2,4	2,6	20	0,6	3,2	3,2	0	0
	Grootdraai	C11	Grootdraai (C11A-L)	25	0,4	0,0	8,5	8,9	20	2,2	11,1	11,1	0	0
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	25	0,6	0,0	4,7	5,3	20	1,3	6,6	6,6	0	0
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	25	0,3	0,0	1,5	1,8	20	0,5	2,3	2,3	0	0
	Klip	C22	Klip (C22A-E)	25	0,2	0,0	0,3	0,5	20	0,1	0,6	0,6	0	0
	Mooi	C23	Mooi (C23D-K)	25	0,4	0,0	2,3	2,7	20	0,7	3,4	3,4	0	0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	25	0,5	0,0	1,6	2,1	20	0,5	2,6	2,5	0	0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	25	0,2	0,0	2,0	2,2	20	0,6	2,8	2,8	0	0
Total in Mpumalanga				**25**	**0,1**	**0**	**13,3**	**13,4**	**20**	**3,3**	**16,7**	**16,7**	**0**	**0**
Total in Gauteng				**25**	**0,8**	**0**	**2,8**	**3,6**	**20**	**0,7**	**4,3**	**4,3**	**0**	**0**
Total in Free State				**25 to 51**	**7,1**	**0**	**16,8**	**23,9**	**20 to 30**	**6,3**	**30,2**	**30,4**	**2,2**	**2,2**
Total in North-West				**25**	**0,4**	**0**	**2,6**	**3,0**	**20**	**0,7**	**3.7**	**3,7**	**0**	**0**
TOTAL IN WMA				**25 to 45**	**8,4**	**0,0**	**35,5**	**43,9**	**20 to 30**	**11,0**	**54,9**	**55,1**	**2,2**	**2,2**

Note: (1) Assurance values estimated from data supplied by the DWAF.

5.4 BULK WATER USE (INDUSTRY, MINING AND THERMAL POWERSTATIONS)

5.4.1 Introduction

This section deals with the water requirements of strategic, industrial and mining bulk water users that have individual bulk water systems, or that receive water directly from water boards, or the DWAF. Industries, powerstations and mines supplied with potable water by municipalities are included in urban water requirements.

The bulk water requirements for each bulk water sector are described in terms of the requirement (on-site), the associated conveyance losses and return flows to the Upper Vaal River network.

5.4.2 Strategic Users

Water requirements

For the purpose of this study, strategic bulk water users were taken to only apply to operational Eskom power stations that require a high assurance (99,5%) of supply. There are three thermal power stations in the Upper Vaal WMA. Details about these power stations can be found in **Section 3.6.2** and in **Appendix F.5 and F.7. Table 5.4.2.1** provides information about the on-site requirements of strategic users for key areas.

Water losses

These losses include transmission and purification losses in the Eskom bulk supply systems. Conveyance losses were estimated by Eskom to be 5 %. Losses are included in **Table 5.4.2.1**.

Return flows

Return flows generated by Eskom power stations are negligible. Tutuka power station in the Grootdraai Key area returns approximately 3 % of its requirement to the Leeuspruit (BKS et al, 1998d). The return flows are included in **Table 5.4.2.1.**

TABLE 5.4.2.1: 1995 STRATEGIC WATER REQUIREMENTS.

CATCHMENT				ON-SITE STRATEGIC REQ. (1) (10^6 m^3/a)	CONVEYANCE LOSSES		TOTAL WATER REQ. (10^6 m^3/a)	TOTAL AT 1:50 YR ASSURANCE (10^6 m^3/a)	RETURN FLOW AT 1:50 YEAR ASSURANCE (10^6 m^3/a)
SECONDARY		TERTIARY			(%)	(10^6 m^3/a)			
No.	Description	No.	Key Area Description						
C8	Wilge	C81,82, C83	Wilge (C81A-M, C82A-H, C83A-M)	0	0	0	0	0	0
C1	Klip	C13	Klip (C13A-H)	2,1	5	0,1	2,2	2,4	0
	Grootdraai	C11	Grootdraai (C11A-L)	32,5	5	1,7	34,2	36,9	1,0 (2)
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	0	0	0	0	0	0
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0	0	0	0	0	0
	Klip	C22	Klip (C22A-E)	0	0	0	0	0	0
	Mooi	C23	Mooi (C23D-K)- Total	0	0	0	0	0	0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	34,7	5	1,8	36,5	33,8	0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	0	0	0	0	0	0
Total in Mpumalanga				**34,6**		**1,8**	**36,4**	**39,3**	**1,0**
Total in Gauteng				**0**		**0**	**0**	**0**	**0**
Total in Free State				**34,7**		**1,8**	**36,5**	**33,8**	**0**
Total in North-West				**0**		**0**	**0**	**0**	**0**
TOTAL IN WMA				**69,3**		**3,6**	**72,9**	**73,1**	**1,0**

: Note : (1) The operational power stations are:
Tutuka Power Station (Grootdraai C11A-L key area)
Majuba Power Station (Klip C13A-H key area)
Lethabo Power Station (Vaal Dam to Vaal Barrage C22F-K key area).
(2) Tutuka Power Station, returns = 3%

5.4.3 Mining

Water requirements

The mining sector requires a level of assurance of water supply of 98 % to 99 % (**Appendix F.9).** Mining activities range from deep underground mining (gold, coal) to surface mining (quarrying).

Details about mines how impact on the hydrology and water quality of this WMA are provided in **Section 3.7**. **Appendix F.6** lists all known operating mines that could impact on the hydrology and water quality of the Vaal system. **Table 5.4.3.1** summarises the 1995 water requirement of mines for key areas. This list of mines can be divided into mines that receive water from the Rand Water or Eskom networks or mines that abstract directly from rivers in the Upper Vaal WMA (e.g. East Daggafontein mine from Blesbokspruit).

Water losses

Transmission and purification losses by mines are estimated to range from 3 % for mines supplied by Rand Water, to 5 % for coal mines supplied by Eskom, to 10 % for mines that abstract directly from the river system. **Table 5.4.3.1** provides a summary of conveyance losses for mines for key areas in the WMA.

Return flows

Returns by mines to the river systems have been divided into:

- Treated effluent returns.
- Groundwater pumpage (decanting).

Treated effluent returns from mines are negligible. However in 1995 mining operations decanted some 122 x $10^6 m^3$ groundwater directly into the river system of the Upper Vaal WMA. The hydrology of the Suikerbosrand, Klip and Mooi catchments, in particular are impacted significantly by this action. For example the Grootvlei Gold Mine in the Suikerbosrand key area decants significants amount of poor quality groundwater into the Blesbokspruit. Gold mines on the West Rand decant poor quality groundwater into the Upper Mooi River (Wonderfonteinspruit) and Loopspruit. It is generally acknowledged that this decanting of groundwater by gold mines does impact negatively on water quality, sometimes affecting downstream users.

In terms of point source discharges within the Vaal Barrage catchment, it has been estimated that because of groundwater pumpage, the gold mines on the reef produce 30 to 45 % of the salt load (DWAF, 1995). In terms of non-point sources, the view is generally that the many sand dumps, slimes dams and waste rock dumps contribute a substantial portion (approximately 12 to 15 %) of the salt load to the Vaal Barrage.

TABLE 5.4.3.1: 1995 WATER REQUIREMENTS OF MINES.

CATCHMENT				ON-SITE USE	CONVEYANCE LOSSES		TOTAL WATER REQ.	TOTAL 1:50 YR ASSURANCE	RETURN FLOW (10^6 m^3/a)			
SECONDARY		TERTIARY										
No.	Description	No.	Key Area Description	(10^6 m^3/a)	(%)	(10^6 m^3/a)	(10^6 m^3/a)	(10^6 m^3/a)	SURFACE RETURNS	GROUND-WATER DECANTING	TOTAL	TOTAL AT 1:50 YEAR ASSURANCE
C8	Wilge	C81, 82, C83	Wilge (C81A-M, C82A-H, C83A-M)	0	0	0	0	0	0	0	0	0
C1	Klip	C13	Klip (C13A-H)	0	0	0	0	0	0	0	0	0
	Grootdraai	C11	Grootdraai (C11A-L)	0,9	5	0,1	1,0	1,1	0	0,6	0,6	0,6
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	0,3	3	0	0,3	0,3	0	1,3	1,3	1,3
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	2,7	3-10	0,3	3,0	3,1	0	45,6	45,6	45,6
	Klip	C22	Klip (C22A-E)	0,7	3	0,1	0,8	0,8	0	15,0	15,0	15,0
	Mooi	C23	Mooi (C23D-K)	3,7	3	0,1	3,8	3,9	1,1	46,0	47,1	47,1
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	0,3	5	0,1	0,4	0,4	0	13,4	13,4	13,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	0	0	0	0	0	0	0	0	0
Total in Mpumalanga				**1,2**	**3% to 5%**	**0,1**	**1,3**	**1,4**	**0**	**1,8**	**1,8**	**1,8**
Total in Gauteng				**6,5**	**3 % to 10%**	**0,5**	**7,0**	**7,2**	**1,1**	**104,0**	**105,1**	**105,1**
Total in Free State				**0**	**0 %**	**0**	**0**	**0**	**0**	**0,0**	**0,0**	**0,0**
Total in North-West				**0,9**	**3 %**	**0,1**	**1,0**	**1,0**	**0**	**16,1**	**16,1**	**16,1**
TOTAL IN WMA				**8,6**	**3 % to 10%**	**0,7**	**9,3**	**9,6**	**1,1**	**121,9**	**123,0**	**123,0[A8]**

5.4.4 Other Bulk Water Users

Water Requirements

This category includes large industries such as Sasol II and III near Secunda and Sasol I and Iscor. These industries account for more than 95 % of the total requirement for this category. Smaller other bulk users include mothballed powerstation's (water required for maintenance) and associated 3rd party users, small Rand Water consumers and small industrial users. The assurance of supply for these users ranges from 95 % to 98 % (**Appendix F.9**). For further details on other bulk water users refer to **Section 3.6.3, Table 5.4.4.1 and Appendix F.5.**

Water losses

Conveyance losses by other bulk users range from 3 % (industries supplied by Rand Water) to 5 % (power stations supplied by Eskom) to 10 % (for all other users like Sasol and Iscor). **Table 5.4.4.1** provides a summary of conveyance losses for other bulk users for key areas in the WMA.

Return flows

The type of industry often determines return flows generated by the bulk users in this category in this WMA. Returns to the Upper Vaal system ranged from 5 % in the case of Sasol II and III to 33 % in the case of Iscor and 28 % in the case of Sasol I. In 1995 return flows from other bulk users was estimated at 22,1 x 10^6 m^3. **Table 5.4.4.1** gives bulk water requirements for this category.

TABLE 5.4.4.1: 1995 OTHER BULK WATER REQUIREMENTS.

CATCHMENT				ON-SITE USE (10^6 m^3/a)	CONVEYANCE LOSSES		TOTAL WATER REQ. (10^6 m^3/a)	TOTAL 1:50 YR ASSURANCE (10^6 m^3/a)	RETURN FLOW (10^6 m^3/a)	RETURN FLOW AT 1:50 YEAR ASSURANCE (10^6 m^3/a)
SECONDARY		TERTIARY			(%)	(10^6 m^3/a)				
No.	Description	No.	Key Area Description							
C8	Wilge	C81, C82,	Wilge (C81A-M, C82A-H, C83A-M)	0	0	0	0	0	0	0
C1	Klip	C13	Klip (C13A-H)	0	0	0	0	0	0	0
	Grootdraai	C11	Grootdraai (C11A-L)	1,0	5	0,1	1,1	1,1	0	0
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	88,3	3-10	8,7	96,7	97,1	5,7	5,7
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0,6	3	0	0,6	0,6	0	0
	Klip	C22	Klip (C22A-E)	0,2	3	0	0,2	0,2	0	0
	Mooi	C23	Mooi (C23D-K)	0	0	0	0	0	0	0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	59,7	3-10	5,6	65,3	60,4	16,4	16,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	0	0	0	0	0	0	0
Total in Mpumalanga				**89,3**		**8,8**	**98,1**	**98,2**	**5,7**	**5,7**
Total in Gauteng				**29,3**		**2,8**	**32,1**	**30,0**	**7,1**	**7,1**
Total in Free State				**31,2**		**2,8**	**34,0**	**31,2**	**9,3**	**9,3**
Total in North-West				**0**		**0**	**0**	**0**	**0**	**0**
TOTAL IN WMA				**149,8**	**3% to 10%**	**14,4**	**164,2**	**159,4**	**22,1**	**22,1**

Note : **For information about other bulk users refer to Appendix F.5.**

5.5 NEIGHBOURING STATES

There is no neighbouring state that receives water from this WMA. Since 1998 this WMA has imported water from Lesotho.

5.6 IRRIGATION

5.6.1 Introduction

Detailed observed data on water use for irrigation was not available therefore irrigation water requirements were estimated from available information on irrigated areas or reaches, typical quotas and assurances of supply. The source of information on irrigation water use in the Upper Vaal WMA is the Vaal River Irrigation Study (Loxton et al, 1999b).

Typical quotas and calculated crop water use data are provided in Section 8 of the Vaal River Irrigation Study (Loxton et al, 1999b). **Section 3.5.2** of this report details how irrigated area data was disaggregated to quaternary area data. **Table 5.6.2.1** summarises the irrigation requirements for 1995 for key areas in the WMA.

In this WMA all of the irrigation is defined as controlled irrigation (Loxton et al, 1999b). The total field irrigation area in this WMA is 259,4 km^2, of which some 25 % (about 63 km^2) is scheduled irrigation. All of the scheduled irrigation occurs downstream of the Vaal Dam, in the Mooi key area (Mooi Government Water Scheme, Klipdrift and Vyfhoek Schemes) and Barrage to Mooi key area (Rietpoort and Koppieskraal Irrigation Boards). These areas require that water be released from dams or rivers, to the canals or pipelines that convey the water to the irrigation areas. The assurance of supply in these areas can be assumed to be higher than in other irrigated areas.

All the other irrigation areas including the Vaal Dam and Vaal River Government Water Control Areas are run of river irrigation abstractions and no special releases of water are made for them.

5.6.2 Water Use Patterns

The water requirement for irrigation has been calculated into two ways. The first method uses the irrigation pre-processor of the Water Situation Assessment Model (WSAM) and is based on the following SAPWAT equation.

IRR(1-CLI) = AIR*(EVT*CRC-REF)*0,001*LER/IRC

Where:
IRR: Irrigation water requirement ($10^6 m^3/m$).
AIR: Irrigation area (km^2).
EVT: Evapotranspiration (A-Pan equivalent in mm/m).

CRC: Crop factor.
REF: Effective rainfall (mm/m).
LER: Leaching factor.
IRC: Irrigation efficiency.
CLI: Irrigation conveyance loss (Proportion of IRR).

The irrigation pre-processor calculates the irrigation water requirement for every crop separately for each of the 12 months, using the appropriate climatic quaternary mean monthly data obtained from the CCWR. This detailed methodology is essential to eliminate the considerable errors that can be made by combining crop factors. The final annual water requirements are then obtained by simple summation of the various crop water requirements. **Appendix D.1** lists crops, crop factors, crop areas etc.

However a second method has been used to calculate the 1995 irrigation requirement using the quota information for this WMA, from the Vaal River Irrigation Study (Loxton et al, 1999b).

The quotas are listed in **Appendix D.4** in the summary table called Irrigation Water Requirements. Two types of quotas were identified in the Vaal River Irrigation Study (Loxton et al, 1999b) and are shown in the summary table. They are the typical or guideline quotas, which were used to calculate the average water allocation for an irrigation area and the calculated crop water use, which was used to determine the actual crop water use during 1995.

Assurance of supply for irrigation ranges from 80 % (1 in 5 yr assurance) to 98 % (1 in 50 yr assurance) and also varies according to value of crop. Higher value crops receive greater assurance of supply in the scheduled irrigation areas.

The irrigation requirement using the typical quotas and field area was 186,7 x 10^6m^3. The actual crop water use in 1995 was 149,5 x 10^6m^3 indicating that 1995 was a dry year in which restrictions of varying severity were applied. Restrictions do not seem to have been applied in the Mooi key area where the actual water used for irrigation was slightly higher then the estimated theoretical water requirement.

Figure 5.6.2.1 shows irrigation water requirements at 1:50 assurance per key area and is estimated at 113,7 x $10^6m^3/a$. The sources of irrigation water for the various irrigation areas are listed in **Table 5.6.2.2**.

TABLE 5.6.2.1: IRRIGATION WATER REQUIREMENTS.

CATCHMENT				FIELD EDGE WATER REQUIREMENT (10^6 m^3/a) (3)	CONVEYANCE LOSSES		TOTAL THEORETICAL WATER REQUIREMENT(1) (10^6 m^3/a)	TOTAL ACTUAL WATER USE(1) (10^6 m^3/a))	TOTAL ACTUAL WATER USE AT 1:50 YEAR ASSURANCE(2) (10^6 m^3/a)	RETURN FLOW (%)	RETURN FLOW AT 1:50 YEAR ASSURANCE (10^6 m^3/a)
SECONDARY		TERTIARY									
No.	Description	No.	Key Area Description		(%)	(10^6 m^3/a)					
C8	Wilge	C81,82, 83	Wilge (C81A-M, C82A-H, C83A-M)	18,5	10	2,1	34,5	20,6	17,8	10	1,8
C1	Klip	C13	Klip (C13A-H)	0,0	0	0	0,0	0,0	0,0	0	0,0
	Grootdraai	C11	Grootdraai (C11A-L)	22,6	10	2,5	26,2	25,1	21,7	10	2,2
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	15,0	10	1,7	18,2	16,7	6,9	10	0,7
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	7,5	10	0,8	15,5	8,3	7,2	10	0,7
	Klip	C22	Klip (C22A-E)	10,7	10	1,2	16,3	11,9	10,3	10	1,0
	Mooi	C23	Mooi (C23D-K)	37,2	20	9,4	43,6	46,6	40,3	10	4,0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	12,0	10	1,3	23,2	13,3	1,5	10	0,2
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	5,6	15-20	1,4	9,2	7,0	8,0	10	0,8
Total in Gauteng				**34,0**	**10**	**3,8**	**47,2**	**37,8**	**28,4**	**10**	**2,9**
Total in Free State				**32,8**	**10-15**	**6,3**	**48,8**	**39,1**	**29,7**	**10**	**3,0**
Total in Mpumalanga				**33,7**	**10**	**3,8**	**46,8**	**37,5**	**28,3**	**10**	**2,8**
Total in North-West				**28,6**	**15-20**	**6,5**	**43,9**	**35,1**	**27,3**	**10**	**2,7**
TOTAL IN WMA				**129,1**	**10-20**	**20,4**	**186,7**	**149,5**	**113,7**	**10**	**11,4**

:

Note : (1) Using guideline water quota, Table 8.2, Vaal River Irrigation Study.
(2) Calculated crop water use, Table 8.2, Vaal River Irrigation Study.
(3) Field edge requirement (Actual water use – conveyance losses), includes irrigation system application losses.[A9]

TABLE 5.6.2.2: SOURCE OF IRRIGATION WATER

KEY AREA DESCRIPTION	IRRIGATION AREA[1]	SOURCE OF IRRIGATION WATER.
Wilge	Wilge River, Sterkfontein Dam to Frankfort.	Wilge River main channel
	Wilge River, Frankfort to Vaal Dam.	Wilge River main channel and Vaal Dam
	Liebensbergvlei River, Saulspoort Dam to Wilge confl.	Liebensbergvlei River main channel
Klip	No irrigation	
Grootdraai	Vaal Dam GWCA (u/s Grootdraai Dam)	Vaal River main channel and Grootdraai Dam
Grootdraai Dam to Vaal Dam	Vaal Dam GWCA (Grootdraai Dam to Bossiespruit)	Vaal River main channel
	Vaal Dam GWCA (Rietvallei to Hartbeesfontein)	Vaal River main channel and Vaal Dam
	Waterval River	Waterval River main channel
Suikerbosrant	Suikerbosrant River (incl. Blesbokspruit)	Suikerbosrant River and Blesbokspruit main channels
Klip	Klip River (incl. Natalspruit, Rietspruit)	Main channels of Klip River, Natalspruit and Rietspruit.
Mooi (scheduled irrigation)	Mooi River GWS (incl. Vyfhoek North MB)	Klerkskraal, Boskop and Lakeside Dams
	Klipdrift Settlement MB	Klipdrift Dam
	Vyfhoek South MB	Modder Dam
Vaal Dam to Vaal Barrage	Vaal River, Vaal Dam to Vaal Barrage (incl. Rietspruit).	Vaal Barrage and Rietspruit
	Rietspruit (incl. Leeuspruit)	Rietspruit and Leeuspruit
Vaal Barrage to Mooi confl.	Vaal River GWCA	Vaal River
	Rietpoort IB	Vaal River
	Koppieskraal IB	Vaal River

Note: (1) Irrigation areas from Vaal River Irrigation Study, Tables 7.2 / 8.2 (Loxton et al., 1999b).

5.6.3 Water losses

Water losses from irrigation are divided into conveyance losses and irrigation application efficiencies.

Conveyance losses

This is the loss (leakage and evaporation) experienced during conveyance of water from the source, (i.e. river, dam or borehole) via canals, dams or pipelines, to the edge of the area under irrigation. This loss is expressed as a portion of the annual irrigation water use.

In this WMA conveyance losses could range from 10 % in the case of run of river abstractions to 15 % in the case of maintained, concrete lined canal distribution schemes to 20 % to 30 % in the case of older, unlined and poorly maintained systems. The conveyance losses to field edge for irrigation are shown for key areas and provinces in **Table 5.6.2.1**.

Irrigation efficiency

Irrigation application efficiency is mainly a function of the irrigation application method used. Irrigation efficiencies typically associated with the common irrigation methods are as follows:

- Flood irrigation 65 %.
- Sprinkler systems 75 %.
- Mechanical systems 80 %.
- Micro systems 85 %.
- Drip systems 90 %.

Where more than one method was used in an area, the efficiencies were combined to determine an average efficiency for the area. The dominant irrigation methods in this WMA are mechanical and sprinkler application systems, therefore average losses range from 20 % to 25 %.

Refer to **Section 3.5.2 and Table 3.5.2.1** for more details.

5.6.4 Return flows

Return flows to the river system from irrigation are divided into returns due to leaching and increased returns caused by rainfall.

Return flow due to leaching beyond the root zone.

Irrigation water not used by the plant is returned to the groundwater or streams due to leaching and is largely dependent on the soil characteristics and water quality. Information about these returns was not readily available therefore 100 % return flow due to leaching was used throughout the WMA.

Additional return flow

The return flow from irrigation can further increase due to the increased rainfall run off due to the higher level of soil moisture when compared with the natural state. This increased return flow can be calculated for a seasonal or yearly crop. Based on the climatic conditions and the different crops under irrigation in the WMA the additional return flow generated is of the order of 10%.

Return flows as a result of irrigation are shown in **Table 5.6.2.1**.

5.7 DRYLAND SUGAR CANE

Except for sugar cane, all dry land crops produced in South Africa are assumed to practically use the same water as that of the natural vegetation it replaces. This implies that the water use of dry land crops is already accounted for in the surface water hydrology. Because of the considerable annual variation in dry land cultivation (due to climatic conditions) reliable dry land data are not always readily available. For the above reason only dry land sugar cane was therefore investigated for the purpose of this study.

There is no dryland sugar cane in the Upper Vaal WMA.

5.8 WATER LOSSES FROM RIVERS, WETLANDS AND DAMS

Losses from rivers, wetlands and dams consist primarily of evaporation losses from the river, wetland or dam surface area, but also include seepage losses. The naturalised catchment hydrology often implicitly accounts for channel losses under natural conditions.

Of interest are the additional channel losses that are associated with releases from reservoirs. These losses expressed as incremental losses arising from river regulation (i.e. the additional loss associated with maintaining a fully wetted channel throughout the year). These losses influence the water balance of a system and have to be taken into account in determining releases from dams and the yield of the system.

The entire main stem of the Vaal River and the Wilge River downstream of Sterkfontein Dam is regarded as regulated. Assessment of river losses is also important when return flows artificially increase base flow (such as urban and industrial discharges to the Klip, Suikerbosrand and Mooi River sub-catchments). In all such instances regulated dry weather flows result in increased channel losses.

Data for evaporation losses from wetlands and rivers was obtained from the VRSAU reports. From the Upper Vaal Report (BKS et al, 1998d), losses in the Wilge catchment were estimated. From the Vaal Barrage Report (BKS et al, 1998e), losses in the Suikerbosrand catchment were estimated. From the Middle Vaal Report (BKS et al, 1998f), losses in the Vaal River below the Vaal Barrage and in the Mooi River catchment were estimated. Information of evaporation losses from dams in the Upper Vaal WMA was provided by the DWAF.

In the absence of information, estimates were based on the potential evapotranspiration loss from free water surfaces and riparian vegetation. Estimates of the incremental losses were based on comparisons of calculated river losses based on naturalised flow sequences with calculated losses assuming a fully wetted channel reach.

Table 5.8.1 summarises the evaporation losses from rivers, wetlands and dams for key areas. Total river, wetlands and dam losses of about 514 x $10^6 m^3/a$ were estimated for this WMA of which evaporation from dams (over 70 %) are the most significant.

TABLE 5.8.1: WATER LOSSES FROM RIVERS, WETLANDS AND DAMS.

CATCHMENT				LOSSES FROM RIVERS AND WETLANDS ($10^6m^3/a$)[1]	EVAPORATION LOSSES FROM DAMS ($10^6m^3/a$)	TOTAL ($10^6m^3/a$)
SECONDARY		TERTIARY				
No.	Description	No.	Key Area Description			
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	105,0	51,1	156,1
C1	Klip	C13	Klip (C13A-H)	0,0	7,4	7,4
	Grootdraai	C11	Grootdraai (C11A-L)	0,0	36,8	36,8
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11, C12A-L)	0,0	23,0	23,0
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	9,8	8,3	18,1
	Klip	C22	Klip (C22A-E)	0,0	3,8	3,8
	Mooi	C23	Mooi (C23D-K)	11,9	14,4	26,3
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	0,0	223,0[2]	223,0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	15,5	4,4	19,9
Total in Mpumalanga				**0,0**	**19,1**	**19,1**
Total in Free State				**112,7**	**226,5**	**339,2**
Total in Gauteng				**9,9**	**119,2**	**129,1**
Total in North-West				**19,6**	**7,4**	**27,0**
TOTAL IN WMA				**142,2**	**372,2**	**514,4**

Note : (1) Wetland and river losses determined by the WRSA consultant.

(2) In terms of WSAM the Vaal Dam and Vaal Barrage are treated as a single system and are located in the Vaal Dam to Vaal Barrage key area.

5.9 AFFORESTATION

The water use by commercial afforestation is based on the so-called CSIR curves (CSIR, 1995), which have replaced the so-called Van der Zel curves that were used for the preparation of WR90 (Midgley, et al., 1994). The Van der Zel curves were considered to be too simplistic compared to the CSIR curves, which now take the species, age and site conditions into account in estimating the stream flow reductions. A study was undertaken (Ninham Shand, 1999) to provide adjusted naturalised flow sequences for the Water Situation Assessment Model (WSAM) (Department of Water Affairs and Forestry, 2000) based on the WR90 naturalised flow data. This now enables the CSIR curve-based stream flow reduction estimates to be used in the WSAM and these reduction estimates have been used in the WRSA reports. Details of the method of estimating the reduction in runoff by or water use of commercial afforestation are described in CSIR (1995).

The impact of the reduction in runoff due to afforestation on the yield of a catchment depends on the storage in that catchment. It was accepted that the storage/yield characteristics of a catchment with afforestation were similar to those of the natural catchment and that the latter characteristics could be used to estimate the yield of a catchment with afforestation. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transposed to its outlet and formed the basis for determining the incremental yield of the catchment under both natural conditions and the effects of only the afforestation. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The difference between the incremental yields under natural conditions and with only the effects of afforestation was the impact of the reduction in runoff due to afforestation in the incremental catchment on the yield of the catchment.

In terms of overall requirements, the reduction in yield from afforestation is negligible, as this WMA is not really suited to forestry. **Table 5.9.1** summarises the runoff reduction from forestry for key areas.

TABLE 5.9.1: 1995 WATER USE BY AFFORESTATION.

CATCHMENT				**REDUCTION IN RUNOFF**		**REDUCTION IN YIELD**	
SECONDARY		**TERTIARY**		**(10^6 m^3/a)**	**(mm/a)**	**(10^6 m^3/a)**	**(mm/a)**
No.	**Description**	**No.**	**Key Area Description**				
C8	Wilge	C81, 82,83	Wilge (C81A-M, C82A-H, C83A-M)	0,5	0,0	0,17	0,07
C1	Klip	C13	Klip (C13A-H)	0,0	0,0	0,0	0,0
	Grootdraai	C11	Grootdraai (C11A-L)	0,1	0,0	0,03	0,0
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	0,0	0,0	0,0	0,0
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0,0	0,0	0,0	0,0
	Klip	C22	Klip (C22A-E)	0,0	0,0	0,0	0,0
	Mooi	C23	Mooi (C23D-K)	0,0	0,0	0,0	0,0
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	0,0	0,0	0,0	0,0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L) – Total	0,0	0,0	0,0	0,0
Total in Gauteng				**0,0**	**0**	**0,0**	**0**
Total in Free State				**0,5**	**0**	**0,17**	**0**
Total in Mpumalanga				**0,1**	**0**	**0,03**	**0**
Total in North-West				**0,0**	**0**	**0,0**	**0**
TOTAL IN WMA				**0,6**	**0,0**	**0,2**	**0,0**

5.10 HYDROPOWER AND PUMPED STORAGE

There are no hydro powerstations in the Upper Vaal WMA. There is one pump storage scheme in this WMA, namely the Drakensberg Pumped Storage Scheme. **Section 4.4** provides some information about this scheme. The only requirement for this scheme would be the losses associated with operating the scheme. These are not known but are not expected to exceed 10 %.

5.11 ALIEN VEGETATION

Tertiary and quaternary catchment information on condensed areas of infestation by alien vegetation and stream flow reductions was obtained from the CSIR (Environmentek) (Versfeld et al, 1997).

It has been assumed that water consumption of alien vegetation outside of the riparian zone cannot exceed the natural runoff and water use inside and outside of the riparian zone has been estimated separately wherever possible. In the absence of any better information, it was assumed that 10% of the condensed area under alien vegetation is riparian. The reduction in runoff due to alien vegetation was taken from WSAM using the above assumptions. The impact of this reduction in runoff on catchment yield was determined in the same manner as for afforestation.

Table 5.11.1 summarises the 1995 water use by alien vegetation for key areas. And **Figure 5.11.1** shows the reduction in runoff caused by alien vegetation for key areas.

TABLE 5.11.1: 1995 WATER USE BY ALIEN VEGETATION.

CATCHMENT				AVERAGE REDUCTION IN RUNOFF		REDUCTION IN SYSTEM 1:50 YEAR YIELD	
SECONDARY		TERTIARY		(10^6 m^3/a)	(mm/a)	(10^6 m^3/a)	(mm/a)
No.	Description	No.	Key Area Description				
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	13,8	0,8	7,2	0,4
C1	Klip	C13	Klip (C13A-H)	1,6	0,3	0,9	0,2
	Grootdraai	C11	Grootdraai (C11A-L)	4,5	0,6	2,3	0,3
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	1,3	0,2	0,7	0,1
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0,6	0,2	0,3	0,1
	Klip	C22	Klip (C22A-E)	2,2	0,9	1,1	0,5
	Mooi	C23	Mooi (C23D-K)	1,0	0,2	0,5	0,1
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	4,3	1,5	2,3	0,8
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, 23L)	0,3	0,1	0,2	0,1
Total in Mpumalanga				**5,9**	**1,0**	**3,1**	**0,5**
Total in Free State				**17,4**	**2,8**	**9,1**	**1,5**
Total in Gauteng				**5,2**	**0,8**	**2,7**	**0,5**
Total in North-West				**1,2**	**0,2**	**0,6**	**0,1**
TOTAL IN WMA				**29,7**	**4,8**	**15,5**	**2,6**

5.12 WATER CONSERVATION AND WATER DEMAND MANAGEMENT

5.12.1 Introduction

The Department of Water Affairs and Forestry is entrenching and insisting on efficient water management and water use. This concept has been strongly emphasised, both in legislation and through key demonstration water conservation and water demand management projects. The Department of Water Affairs and Forestry is therefore developing a National Water Conservation and Water Demand Management Strategy, which is aimed at the water supply industry and South African society at large and aims to cover all water use sectors including agriculture, forestry, industry, recreational, ecological, and water services.

Evidence of inefficient water usage can be found in all water use sectors throughout the country and the value of water seems largely unrecognised by many water users. South Africa is a developing country that is water stressed and requires improved management of its limited water resources.

The implementation of water conservation and water demand management principles is essential in meeting the national goals of basic water supply for all South Africans and the sustainable use of water resources.

Water conservation and water demand management are not synonymous. The following meanings are therefore assigned to these terms in this report:

- Water conservation is the minimisation of loss or waste, the preservation, care and protection of water resources and the efficient and effective use of water. Water conservation should be both an objective in water resource and water services management as well as a strategy.
- Water demand management is the adaptation and implementation of a strategy (policies and initiatives) by a water institution to influence the water requirements and use of water in order to meet any of the objectives of economic efficiency, social development, social equity, environmental protection, sustainability of water supply and services and political acceptability. Water supply institutions should set water demand goals and targets by managing the distribution systems and consumer requirements in order to achieve the above objectives.

Water demand management is deemed to include the entire water supply chain - from the point of abstraction at the source to the point of use. This includes all levels of water distribution management and consumer demand management. The conservation measures related to the water resources and return flow are part of water resource management and return flow management respectively.

Various obstacles and constraints have to be overcome before the full potential of water conservation and water demand management can be achieved.

This section describes the National Water Conservation and Water Demand Management Objectives that will lead to the development of action plans to be implemented by the various water institutions. The needs and opportunities for the implementation of water conservation are described, as are some of the important principles on water conservation and water demand management. This section also describes the platform on which the National Water Conservation and Water Demand Management Strategy will be based. This National Strategy Framework will also be used to develop the functions of the Directorate: Water Conservation within the Department of Water Affairs and Forestry and the functions of other departments and other water institutions. It is also intended that those principles will assist the water industry to comprehensively implement water conservation and water demand management.

5.12.2 Background

Water resources and supply

The sustainability of the limited water resources is threatened in terms of quantity and quality. Unless the current water use pattern is changed, future water requirements will greatly exceed existing available fresh water resources. Frequently the water supply and quality are unreliable or improperly managed, leading to the wasteful use of water by consumers in anticipation of possible supply failures.

Environment

Environmental degradation and the prevention thereof is a key focus in the current policy and legislation. Measures such as providing for water of suitable quality in sufficient quantity in the Reserve to protect the integrity, health and productivity of the rich and diverse ecosystems have become necessary.

Neighbouring states

South Africa and the neighbouring states of Botswana, Lesotho, Mozambique, Namibia, Swaziland and Zimbabwe have certain common water resources and must collaborate to achieve the optimal use of these resources. Except for Lesotho all of these countries are water scarce and it is imperative that none of them should allow the wastage of water resources to the detriment of the other countries.

Basic water supply needs

By the application of water demand management measures to existing water services, water resources and bulk infrastructure can be reallocated for the provision of new services where adequate services do not yet exist. Water demand management is also essential in ensuring the sustainability of the new water service delivery projects and can help to ensure that water remains affordable.

Existing water services

It is estimated that up to 50% of the total quantity of water that is supplied is not accounted for in many of the urban areas. This unaccounted for water consists of a combination of reticulation system leaks, unauthorised water connections, faulty water meters and domestic plumbing leaks. These factors, combined with the low levels of payment and institutional problems of local authorities, affect the sustainability of water services. Current indications are that levels of unaccounted for water are growing despite the formulation of several water conservation strategies in the past.

Irrigation

Irrigation accounts for an estimated 3,8 % of total water use in the Upper Vaal Water Management Area. Irrigation losses are often quite significant and it is estimated that often no more than 75 – 80 % (sprinkler and mechanical respectively) of water abstracted from water resources is correctly applied to the root systems of plants. Some irrigation system losses return to the river systems but this return water can be of reduced quality. Irrigation methods, irrigation scheduling, soil preparation, crop selection, crop yield targets and evaporation all affect the efficient use of water.

Forestry

Forestry accounts for an estimated 0,02% of total water use in the Upper Vaal Water Management Area. Issues such as site selection and preparation, species selection, rotation periods and plantation management all affect the efficient use of water.

Industry, mining and power generation

Industry is expected to be the biggest contributor to future economic growth in South Africa. The industrial sector is projected to have the greatest growth in water requirements. Much of this growth will occur in major urban centres that only have limited water resources nearby. It is imperative to have assured water supplies at a reasonable cost to support the industrial development and for the industrial sector to improve its efficiency of water use and to minimise waste.

5.12.3 Legal and regulatory framework

General

The Water Services Act, 1997 (Act No. 108 of 1997) and the National Water Act, 1998 (Act No. 36 of 1998) variously require and provide for the implementation of water conservation and demand management measures. One of the functions of the National Water Conservation and Demand Management Strategy is to fulfil the requirements made through the legislation and to utilise the opportunities created through the legislation to develop comprehensive policies and to identify and develop regulations.

Complimentary to the regulations promulgated in terms of the above two Acts are codes of practice that present guidelines for the maintenance of uniform standards within the water supply industry.

Water Services Act

The Water Services Act, 1997 (Act No. 108 of 1997) sets out a framework to ensure the provision of basic water supply and sanitation and a regulatory framework for water services institutions. All water services institutions are required to develop conditions for the provision of water services that must include for measures to promote water conservation and water demand management.

National Water Act

The purpose of the National Water Act, 1998 (Act No. 36 of 1998) is to inter alia ensure that the nation's water resources are protected, used, developed, conserved, managed and controlled in ways that, amongst others, promote efficient, sustainable and beneficial use of water in the public interest.

Codes of Practice

The SABS Code of Practice 0306:1998 titled *The Management of Potable Water in Distribution Systems* has been drafted to establish the management, administrative and operational functions required by a water services institution to account for potable water within distribution systems and apply corrective actions to reduce and control unaccounted for water.

5.12.4 The role of water conservation and water demand management

Security of supply

The role of water conservation and water demand management in ensuring security of supply can be divided into short-term rationing measures during droughts, which amount to a reduction in assurance of supply in respect of some of the water, and sustainable long-term functions.

With the current growth of water requirements it is estimated that unless water conservation and sustainable development policies are implemented, South Africa will utilise all its natural fresh water resources within 30 years. Possible alternative water resources such as importation of water from neighbouring states, desalination and harvesting icebergs are considered to be too expensive.

Protection of the aquatic environment

Aquatic ecosystems are under threat from current land use practices and over-utilisation of water resources. Reducing water requirements reduces water abstractions that affect the aquatic environment and results in increased stream flows and/or decreased demand on groundwater sources and also reduces or defers the need for dams that have their own impacts on the environment

Protection of existing water resources

The protection of water resources through water conservation measures can be achieved as follows:

- The removal of alien invading plants, which reduce surface runoff and the yield of existing resources.
- Rehabilitation of wetlands.
- Protection of groundwater resources by limiting abstraction to the sustainable yield.
- Minimising pollution of water resources.

Economic efficiency

One of the main objectives of water demand management is economic efficiency through the entire water cycle.

In the potable water services sector, economic efficiency may often be a more important objective than water resource considerations. A certain measure that may be economically efficient from the perspective of society may not be economically efficient from the perspective of a specific water institution or user, which can be a major constraint on water demand management. However, the perspective of society needs to have priority over the economic efficiency perspective of the various water institutions or users.

Reducing the growth in water requirements can postpone large infrastructure development costs.

Social development, equity and accountability

Water demand management can enhance the objectives of social development and equity in a number of ways, some of which are given below:

- To promote maintenance, management and prevention of abuse of water infrastructure.
- To reduce domestic water consumption and waste and the cost of potable water services.
- To provide new services to people by using existing resources and bulk infrastructure.

- To offer more employment opportunities to the community.
- To make water institutions accountable to the public and understand the consumers and their needs.

5.12.5 Planning considerations

Water conservation and water demand management initiatives are not only strategies associated with environmental or communications initiatives but must be integrated into the water resource planning process as potential alternatives to increasingly expensive supply side management options.

All water demand management activities that decrease the water requirement tend to affect supply management because existing system capacity is released for other users.

The opportunities for water demand management exist where there are high levels of loss and inefficient use, particularly where water is used for the service that is derived from it and not for the water itself.

5.12.6 Water conservation and water demand measures

There are a number of categories of water conservation and water demand management measures and initiatives that can be implemented. The following categories are general for all water sectors and are according to the different components of the water supply chain:

- Water conservation measures in resource management.
- Water demand management in distribution of supply management.
- Water demand management measures of customer or end user.
- Water conservation measures for return flow management.

5.12.7 Objectives of the national water conservation and water demand management strategy

The objectives of the National Water Conservation and Water Demand Management Strategy are as follows:

- Create a culture of water conservation and water demand management within all water management and water service institutions in South Africa.
- Support water management and water services institutions to implement water demand management and water conservation.
- Create a culture of water conservation and water demand management for all consumers and users in South Africa.
- Promote international co-operation and participate with other Southern African countries, particularly co-watercourse states, to develop joint water conservation and water demand management strategies.

- Enable water management and water resources institutions to adopt integrated resource planning.
- Promote social development and equity in South Africa.
- Contribute to the protection of the environment, ecology and water resources.
- Contribute the parameters of water economics to development planning processes.

5.12.8 Water conservation in South Africa

History

Since 1982 the droughts have accentuated the awareness of the need to conserve water. In 1985 the Water Research Commission initiated a process to establish the National Water Supply Regulation (NWSR), which was proposed to be promulgated under the then Water Act. Participating local authorities were however, encouraged to promulgate the NWSR as their own Water Regulations (by-laws). Port Elizabeth Municipality was the first to adopt the NWSR in 1987. However, in 1992 the Department of Water Affairs and Forestry indicated it would not be involved with the administration of the (then) proposed NWSR and although the United Municipal Executive resolved in 1993 that the NWSR should be adopted by local authorities, little progress was made.

The proceedings of the National Water Supply and Sanitation Policy Conference of 1994 included an estimate of the extent of the problem of water losses due to leakage at 330 million m^3/a and proposed a policy of water demand management. The subsequent Water Supply and Sanitation Policy White Paper published in 1994 referred to water conservation and demand management and encouraged a culture of water conservation and the introduction of stringent water demand management strategies to reduce water usage and the stress on resources.

The Working for Water programme

The Working for Water programme is part of the National Water Conservation Campaign and is based on the key assumption that invading alien plants pose a considerable threat to South Africa’s extremely rich biological diversity, and to the ecological functioning of its natural systems. Also provided by the campaign is a catalogue of devices that can contribute to the efficient consumption of water.

Water restrictions

Restricting water use during extreme droughts through the imposition of conservation measures on consumers is an intermittent form of water demand management. The effects of past water restrictions give an indication of the extent and direction that future water conservation strategies could have.

Overall savings in water use (median estimates) achieved through water restrictions were found to vary according to region and severity of restriction. In the Rand Water area of supply mild restrictions saved about 15% whereas stringent restrictions saved about 27%. For the rest of Gauteng, Free State and Northern Cape these savings were about 19% (mild) and 34% (stringent). In the Umgeni Water area of supply mild restrictions saved only 1% to 5%, whereas stringent measures saved as much as 50%. For the rest of KwaZulu/Natal these savings were 29% (mild) and 46% (stringent).

It was difficult to determine the financial effects of water restrictions. In the Vaal River Supply Area the reduction in water requirements due to water restrictions for the Rand Water, Goldfields and Vaal River supply areas for the period 1982 to 1984 was almost 240 million m^3 of water or 22,5% of the requirement for the year 1982. The greatest total direct tangible financial impact was on public institutions such as the Department of Water Affairs and Forestry, Water Boards, Local Authorities and Eskom. Private households also bore a large financial impact of water restrictions. Mining had the least financial burden to bear because of water restrictions, yet achieved a net saving in water use of almost 32% in the same period. The greatest reduction in water use was for the agricultural sector, which had the second lowest direct financial impact.

From analyses of return flows in Gauteng it is concluded that the ratio of return flow to water use is not materially altered by the imposition of water restrictions. In other words, if the supply is reduced by (say) 20%, it can be assumed that the return flow will also be reduced by 20%.

Experience from past water restrictions that have proved to be the most effective during times of drought, which are relevant to future water conservation efforts are:

- The overall reduction in water use depends on a number of factors. However, when water use is reduced beyond 30% it can be detrimental to the user from a financial and motivational perspective.
- Voluntary reduction in water use fails to achieve the savings possible with mandatory steps.
- The most effective methods of reducing water use are higher tariffs, restriction of garden watering times, the banning of domestic hose pipe usage and allotting quotas to industry, bulk consumers and irrigators.
- The most effective motivations are pamphlets/newsletters, higher tariffs and punitive measures.
- The major interventions required to reduce both physical and non-physical losses from pipe networks are leak detection/monitoring, replacing old plumbing and the repair/monitoring of meters.
- The most effective methods of saving water used by commerce and industry are technical adjustments, recycle/re-use and promotion campaigns.

- The ratio of return flow to water use is not materially changed by changes in water use.

The measures implemented during the drought in the mid-1980's reduced water use and the growth rate in water usage after the drought had ended. However, there is little or no incentive for existing or new consumers to continue to retain or to adopt the water saving measures when there is no drought.

5.12.9 Water conservation in the Upper Vaal WMA

Based on experience elsewhere in South Africa an overall sustainable reduction in water use of up to 25% can be expected without having a detrimental effect on users. Return flows could be reduced by up to 10% of total water use.

The following analysis of various selected reports for areas within Gauteng provides an indication of the extent of the problem as well as future water conservation policies that could address the situation.

- **Soweto**

In 1994 it was roughly estimated that of the 250 Mℓ/day of water feeding Greater Soweto, as much as 50 % (125 Mℓ/day) is unaccounted for water. Approximately 40 Mℓ/day is thought to be lost to the sewer system, mainly via leaking domestic fittings and 30 Mℓ/day is attributable to leakage from water mains, whilst the remainder can not be accounted for because of faulty meters (City Manager, Greater Soweto, 1994), (GJTMC, 1996).

Specific burst rates for the various areas of Soweto vary from 5 bursts per month per kilometer piping (no/month/km) to as little as 0,1 with an average of 0,88 for a sample for 19 townships within Soweto (GJTMC, 1995).

There have been initiatives by Johannesburg Water to create water management/loss districts whose responsibility it is to reduce leakages, burst pipes etc.

- **Greater Johannesburg Metropolitan Council**

A report was compiled dealing with the formulation of a policy for water conservation for the Greater Johannesburg Council area of jurisdiction in 1997 (GJTMC, 1997).

A proposal for the implementation of this policy has been drafted and has still to be discussed with the various local councils. The proposed implementation is detailed as follows (GJTMC, 1998):

General objectives, relating to all policy statements are:

- To create public awareness through publicity, education, etc.
- To develop uniform metropolitan-wide design and material standards to facilitate achievement of objectives.
- To promulgate uniform metropolitan-wide by-laws to facilitate achievement of objectives.
- To ensure enforcement of conservation-related legislation.

Co-operation with regional or national water supply authorities should be sought, where relevant, in order to optimise conservation efforts.

There are joint initiatives involving Johannesburg Water, Rand Water and the Gauteng Province to address losses.

- **Rand Water**

Various studies have been carried out in RW's area of supply and although these are estimates the potential to reduce use is considered by Rand Water to be up to 40% without negatively affecting economic activity or the lifestyle of people. It is estimated that 27% of water sold by Rand Water is lost through reticulation and domestic leaks, and a further 25% of the water is used inefficiently. Possible water reduction initiatives should be viewed in the context of favourable cost benefit ratios, according to priorities and according to various demand management objectives from various perspectives.

The impact of any water demand management and water conservation initiative or programme needs to be measured not only according to the change in water use but also according to the following objectives:

- Economic and financial benefits of reduced consumer costs including the cost of "lost" water being included in the price of water.
- Environmental benefits.

Although a detailed assessment of the various initiatives is not included in this report some indication of the overall impact and the range of impact of individual initiatives is indicated.

During the drought in 1995 the sales of Rand Water in the 1994/95 financial year averaged 2 833 Mℓ/day. Four years later the projected average for the 1998/99 financial year is 2 900 Mℓ/day. Comparing the previous rate of growth of 4% to 5%, the actual average growth in demand over the last four years has been only 0,586%. This is artificially low because there is wastage. Eventually the growth in use will mimic the population growth. Although it is difficult to assess the exact reasons for the overall drop in the rate of growth in water use, one can argue that the objective of an overall water demand management strategy has been met. It is important to recognise that without any detailed costing exercise to evaluate the net benefit, it is undesirable to reduce actual water sales and the savings achieved from water demand management initiatives should be designed to restrict the natural growth in demand.

5.13 WATER ALLOCATIONS

5.13.1 Introduction

For details of the National Water Act, refer to **Section 3.4.2** of Legal Aspects.

In terms of Section 34 of the old Water Act, 1956 (Act No. 54 of 1956), Water Courts were established to apportion water and to determine individual water rights. In order to control the use of water, the Minister, subject to the conditions of various sections of the Water Act, issued permits or authorisations to water users.

The various types of allocations are summarised below. Allocation information that is readily available is detailed in **Appendix C**.

5.13.2 Allocations and permits which were issued under the old Water Act

Authorisations in terms of Section 9B and 9C of the Water Act
A permit is required for the construction, operation or enlargement of any water work, which will enable more than 110ℓ/s of water to be abstracted or diverted from a public stream (river). A permit is required for the impoundment on any piece of ground of more than 250 000 m^3 of water from a public stream.

Any dam having a storage capacity greater than 50 000 m^3 and a wall height greater than 5m is deemed to be a dam with a safety risk and no person may design, construct, operate, alter, enlarge or use such a dam without a permit. All such dams have to be registered at the Dam Safety Office of DWAF. Data about these dams can be obtained from the Dam Safety Database.

Appendix C.1 lists some of the information on dams that was extracted from the Dam Safety Database (the volume of information is too great to include it all).

Authorisations in terms of Sections 11 and 12 of the old Water Act

Section 11: Use of water for industrial purposes is subject to permission of a Water Court, except where water is supplied by a local authority or by the Minister from a Government Water Scheme, or where water is allocated by the Minister in a Government Water Control Area.

Section 12: If use of water for industrial purposes is greater than 150m^3 on any one day, a permit of authority is required for the use of the water regardless of the source of the water. This permit must accompany the application to the Water Court as provided for in Section 11.

Data about these permits can be obtained from the PCPolman database, DWAF. Examples of these types of permits can be found in **Appendix C.2**.

Authorisations in terms of Section 13 of the old Water Act

A local authority requires a permit to construct, alter or enlarge any water work by means of which more than 5 000 m^3/d can be abstracted or diverted from a public stream. Section 13/3 states that a local authority requires a permit to construct, alter or enlarge any water work by means of which more than 125 000 m^3 of public water can be impounded.

Examples of these types of permits can be found in **Appendix C.1** and have been extracted from the Dam Safety Database.

Authorisations in terms of Section 30 (2) of the old Water Act

The Minister can control the abstraction of underground water in a Subterranean Government Water Control Area (SGWCA). There are no known SGWCAs in this WMA.

Authorisations in terms of Section 56 (3) of the old Water Act

The Minister may supply water from a Government Water Work. In the Upper Vaal WMA, section 56 (3) authorisations allow various water users to abstract water in terms of the Vaal River Development Scheme Act, 1934 (Act 38 of 1934). **Appendix C.3** lists the known authorisations.

Authorisations in terms of Section 62 and 63 of the old Water Act

Control of public water in a Government Water Control Area (GWCA) vests in the Minister and no person may construct, alter, enlarge or use a water work for abstraction except under permit from the Minister. The Minister may allow the abstraction of water from a Government Water Control Area for irrigation purposes to anyone within or outside the control area.

5.13.3 Government Water Control Areas in the Study Area

There are two Government Water Control areas in this WMA, namely:

- Vaal Dam Catchment GWCA (u/s Vaal Dam).
- Vaal River GWCA (d/s Vaal Barrage).

However the following areas are controlled in terms of irrigation abstractions (DWAF, 1999):

- Waterval River Irrigation area.
- Wilge River Irrigation area.
- Liebensbergvlei River Irrigation area.
- Vaal River from Vaal Dam to Barrage.
- Klip River Irrigation area.
- Suikerbosrant Irrigation area.

5.13.4 Permits and other allocations

Comprehensive and reliable information on permits, authorisations and allocations was not readily available. This is because the data for different permits or allocations is not centrally located.

A summary of the irrigation scheduling and quotas (Article 63 permits) from Government Water Schemes is provided in **Table 5.13.4.1**. The Mooi GWS is the largest Government Water Scheme is this WMA.

The irrigation areas and quotas for Government Water Control Areas (Article 62 permits) are provided in **Table 5.13.4.2**.

TABLE 5.13.4.1: ARTICLE 63 – IRRIGATION SCHEDULING AND QUOTAS FROM GOVERNMENT WATER SCHEMES.

SCHEME	QUATERNARY CATCHMENTS	SCHEDULED(1) (ha)	QUOTA(1)	ALLOCATION
			(m^3 /ha/a)	(10^6 m^3/a) (2)
Rietpoort IB (Free State)	C23C	193	6 100	1,2
Koppieskraal IB (Free State)	C23C	170	6 100	1,0
Mooi GWS (North West Province)	C23G, H, L	4 760	7 700	36,7
Klipdrift Settlement MB (North West Province)	C23K	1 027	5 875	6,0
Vyfhoek South MB (North West Province)	C23K	114	7 700	0,9
Total for Free State	C23C	363	6 100	2,2
Total for North West	C23G, H, K, L	5 901	5 875 / 7 700	43,6
Total for WMA		**6 264**	**5 875 / 6 100 / 7 700**	**45,8**

Note: (1) From Table 8.2 of Vaal River Irrigation Study (PC000/00/21599).
(2) Refer to appendix D.1 for quaternary crop area data.

TABLE 5.13.4.2: ARTICLE 62 – IRRIGATION SCHEDULING AND QUOTAS IN GOVERNMENT WATER CONTROL AREAS.

WATER CONTROL AREA	QUATERNARY CATCHMENTS	IRRIGATION AREA (1) (ha)	QUOTA(1) (m^3/ha/a)	ALLOCATION (10^{6}m^3/a)
Vaal Dam Catchment GWCA – u/s Grootdraai Dam (Mpumalanga)	C11B, D, E, J and L	4 289	6 100	26,2
Vaal Dam Catchment GWCA – d/s Grootdraai Dam (Mpumalanga and Free State)	C11L, C12B, C12H, C12L	2 249	6 100	13,7
Waterval River (Mpumalanga)	C12D, E, F and G	741	6 100	4,5
Wilge River and Liebensberg Vlei Irrigation Area (Free State)	C81E, K C82C, G, H C83C, F, G, G, M	5 517	6 100 / 8 130 / 8 640	34,5
Vaal, Klip, Suikerbosrant and Rietspruit Irrigation Areas (Gauteng and Free State)	C21A, B, C, E, F, G C22C, D, E, H, J	9 008	6 100	55,0
Vaal River GWCA (Free State and North West)	C23C, C23L	1 154	6 100	7,0
Total for Mpumalanga		**6 155**	**6 100**	**37,5**
Total for Free State		**8 557**	**6 100 / 8 130 / 8 640**	**53,1**
Total for Gauteng		**7 670**	**6 100**	**46,8**
Total for North West		**577**	**6 100**	**3,5**
Total for WMA		**22 958**	**6 100 / 8 130 / 8 640**	**140,9**

Note: (1) From Table 8.2 (Loxton et al, 1999b).

Data for Section 56 (3) water allocations to other users from Government Water Schemes or Water Control Areas was provided by the DWAF for Gauteng and Free State Provinces. Section 56 (3) allocations for the Grootdraai and Mooi key areas were provided to the WRSAS consultants responsible for Mpumlanga and North West Provinces respectively. The available information therefore does not represent the situation for the whole of the WMA. For example the allocations from Grootdraai Dam for industries like Sasol II and III and Eskom are not known etc. **Table 5.13.4.3** summarises the available data. All known data is listed in **Appendix C.3**.

The largest known allocation is the Rand Water allocation (Permit No: 60/12/2/91) from Vaal Dam of 1 260 x $10^6 m^3/a$.

TABLE 5.13.4.3: ARTICLE 56(3) – RAND WATER ALLOCATIONS FROM THE VAAL GOVERNMENT WATER CONTROL AREA.

SCHEME	QUATERNARY CATCHMENTS	ALLOCATION ($10^6 m^3/a$)				
		HOUSEHOLD & STOCK WATERING	MUNICIP – ALITIES	BULK STRATEGIC	BULK & MINING	TOTAL
Rand Water (Gauteng, Mpumalanga, Free State and North West Provinces)	C12L; C83M; C22F	Not known	Not known	Not known	Not known	**1 260(1)**
Other users (Gauteng, Free State)	*	0,25	16,25	Not available	26,5	**43**
Total for Free State	*	*	*	*	*	*
Total for Gauteng	*	*	*	*	*	*
Total for WMA	*****	**0,25(1)**	**16,25(1)**	*****	**26,5(1)**	**1 303**

Note: * information is not readily available.
(1) Information on Rand Water supply to various users is not known.

No other allocation, permit or authorisation data is readily available.

5.13.5 Allocations in Relation to Water Requirements and availability

Knowledge of total allocations in this WMA is important. However it is impossible with the available information to compare allocations with water requirements and or water resources. The Situation Assessment consultant has a digital database that could be used as a base to set up a more comprehensive allocations database for this WMA.

5.14 WATER TRANSFERS

5.14.1 Introduction

The water resources of a catchment can be exported by pipeline or canal out of the catchment. This transfer out is described as a water requirement from the catchment's water resources. Conversely the water resources of a catchment can be augmented by the import of water by canal or pipeline. This transfer is described as contributing to the resource or source of supply of the catchment.

Water transfers to augment the supply of water for rural, urban, bulk and agricultural requirements are categorised as follows:

- Transfers to or from neighbouring states.
- Transfers between Water Management Areas (e.g. Thukela – Vaal transfer).
- Transfers within WMAs are transfers between quaternary catchments (e.g. transfers by Rand Water to the various MLCs and TLCs within the Vaal Basin).

Since 1998, the Upper Vaal WMA receives (imports) water from Lesotho from the Lesotho Highlands Water Scheme.

In 1995 The Upper Vaal WMA received (imports) water from the following WMAs:

- Usutu to Mhlatuze WMA to augment Grootdraai Dam.
- Thukela WMA to augment Vaal Dam.

This WMA received effluent from the following WMAs:

- Crocodile (West) and Marico WMA (Krugersdorp effluent returns to Flip Human STW).

This WMA delivered (exports) water to the following WMAs:

- Crocodile (West) and Marico WMA for the Rand Water Northern supply region.
- Olifants WMA for Eskom power stations.
- Middle Vaal WMA for Heilbron supply.

This WMA returned (exports) effluent to the following WMAs:

- Olifants WMA (Kinross and Trichardt TLC's to Trichardtspruit).

Figure 5.14.1 shows the positions of the major water transfer schemes and the quantity of water transferred per annum at 1995 levels of development. All known inter-basin transfers (including effluent transfers) are listed in **Appendix F.4.**

5.14.2 Transfers to and from Neighbouring States.

There is one such transfer, namely the transfer from Lesotho from the Lesotho Highlands Water Project. Although this scheme was not operational in 1995 it has been included due to its importance in meeting the future water requirements of the Upper Vaal WMA. The transfer of water from Katse Dam in Lesotho to Liebenbergspruit in the Upper Vaal WMA commenced in 1998 (Lesotho Highlands Water Authority, 2001) and is summarised in **Table 5.14.3.1.**

5.14.3 Transfers between WMAs

There are a number of inter-basin transfers connected to this WMA. The major schemes have been briefly described in **Section 4.2**. The major inter-basin transfers for 1995 are summarised in **Table 5.14.3.1** and all know transfers are listed in **Appendix F.4**.

During 1995 about 870 x $10^6 m^3$ of water was imported from various WMA's to augment the water resources of the Upper Vaal WMA. The most significant imports were the Thukela – Vaal, Usutu (Heyshope sub-systems) and Zaaihoek transfers. The import of water has risen significantly since 1995 with the commencement (1998) of transfers from the Lesotho Highlands Water Project.

During 1995 approximately 508 x $10^6 m^3$ of water was exported from the Upper Vaal WMA to various WMA's. The most significant export was by Rand Water to the Crocodile West and Malopo WMA (472 x $10^6 m^3$) to supply urban (Johannesburg North, Midrand, Greater Pretoria, Rustenburg etc), industrial and mining requirements.

TABLE 5.14.3.1: TRANSFERS TO AND FROM NEIGHBOURING STATES AND INTER-WATER MANAGEMENT AREA TRANSFERS UNDER 1995 DEVELOPMENT CONDITIONS.

DESCRIPTION OF TRANSFER	SOURCE	RECEIVER WMA	TRANSFER QUANTITY ($10^6 m^3/a$)		
			RECEIVER WMA	LOSSES	SOURCE WMA
Transfers to and from neighbouring states:					
Lesotho Highlands Water Project(1) (1a) - 1998	Lesotho (Katse Dam)	Upper Vaal (Liebenbergsvlei)	(+) 364	32	396
Lesotho Highlands Water Project(1) (1a and 1b) – 2003	Lesotho (Katse Dam)	Upper Vaal (Liebenbergsvlei)	(+) 1 200	100	1 300
Interbasin IMPORTS:					
Thukela-Vaal Water Project	Thukela (Driel Dam)	Upper Vaal (Sterkfontein Dam)	(+) 731,4	22,6	754
Usutu-Vaal (Heyshope)	Usutu to Mhlatuze (Heyshope Dam)	Upper Vaal (Grootdraai Dam)	(+) 58,2	1,8	63
Zaaihoek transfer	Thukela (Zaaihoek Dam)	Upper Vaal (Perdewaterspruit)	(+) 48,5	1,5	52
Interbasin EXPORTS:					
Rand Water transfers Northern supply area	Upper Vaal (Vaal Dam)	Crocodile (West) and Marico (Pta, Mid Rand, Randfontein etc)	(-) 467,8	14,2	472
Eskom transfer to Matla / Kriel power stations	Upper Vaal (Grootdraai Dam)	Olifants (Trichardtspruit)	(+) 34,3	1,1	35,4
Heilbron Transfer (via Sasolberg from 1998 by RW)	Upper Vaal (Vaal Dam)	Middle Vaal (Heilbron)	(-) 0,87	0,03	0,9

NOTE : (1) Lesotho information from Lesotho Highlands Water Authority, Mohale Consultants group.
(+/-) A (+) in the transfer column indicates a surplus in the receiver quaternary that will be routed through the system, while a (-) symbol represents the supply of a demand in the receiving quaternary.

5.14.4 Transfers Within the Water Management Area

Within the WMA there are numerous transfers between and within quaternary catchments. Rand Water transfers approximately 480 x $10^6 m^3/a$ of potable bulk water to its Vaal or southern supply area. Most of this water (>95 %) is for urban requirements. The most significant transfers by Rand Water are to Greater Johannesburg (south) and Germiston MLCs and the cities and towns of the East Rand.

The transfers by Eskom to operating powerstations was in the region of 71 x $10^6 m^3/a$. Large industrial users such as Sasol I, II and III, and Iscor transferred approximately 144 x $10^6 m^3/a$ of both treated and untreated water.

The main transfers are summarised in **Table 5.14.4.1**. A number of large within quaternary transfers are also listed. For example the transfer by Sedibeng water to urban and rural users in the Phuthaditjhaba area (quaternary catchment C81F). All transfers are listed in detail in **Appendix F.4**.

TABLE 5.14.4.1: AVERAGE TRANSFERS WITHIN THE UPPER VAAL WMA AT 1995 DEVELOPMENT LEVELS.

DESCRIPTION OF TRANSFER	SOURCE	DESTINATION	QUANTITY ($10^6 m^3/a$)
Rand Water – Klip supply area	Vaal Dam	Greater Johannesburg (South)	205,0
Rand Water – East Rand supply area	Vaal Dam	Germiston, Boksberg, Alberton, Springs, Brakpan etc and mines	201,0
Rand Water – Mooi supply area	Vaal Dam and Zuurbekom boreholes	West Rand TLCs and mines	16,4
Rand Water – Upper Vaal supply area	Vaal Dam	Highveld Ridge & Bethal and mines	15,2
Rand Water – Vaal Barrage supply area	Vaal Dam	Vanderbijl, Sasolburg and Vereeniging	61,1
Sasol II and III Transfer	Grootdraai Dam	Sasol II, III	90,5
Eskom Transfer	Grootdraai Dam	Tutuka Power station	34,2
Sasol I Transfer (Vaal Barrage)	Vaal Dam	Sasol I	29,2
Iscor Transfer (Vaal Barrage)	Vaal Dam	Iscor	24,0
Significant within quaternary transfers			
Eskom Transfer (Vaal Barrage)	Vaal Dam	Lethabo Power station	36,5
Qwa Qwa supply area Sedibeng Water	Fika Patso & Metsi Matso Dams	Phuthaditjhaba (urban) / Witsieshoek (rural)	14,4

Note : (1) Large transfers within quaternary catchments have been included.

5.14.5 Effluent transfers

There are a number of transfers of effluent within, into and from this WMA. This is because a number of towns and cities straddle the catchment divides between quaternary catchments within the WMA and with the Olifants and Crocodile (West) and Marico WMAs. The most significant "export" is related to the transfer of water from Greater Johannesburg MLC (South) to the Bushkoppies sewage works.

During 1995 about 124 x $10^6 m^3$ of effluent was exported to other quaternary catchments or WMAs. **Table 5.14.5.1** lists the main transfers and **Appendix F.4** lists all known 1995 transfers of effluent in the WMA.

TABLE 5.14.5.1: SIGNIFICANT AVERAGE EFFLUENT TRANSFERS WITHIN AND OUT OF THE UPPER VAAL WMA AT 1995 DEVELOPMENT LEVELS.

DESCRIPTION OF TRANSFER	SOURCE	DESTINATION	QUANTITY (10^6 m^3/a)
Bushkoppies transfer	Greater Johannesburg MLC	Bushkoppies STW (Klip River)	69,3
Waterval transfer	Germiston and Alberton MLCs	Waterval STW (Rietspruit)	23,7
Sasol 1 transfer	Sasol 1 and Sasolburg TLC	Sasol 1 STW (Vaal River d/s Barrage)	17,3
Effluent exports imports			
Krugersdorp transfer	Krugersdorp TLC (Crocodile West and Marico)	Flip Human STW (Mooi key area)	3,7
Kinross and Trichardt transfers	Kinross and Trichardt TLCs (Upper Vaal WMA)	To Trichardtspruit (Olifants WMA)	0,6

5.15 SUMMARY OF WATER REQUIREMENTS, LOSSES AND RETURN FLOWS

The 1995 water requirements, water losses and return flows for the various user categories in the Upper Vaal WMA are summarised in **Table 5.15.1**. Urban water requirements, the inter-basin export of water and losses from dams rivers and wetlands are the most significant users of water in the WMA. Urban losses represent the most significant conveyance losses. Urban returns, which combine effluent returns, stormwater returns and clean returns, are the most significant returns to the system.

Pie diagrams of on-site water requirements, losses and return flows are given in **Diagrams 5.15.1, 5.15.2 and 5.15.3.**

TABLE 5.15.1: SUMMARY OF UNASSURED 1995 WATER REQUIREMENTS, LOSSES AND RETURN FLOWS.

CATEGORY		ON-SITE WATER REQUIREMENT (10^6 m^3/a)	CONVEYANCE LOSSES[3]		GROSS WATER REQUIREMENT (10^6 m^3/a)	RETURN FLOW (10^6 m^3/a)
			(%)	(10^6 m^3/a)		
Irrigation		129,1	10 - 20	20,4	149,5	11,4
Urban (Direct and indirect users)		440,8	3 - 25	98,3	539,1	406,9[1]
Rural (Domestic, livestock and subsistence irrigation)		43,9	20 - 30	11,0	54,9	2,2
Bulk	a) Strategic (Power Stations)	69,3	5	3,6	72,9	1,0
	b) Mining	8,6	3 - 10	0,7	9,3	123,0[2]
	c) Other (Industrial etc,)	149,8	3 - 10	14,1	163,9	22,1
Hydro-power		0,0	0	0,0	0,0	0,0
Transfers (export)		491,3	3 - 5	17,0	508,3	0,0
Alien vegetation		29,7	n/a	n/a	29,7	0,0
Afforestation (runoff reduction)		0,6	n/a	n/a	0,6	0,0
Rivers, wetlands, dams		514,4	n/a	n/a	514,4	0,0
TOTAL WMA		**1 877,5**	**3 - 30**	**165,1**	**2 042,6**	**566,6**

Note : (1) Urban returns includes effluent returns (276,2), stormwater returns (111,4) and clean returns (19,3).
(2) Mining returns includes groundwater decanted by mines into rivers of WMA.
(3) Only losses associated with the conveyance and distribution of potable water.

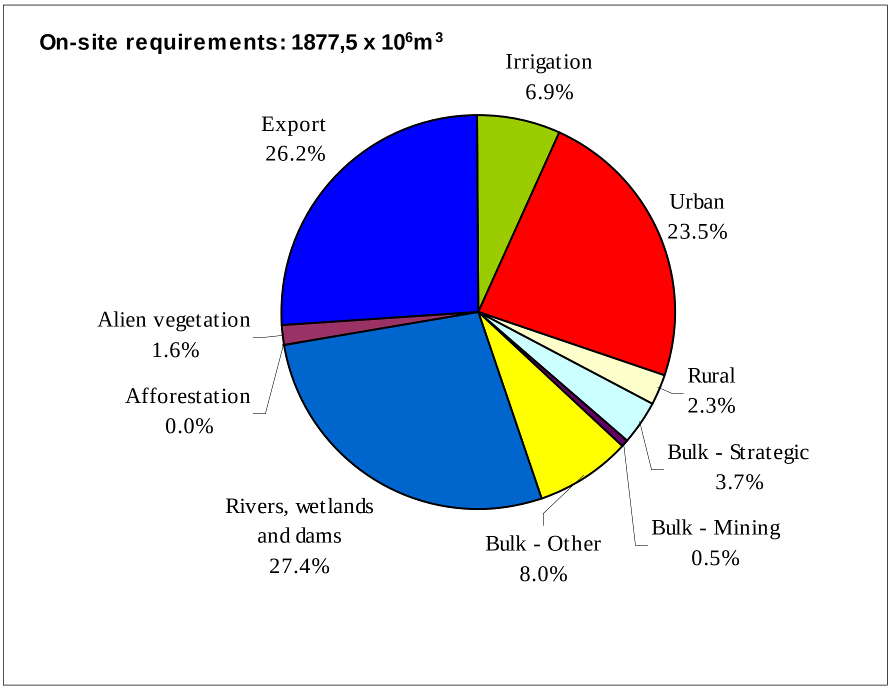


Diagram 5.15.1: Water requirements (excluding losses) in the Upper Vaal WMA in 1995.

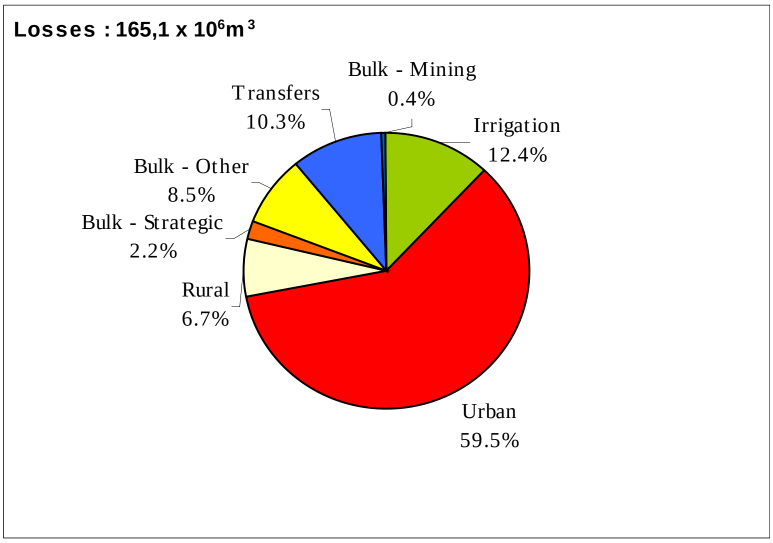


Diagram 5.15.2: Conveyance losses in the Upper Vaal WMA in 1995.

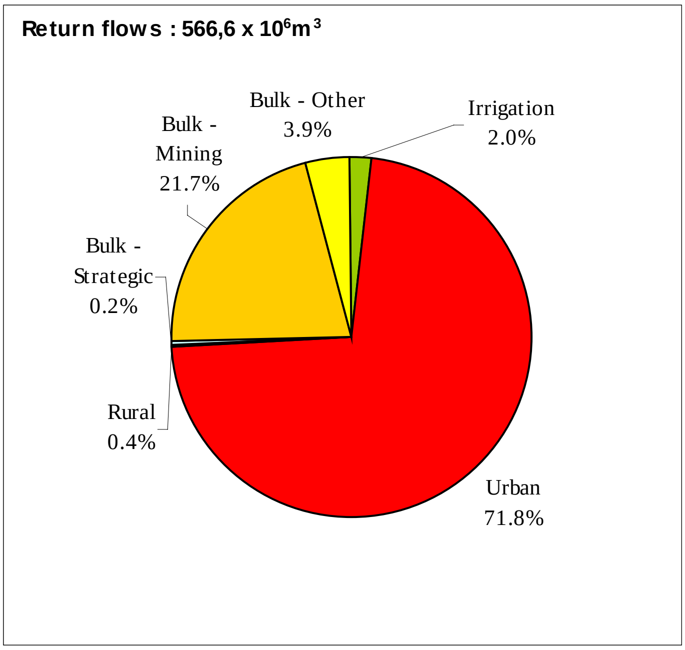


Diagram 5.15.3: Return flows in the Upper Vaal WMA in 1995.

CHAPTER 6: WATER RESOURCES

6.1 EXTENT OF WATER RESOURCES

Natural mean annual runoff (MAR) from the total Vaal River catchment is approximately 4 000 x $10^6 m^3$/a. For the Upper Vaal WMA, the natural MAR totals 2 422,8 x $10^6 m^3$/a. When expressed as an equivalent unit runoff from the 196 000 km^2 Vaal River catchment, the MAR averages out at about 20 mm. However, the pattern of runoff over the catchment is one of a fairly gradual decline from east to west, in accordance with the east to west decline of rainfall associated with an increase in evaporation rates Unit runoff varies from over 100 mm in the upper reaches of the Wilge and Elands River tributaries to as little as 20 mm on the western side of the WMA. Equivalent figures for mean annual rainfall (MAP) are 800 mm (east) and 550 mm (west) and, for gross mean annual Symons Pan evaporation (MAE) are 1 300 mm (east) and 2 300 mm (west).

The developed yield from surface water in the absence of any use in 1995 totals 2 562,3 x $10^6 m^3$ and the total potential surface water yield is the same due to the fact that the Upper Vaal WMA as part of the total Vaal system is fully developed. The developed yield from groundwater in 1995 is 33,8 x $10^6 m^3$ and the potential yield is 385,4 x $10^6 m^3$. If the relationship between surface water and groundwater is taken into account, the total developed yield is 2 596,1 x $10^6 m^3$/a. Surface water yields have not had the ecological Reserve deducted from them i.e the yield is calculated as if the ecological Reserve is zero and there is no development from these catchments.

The full existing yield was determined by adding the surface water and groundwater yields.

Table 6.1.1 gives a summary of the water resources per key area. The net 1:50 year yield of the total water resource as developed in 1995 is given in **Figure 6.1.1**.

TABLE 6.1.1: WATER RESOURCES

CATCHMENT				SURFACE WATER RESOURCES ($10^6 m^3/a$)			SUSTAINABLE GROUNDWATER EXPLOITATION POTENTIAL NOT LINKED TO SURFACE WATER ($10^6 m^3/a$)		TOTAL WATER RESOURCE ($10^6 m^3/a$)	
SECONDARY		TERTIARY		NATURAL MAR	1:50 YEAR DEVELOPED YIELD IN 1995[(2)]	1:50 YEAR TOTAL POTENTIAL YIELD	DEVELOPED IN 1995	TOTAL POTENTIAL	1:50 YEAR DEVELOPED IN 1995	1:50 YEAR TOTAL POTENTIAL
No.	**Description**	**No.**	**Key Area Description**							
C8	Wilge	C81-C83	Wilge (C81A-M, C82A-H, C83A-M	868,3	64,1	64,1	4,0	84,6	68,1	148,7
C1	Klip	C13	Klip (C13A-H)	291,1	7,6	7,6	0,7	22,1	8,3	29,7
C1	Grootdraai	C11	Grootdraai (C11A-L)	457,7	288,6	288,6	5,0	70,6	293,6	359,2
C1	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11, C12A-L)	360,0	109,0	109,0	2,2	50,1	111,2	159,1
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	92,4	99,8	99,8	1,3	42,7	101,1	142,5
C2	Klip	C22	Klip (C22A-E) – Gauteng	96,2	293,2	293,2	**3,7[(1)]**	13,1	296,9	306,3
C2	Mooi	C23	Mooi (C23D-K)	113,0	16,3	16,3	9,0	25,1	25,3	41,4
C2	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	68,5	1 691,7	1 691,7	3,4	44,8	1 695,1	1 736,5
C2	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	75,6	-8,0	-8,0	4,5	32,3	-3,5	24,3
Total in Mpumalanga				**855,6**	**&**	**&**	**7,4**	**120,6**	**&**	**&**
Total in Gauteng				**240,1**	**&**	**&**	**7,1**	**136,7**	**&**	**&**
Total in Free State				**1 208,6**	**&**	**&**	**8,6**	**111,6**	**&**	**&**
Total in North-West				**118,5**	**&**	**&**	**10,7**	**16,5**	**&**	**&**
TOTAL IN WMA				**2 422,8**	**2 562,3**	**2 562,3**	**33,8**	**385,4**	**2 596,1**	**2 947,7** **[Ss(L1][Ss(L2]**

Notes : (1) Figure adjusted by WRSA consultant from 1,7 to 3,7 because Zuurbekom abstractions are 10 Mℓ/ day (3,7 x $10^6 m^3/a$).
(2) Yield determined by the DWAF and includes impact of dam evaporation losses.
(&) Provincial split not readily available.

6.2 GROUNDWATER RESOURCES

Groundwater is an important part of the total water resources of South Africa and must be seen as part of the total hydrological cycle. The information provided here gives an overview of the groundwater resources, it's interaction with surface water, the present use, (1995) and it's potential for further development.

It must be noted that this information is intended for regional strategic planning and is not suitable for local site evaluations. More detailed information on the approach and methodology can be obtained in **Appendix G**. All information was collated on a quaternary catchment basis.

The Ground Water Harvest Potential (Seward and Seymour, 1996) was used as the basis for the evaluation. The Harvest Potential is defined as the maximum volume of groundwater that is available for abstraction without depleting the aquifer systems, and takes into account recharge, storage and drought periods (see **Figure 6.2.1**).

The Harvest Potential was then reduced by an exploitation factor, determined from borehole yield data, to obtain an exploitation potential ie the portion of the Harvest Potential which can practically be exploited (see **Table 6.2.1 and Figure 6.2.2**).

Groundwater, surface water interaction was determined by evaluating the base flow or more specifically the contribution of Harvest Potential to the base flow. This contribution can be seen as water which can either be abstracted as groundwater or surface water. From this, the extent to which groundwater abstraction will impact on surface water has been qualitatively evaluated (see **Figure 6.2.3**) ie where the contribution is 0 the impact will be negligible where the contribution is ≤ 30% of the baseflow the impact will be low where the contribution is 30% - 80% of the baseflow, the impact will be moderate and a high impact has been evaluated where the contribution to baseflow is > 80%.

The existing groundwater use was determined by Baron and Seward 2000. The information was then verified at a workshop held in the Upper Vaal WMA by the Water Resources Situation Assessment team. This provided local input to the groundwater use numbers provided by Baron and Seward which were then adjusted accordingly (see **Table 6.2.1 and Figure 6.2.4**).

The groundwater balance then compares existing groundwater use to Harvest and Exploitation Potential to determine the extent to which the groundwater resources are utilized (see **Figure 6.2.5**) ie, if total use was greater then the Harvest Potential, the catchment was considered over-utilized, if the total use was greater than the exploitation potential but less than the Harvest Potential, the catchment was considered heavily utilized, if the total use was more than 2/3 of the Exploitation Potential the catchment was considered moderately-utilized and if the total us was less than 2/3 of the exploitation potential the catchment was considered under-utilized.

TABLE 6.2.1: GROUNDWATER RESOURCES AT 1 IN 50 YEAR ASSURANCE OF SUPPLY.

CATCHMENT				GROUNDWATER EXPLOITATION POTENTIAL (10^6 m^3/a)	GROUNDWATER USE IN 1995 (10^6 m^3/a)	UNUSED GROUNDWATER EXPLOITATION POTENTIAL IN 1995 (10^6 m^3/a)	GROUNDWATER CONTRIBUTION TO SURFACE BASE FLOW (10^6 m^3/a)	PORTION OF GROUNDWATER EXPLOITATION POTENTIAL NOT CONTRIBUTING TO SURFACE BASE FLOW (10^6 m^3/a)
SECONDARY		TERTIARY						
No.	Description	No.	Key Area Description					
C8	Wilge	C81, 82, 83	Wilge (C81A-M, C82A-H, C83A-M)	148,7	4,0	84,6	60,1	88,6
C1	Klip	C13	Klip (C13A-H)	37,3	0,7	22,1	14,5	22,8
	Grootdraai	C11	Grootdraai (C11A-L)	87,2	5,0	70,6	11,6	75,6
	Grootdraai to Vaal Dam	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	60,2	2,2	50,1	7,9	52,3
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	51,0	1,3	42,7	7,0	44,0
	Klip	C22	Klip (C22A-E)	30,7	3,7[(1)]	13,1	13,9	16,8
	Mooi	C23	Mooi (C23D-K)	78,0	9,0	25,1	43,9	34,1
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	61,4	3,4	44,8	13,2	48,2
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	39,0	4,5	32,4	2,1	36,9
Total (Mpumalangaanga)				**150,3**	**7,4**	**120,6**	**22,3**	**128,0**
Total (Free State)				**224,1**	**7,1**	**136,7**	**80,3**	**143,8**
Total (Gauteng)				**161,4**	**8,6**	**111,6**	**41,2**	**120,2**
Total (North-West)				**57,6**	**10,7**	**16,5**	**30,4**	**27,2**
TOTAL IN WMA				**593,4**	**33,8**	**385,4**	**174,2**	**419,2**

Note: (1) Adjusted from 1,7 to 3,7 by WRSA consultant. Zuurbekom Wellfield abstractions by Rand Water are 10 Mℓ/ day (3,7 x $10^6 m^3/a$).

6.3 SURFACE WATER RESOURCES

6.3.1 Streamflow data

The basis for the analysis of surface water resources for all WMAs was the synthesised streamflow data at quaternary catchment level developed for the Water Research Commission funded study of the water resources of South Africa (Midgley et al, 1994), which is commonly referred to as WR90. Certain adjustments, as described below, were made to these flow sequences.

The WR90 naturalised flows have taken account of afforestation-related streamflow reductions according to the “Van der Zel curves”. Recently these curves have been seen as too simplistic, and have been superseded by the “CSIR curves”. These curves allow the species, age and site conditions of the afforested area to be taken into account in estimating the streamflow reduction, and are currently the preferred estimation method.

For the purpose of the Water Situation Assessment Model it was decided to adjust the WR90 quaternary naturalised flows to reflect the CSIR afforestation-related streamflow reduction effects. An investigation to determine a method of making the adjustments without serious time or cost implications was conducted (Ninham Shand, 1999). The selected method consisted of the following steps:

(1) The afforestation water use time series based on the Van der Zel 15-year rotation curve was generated.

(2) This time series (the result of (1)) was then subtracted from the Van der Zel-based naturalised flow time series generated for the whole calibration catchment.

(3) The naturalised flow from the afforested portion of the catchment (Van der Zel-based) was used to obtain an afforestation water use time series based on the CSIR curves. This result was added to the result of (2), yielding a time series of adjusted (CSIR-based) naturalised flows.

These adjusted flows have been used for the catchments that contain afforestation.

A validation of this adjustment method was carried out for five gauged catchments from three geographically different regions, which had full hydrological studies available from recent basin studies. Calibration configurations were obtained from these studies. An identical configuration was set up to include the CSIR afforestation-related flow reduction function, and the Pitman model was recalibrated. This resulted in two “calibrated” sets of Pitman model parameters for each catchment, the one using the Van der Zel, and the other using the CSIR afforestation-related streamflow reduction functions.

Monthly naturalised flows were simulated using the two calibrated parameter sets. The CSIR series was used as the "true" series for validation and compared with the Van der Zel time series after it was adjusted as described above.

Differences between the MARs of the adjusted (CSIR-based) naturalised flows and the re-calibrated "true" naturalised flows were within 5%, which was considered to be acceptable.

Based on the three steps described above, the WR90 naturalised flow series were then adjusted for all the afforested quaternary catchments in the country. If the runoff reduction due to afforestation estimated by means of the CSIR curves was lower than the runoff reduction estimated by means of the Van der Zel curves, the virgin runoff of WR90 would have been reduced and vice versa. The difference between the adjusted MARs and the original WR90 values ranges between a reduction of 18% and an increase of 28%. For most of the catchments the difference varies between zero and an increase of 7%.

The proposed methodology ensures that the calculated runoff from an afforested catchment (which would be observed at a streamflow gauge) is the same, irrespective of the afforestation water use model that has been used.

The most important limitations of the method described above are:

- The updated afforestation water use was estimated by means of the CSIR curves (as described in (3)), but the uncorrected naturalised flows based on the original Van der Zel curves were used as an input into this calculation. As a refinement, one could consider the possibility of repeating the process, but this time estimating afforestation water use, not using the original WR90 naturalised flows, but rather the newly adjusted ones. This could then be used to make a second estimate of the CSIR-based natural flows. Further re-iterations of this process might improve the accuracy.

- Catchments upstream of some calibration gauges contained quaternary catchments with and without afforestation. Changing the MARs of only afforested quaternary catchments therefore made the naturalised MAR of the total catchment less accurate, as the MARs of unafforested catchments were not adjusted.

The perfect solution is to re-calibrate all affected catchments. However, this is not necessary in this WMA because there is no appreciable afforestation.

The primary source of information was the "Surface Water Resources of South Africa 1990", hereinafter referred to as WR90 which was undertaken by a consortium involving Steffen, Robertson and Kirsten Inc., Stewart Scott Inc. and Watermeyer, Legge, Piesold and Uhlmann (now Knight Piesold) for the Water Research Commission which was completed in 1994. This publication is the only one that provides water resources information down to the quaternary catchment level. It is of interest to report on some of the more important problems encountered by the WR90 team, as they give an insight as to the reliability of the hydrology of the Vaal River catchment.

The increasing aridity of the catchment with progress westwards presented a problem in preserving a mass balance as more rivers converge towards the western portion of the catchment. In this area channel losses are significant and the contribution from tributaries are difficult to define because they are relatively insignificant in relation to the flow in the Vaal River.

The catchment of the Vaal Barrage also presented problems for a number of reasons. Flow gauging stations within this heavily populated and industrialised region are scarce relative to the large number of effluent discharge points, making it difficult to conduct meaningful simulations without extensive data processing to accommodate all the abstractions and effluent discharges.

A further problem was the lack of information on small unregistered dams in the Vaal River catchment.

The latter two problem areas (i.e. modification of hydrology by effluent discharges and by small dams) were addressed to a large extent in the "Vaal River System Analysis Update" study (BKS et al, 1998d, 1998e, 1998f), hereinafter referred to as the VRSAU study. As part of this study the hydrology of the Vaal River catchment was studied in some detail. Four reports were issued, covering the following catchment sub-divisions: Upper Vaal, Vaal Barrage, Middle Vaal and Lower Vaal. This study was undertaken by a consortium involving BKS Inc., Stewart Scott Inc. and Ninham Shand Inc. for DWAF and reports were finalised in January 1999. Information on small dams was obtained from satellite imagery (Upper Vaal River catchment only) and from 1:50 000 scale mapping (remainder of catchment). In modelling the Vaal Barrage catchment, account was taken of all known abstractions and discharges. Furthermore, an attempt was made to simulate the enhanced runoff from the urbanised areas.

A summary of some of the more important problems encountered in the VRSAU study (in addition to those of the WR90 study) is given below.

Upper Vaal catchment

Of the many streamflow gauges in the catchment, most are of little use due to unfavourable locations or short records, some of which are also unreliable. Only six gauges were selected, namely Delangesdrift in the Klip River (C1H002), Frankfort in the Wilge River (C8H001), Standerton in the Vaal River (C1H001), supplemented by Grootdraai Dam (C1R002) and Vaal Dam (C1R001), supplemented by Engelbrechtsdrift (C2H003).

Vaal Barrage catchment

The hydrological analysis was hindered by the lack of reliable streamflow gauges in the tributary catchments. It was also impossible to obtain a satisfactory mass balance between outflow from Vaal Dam and releases from the Barrage (C2R008). The latter is a gated structure designed primarily for control of the water level upstream, with flow measurement of secondary importance. Accordingly, the hydrological analysis was extended further downstream to station C2H018 at Schoemansdrift, where a satisfactory balance was obtained.

Downstream of the Vaal Barrage

Modelling of the Mooi River hydrology was difficult, owing to the dolomitic nature of the catchment, coupled with extensive dewatering by some of the mines in the catchment.

Strategically located gauges in other sub-catchments that were identified as being unreliable are listed below.

Mooi River at Hoogekraal (C2H085) and at Klipdrift Dam (C2R005)

Assessment of MAR

As stated in the previous section, only the WR90 information is presented at a quaternary catchment level. However, as the Vaal River Ssystem Aanalysis Update study (VRSAU) was undertaken at a greater level of detail, these hydrological assessments should be the more reliable. Accordingly, the VRSAU estimates of MAR were used to verify/adjust the WR90 data on the basis of comparisons at key points in the Vaal River catchment.

Prior to any adjustments an assessment was made concerning the impact on natural MAR of the different periods adopted in the WR90 and VRSAU studies. WR90 covered the period 1920 to 1989 and VRSAU covered the period 1920 to 1994. The additional five years included by VRSAU had a minimal impact, resulting in reductions of about one percent in natural MAR. It was, therefore, considered unnecessary to make any adjustments to cater for the different periods.

The method of adjustment is very simple, as shown below:

Let:

MK_{WR90} = Incremental MAR at key point from WR90
MK_{VRSAU} = Incremental MAR at key point from VRSAU
MQ_jK_{WR90}= MAR of j^{th} Quaternary in incremental catchment

Then, for each of the quaternary catchments making up the incremental catchment, the adjusted natural MAR is as follows:

MQ_jK_{ADJ}= Adjusted MAR of j^{th} Quaternary in incremental catchment
$= MQ_jK_{WR90} \times MK_{VRSAU} / MK_{WR90}$

Table 6.3.1.1 summarises the adjustments made on the basis of MAR comparisons at key gauge points. The adjusted natural MARs of each quaternary catchment are given in **Appendix G.1**.

TABLE 6.3.1.1: ADJUSTMENT OF QUATERNARY CATCHMENT MAR'S.

Key gauge point	Quaternary catchments making up incremental catchment	Natural Incremental MAR ($10^6 m^3$)		Adjustment ratio
		WR90	VRSAU	
C1R002	C11A – C11L	514,0	457,7	0,890
C1H002	C13A – C13F	253,4	249,5	0,985
C2H004	C21A – C21G	141,7	92,3	0,651
C2H071	C22A – C22E	70,2	91,8	1,308
C2R008	C22F – C22K	61,4	68,5	1,116
C2H018	C23A – C23C	68,0	42,6	0,626
C2R003	C23F	23,5	37,4	1,592
C2R001	C23D,E,G	45,5	48,8	1,073
C2H001	C23H	10,6	10,7	1,009
C2R005	C23J	34,0	20,7	0,609
C2H085	C23K,L	57,3	34,7	0,606
C8H001	C81; C82; C83A – C83J	824,8	751,4	0,911
C1R001	C11M; C12; C13G,H; C83K,L,M	476,6	518,7	1,088
Total		**2 581,0**	**2 424,8**	

It was not considered necessary to adjust MAR's due to afforestation because there is negligable afforestation in this WMA. The original WR90 MAR's were used for the determination of non-dimensionalised storage/yield curves. This does not give rise to any inconsistency because they are non-dimensionalised.

Table 6.3.1.2 summarises natural MAR at the tertiary catchment level and gives a comparison between the original MARs of the WR90 study and the adjusted values. Reasons are given for cases where the adjusted MAR differs substantially from the WR90 estimate.

TABLE 6.3.1.2: TERTIARY CATCHMENT MAR.

Tertiary Number	Description	Net area (km^2)	Natural MAR ($10^6 m^3$)		
			WR90	Adjusted	Change
C11	Upper Vaal	8 791	548,1	494,9	-53,2[1]
C12	Waterval, upper Vaal	6 498	296,7	322,9	+26,2
C13	Klip (upper Vaal)	5 182	291,6	291,1	-0,5
C21	Suikerbosrand	3 541	141,7	92,3	-49,4[2]
C22	Klip (middle Vaal)	5 110	131,6	160,3	+28,7
C23	Mooi	7 733	238,9	192,9	-46,0[3]
C81	Upper Wilge	6 167	450,5	410,4	-40,1
C82	Lower Wilge	4 471	198,0	180,3	-17,7
C83	Liebenbergsvlei	7 529	283,9	277,6	-6,3
TOTAL		**55 022**	**2 581**	**2 422,7**	**-158,36**

Notes:
1. Quality of C1R002 (Grootdraai Dam) record doubtful at time of WR90 study
2. Calibration on C2H004 record indicated lower runoff for Suikerbosrand
3. In the WR90 study there was no river bed loss information. This information was available for the VRSAU study and as this is a dolomitic area, there was an appreciable difference.

The mean annual naturalised surface runoff is shown in **Figure 6.3.1**.

Diagram 6.3.1 provides a comparison of natural MAR at the secondary catchment level. The diagram shows the revised natural MAR's to be generally lower than the WR90 values. **Figure 6.3.1** gives the mean annual naturalised surface runoff per quaternary.

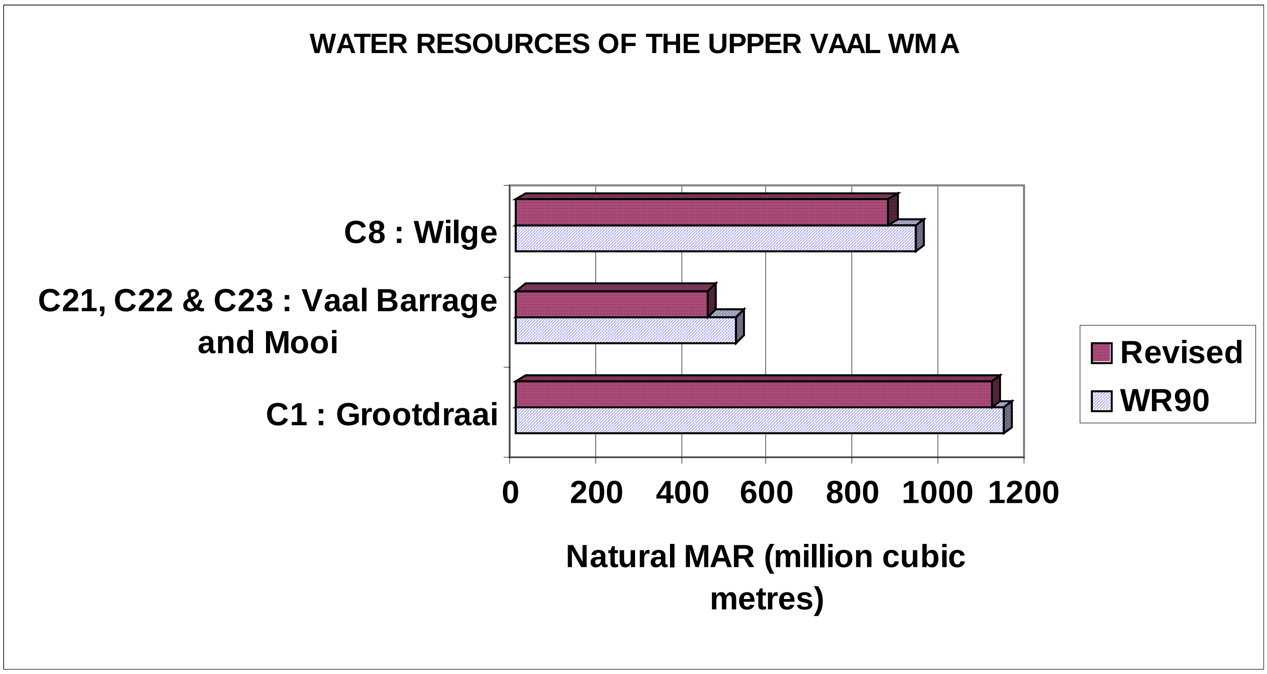


Diagram 6.3.1: Water Resources of the Upper Vaal WMA.

6.3.2 Yield Analysis

In order to estimate the total potential yield available from the catchments within the WMA, future storage dams of a particular maximum net storage capacity have been postulated. The net incremental storage capacities that have been adopted within the WMA are given in **Appendix G.1** for all the quaternary catchments. These normally range from lower percentages of MAR for higher rainfall catchments to higher percentages of MAR in the drier catchments but the presence of dolomitic outcrops in the Upper Vaal WMA affects this trend in the range from 100% to 200% of the MAR. **Table 6.3.2.1** shows the comparison between actual dam storage (major and farm dams) and postulated dam storage based on estimates of maximum feasible storage for the tertiary catchments in the Upper Vaal WMA.

TABLE 6.3.2.1: COMPARISON BETWEEN POSTULATED DAM STORAGE AND ACTUAL STORAGE.

Tertiary Number	Description	Existing Storage ($10^6 m^3$)	Postulated storage ($10^6 m^3$)
C11	Upper Vaal	409,6	989,7
C12	Waterval, Upper Vaal	31,1	645,8
C13	Klip (Upper Vaal)	14,9	582,3
C21	Suikerbosrand	23,4	184,7
C22	Klip (Middle Vaal)	320,6	20,8
C23	Mooi	290,9	68,5
C81	Upper Wilge	2 633,2	820,9
C82	Lower Wilge	7,2	360,7
C83	Liebenbergsvlei	2 587,3	555,3
TOTAL		**6 318,2**	**4 228,7**

Note : It is unrealistic to compare existing storage and postulated storage in this WMA. Some key areas show a higher existing storage than postulated storage because water is coming in from outside the WMA, e.g Sterkfontein Dam. In other key areas, existing storage is lower than postulated storage but this does not mean that the key area is underdeveloped. The entire Vaal catchment is fully developed on a macro scale.

Dams that will capture and regulate all the runoff from a catchment are not economical to build. In the drier areas where the runoff is more variable the sizes of such dams also become prohibitive. A simple technique, based on past experience, has therefore been developed whereby plausible estimates of maximum feasible dam size have been derived for the entire South Africa and which will provide consistent results throughout the country. The water balance model will however, be enhanced in future to contain additional functionality to allow users to optimise the likely maximum storage capacity.

The technique that was adopted introduces a limit line to the net storage-gross yield relationship for a 50-year recurrence interval, as shown in **Diagram 6.3.2.1**. The net total incremental quaternary catchment storage capacity used to estimate the potential contribution to the yield by a quaternary catchment has been determined from the intersection of the net storage–gross yield relationship for a 50-year recurrence interval for a particular hydrologic zone, and the limit line shown in **Diagram 6.3.2.1**. This is illustrated by means of the typical net storage-gross yield relationships shown in **Diagram 6.3.2.1** for rivers of low, moderate and high flow variability, which generally correspond to rivers draining high, moderate and low rainfall catchment areas respectively. The net total incremental storage capacities derived by means of this method have been rounded off to 100%, 125%, 150%, 200%, 250%, 300% and 400% of the MAR as appropriate.

Table 6.3.2.2 gives details on surface water resources.

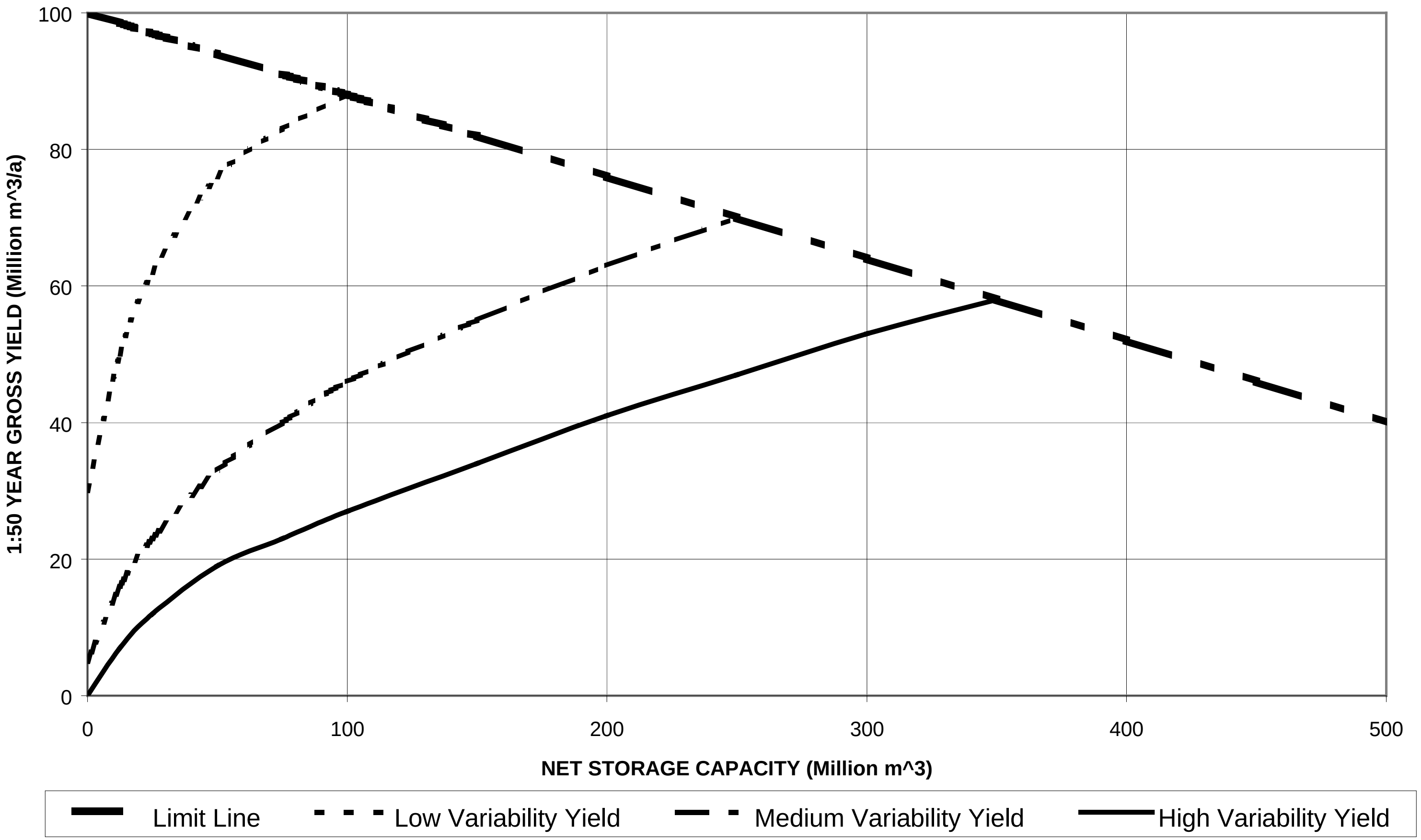


DIAGRAM 6.3.2.1: DAM STORAGE LIMITS

TABLE 6.3.2.2: SURFACE WATER RESOURCES.

CATCHMENT				CATCHMENT AREA (km^2)	MEAN ANNUAL PRECIPITATION (mm)	GROSS MEAN ANNUAL SYMONS PAN EVAPORATION (mm)	NATURALISED MAR		YIELD (1:50 YEAR)	
SECONDARY		TERTIARY					INCREMENTAL ($10^6 m^3/a$)	CUMULATIVE ($10^6 m^3/a$)	DEVELOPED IN 1995 ($10^6 m^3/a$)	TOTAL POTENTIAL ($10^6 m^3/a$)
No.	**Description**	**No.**	**Key Area Description**							
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	18 170	673,7	1 343,0	868,3	868,3	64,1	64,1
C1	Klip	C13	Klip (C13A-H)	5 182	699,2	1 416,0	291,1	291,1	7,6	7,6
	Grootdraai	C11	Grootdraai (C11A-L)	7 995	689,8	1 450,0	457,7	457,7	288,6	288,6
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11, C12A-L)	7 294	636,8	1 573,0	360,0	1 108,8	109,0	109,0
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	3 541	685,5	1 617,0	92,4	92,4	99,8	99,8
	Klip	C22	Klip (C22A-E)	2 282	686,9	1 637,0	96,2	96,2	293,2	293,2
	Mooi	C23	Mooi (C23D-K)	5 034	617,1	1 685,0	113,0	113,0	16,3	16,3
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	2 828	633,2	1 648,0	68,5	2 234,2	1 691,7	1 691,7
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	3 239	612,5	1 640,0	75,6	2 422,8	-8,0	-8,0
Total (Mpumalanga)				**15568**	**675**	**1501**	**855,6**	**#**	**&**	**&**
Total (Free State)				**26848**	**651**	**1460**	**240,1**	**#**	**&**	**&**
Total (Gauteng)				**8202**	**663**	**1638**	**1208,6**	**#**	**&**	**&**
Total (North-West)				**4947**	**615**	**1684**	**118,5**	**#**	**&**	**&**
TOTAL/AVERAGE IN WMA				**55 565**	**659**	**1 557**	**2 422,8**	**#**	**2 562,3**	**2 562,3**

Note : & Not readily available
Not applicable.

Using WR90 information, present day gross yields (1995) were determined for selected areas and have been shown in **Diagram 6.3.2.2**. These figures are gross yield and therefore cannot be compared with the net yields in **Table 6.3.2.2**.

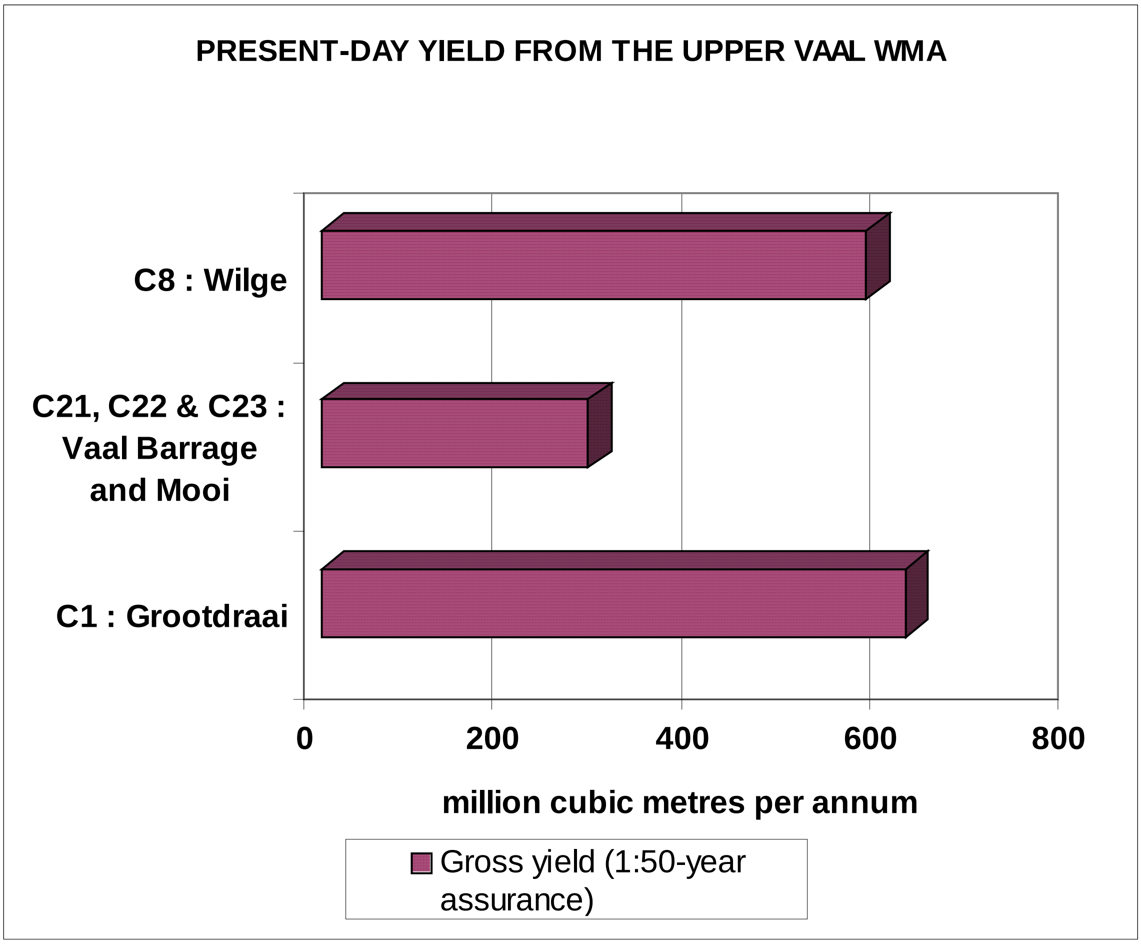


Diagram 6.3.2.2: Present day yield from the Upper Vaal WMA

6.4 WATER QUALITY

6.4.1 Mineralogical Surface Water Quality

The purpose of this assessment is to provide an indication of where water quality problems can be expected rather than provide a comprehensive overview of water quality in the WMA.

The mineralogical water quality of the surface water bodies is only described in terms of total dissolved salts (TDS). Data for the assessment were obtained from the water quality data base of the Department of Water Affairs and Forestry.

There are three water quality monitoring networks in the study area. Two belong to DWAF and the third to Rand Water. Water quality monitoring is carried out at streamflow gauging stations and reservoirs. There is also a more informal network of certain points where mine effluent is returned to streams, canals etc. and this monitoring is carried out by various industries. In the Upper Vaal WMA there are of the order of 63 DWAF flow measuring stations of which about 34 have water quality measurements of some frequency taken. DWAF have about 9 reservoirs most of which have weekly quality measements taken. Rand Water have about 38 flow measuring stations of which about 32 have water quality measurements taken.

Sampling of water quality should preferably take place at flow monitoring stations. Sampling frequency can be divided into the following four classes, namely:

- Continuous.
- Weekly.
- Monthly.
- Irregular.

Full details of the water quality monitoring networks can be found in the DWAF reports on the Vaal River Salinity Study: Water quality monitoring requirements for salinity modelling Volumes I to III (DWAF, 1993).

Only data sets that had data for the last five years (1990 to 1995) were used. The data sets were filtered to monthly data, and various techniques were used to fill in missing values where possible. Only those data sets that spanned at least two years and contained at least 24 data points were eventually selected for analysis. These were used to derive the mean and maximum TDS concentrations.

Details of the TDS and electrical conductivity (EC) for the various catchments are given in **Appendix G.4**.

The water quality is described in terms of a classification system developed for this water resources situation assessment. The uses that were taken into account were domestic use and irrigation. It was assumed that if the water quality met the requirements for domestic and irrigation use it would in most cases satisfy the requirements of other uses. The South African Water Quality Guidelines of the Department of Water affairs and Forestry (1996) for these two uses were combined into a single classification system as shown in **Table 6.4.1.1**.

TABLE 6.4.1.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY.

Class	Colour Code	Description	TDS Range (mg/ℓ)
0	Blue	Ideal water quality	<260
1	Green	Good water quality	260 – 600
2	Yellow	Marginal water quality	601 – 1 800
3	Red	Poor water quality	1 801 – 3 400
4	Purple	Completely unacceptable water quality	>3 400

Where water quality data were available, water quality was assessed at a quaternary catchment level of resolution. The final classification of the mineralogical surface water quality of a quaternary catchment was based on both average conditions and extreme conditions. For this purpose the data set was inspected for the worst two-year period observed. The average concentration and the maximum were used to determine the class of the water as shown in **Table 6.4.1.2**.

TABLE 6.4.1.2: OVERALL CLASSIFICATION.

Average Concentration Class	Maximum Concentration Class	Overall Classification
Blue	Blue	Blue
	Green	Green
	Yellow	Green
	Red	Yellow
	Purple	Purple
Green	Green	Green
	Yellow	Yellow
	Red	Yellow
	Purple	Purple
Yellow	Yellow	Yellow
	Red	Red
	Purple	Purple
Red	Red	Red
	Purple	Purple
Purple	Purple	Purple

The surface water quality class of the Upper Vaal WMA is summarised in **Table 6.4.1.3**. The surface water class is shown in **Figure 6.4.1.1**.

TABLE 6.4.1.3: SUMMARY OF MINERALOGICAL SURFACE WATER QUALITY OF THE UPPER VAAL WMA.

Secondary Catchment	No. of Quaternary Catchments	No of Quaternary Catchments in Class					
		Blue	Green	Yellow	Red	Purple	No Data
C1	31	3	4	1	0	0	23
C2	30	1	5	8	0	0	16
C8	32	4	6	0	0	0	22

The mineralogical surface water quality of the Upper Vaal WMA is generally not good. **Section 6.4.4** gives details on the issues of concern

6.4.2 Mineralogical Groundwater Quality

The ground water quality is one of the main factors affecting the development of available ground water resources. Although there are numerous problems associated with water quality, some of which are easily remediated, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (Simonic, 2000). The mean TDS together with the highest value, lowest value and range is given for each catchment where analyses were available. Where no analyses were available an estimate of the mean was made using Vegters Maps (Vegter, 1995). The potability evaluation done by Simonic (Simonic, 2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The portion of the ground water resources considered potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) and according to Quality of Domestic Water Supplies, Volume I (DWAF, 1998). Water classified as poor and unacceptable (Class 3 and 4) has been considered **not** potable.

In catchments where no information was available estimates of the portion potable were made using Vegters maps (Vegter 1995).

Figure 6.4.2.1 gives an evaluation of the mean TDS per quaternary catchment and **Figure 6.4.2.2** gives an estimate of the % potable water per quaternary catchment

6.4.3 Microbiological (or Microbial) Water Quality

Background

A method was developed and applied to assess the risk of microbial contamination of surface water and groundwater resources in South Africa. (Refer to **Appendix G.3** for details of the study). Maps depicting the potential vulnerability of surface water and groundwater to microbial contamination were produced at a quaternary catchment resolution. The maps provide a comparative rating of the risk of faecal contamination of the surface water and groundwater resources. The microbial information that has been provided is, however, intended for planning purposes only and is not suitable for detailed water quality assessments.

Mapping microbial contamination of surface water resources

As part of the National Microbiological Monitoring Programme a screening method was developed to identify the risk of faecal contamination in various catchments. This screening method uses a simple rule based weighting system to indicate the relative faecal contamination from different land use areas. It has been confirmed that the highest faecal contamination rate is derived from high population densities with poor sanitation services. The Programme produced a map, at quaternary catchment resolution, showing the potential faecal contamination in the selected catchments. Unfortunately, the map did not cover the entire country.

As part of this study, the same screening method was applied to produce a potential surface faecal contamination map for the whole of South Africa using national databases for population density and degree of sanitation. The portion applicable to the Upper Vaal WMA is given in **Figure 6.4.3.1**.

Mapping aquifer vulnerability of groundwater resources

Certain aquifers are more vulnerable to contamination than others. The DRASTIC method used in this study is an acknowledged method for assessing aquifer vulnerability to contamination. The method is a weighting and rating technique that considers up to seven geologically and geohydrologically based factors to estimate groundwater vulnerability. The magnitudes or severities of pollution sources are, however, not considered. Three of the above factors were used in this study to estimate the vulnerability of groundwater to microbial contamination.

Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider groundwater depth, soil media and impact of the vadose zone media. Comparison of the different maps showed remarkable similarity and confirmed that the vulnerability is largely controlled by the selected three parameters. This similarity promotes confidence in the resultant microbial contamination vulnerability map.

A GIS model, which considered the three factors, was developed and a vulnerability rating of low, medium and high was calculated for each grid element in the GIS coverage. A numerical control was included to account for deep groundwater below 35 metres. At this depth it was assumed that the surface contamination rate would be low, irrespective of the other two factors.

Mapping microbial contamination of groundwater resources

The potential surface faecal contamination and aquifer vulnerability maps were then intersected to derive a potential groundwater faecal contamination map for South Africa at a quaternary scale. The portion applicable to the Upper Vaal WMA is given in **Figure 6.4.3.2**. This map shows the degree of potential faecal contamination in groundwater using a rating scale which ranges from low to medium to high.

Conclusions and recommendations

A limitation of the study was the inability to validate results due to the limited information on groundwater contamination resulting from human wastes.

Once sufficient microbial data becomes available, the numerical methods and associated assumptions should be validated and the maps replotted. Monitoring data from selected areas should also be collected to assess the validity of the vulnerability assessment presented in this report.

6.4.4 Water Quality Issues

The Vaal Dam catchment (C1 and C8 secondary catchments)

The Vaal Dam catchment is subject to the effects of atmospheric deposition. A recent study (Herold and Taviv, 1997) indicates that by 1995 these effects had increased the TDS concentration of the Klip River catchment by 24 mg/ℓ (22%) and sulphate concentration by 17 mg/ℓ (1 200%)..

Problems with oxygen demanding substances, nutrients and bacteriological pollutants occur at existing sewage treatment works and downstream of expanding informal settlement areas.

There are no significant aquifers in this catchment

Vaal Barrage catchment (C21 and C22 tertiary catchments)

The Vaal Barrage catchment (C21 and C22 secondary catchments) is subject to extensive urban, industrial and mining development that has resulted in extremely large pollutant loads.

Over the last 20 years the Vaal Barrage catchment contributed nearly half of the salt load of the entire Upper Vaal WMA, from only 16% of the catchment area. The average TDS concentration of the runoff from the developed portions of the catchment was 5,4 times higher than that of the Vaal Dam catchment.

Most of the TDS pollutant load (71%) emanated from the Klip River catchment (C22A toC22E quaternary catchments), which comprises 26% of the catchment area. The Blesbokspruit and the Groot Rietspruit each contributed a further 10%. The relatively small upper portion of the Klip River catchment (1 574 km^2 - only 2,9% of the WMA) contributed 45% of the salt load. The salt load export per unit area of this catchment was more than 20 times higher than that of the Vaal Dam catchment. About 40% of the export load was associated with non-point sources.

The high TDS concentration of the runoff is attributable to extensive urbanisation, industrial development and mining activities.

The sulphate anion (up to 40% of the TDS) is strongly associated with the TDS loads, due to its predominance in the water pumped from underground gold mining workings. Calcium tends to be the predominant cation associated with this gold mining effluent. Sappi's effluent (C21D quaternary catchment) has a greater preponderance of sodium and chloride, which can be more problematic for irrigation use in the Blesbokspruit catchment.

Since 1995, Grootvlei Gold mine has resumed pumping, and now has to pump large quantities of underground water to the Blesbokspruit (quaternary catchment C21E) that were previously discharged to the Klip River catchment via the now defunct Sallies Gold mine. This source now contributes a further $40x10^6$ m^3/a of saline (about 4 000 mg/ℓ TDS) water to the Blesbokspruit and its RAMSAR wetland.

Operating collieries are located in the Vereeniging-Vanderbijlpark-Sasolburg area adjacent to the Vaal River, while old abandoned coal mine workings are located adjacent to the Blesbokspruit. These operations also give rise to salinity problems.

The large Lethaba power station is located in quaternary catchment C22F. However, significant pollution from this source has not been recorded, mainly because it is a zero discharge entity, with the entire excess blow down water being absorbed by the ash heaps.

The Sasol I petrochemical industry results in significant discharge of saline effluent, which is discharged to the Vaal River just downstream of Vaal Barrage. This effluent is also characterised by high fluoride and boron concentrations. A discharge of about 2,5 m^3/s has to be maintained from Vaal Barrage to ensure dilution of the fluoride and boron to safe levels in the Vaal River. (This is easily achieved due to the magnitude of the downstream water demand.)

The Western Areas Gold Mine (WAGM) discharges water to the Groot Rietspruit catchment (quaternary catchment C22J). The TDS concentration of this effluent is significantly lower than that of the Central and Eastern Witwatersrand gold mines.

Extensive urban and industrial centres are located in the upper portion of the Klip River (C22A, C22B and C22D quaternary catchments) and Suikerbosrand (C21D and C21E quaternary catchments). Further such development is found in the lower portion of the catchment surrounding the Vaal River in the Vereeniging–Vanderbijlpark–Sasolburg area. Associated Water Care Works and informal settlements result in elevated nutrient, *E-coli* and COD levels. In the case of the Blesbokspruit, these concentrations are decreased to almost negligible levels by the extensive wetland system. However, it is unknown for how long the wetland can continue to absorb nutrients before breakthrough occurs. Significant decay also occurs in the upper portion of the Klip River below Johannesburg's wastewater treatment works. However, there is little evidence of decay in the Klip River below its confluence with the Riet River. As a result the lower Klip River results in a significant contamination of the Vaal Barrage. Vaal Barrage is subject to frequent algal blooms. The relatively short detention time and high turbidity limit more serious and frequent eutrophication of this water body.

Irrigation along the Klip River, Rietspruit and Blesbokspruit and lower Suikerbosrand is adversely affected by salinity. This is particularly so for the Blesbokspruit / Suikerbosrand since the resumption of pumping at higher rates and salinity from Grootvlei mine. Salt concentrations in the Klip River and Rietspruit have declined in line with the reduction in mining activities. Bacterial pollution also imposes limits on irrigation practice, particularly for overhead spray irrigation of vegetables. It can also adversely affect dairy farming.

This catchment contributed about 6,5% to the salt load of the Upper Vaal WMA during the last 20 years. This was from 8,9% of the catchment area, giving a similar net export to the Vaal River per km^2 of catchment as for the Vaal Dam catchment. However, it must be stressed that Boskop Dam (largely for irrigation) and Potchefstroom exploited much of the runoff from the Mooi River catchment before discharge to the Vaal River. The TDS of this runoff was significantly elevated by mining activities in the Mooi River catchment.

Mining has led to significant contamination of the Mooirivierloop (quaternary catchments C23D and C23E). The average TDS concentration at the end of quaternary catchment C23E was 1 088 mg/ℓ. Problems have also been cited regarding radionuclides. The extensive underlying dolomitic compartments also appear to be significantly contaminated. These problems have been compounded by earlier attempts to fill sinkholes with mine tailings. The full extent of the contamination is hard to gauge since the affected dolomitic compartments have been de-watered by mining activities.

The Loopspruit is also affected by mining discharges (C23J).

The Mooi River is also affected by effluent discharges. Significant phosphate pollution appears to arise from non-point sources in the industrial area of Potchefstroom (C23H).

Water quality in the Vaal River between Vaal Barrage and its confluence with the Mooi River is dominated by the discharge from Vaal Barrage. Nutrient levels are affected locally by input from the Parys and Vanderbijlpark wastewater treatment works.

Rand Water does abstract water from the Zuurbekom dolomite aquifer on the West Rand where there is some concern that this aquifer is vulnerable to pollution. Detailed information on groundwater supply and areas of concern are given in the report produced by Water Service Division of DWAF (DWAF, 1999).

Water quality issues are shown in **Figure 6.4.4.1**.

6.5 SEDIMENTATION

Introduction

Sedimentation was originally analysed according to river basin (by the consultant using data from Rooseboom) i.e the Upper Orange Basin and Vaal Basin. Sediment yield from the Upper Vaal WMA varies from less than 5 tonnes/km^2/a in dolomitic catchments and areas of very low runoff to almost 200 tonnes/km^2/a in the southern and south eastern regions. For the Upper Vaal WMA the average sediment yield is about 147 tonnes/km^2/a (refer to **Appendix G.2**, sediment yield (t/a) divided by the total gross area (km^2)). The total sediment load is of the order of 8 million tonnes/a, which is equivalent to an average annual volume of about 6 million cubic metres after 25 years of sediment deposition. For the Upper Vaal WMA, this volume amounts to about 0,2 % per year of the mean annual runoff.

Sources of information

The primary source of information was the report entitled “The development of the new sediment yield map of southern Africa”, (Rooseboom et al., 1975) The results of this investigation were incorporated into the “Surface Water Resources of South Africa 1990” (WR90) set of reports (Steffen et al, 1994). The WR90 reports were the most convenient to use as the sediment map was superimposed on the quaternary catchment sub-divisions.

Another useful source of data is to be found in the periodic surveys of major reservoir basins, undertaken by DWAF. This information can be used to detect the rate of decrease in storage capacity over time, which can be attributed to the accumulation of sediment in the reservoir basins.

Sediment yields from map by Rooseboom et al

The sediment map is based on two layers of information. The first layer divides the country into nine sediment yield regions with an associated medium yield, expressed in tonnes/km^2/annum. The second layer depicts the erodibility index, which varies between 1 (highest erodibility) to 20 (lowest erodibility). These indices have been grouped into three classes, namely HIGH (1 to 8), MEDIUM (9 to 15) and LOW (16 to 20). Each sediment yield region has factors to apply to the medium yield, depending on whether the erodibility is high or low. (A factor of unity is applied in cases of medium erodibility.)

Each region has a family of confidence bands to indicate how, in most regions, the degree of confidence deteriorates as the catchment area decreases. However, as this WRSAS study covers the entire Vaal River catchment only the mean yield has been used.

Sediment yield for each quaternary catchment was determined using the data from the sediment map. For the Upper Vaal WMA, the results of this analysis appear in **Appendix G.2** and a brief summary of the results is given below.

Total sediment yield:	8,19 million tonnes/a
Gross catchment area:	55 565 km^2
Average yield:	147 tonnes per km^2 /a

Sediment yields from reservoir basin surveys

An important factor in the conversion of sediment volumes determined from basin surveys into mass is the variable density of sediment deposits. In order to overcome this problem an indirect method was developed by Rooseboom (Rooseboom et al, 1975) for converting volume into mass, which overcomes the difficulties involved in estimating average density at a given stage. The sediment volume in a reservoir (with high sediment trap efficiency) after a period of time has been found to follow a logarithmic relationship for accumulations longer than about 10 years. It was found that for a number of South African and USA reservoirs it was possible to express the volume of sediment deposit after t years (V_t), in relation to the sediment volume after 50 years (V_{50}), as follows:

$$V_t = V_{50} \times 0{,}376 \times \ln (t/3{,}5)$$

By means of this equation it is possible to convert the volume after t years into an equivalent volume after 50 years and vice versa. Choice of the 50 year volume as a reference is arbitrary but it is possible to estimate the average density after 50 years more accurately than after say 10 years. A density of 1 350 kg/m^3 for the 50 year sediment deposit was found to be appropriate for South African reservoirs.

In order to obtain 25 year sediment accumulation, the formula given above was used to determine the equivalent volume after 25 years. The appropriate density after 25 years accumulation was then determined proportionately. For both the Upper Vaal WMA it was found to be 998 kg/$m^{3.}$ Sediment yield (in tons/km^2/a) was then determined using the density for the 25 year accumulation period.

The calculations for sediment yields based on available reservoir surveys are set out in **Table 6.5.1**, which lists the dam name, record period, sediment volume at end of period (V_t), equivalent 50-year volume (V_{50}), net catchment area, equivalent 25-year volume (V25) and average sediment yield. Also listed for purposes of comparison are the sediment yields derived from Rooseboom's map (as published in WR90).

The potential for sediment accumulation in reservoirs in a 25 year period (as a percentage of MAR) is shown in **Figure 6.5.1**. In a few quaternary catchments with very low runoff, the value exceeded 100%. This is probably because the sediment map was based on soil characteristics. However, the great majority of quaternary catchments show realistic values and the few isolated over-estimations are in quaternary catchments where water resources are insignificant.

The surveyed sedimentation rates display a wide variation among the reservoirs, ranging from as low as 4 tonnes/km^2/a to as high as 200 tonnes/km^2/a. This wide range is attributable more to the inaccuracies inherent in assessing small differences between successive surveys than to actual differences in sediment yield. Another factor, which impacts on short record periods in particular, is the high variation in sediment load from year to year. Significant sediment deposits are associated with the major floods; thus several years may elapse with negligible sediment volumes being deposited.

The average sediment yield for all reservoirs was calculated to be 117 tonnes/km^2/a, which is about 20% lower than the figure derived from the sediment map.

Reconciliation of sediment yields from surveys and map

The difference between the two estimates of total sediment yield is considered to be acceptable in the light of the difficulties associated with measurement of sediment. As the sediment map produced the higher estimate for the Vaal catchment it was decided to accept the sediment loads obtained from this source. **Table 6.5.2** summarises the sediment data at the tertiary catchment level. **Appendix G.2** contains details of sediment load calculations for each quaternary catchment (WR90 information).

TABLE 6.5.1: RECORDED RESERVOIR SEDIMENTATION RATES FOR RESERVOIRS IN THE VICINITY OF THE UPPER VAAL WMA.

Dam name And quaternary catchment	Year Constructed or last raised	Year of last survey	Original Capacity (10^6m^3)	Surveyed Capacity (10^6m^3)	Sediment Volume (10^6m^3)	Number Of Years	V50 (10^6m^3)	Volume per year ($10^6m^3/a$)	Net catchment area (km^2)	Sediment Yield ($m^3/km^2/a$)	V25 (10^6m^3)	Sediment yield ($t/km^2/a$)	Yield from map ($t/km^2/a$)
Vaal (C12L)	1956	1978	2358	2195	163	22	235,82	4,71648	38 505	122,49	174,33	122,25	153
Boskop (C23G)	1958	1981	21,44	20,99	0,45	23	0,64	0,01271	3 287	3,87	0,47	3,86	153
Koppies (C70D)	1969	1976	46,67	41,2	5,47	7	20,99	0,41976	2 147	195,51	15,52	195,12	153
Saulspoort (C83B)	1969	1989	18,8	16,87	1,93	20	2,94	0,05890	746	78,95	2,18	78,80	82
						Totals	260	5,20785	44 685	116,60	193	116,37	147

TABLE 6.5.2: SEDIMENT YIELD FROM TERTIARY CATCHMENTS.

Tertiary Number	Description	Net area (km^2)	Sediment yield		
			($t/km^2/a$)	($10^6 t/a$)	($10^6 m^3/a$)
C11	Upper Vaal	8 791	153	1,348	1,351
C12	Waterval, Upper Vaal	6 498	153	0,996	0,998
C13	Klip (Upper Vaal)	5 182	153	0,795	0,796
C21	Suikerbosrand	3 541	153	0,543	0,544
C22	Klip (Middle Vaal)	5 110	153	0,784	0,785
C23	Mooi	7 733	153	1,186	1,188
C81	Upper Wilge	6 167	124	0,765	0,767
C82	Lower Wilge	4 471	153	0,686	0,687
C83	Liebenbergsvlei	7 529	144	1,083	1,086
TOTAL	Upper Vaal WMA	55 022	149*	8,190	8,202

* Higher than figure of 147 $t/km^2/a$ quoted earlier, which is based on gross catchment area..

CHAPTER 7: WATER BALANCE

7.1 METHODOLOGY

7.1.1 The Water Situation Assessment Model

The Water Situation Assessment Model (WSAM) was developed with the purpose of providing a reconnaissance level decision support tool. The model is intended to provide a broad overview of the water situation in South Africa taking into account all significant water uses and resources. The model can produce output at a variable resolution, down to quaternary catchment scale.

The data input to the model was gathered by various organisations and individuals, but the Water Resources Situation Assessments (WRSA) were the main vehicle for providing data for the model. Appendix H lists the organisations responsible for the various components of the data. This list also gives the reader a good indication of the type of data in the database.

The intention was to use the WSAM to determine the water balance for the WRSA reports and also to use the WSAM reporting tools to produce as many of the tables in the WRSA reports as was practical. However, due to various unresolved developmental problems with the WSAM, another approach was adopted, as described in this section. For this reason, the WSAM is not described in any detail in this report. The reader is referred to the WSAM user manual for more information on this model.

7.1.2 Estimating the water balance

The water balance is simply the difference between the water resource and the sum of all the water requirements and losses. While the water requirements and losses are easily abstracted from the database, to estimate the water resource directly from the known yields of dams would be difficult and impractical. The main reason for this is that the run-of-river component of the resource is difficult to determine without some form of modelling, especially where there are multiple dams and abstractions and the different modes of operation of the dams influence the yields.

The water balance produced by the WSAM is not yet correct in all cases due to the following unresolved problems:

- The ecological Reserve has spurious impacts on the water balance, which do not appear to be correct.
- The impacts of afforestation and alien vegetation, as reported on the balance do not appear to be correct.
- It is not possible to model actual known river losses.
- Return flows from irrigation are not modelled correctly.

The approach taken to determine the water balance was therefore to remove the above questionable components out of the WSAM modelling procedure. This is done relatively easily. The above impacts (ecological Reserve, etc.) were then determined external to the model and added or subtracted from the WSAM water balance as appropriate. This procedure achieved a resultant water balance that seemed to be in reasonable agreement with other estimates in most cases.

7.1.3 Estimating the water requirements

The water requirements determined by the WSAM are generally not correct. In order to facilitate the production of the WRSA reports, the database created by the consultant was compared with the data abstracted from the WSAM into a spreadsheet and various worksheets set up, which reference this abstracted data. These worksheet were structured so a to present most of the information contained in the tables of this report. This is not only limited to water requirements but also lists land uses such as irrigated areas, afforested areas, etc.

The data was abstracted in two different formats: at key area resolution (incremental between key points) and at quaternary catchment resolution. The key area data has been aggregated by the WSAM except for a few parameters relating mainly to irrigation, which the WSAM did not aggregate correctly. In these cases, default values were used. A list of these parameters and the default values is attached as Appendix H. The data at quaternary catchment resolution was abstracted for information purposes only. It is attached in the Appendixes to this report.

Water requirements or gains that the WSAM could not calculate were determined as follows:

Ecological Reserve

The impact of the ecological Reserve on the yield of a catchment depends on the storage in that catchment. It was accepted that the water required for the ecological Reserve follows the same general pattern of (i.e. mimics) the natural flow and that the storage/yield characteristics of the natural catchment could therefore also be used to estimate the yield of the catchment after allowing for the water requirements of the ecological Reserve. The estimates of the impact on the yield of a catchment were made separately for each of the incremental catchments between key points. The total storage within the incremental catchment was transposed to its outlet and formed the basis for determining the incremental yield of the catchment under natural conditions, both with and without provision for the ecological Reserve. The yields were estimated from the storage yield characteristics used in the WSAM for any particular recurrence interval of concern. The incremental impact of the ecological Reserve on the water resources of a particular key area was taken to be the difference between the impact at the downstream key point less the impact at the upstream key point.

The impact of the ecological Reserve on the run-of-river yield was accepted to be the annual equivalent of the lowest 4-month water requirement for the ecological Reserve. This value was used to establish the incremental impact of the ecological Reserve on the yield at a key point at which there was no significant storage in the incremental catchment.

Using the above method, negative impacts are sometimes possible. The reason for this is that the water required for the ecological Reserve at an upstream point may become available for use further downstream, if the ecological Reserve is less at the downstream point.

Water losses
The WSAM models losses as a function of the flow in the river. The water loss under natural flow conditions is used in the WSAM to calculate the water loss under the altered flow conditions. While this is conceptually correct, it is found to be very difficult to model the known loss under current conditions. For this reason, the WSAM was run with zero losses and the known losses taken into account external to the model when determining the water balance.

Irrigation return flows
The average return flow from irrigation in South Africa according to the WSAM is in the order of 3%. This is clearly erroneous and not in accordance with the 10% to 15% default agreed upon at various workshops. Irrigation return flows were therefore calculated external to the model and were usually assumed to be 10%. Where the consultant and/or other persons had more detailed information of the return flows that could be expected these were adopted instead.

7.1.4 Estimating the water resources

The WSAM does not report directly on the available water resource, as required for this WRSA report. This was therefore calculated external to the model:

The so-called effective yield balance produced by WSAM, as described in **Section 7.1** above, was mostly assumed correct (WRSA consultants estimates were preferred). There are a few instances where it was clearly incorrect and an adjustment was made based on the results of other studies. These changes have been documented. A few adjustments were made to the model to allow for the following.

Runoff into minor dams

It appears as if the WSAM assumes that the runoff into minor dams is equal to the entire incremental flow generated within a quaternary catchment. Considering the definition of a minor dam, i.e. a dam that is not situated on the main stream of the catchment, this is not possible. An assumption was made that only 50% of the runoff of a catchment flows into minor dams and this assumption was applied throughout the WMA.

Impact of afforestation and alien vegetation on catchment yield

The WSAM seems to determine the impact of afforestation and alien vegetation on yield in a realistic manner. However, it does not report correctly on what this impact is. This problem was resolved by adopting zero afforestation and alien vegetation in the catchments when running the WSAM and calculating these impacts external to the model. The impacts on the yield of the catchments were then accounted for external to the model when determining the water balance.

- The available water resource was then assumed to be the difference between the water balance and the water requirements that are supplied from the catchment.

- In some cases, there are negative balances within the quaternary catchments making up a key area. These negative balances are not routed through the system, and it was therefore necessary to sum these negative balances and subtract them from the water resource.

- In some cases the WSAM did not model the yield of major dams correctly and the yield curves were adjusted to approximate the yield as obtained from more detailed studies.

7.2 OVERVIEW

Key areas were selected on the basis that they represented major dams, tertiary catchments or the outflows from tributaries into major rivers. **Table 7.2.1** lists the selected key areas for the Upper Vaal WMA.

TABLE 7.2.1: KEY POINTS FOR YIELD DETERMINATION.

LOCATION OF KEY POINT			DESCRIPTION
PRIMARY CATCHMENT		QUATERNARY CATCHMENT NO.	
NO.	KEY AREA NAME AND POINT		
C	Wilge – C83M outlet	C81A-M, C82A-H,C83A-M	C8 Secondary catchment
	Klip – C13H outlet	C13A-H	C13 Tertiary catchment
	Grootdraai – C11L outlet	C11A-L	Grootdraai Dam
	Grotdraai to Vaal Dam – C12L outlet	C11M, C12A-L	Vaal Dam (together with C8)
	Suikerbosrand – C21G outlet	C21A-G	C21 Tertiary catchment
	Klip – C22E outlet	C22A-E	Klip River catchment
	Mooi – C23K outlet	C23D-K	Mooi River catchment
	Vaal Dam to Vaal Barrage – C22K outlet	C22F-K	Barrage catchment
	Barrage to Mooi	C23A-C, C23L	Remaining Vaal River catchment in the Upper Vaal WMA

The 1995 water requirements (at equivalent 1:50 year assurance) for key areas are summarised in **Table 7.2.2**. The total requirement for this WMA is estimated to be 1 559 x $10^6 m^3/a$. This figure excludes evaporation from dams and wetlands, river losses in the Wilge key area because the available yield provided by the DWAF takes these ‘requirements’ into consideration. **Table 7.2.3** summarises the water balance for key areas. It is estimated that in 1995 about 678 x $10^6 m^3$ was available to the downstream Middle Vaal WMA.

In terms of estimating the water requirements of the WMA and the water requirements of key areas it is important to note that transfers (exports) affect the balance in different ways. For example the Grootdraai key area, exports water to the adjacent key area, Grootdraai to Vaal Dam (for the Sasol II, III requirement) and also exports water to the Olifants WMA (Eskom requirement). The transfer requirement for the Grootdraai key area includes both of these transfers, however the transfer requirement for the WMA as a whole is only the transfer out of the WMA. Total transfers are calculated at 1 036,7 x $10^6 m^3/a$ comprising between key area transfers that are estimated to be 529 x $10^6 m^3/a$ and exports out of the WMA of about 508 x $10^6 m^3/a$.

The cumulative water use and availability at equivalent 1:50 year assurance at each key area area outlet has been shown by pie diagrams (in units of 10^6 m^3/a) in **Figure 7.2.1**. Categories shown are consumptive requirements (urban, rural, irrigation, bulk, alien vegetation, afforestation and exports), ecological Reserve requirement and losses. Where there is a surplus of water (includes imports and re-usable return flows), a larger circle has been superimposed on the pie diagram and where there is a deficit, a smaller circle has been superimposed. The water resources situation assessment in each key area is described below.

7.3 WILGE KEY AREA

Comprising the Wilge (C81, C82) and Liebensbergvlei (C83) catchment this key area had a small surplus of about 9,6 x $10^6 m^3$ **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3)** does not include the Thukela Vaal Transfer or any river losses along the Wilge River but includes dam evaporation losses. The Thukela Vaal Transfer is included in the available yield of the downstream Vaal Dam to Vaal Barrage key area.

This key area is rural in nature and rural requirements are relatively significant. Domestic rural and irrigation water requirements make about 50 % of total requirements. Non-consumptive requirements by alien vegetation and the ecological Reserve are about a ¼ of total requirements. Phuthaditjhaba, Harrismith and Bethlehem are the most significant urban centres in the area. Re-usable returns, from urban, rural and agricultural users are relatively significant and add to the baseflow of the river system.

The potential for water resources development within the key area is dependent on a number of factors. Water from the Lesotho Highlands Project could be used in the Liebensbergvlei sub-catchment depending on the water requirement situation in the Gauteng area and the downstream Middle and Lower Vaal WMA's. There is potential for the exploitation of the groundwater resources of this key area. Currently less then 5 % of exploitable groundwater has been developed (**Table 6.2.1**).

7.4 KLIP (C13) KEY AREA

Comprising the C13 tertiary area this key area was mostly in balance in 1995 (0,6 x $10^6 m^3$) at equivalent 1 in 50 year assurance. The available yield of the area **(Table 7.2.3)** includes the impact of river and dam evaporation losses.

This key area is rural in nature and rural requirements (domestic and livestock) are relatively significant (about 33 % of total requirements). Non-consumptive requirements by alien vegetation and the ecological reserve are also relatively significant (about a third of total requirements). Vrede is the most significant urban centre in the area. There is no significant irrigation or re-usable returns in this area. The newly commissioned Majuba Power Station imports water from the Thukela via the Zaaihoek Transfer Scheme. A small export of water from muncipal dams on the Schulpspruit is made to the Volkrust TLC in the Thukela WMA.

This key area does not contribute to the yield of the Vaal River however there appears to be potential locally for the development of additional storage (**Table 6.3.2.1**). This, however, is subject to downstream users being affected because the Vaal macro system is fully developed. There also appears to be some potential in developing the groundwater resources of this area. Currently almost none of the exploitable groundwater has been developed (**Table 6.2.1**).

7.5 GROOTDRAAI KEY AREA

Comprising the area including and upstream of Grootdraai Dam this area had a surplus in yield of about 81,5 x $10^6 m^3$ **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3),** does include the impact of the Heyshope and Zaaihoek Transfer Schemes and river and dam evaporation losses, on the water resources of the key area. The surplus in yield is available to downstream key areas.

TABLE 7.2.2: 1995 WATER REQUIREMENTS BY KEY AREA (AT 1:50 YEAR ASSURANCE).

CATCHMENT				STREAMFLOW REDUCTION ACTIVITIES ($10^6 m^3/a$)		WATER USE ($10^6 m^3/a$)		WATER REQUIREMENT ($10^6 m^3/a$)						ECOLOGICAL RESERVE* ($10^6 m^3/a$)	TOTAL ($10^6 m^3/a$)
SECONDARY		TERTIARY													
No.	Description	No.	Key Area Description	AFFOREST-ATION	DRYLAND SUGAR CANE	ALIEN VEG.	RIVER LOSSES(4)	BULK	IRRI-GATION	RURAL	URBAN	WATER TRANSFERS OUT(1)	NEIGH-BOURING STATES		
C8	Wilge	C81,82,83	Wilge (C81A-M, C82A-H, C83A-M)	0,2	0	7,2	0,0	0	17,8	22,5	18,7	0,0	0	15,5	81,9
C1	Klip	C13	Klip (C13A-H)	0,0	0	0,9	0,0	2,4	0,0	3,2	1,2	0,3	0	2,1	10,1
	Grootdraai	C11	Grootdraai (C11A-L)	0,0	0	2,3	0,0	39,1	21,7	11,1	7,3	125,9	0	13,5	220,9
	Grootdraai	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	0,0	0	0,7	0,0	97,4	6,9	6,6	19,2	0,0	0	0*	130,8
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	0,0	0	0,3	9,8	3,7	7,2	2,3	96,5	0,0	0	1,2	121,0
	Klip	C22	Klip (C22A-E)	0,0	0	1,1	0,0	1,0	10,3	0,6	306,4	3,7	0	3,3	326,4
	Mooi	C23	Mooi (C23D-K)	0,0	0	0,5	11,9	3,9	40,3	3,4	25,3	0,0	0	11,4	96,7
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	0,0	0	2,3	0,0	94,6	1,5	2,6	61,0	906,8	0	1,2	1 070,0
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, L)	0,0	0	0,2	15,5	0,0	8,0	2,8	4,1	0,0	0	0*	30,6
Total (Mpumalanga)				**0,0**	**0**	**3,1**	**0,0**	**133,6**	**28,4**	**17,8**	**26,8**	**126,2**	**0**	**14,1**	**350,0**
Total (Free State)				**0,2**	**0**	**9,2**	**7,7**	**69,2**	**29,7**	**28,4**	**45,8**	**453,4**	**0**	**17,0**	**660,6**
Total (Gauteng)				**0,0**	**0**	**2,8**	**9,9**	**38,4**	**28,3**	**6,7**	**457,8**	**457,1**	**0**	**8,5**	**1 009,5**
Total (North-West)				**0,0**	**0**	**0,4**	**19,6**	**0,9**	**27,3**	**2,2**	**9,3**	**0,0**	**0**	**8,6**	**68,3**
TOTAL/AVERAGE IN WMA				**0,2**	**0**	**15,5**	**37,2**	**242,1**	**113,7**	**55,1**	**539,7**	**1 036,7(2)**	**0**	**48,2**	**2 088,4 (3)**

Notes: * Negative values for ecological reserve taken as zero.

(1) Only potable water transfers considered.

(2) Total transfers (including those between key areas) = 1 036,7 x 10^6 m^3/a, transfers out of WMA are: 472 x 10^6 m^3/a to Crocodile West and Marico WMA (by Rand Water), 35,4 x 10^6 m^3 to Eskom in Olifants WMA and 0,3 x 10^6 m^3/a to Volksrust in the Thukela WMA (total of 507,7 x 10^6 m^3/a). The remainder are transfers within the WMA between key areas = 529 x 10^6 m^3/a.

(3) Total requirement in 1995 at 1:50 assurance: 2 088,4 x 10^6 m^3/a – 529 x 10^6 m^3/a = 1 559,4 x 10^6 m^3/a because the internal transfers are accounted for in the water requirements of key areas.

(4) Evaporation losses from dams and wetlands not included. These losses including Wilge River losses are included in the yield determinations (Mallory, 2001).

TABLE 7.2.3: WATER REQUIREMENTS AND AVAILABILITY.

CATCHMENT				AVAILABLE 1:50 YEAR YIELD IN 1995 ($10^6m^3/a$)(1)			WATER TRANSFERS AT 1:50 YEAR ASSURANCE ($10^6m^3/a$)		RETURN FLOWS AT 1:50 YEAR ASSURANCE		WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE(3) ($10^6m^3/a$)	WATER BALANCE AT 1:50 YEAR ASSURANCE ($10^6m^3/a$)
SECONDARY		TERTIARY										
No.	Description	No.	Key Area Description	SURFACE WATER	GROUND-WATER USE IN 1995	TOTAL YIELD	IMPORTS(2)	EXPORTS (2)	RE-USABLE	TO SEA		
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	64,1	4,0	(+) 68,1	0	0	(+) 23,4	0	(-) 81,9	[(+) 9,6]
C1	Klip	C13	Klip (C13A-H)	7,6	0,7	(+) 8,3	(+) 2,4	(-) 0,3	(+) 0,0	0	(-) 9,7	[(+) 0,7]
	Grootdraai	C11	Grootdraai (C11A-L)	288,6	5,0	(+) 293,6(1)	(+) 0,8 / 115,8(1)	(-) 125,9	(+) 8,6	0	(-) 95,0	[(+) 82,1]
	Grootdraai to Vaal Dam	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	109,0	2,2	(+) 111,2	(+) 102,5	0,0	(+) 16,9	0	(-)130,8	[(+) 99,8]
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	99,8	1,3	(+) 101,1	(+) 95,5	0,0	(+) 107,1	0	(-) 121,0	[(+) 182,7]
	Klip	C22	Klip (C22A-E)	293,2	3,7	(+) 296,9	(+) 311,1	(-) 3,7	(+) 268,0	0	(-) 322,7	[(+) 549,6]
	Mooi	C23	Mooi (C23D-K)	16,3	9,0	(+) 25,3	(+) 16,4	0,0	(+) 73,9	0	(-) 96,7	(+) 18,9
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	1 691,7	3,4	(+) 1 695,1(1)	(+) 0,0/ 754,0(1)	(-) 906,8	(+) 66,3	0	(-)163,2	**(+)** 691,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	-8,0	4,5	-3,5	(+) 0,0	0,0	(+) 2,4	0	(-) 30,7	(+) 678,5(4)
Total (Mpumalanga)				**&**	**7,4**	**&**	**105,7**	**126,2**	**25,5**	**0**	**(-) 223,8**	**&**
Total (Free State)				**&**	**7,1**	**&**	**0,0**	**453,4**	**45,8**	**0**	**(-) 207,2**	**&**
Total (Gauteng)				**&**	**8,6**	**&**	**419,6**	**457,1**	**444,4**	**0**	**(-) 552,4**	**&**
Total (North-West)				**&**	**10,7**	**&**	**3,4**	**0,0**	**50,9**	**0**	**(-) 68,3**	**&**
TOTAL in WMA				**2 562,3**	**33,8**	**(+) 2 596,1**	**(+) 1 398,5(1)**	**(-) 1 036,7(2)**	**(+) 566,6**	**0**	**(-) 1 051,7(3)**	
Surplus yield to Middle Vaal WMA												**(+) 678,5**

Notes: (1) Available yield provided by the DWAF and includes interbasin transfers from Thukela, Heyshope and Zaaihoek transfer schemes and evaporation losses from dams.
(2) Only potable water transfers. Totals for transfers out of or into WMA and total for all transfers given in the last row (including those between key areas).
(3) Water requirements, refer to **Table 7.2.2** less any transfers out of the key area. (2 088,4 x $10^6m^3/a$ – 1 036,7 x $10^6m^3/a$)
(4) Surplus yield to Middle Vaal includes surplus from Mooi and Vaal Dam to Vaal Barrage key areas.
[ ] These balances - if positive (surplus) are included in “Surface Water” for the Vaal Dam to Vaal Barrage key area. .
(&) Provincial split not readily available

This key area is a major importer and exporter of surface water. About 115 x $10^6 m^3/a$ is imported from the Usutu to Mhlathuze WMA (Heyshope transfer) and the Thukula WMA (Zaaihoek transfer). About 126 x $10^6 m^3/a$ is exported from Grootdraai dam to the Sasol II / III complex (Grootdraai to Vaal Dam key area) and for Eskom power stations in the Olifants WMA.

The largest water user within the key area is the Tutuka power station, its associated colliery and 3rd party users. Agricultural and rural domestic requirements are significant, using about 15 % of the total requirement. Ermelo and Bethal TLCs are the main urban centres in this key area. Bethal receives water from Vaal Dam via the Rand Water bulk water supply network.

The potential for water resources development within the key area is dependent on a number of factors. Surplus yield from this key area is required by downstream users in the Gauteng area and the downstream Middle and Lower Vaal WMA's. Implementation of the Lesotho Highlands Project could mean that the yield from this key area could become available for other requirements. Locally there appears to be potential for the development of additional surface water storage **(Table 6.3.2.1).** This, however, is subject to downstream users being affected because the Vaal macro system is fully developed. There is potential for the exploitation of the groundwater resources of this key area. Currently less then 10 % of the exploitable groundwater has been developed **(Table 6.2.1)**.

7.6 GROOTDRAAI TO VAAL DAM KEY AREA

Comprising the area downstream of Grootdraai Dam and upstream of Vaal Dam this key area had a surplus of about 82,0 x $10^6 m^3$ **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3),** does include the impact of river and dam evaporation losses on the water resources of the key area. The surplus in yield is available to the downstream Vaal Dam to Vaal Barrage key area.

This area is a significant importer of water from both Grootdraai and Vaal Dams. The major water user is the Sasol II/III industrial complex, which receives its water from Grootdraai Dam. Bulk water requirements make up over 75 % of the total water requirements. The Highveld Ridge TLC, gold and coal mines in the area (e.g. Lesley, Braken) receive water from Vaal Dam via the Rand Water water supply infrastructure. The Highveld Ridge and Standerton TLCs are the main urban centres in this area.

The potential for water resources development within the key area is dependent on a number of factors. Surplus yield from this key area is required by downstream users in the Gauteng area and the downstream Middle and Lower Vaal WMA's. Implementation of the Lesotho Highlands Project could mean that the yield from this key area could become available for other requirements. Locally there appears to be potential for the development of additional surface water storage **(Table 6.3.2.1)**. This, however, is subject to downstream users being affected because the Vaal macro system is fully developed. There is potential for the exploitation of the groundwater resources of this key area. Currently less then 5 % of the exploitable groundwater has been developed **(Table 6.2.1)**.

7.7 SUIKERBOSRAND KEY AREA

Comprising the entire C21 tertiary catchment this key area had a surplus of about 183,0 x $10^6 m^3$ **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3),** does include the impact of river and dam evaporation losses on the water resources of the key area. The surplus in yield is available to the downstream Vaal Dam to Vaal Barrage key area.

This key area is urban in nature and is a significant importer of water from Vaal Dam (via Rand Water network). The main cities and towns are the East Rand centres of Benoni, Brakpan, Springs, Nigel and Heidelburg. Urban requirements are significant and make up 80 % of total requirements. Urban and industrial users in this area generate significants amounts of return flow (effluent, stormwater and clean returns) that contribute significantly (increases flow by 100 %) to the base flow of the system. Effluent returns in this area are dominated by pumpage from Grootvlei mine (45 x $10^6 m^3$ in 1995) into the system. This pumpage is expected to decline and stop over time.

The potential for water resources development within the key area is dependent on a number of factors. Locally there is potential for the development of additional surface water storage **(Table 6.3.2.1)**. However the impact of the poor quality effluent returns is expected to impact on decisions to construct additional storage and can negatively impact on downstream users within the key area and in the downstream Vaal Dam to Vaal Barrage key area and the downstream Middle and Lower Vaal WMA's. There is potential for the exploitation of the groundwater resources of this key area, although pollution from gold mines of the aquifer may hinder development. Currently less than 5 % of the exploitable groundwater has been developed (refer to **Table 6.2.1**).

7.8 KLIP (C22) KEY AREA

Comprising the Klip catchment this key area had a large surplus of about 550,0 x $10^6 m^3$ **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3),** does include the impact of river and dam evaporation losses on the water resources of the key area. The surplus in yield is available to the downstream Vaal Dam to Vaal Barrage key area.

This area is highly urbanised and is a significant importer of water from Vaal Dam (via Rand Water network). There is a small export of 3,7 x $10^6 m^3/a$ (10 Mℓ/day) by Randwater from the Zuurbekom Wellfield to Carltonville TLC and gold mines in the Mooi key area.

The requirements of the area are dominated by urban requirements (94 % of total requirements). The requirement of Johannesburg South MLC is the single largest consumptive requirement in the WMA. Germiston, Boksburg and Alberton MLCs also have significant requirements. Urban centres and to a lesser extent mines in this area generate significant amounts of return flows (effluent, groundwater discharges, stormwater and clean returns) that contribute significantly (increases flow by almost 100 %) to the base flow of the key area.

The potential for water resources development within the key area is dependent on a number of factors. Locally there is potential for the development of additional surface water storage (**Table 6.3.2.1**). However the impact of the generally poor quality effluent returns are expected to impact on decisions to construct additional storage in the area and does negatively impact on downstream users within the key area and in the downstream Vaal Dam to Vaal Barrage key area and the downstream Middle and Lower Vaal WMA's. There is potential for the exploitation of the groundwater resources of this key area, although pollution from gold mines of the aquifer may hinder development. Currently about 25 % of the exploitable groundwater has been developed **(Table 6.2.1)**.

7.9 MOOI KEY AREA

Comprising the Mooi catchment this key area had a small surplus of about 19,6 x $10^6 m^3$ **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3),** does include the impact of river and dam evaporation losses on the water resources of the key area. The surplus in yield is available to the downstream Vaal Dam to Vaal Barrage key area.

This area imports water from Vaal Dam and the Zuurbekom Wellfield (via the Rand Water network) for the West Rand towns of Westonaria, Carltonville and Fochville. Potchefstroom obtains its water from the Mooi River. Urban requirements account for a quarter of total requirements **(Table 7.2.2)**. The major user of water in this area is agricultural for irrigation (40 % of total requirements). This is due to of the presence in the area of several Government Water Schemes (e.g. Mooi GWS, Klipdrift Settlement MB). Re-usable returns mainly from the gold mines in the area are significant and treble the base flow of the system. Most irrigation schemes appear dependent on these returns.

The potential for water resources development within the key area is dependent on a number of factors. Surplus yield from this key area is mainly effluent returns that can have water quality impacts on downstream irrigation users within the key area and the downstream Middle and Lower Vaal WMA's. There is potential for the exploitation of the groundwater resources of this key area, although pollution from mines of underground aquifers may hinder development. Currently about 30 % of exploitable groundwater has been developed **(Table 6.2.1)**. This is the highest in the WMA.

7.10 VAAL DAM TO VAAL BARRAGE KEY AREA

Comprising the area from Vaal Dam to Vaal Barrage this key area had a surplus in yield of about 691 x 10^6m^3 **(Table 7.2.3)** in 1995 at equivalent 1 in 50 year assurance. The available yield in this area is estimated by the DWAF to be 1 695,1 x 10^6m^3 (1995). The available yield included the impact of water from the Thukela Vaal Transfer (754 x 10^6m^3 in 1995), surplus water from the upstream catchments of Grootdraai, Wilge, Suikerbosrand and Klip (about 925 x 10^6m^3 in 1995) and river and dam evaporation losses on the water resources of the key area.

The requirements of this area are dominated by the transfer of potable water from the Vaal Dam (about 907 x 10^6m^3 in 1995). Most transfers are by Rand Water, to urban and industrial users in the Crocodile WMA, to Heilbron TLC in the Middle Vaal WMA, to urban and industrial users in the Klip, Suikerbosrand, Mooi, Grootdraai to Vaal Dam and Grootdraai key areas. Bulk requirements by industries such as Eskom, Sasol I and Iscor are also significant and emphasise the highly industrialised nature of this key area. The main urban centres are Vereeniging, Vanderbijlpark and Sasolburg who also receive bulk water from the Rand Water network.

The potential for water resources development within the key area is dependent on a number of factors. Surplus yield from this key area is required by downstream users in the downstream Barrage to Mooi key area and the Middle and Lower Vaal WMA's. There is potential for the exploitation of the groundwater resources of this key area. Currently less then 10 % of the exploitable groundwater has been developed **(Table 6.2.1)**.

7.11 BARRAGE TO MOOI CONFLUENCE KEY AREA

In 1995 this key area had a surplus in yield of about 678 x $10^6 m^3$ **(Table 7.2.3)** at equivalent 1 in 50 year assurance. The available yield determined for this area **(Table 7.2.3),** does include the impact of river and dam evaporation losses on the water resources of the key area. The area receives about 710 x $10^6 m^3$ (in 1995) from the upstream Vaal Dam to Vaal Barrage and Mooi key areas.

The key area is rural in nature and rural and agricultural (irrigation) requirements (35 %) are relatively significant. Non-consumptive requirements of river losses and alien vegetation account for over 50 % of total requirements. The main urban centre is Parys.

The potential for water resources development within the key area is dependent on surplus yield from the upstream Vaal Dam to Barrage key area and on the requirements of downstream users in the downstream Middle and Lower Vaal WMA's. There is potential for the exploitation of the groundwater resources of this key area. Currently about 15 % of the exploitable groundwater has been developed **(Table 6.2.1)**.

CHAPTER 8: COSTS OF WATER RESOURCE DEVELOPMENT

8.1 METHODOLOGY

The Upper Vaal has been very highly developed and there is not much potential for developing it further. While **Table 6.3.2.1** may indicate that local water resources may still be developed, on a macro scale the total Vaal River system is fully utilised. The only possibility within the WMA is a dam on the Klip River (C13 tertiary), however this will not increase the yield balance but only re-distribute it to a certain degree.

The potential unexploited groundwater resource is estimated at about 265 x $10^6 m^3/a$. However there are no known potential wellfields that could be developed on a major scale.

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

The Upper Vaal WMA is a highly developed and therefore extremely complex catchment. While **Table 6.3.2.1** may indicate that local water resources may still be developed, on a macro scale the total Vaal River system is fully utilised. Hence a number of transfer schemes are in operation to provide for the increasing urban, rural, industrial, mining, ecological and irrigation requirements. At the 1:50 year level of assurance as at 1995, the Upper Vaal WMA has a surplus of 678 x $10^6 m^3$. This surplus should, however, not be viewed in isolation but must be considered along with the requirements of Middle Vaal and Lower Vaal WMA's.

Although surface water in the total Vaal River system has been fully developed, exploitation of groundwater in the key areas is low and ranges from less than 5% to 30%. Pollution of groundwater by mines may hinder potential development.

Return flows are extremely significant in some of the key areas but also carry pollution effects.

The following **Table 9.1** summarises available yield and water requirements. It should be noted that because this report is based on the 1995 situation, the Lesotho Highlands scheme has not been included (1998). It does, however, add very significantly (396 x $10^6 m^3$ in 1998) to the surplus of 678 x $10^6 m^3$.

TABLE 9.1: SUMMARY OF YIELD AND WATER REQUIREMENTS

CATCHMENT				AVAILABLE 1:50 YEAR YIELD IN 1995 ($10^6 m^3/a$)(1)	WATER TRANSFERS AT 1:50 YEAR ASSURANCE ($10^6 m^3/a$)		RETURN FLOWS AT 1:50 YEAR ASSUR-ANCE ($10^6 m^3/a$)	WATER REQUIRE-MENTS AT 1:50 YEAR ASSUR-ANCE(3) ($10^6 m^3/a$)	WATER BALANCE AT 1:50 YEAR ASSURANCE ($10^6 m^3/a$)
SECONDARY		TERTIARY							
No.	Description	No.	Key Area Description	TOTAL YIELD(5)	IMPORTS(2)	EXPORTS(2)	RE-USABLE		
C8	Wilge	C81, C82, C83	Wilge (C81A-M, C82A-H, C83A-M)	(+) 68,1	0	0	(+) 23,4	(-) 81,9	[(+) 9,6]
C1	Klip	C13	Klip (C13A-H)	(+) 8,3	(+) 2,4	(-) 0,3	(+) 0,0	(-) 9,7	[(+) 0,7]
	Grootdraai	C11	Grootdraai (C11A-L)	(+) 293,6(1)	(+) 0,8 / [115,8](1)	(-) 125,9	(+) 8,6	(-) 95,0	[(+) 82,1]
	Grootdraai to Vaal Dam	C11-C12	Grootdraai to Vaal Dam (C11M, C12A-L)	(+) 111,2	(+) 102,5	0,0	(+) 16,9	(-)130,8	[(+) 99,8]
C2	Suikerbosrand	C21	Suikerbosrand (C21A-G)	(+) 101,1	(+) 95,5	0,0	(+) 107,1	(-) 121,0	[(+) 182,7]
	Klip	C22	Klip (C22A-E)	(+) 296,9	(+) 311,1	(-) 3,7	(+) 268,0	(-) 322,7	[(+) 549,6]
	Mooi	C23	Mooi (C23D-K)	(+) 25,3	(+) 16,4	0,0	(+) 73,9	(-) 96,7	(+) 18,9
	Vaal Dam to Vaal Barrage	C22	Vaal Dam to Vaal Barrage (C22F-K)	(+) 1 695,1(1)	(+) 0,0/ [754,0](1)	(-) 906,8	(+) 66,3	(-)163,2	**(+)** 691,4
	Barrage to Mooi	C23	Barrage to Mooi (C23A-C, C23L)	-3,5	(+) 0,0	0,0	(+) 2,4	(-) 30,7	(+) 678,5(4)
TOTAL in WMA				**(+) 2 596,1**	**(+) 1 398,5** (1)	**(-) 1 036,7** (2)	**(+) 566,6**	**(-) 1 051,7**	
Surplus yield to Middle Vaal WMA									**(+) 678,5**

Notes:

(1) Available yield provided by the DWAF and includes interbasin transfers from Thukela, Heyshope and Zaaihoek transfer schemes and evaporation losses from dams.

(1) Only potable water transfers. Totals for transfers out of or into WMA and total for all transfers given (including between key areas).

(2) Water requirements, refer to **Table 7.2.2** less any transfers out of the key area (2 088,4 x $10^6 m^3/a$ – 1 036,7 x $10^6 m^3/a$).

(4) Surplus yield to Middle Vaal includes surplus from Mooi and Vaal Dam to Vaal Barrage key areas.

[ ] These balances - if positive (surplus) are included in “Surface Water” for the Vaal Dam to Vaal Barrage key area.

Although every effort has been spent in obtaining accurate data, manipulation of this data and checking and verification thereof, the information presented in this report is dependent on the accuracy and quality of the numerous reports and documentation previously compiled by other organisations. It is therefore likely that some information may have to be revised in the future. A great deal of effort was spent on the metadata (which is information about the quality of data which was supplied to DWAF) for the project database in order to make future enhancements as efficient a process as possible.

9.2 RECOMMENDATIONS

The following recommendations refer to required improvements in the quality of quaternary catchment level data.

- While overall irrigation data at key area (river reach data – (Loxton et al., 1999b)) can be considered reliable, this data is not available on a quaternary catchment basis and therefore quaternary catchment irrigation data represents an estimate only and must be considered to be of poor quality. In order to improve on the accuracy of the disaggregated information it is therefore recommended that a study is undertaken to determine the areal distribution and crop types at quaternary catchment scale.

- The urban area data from WR90 represents the 1990 situation and is probably underestimated in the catchments above Vaal Dam and in the Mooi River catchment. It is therefore recommended that the WR90 study be updated.

- The available information on livestock and game was for 1988 and 1990. In addition this data was only available at Magisterial district level and like irrigation the data at quaternary catchment level must be considered to be approximate.

- A survey of a number of TLC’s was undertaken to try and determine urban water requirements. This exercise was fairly successful and should be extended to the remaining TLC’s. Most small TLC's were not surveyed and their water requirements were estimated using estimated water requirements. It is considered that the estimated water requirements are too high for most small towns and as a consequence the water requirements have been inflated.

- The situation assessment consultant did review river losses, however this data appears to have been ignored. This is possibly a result of problems with the river losses sub-model of WSAM.

- Information on water allocations, authorisations and permits need to be centralised and reviewed by an organisation (persons) skilled in the interpretation of these allocations, thus allowing the assessment of the available resources and the volumes allocated.

- Information concerning conveyance losses (most kinds) were generally not readily available. While estimates were provided and these were used extensively a study of this crucial ‘use’ is recommended.

- For effective Conservation Management and Demand Management measures to be implemented reliable information on conveyance losses in required. With this information it would be possible to set initial targets for Conservation Management and Demand Management. For example a 5 % reduction in conveyance losses for most requirements could impact on the available yield. This is especially true for irrigation and urban conveyance losses.

- Regarding the ecological water requirements, negative values (that were taken as zero) should be investigated

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APPENDICES

Note: Blanks indicate that data was not readily available.

APPENDIX A DEMOGRAPHICS

Comprising:

Appendix A.1 Urban population data

Appendix A.2 Rural population data

APPENDIX A.1

URBAN POPULATION DATA

Appendix A.1 URBAN POPULATION

Source of RSA population data: Markdata Demographic Study

Quaternary catchment	Province	Transitional councils	Population
Wilge key area:			
C81E	FS	HARRISMITH / 42ND HILL / TSIAME	34,950
C81F	FS	PHUTHADITJHABA	41,800
C81G	FS	KESTELL / TLHOLONG	4,400
C82B	FS	WARDEN / EZENZELENI	5,650
C83C	FS	BETHLEHEM / BOHLOKONG	56,150
C83G	FS	REITZ / PETSANA	14,650
C83H	FS	TWEELING / MAFAHLANENG	2,700
C83J	FS	FRANKFORT / NAMAHADI	19,400
C83M	FS	ORANJEVILLE / METSIMAHOLO	1,300
Total			**181,000**
Grootdraai key area:			
C11A	MPA	BREYTEN / KWAZANELE	11,950
C11E	MPA	AMERSFOORT / EZAMOKUHLE	6,850
C11F	MPA	ERMELO / WESSELTON	47,950
C11H	MPA	BETHAL / EMZINONI & MORGENZON / SIVUKILE	46,600
C11L	MPA	PAARDEKOP / SIYAZENZELA	2,950
Total			**116,300**
Grootdraai to Vaal Dam key area:			
C11M	MPA	STANDERTON / SAKHILE	45,950
C12C	FS	CORNELIA / NTSWANATSATSI	2,350
C12D	MPA	HIGHVELD RIDGE (Secunda, Embalenhle, Evander, Kinross, Trichar	132,509
C12E	MPA	CHARL CILLIERS / THUTHUKANI	2,600
C12G	MPA	GREYLINGSTAD / NTHORWANE	4,350
C12H	FS	VILLIERS / QALABOTJHA	10,250
Total			**198,009**
C13 key area:			
C13C	FS	MEMEL / ZAMANI	3,800
C13G	FS	VREDE / THEMBALIHLE	13,600
Total			**17,400**
Urban population - u/s Vaal Dam			**331,709**
Urban population - u/s Vaal & Wilge			**512,709**
Suikerbos key area:			
C21B	MPA	BALFOUR / SIYATHEMBA	20,150
C21D	GT	BRAKPAN / TSAKANE & BENONI / DAVEYTON / WATTVILLE	529,250
C21E	GT	SPRINGS / KWATHEMA / VISCHKUIL & NIGEL / DUDUZA	260,950
C21F	GT	HEIDELBERG / RATANDA	42,324
Total			**852,674**
Klip key area:			
C22A	GT	JOHANNESBURG METRO (South)	1,520,557

Appendix A.1 URBAN POPULATION			
Source of RSA population data: Markdata Demographic Study			
Quaternary catchment	**Province**	**Transitional councils**	**Population**
C22B	GT	GERMISTON / KATLEHONG; ALBERTON / TOKOSA & BOKSBURG / VOSLOORUS	837,873
Total			**2,358,430**
Barrage key area:			
C22F	GT	VEREENIGING / KOPENONG METRO	385,365
C22G	FS	DENEYSVILLE / REFENGKGOTSO	10,750
C22J	GT	WESTERN VAAL METRO [Vanderbijlpark]	283,858
C22K	FS	SASOLBURG / ZAMDELA	69,200
Total			**749,173**
Vaal d/s Barrage to Mooi key area:			
C23C	FS	PARYS / TUMAHOLE & VREDEFORT / MOKWALLO	56,800
C23L	FS	RENOVAAL	500
Total			**57,300**
Mooi key area:			
C23D	GT	WESTONARIA	160,800
C23E	GT	CARLETONVILLE / KHUTSONG	175,200
C23H	NW	POTCHEFSTROOM / IKAGENG	121,000
C23J	NW	FOCHVILLE / KOKOZI & WEDELA	32,450
Total			**489,450**
Urban population - d/s Vaal Dam			**4,507,027**
Total urban population - Upper Vaal			**5,019,736**

APPENDIX A.2

RURAL POPULATION DATA

Appendix A.2 RURAL POPULATION

Quaternary catchment	Rural population	Net per capita consumption [l / c / day]	Consumptive use	Comment
Wilge key area:				
C81A	673	25	1	
C81B	2,198	25	1	
C81C	570	25	1	
C81D	218	25	1	
C81E	1,763	25	1	
C81F	**262,300**	**51**	**0.57**	**Witsieshoek (former Qwa Qwa), extensive network operated by Sedibeng Water.**
C81G	1,413	25	1	
C81H	964	25	1	
C81J	2,718	25	1	
C81K	976	25	1	
C81L	1,353	25	1	
C81M	4,463	25	1	
C82A	1,892	25	1	
C82B	2,095	25	1	
C82C	1,414	25	1	
C82D	3,089	25	1	
C82E	2,334	25	1	
C82F	1,311	25	1	
C82G	1,931	25	1	
C82H	3,055	25	1	
C83A	5,701	25	1	
C83B	2,815	25	1	
C83C	8,993	25	1	
C83D	2,437	25	1	
C83E	3,011	25	1	
C83F	4,709	25	1	
C83G	3,543	25	1	
C83H	2,158	25	1	
C83J	1,211	25	1	
C83K	2,226	25	1	
C83L	4,883	25	1	
C83M	4,462	25	1	
Total:	**342,879**			
Rural requirement (million cubic meters):			**12,893,630.61**	**all in Free State**
Grootdraai key area:				
C11A	3,590	25	1	
C11B	3,950	25	1	
C11C	286	25	1	
C11D	586	25	1	
C11E	4,440	25	1	
C11F	5,232	25	1	
C11G	1,698	25	1	
C11H	5,463	25	1	
C11J	3,028	25	1	
C11K	4,428	25	1	
C11L	7,254	25	1	
Total:	**39,954**			
Rural requirement (million cubic meters):			**0.36**	**all in Mpumalanga**

Appendix A.2 RURAL POPULATION

Quaternary catchment	Rural population	Net per capita consumption [l / c / day]	Consumptive use	Comment
Grootdraai to Vaal Dam key area:				
C11M	8,014	25	1	
C12A	1,465	25	1	
C12B	4,103	25	1	
C12C	2,240	25	1	
C12D	20,390	25	1	
C12E	4,007	25	1	
C12F	6,836	25	1	
C12G	3,281	25	1	
C12H	1,324	25	1	
C12J	2,217	25	1	
C12K	3,709	25	1	
C12L	4,189	25	1	
Total:	**61,775**			
Rural requirement (million cubic meters):			**0.56**	**Mpa, FS; Gt**
C13 key area:				
C13A	2,585	25	1	
C13B	3,320	25	1	
C13C	1,790	25	1	
C13D	2,657	25	1	
C13E	1,629	25	1	
C13F	2,093	25	1	
C13G	1,409	25	1	
C13H	2,412	25	1	
Total:	**17,895**			
Rural requirement (million cubic meters):			**0.16**	**Mpa & FS (57 %)**
Rural population - u/s Vaal Dam			**119,624**	
Rural population - u/s Vaal Dam & Wilge			**462,504**	
Rural requirement -u/s Vaal Dam			**1.09**	
Rural requirement -u/s Vaal Dam & Wilge			**12,893,631.70**	
Suikerbosrand key area:				
C21A	4,637	25	1	
C21B	2,902	25	1	
C21C	4,267	25	1	
C21D	3,722	25	1	
C21E	6,410	25	1	
C21F	5,839	25	1	
C21G	5,125	25	1	
Total:	**32,902**			
Rural requirement (million cubic meters):			**0.30**	**Gt (81 %; Mpa (19%)**
Klip River key area:				
C22A	3,120	25	1	
C22B	1,159	25	1	
C22C	3,248	25	1	
C22D	5,303	25	1	
C22E	4,729	25	1	
Total:	**17,559**			
Rural requirement (million cubic meters):			**0.16**	**all Gt**

Appendix A.2 RURAL POPULATION

Quaternary catchment	Rural population	Net per capita consumption [l / c / day]	Consumptive use	Comment
Vaal Dam to Vaal Barrage key area:				
C22F	9,375	25	1	
C22G	10,590	25	1	
C22H	11,210	25	1	
C22J	6,394	25	1	
C22K	10,410	25	1	
Total:	**47,979**			
Rural requirement (million cubic meters):			**0.44**	**Gt ; FS; NW (1 %)**
Barrage to Mooi key area:				
C23A	1,531	25	1	
C23B	6,493	25	1	
C23C	5,357	25	1	
C23L	12,590	25	1	
Total:	**25,971**			
Rural requirement (million cubic meters):			**0.24**	**FS; NW; GT (2 %)**
Mooi key area:				
C23D	5,149	25	1	
C23E	5,416	25	1	
C23F	6,197	25	1	
C23G	3,851	25	1	
C23H	3,878	25	1	
C23J	11,180	25	1	
C23K	7,010	25	1	
Total:	**42,681**			
Rural requirement (million cubic meters):			**0.39**	**NW; FS**
Rural population - d/s Vaal Dam			**167,092**	
Rural requirement - d/s Vaal Dam			**1.53**	
Rural population - Free State Province			**397,754**	
Rural population - Mpumalanga Province			**105,355**	
Rural population - Gauteng Province			**82,681**	
Rural population - North West Province			**43,806**	
Total Rural population - Upper Vaal WMA			**629,596**	
Rural requirement - Upper Vaal WMA			**12,893,633.23**	

APPENDIX B MACRO ECONOMICS

Comprising:

APPENDICES
SUPPLEMENTARY ECONOMIC INFORMATION

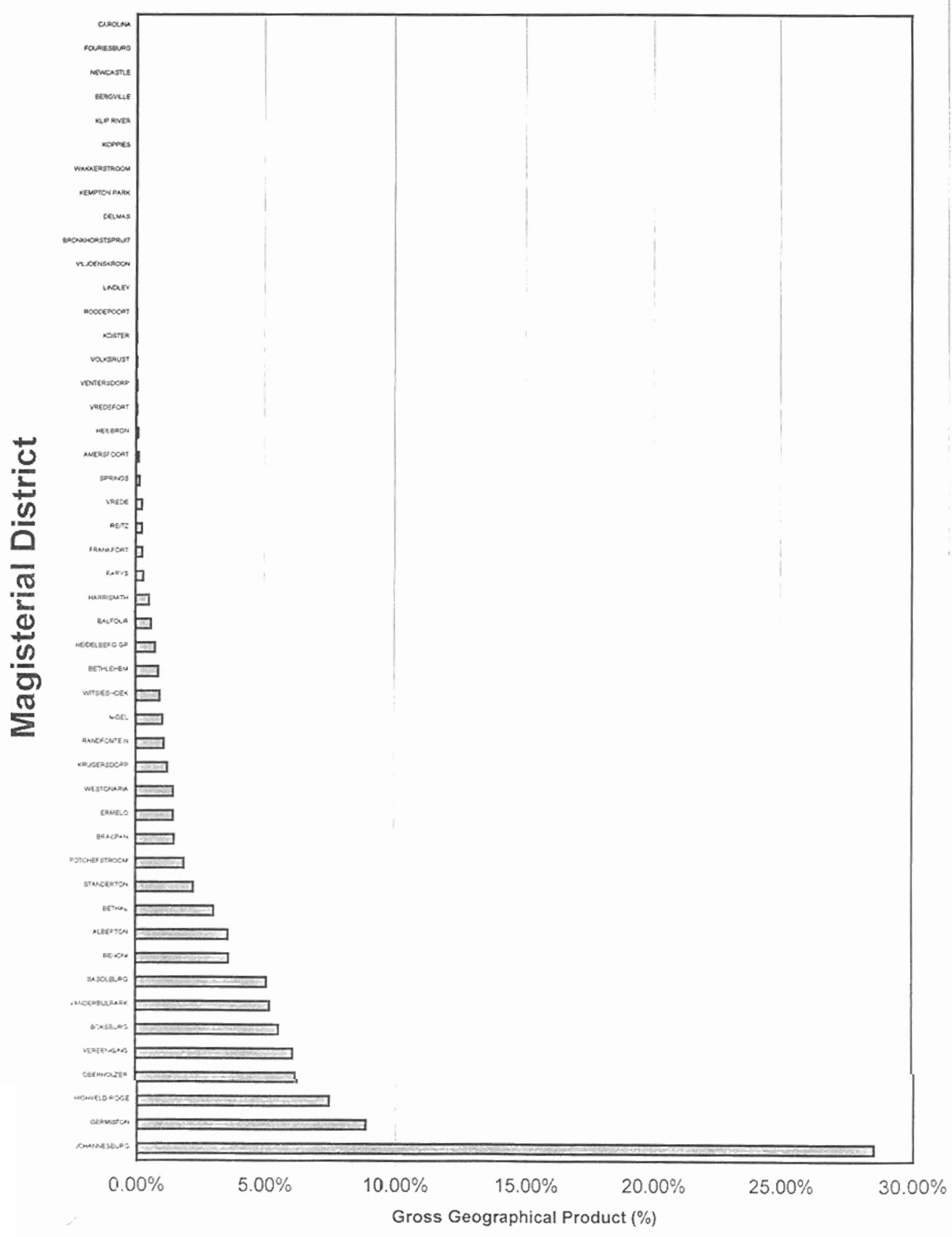
APPENDIX B.1

GRAPHS: GROSS GEOGRAPHIC PRODUCT, LABOUR AND SHIFT-SHARE

APPENDIX B.1
DESCRIPTION OF GRAPHS

Diagram No	Graphic Illustration	Description
	• **Gross Geographic Product**:	
B.1	⇨ Contribution by Magisterial District to Berg Economy, 1997 (%)	Each WMA comprises a number of Magisterial Districts. This graph illustrates the percentage contribution of each MD to the WMA economy as a whole. It shows which are the most important sub-economies in the region.
B.2	⇨ Contribution by sector to National Economy, 1988 and 1997 (%)	This graph illustrates the percentage contribution of each sector in the WMA economy, e.g. agriculture, to the corresponding sector in the national economy.
	• **Labour Force Characteristics**:	
B.3	⇨ Composition of Berg Labour Force 1994 (%)	The total labour force may be divided into three main categories, namely formal employment, informal employment and unemployment, as outlined in this graph.
B.4	⇨ Contribution by Sector to Berg Employment, 1980 and 1994 (%)	Shows the sectoral composition of the formal WMA labour force.
B.5	⇨ Contribution by Sectors of Berg Employment to National Sectoral Employment, 1980 and 1994 (%)	Similar to the production function (i.e. GGP), this graph illustrates the percentage contribution of each sector in the WMA economy, e.g. mining, to the corresponding sector in the national economy.
B.6	⇨ Compound Annual Employment Growth by Sector of Berg versus South Africa, 1988 to 1994 (%)	Annual compound growth by sector is shown for the period 1980 to 1994.
	• **Shift-Share**:	
B.7	⇨ Shift-Share Analysis, 1997	Compares the contribution of each sector in the WMA economy to its recent growth performance. This serves as an instrument to identify sectors of future importance (towards top right hand side of the graph) and sectors in distress (towards the bottom left hand side of the graph).

Figure B.1: Contribution by Magisterial District to Upper Vaal economy, 1997 (%)



FigureB.2: Contribution by Sector to National Economy, 1988 and 1997 (%)

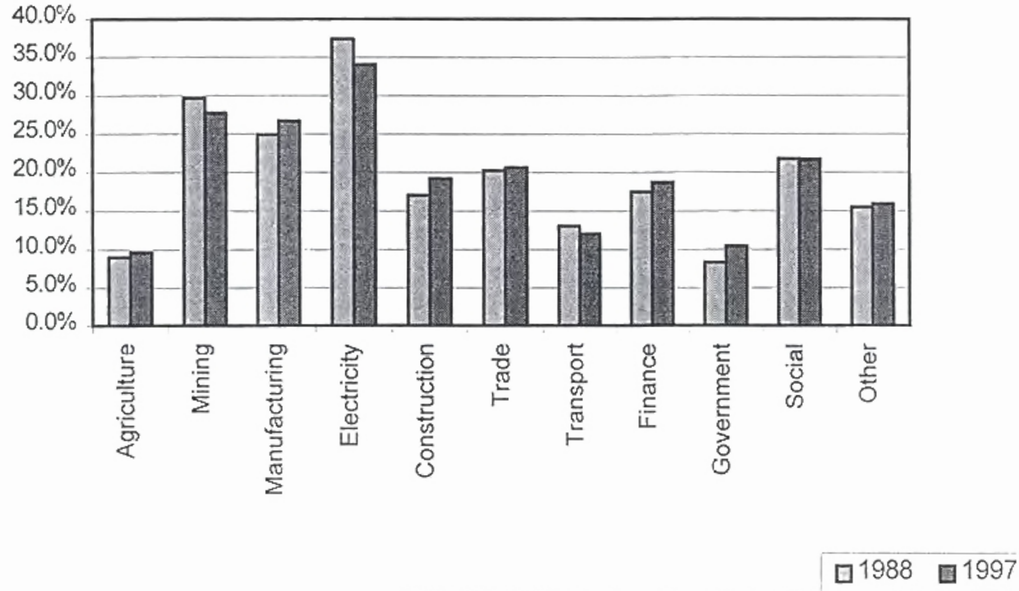


Figure B.3: Composition of Upper Vaal Labour Force, 1994 (%)

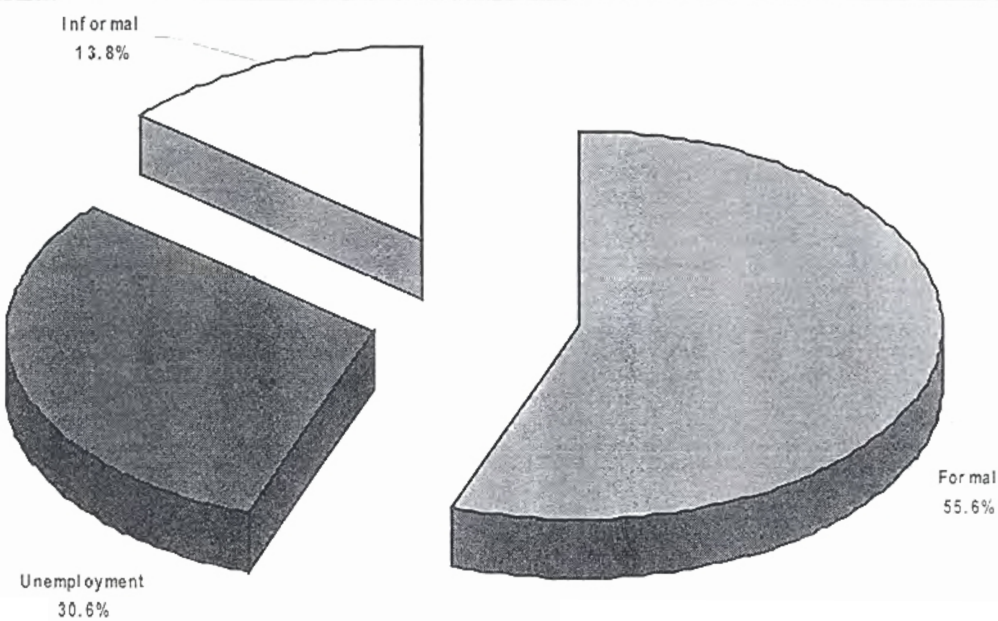


Figure B.4: Contribution by Sector to Upper Vaal Employment, 1980 and 1994(%)

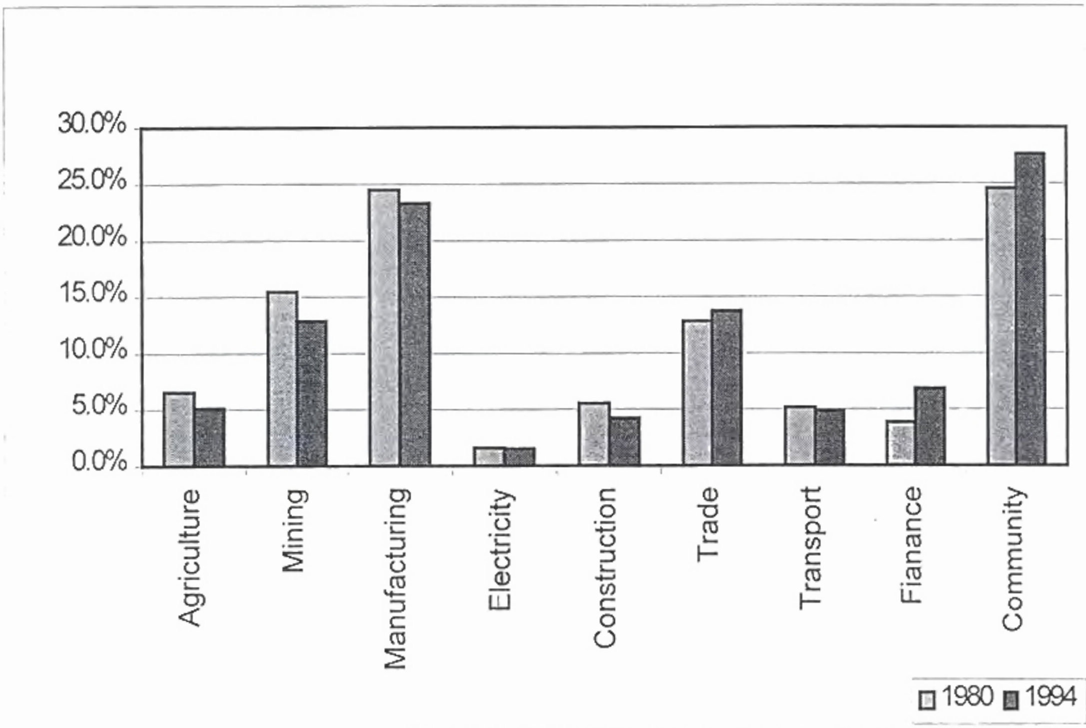


Figure B.5 Contribution by Sectors of Upper Vaal Employment to National Sectoral Employment, 1980 and 1994 (%)

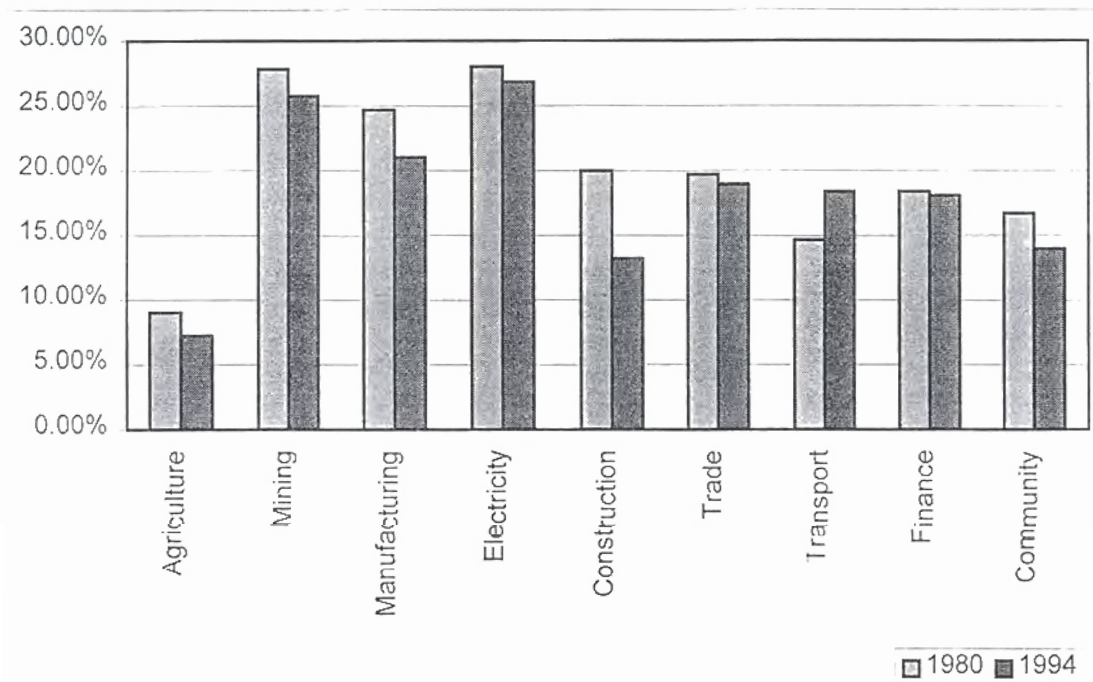


Figure B.6: Average Annual Employment Growth by Sector of Upper Vaal versus South Africa, 1980 to 1994 (%)

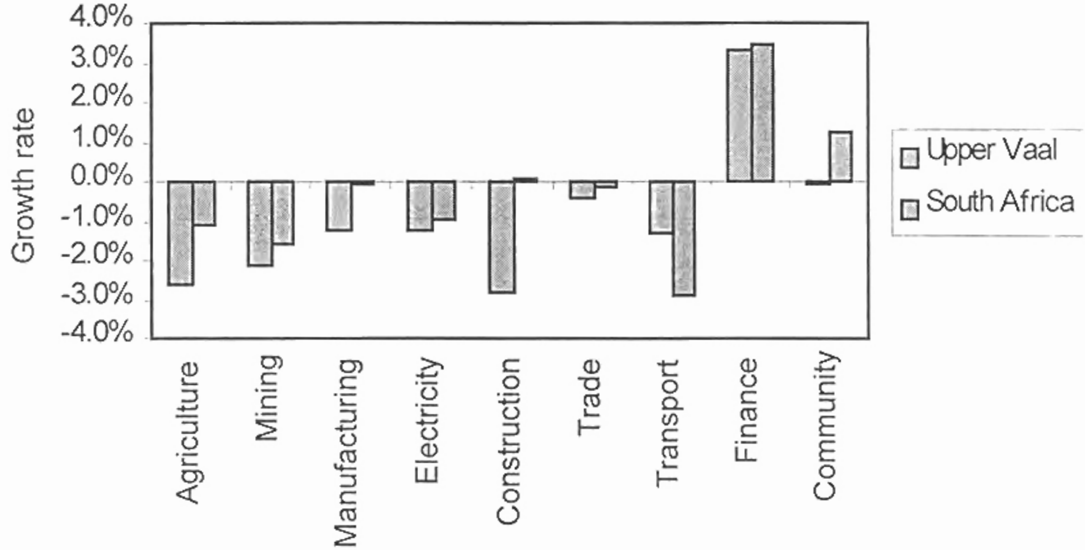
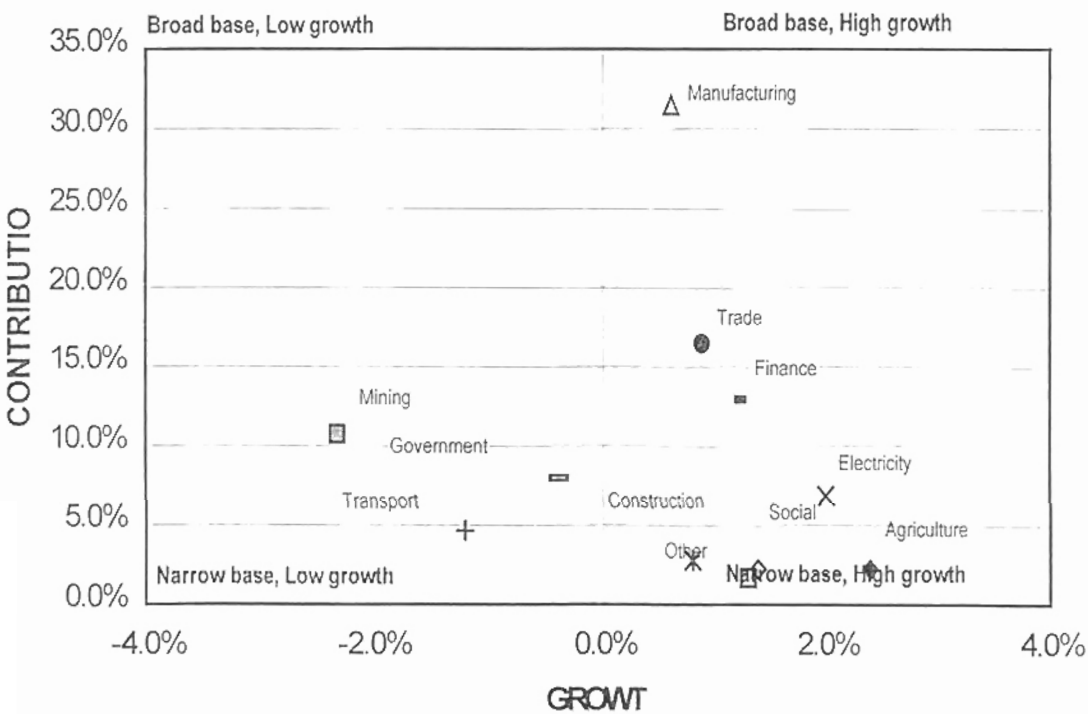


Figure B.7: Shift-Share Analysis, 1997



APPENDIX B.2

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

WATER MANAGEMENT AREAS IN NATIONAL CONTEXT

B.1 INTRODUCTION

The purpose of this section is to illustrate the relative importance of the nineteen different water management areas (WMAs) in South Africa. The following aspects are outlined:

- Contribution by WMA to national economy
- Contribution by WMA to formal employment
- Economic growth by WMA.

B.2 CONTRIBUTION BY WATER MANAGEMENT AREA TO NATIONAL ECONOMY

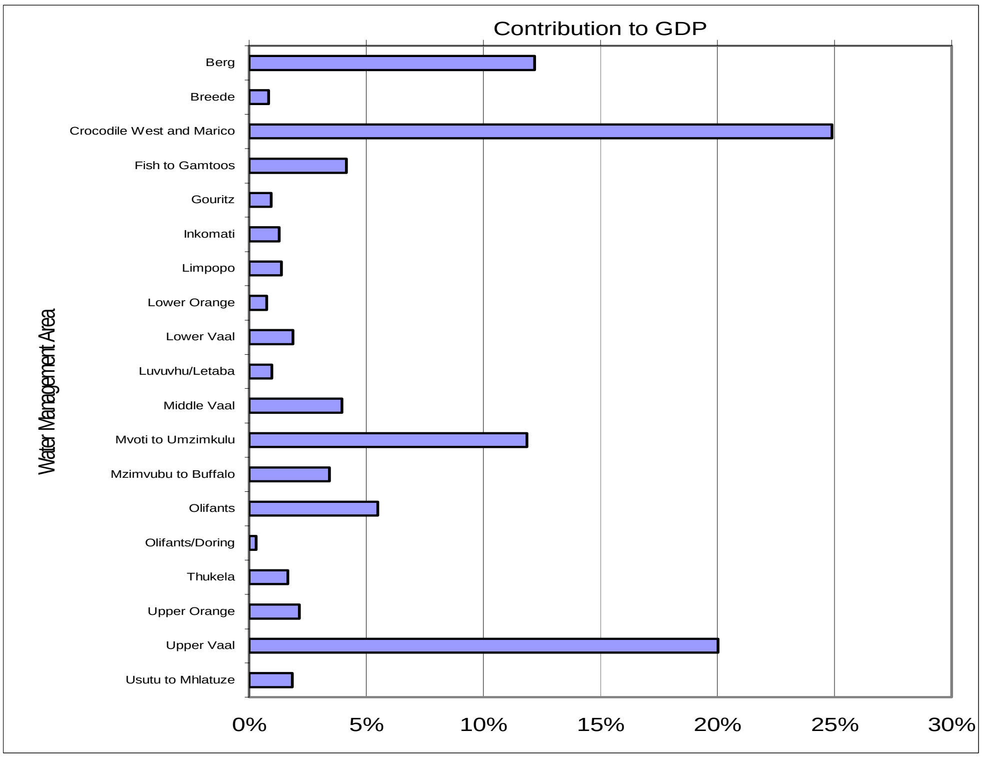
- The largest contribution to the national economy is made by the Crocodile West and Marico WMA which contributes (19.1%) to GDP. This WMA comprises, inter alia, magistrates districts of Pretoria, Johannesburg, Germiston, Kempton Park, Benoni, Thabazimbi and Lichtenburg.

- The second largest WMA to the national economy, is the Upper Vaal, which contributes 16.6% to GDP. This WMA comprises mainly portions of Johannesburg, Vereeniging and Vanderbijlpark.

- The Berg WMA contributes 11.25% to the GDP of the national economy and comprises mainly the Cape Metropolitan Area (CMA).

- Mvoti to Umzimkulu WMA makes the fourth largest contribution of 10.72% to the GDP of the national economy. This WMA includes the Durban-Pinetown Metropolitan Area.

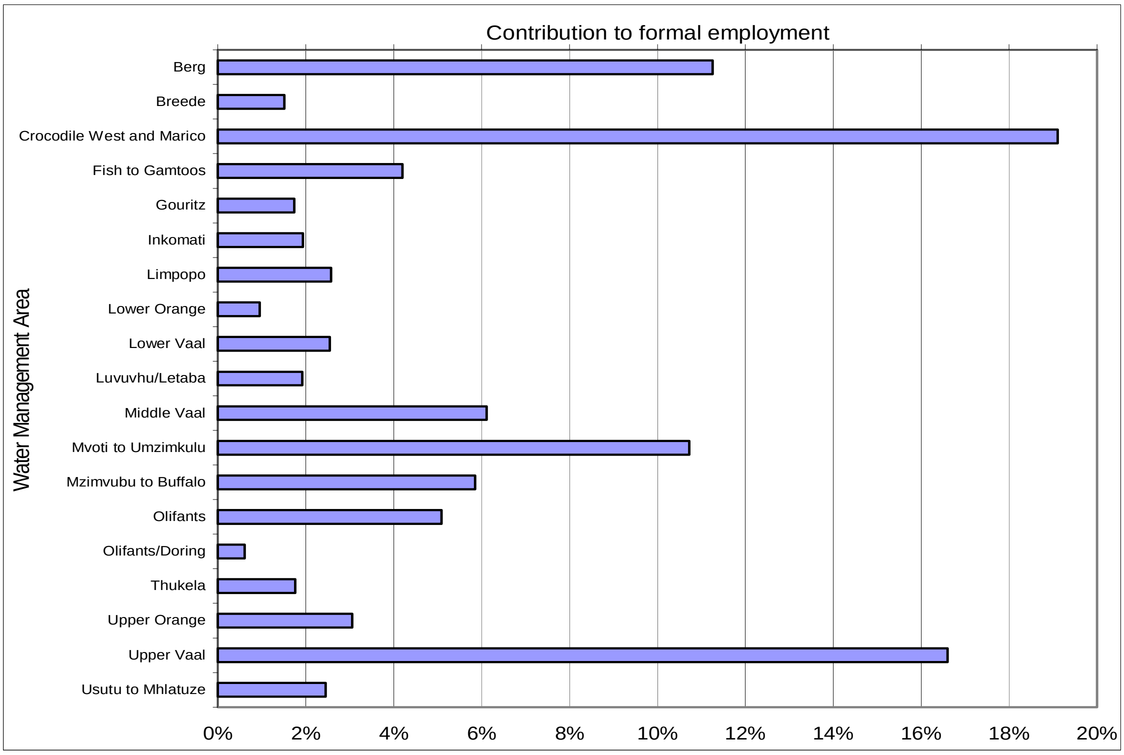
Figure B.1: Total GGP by Water Management Area (% of Country)



B.3 CONTRIBUTION BY WATER MANAGEMENT AREA TO NATIONAL EMPLOYMENT

- Contribution to formal employment corresponds to economic production and is mainly concentrated in the four dominant WMAs.

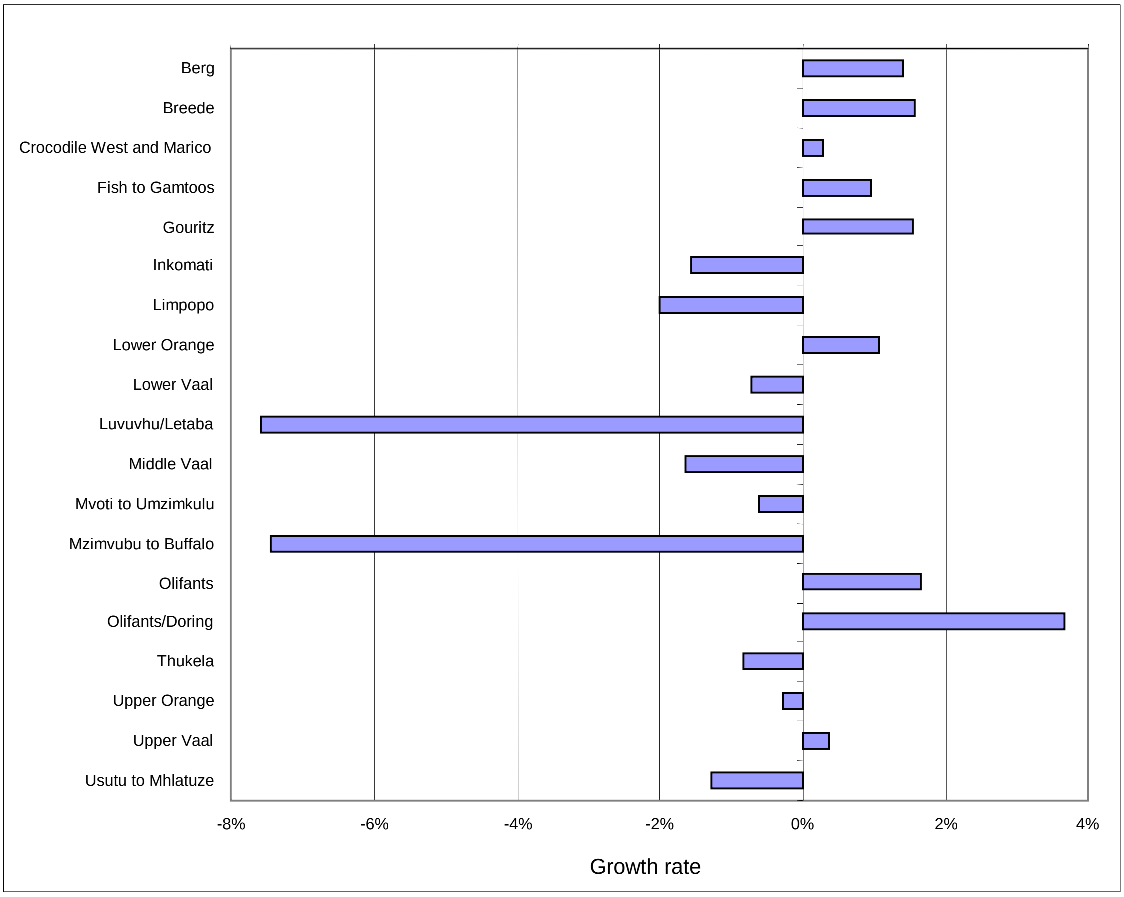
Figure B.2: Formal Employment by Water Management Area (% of country)



B.4 ECONOMIC GROWTH BY WATER MANAGEMENT AREA

- In terms of economic growth, three of the dominant four WMAs recorded positive economic growth between 1988 and 1997: the Berg grew at 1.4% per annum, Crocodile West and Marico at 0.28% per annum and Upper Vaal at 0.36% per annum. Marginal negative growth was recorded over the nine year period in the Mvoti to Umzimkulu WMA: -0.62% per annum.

Figure B.3: Average Annual Economic Growth by Water Management Area, 1988-1997 (%)



APPENDIX B.3
ECONOMIC SECTOR DESCRIPTION

ECONOMIC SECTOR DESCRIPTION

- **Agriculture:** This sector includes agriculture, hunting and related services. It comprises activities such as growing of crops, market gardening, horticulture, mixed farming, production of organic fertilizer, forestry, logging and related services and fishing, operation of fish hatcheries and fish farms.

- **Mining:** This section entails the mining and quarrying of metallic minerals (coal, lignite, gold, cranium ore, iron ore, etc); extraction of crude petroleum and natural gas, service activities incidental to oil and gas extraction; stone quarrying; clay and sand pits; and the mining of diamonds and other minerals.

- **Manufacturing:** Manufacturing includes, inter alia, the manufacturing of food products, beverages and tobacco products; production, processing and preserving of meat, fish, fruit, vegetables, oils and fats, dairy products and grain mill products; textile and clothing; spinning and weaving; tanning and dressing of leather; footwear; wood and wood products; paper and paper products; printing and publishing; petroleum products; nuclear fuel; and other chemical substances.

- **Electricity, Water and Gas:** Utilities comprise mainly three elements, namely electricity, water and gas. The services rendered to the economy include the supply of electricity, gas and hot water, the production, collection and distribution of electricity, the manufacture of gas and distribution of gaseous fuels through mains, supply of steam and hot water, and the collection, purification and distribution of water.

- **Construction:** This sector includes construction; site preparation building of complete constructions or parts thereof; civil engineering; building installation; building completion; and the renting of construction or demolition equipment with operators all form part of the construction sector.

- **Trade:** Trade entails wholesale and commission trade; retail trade; repair of personal household goods; sale, maintenance and repair of motor vehicles and motor cycles; hotels, restaurants, bars canteens, camping sites and other provision of short-stay accommodation.

- **Transport:** The transportation sector comprises land transport; railway transport; water transport; transport via pipelines; air transport; activities of travel agencies; post and telecommunications; courier activities; and storage.

- **Business and Financial Services:** The economic activities under this category include, inter alia, financial intermediation; insurance and pension funding; real estate activities; renting of transport equipment; computer and related activities; research and development; legal; accounting, book-keeping and auditing activities; architectural, engineering and other technical activities; and business activities not classified elsewhere.

- **Government and Social services (Community Services)**: This sector includes public administration and defence, social and related community services (education, medical, welfare and religious organisations), recreational and cultural services and personal and household services.

- **Other:** Private households, extraterritorial organisations, representatives of foreign governments and other activities not adequately defined.

APPENDIX B.4
ECONOMIC INFORMATION SYSTEM

ECONOMIC INFORMATION SYSTEM for Department of Water Affairs and Forestry

1. Background

The Economic Information System was developed for the Department of Water Affairs and Forestry due to a need for a comprehensive source of readily available economic data that can be utilised as a management tool for decision making.

Relevant information required for planning the allocation and utilisation of scarce resources such as water has always been a difficult process due to:

- **Inaccessibility of information**
- **Incompatibility of information**
- **No framework of reference for analysis**

The purpose of the Economic Information System was thus to combine all readily available economic information into a single computer package that would be readily accessible, easy to use and could be distributed without restrictions.

2. The System

The characteristics of the Economic Information System can be summarised as follows:

- Provides immediate access to a comprehensive economic database.
- Stand alone software programme that can be loaded onto a personal computer.
- System provides not only the existing data but also allows first degree transformation of data both geographically and functionally.
- Allows multidimensional access and presentation of information, that is, on a sectoral, geographical and functional basis.
- Provides time series information to enable users to determine trends and make projections.

Urban-Econ collected existing data from a range of secondary sources. The following data were combined in a single database which can be queried spatially, thematically and temporally *via* a user-friendly computer interface.

Diagram 1 depicts the economic information system in a flow chart format. It is possible to display the data in:

- Tables
- Graphs

- Thematic maps (this provides a better perspective of the spatial context and significance of other spatial features relevant to the data.

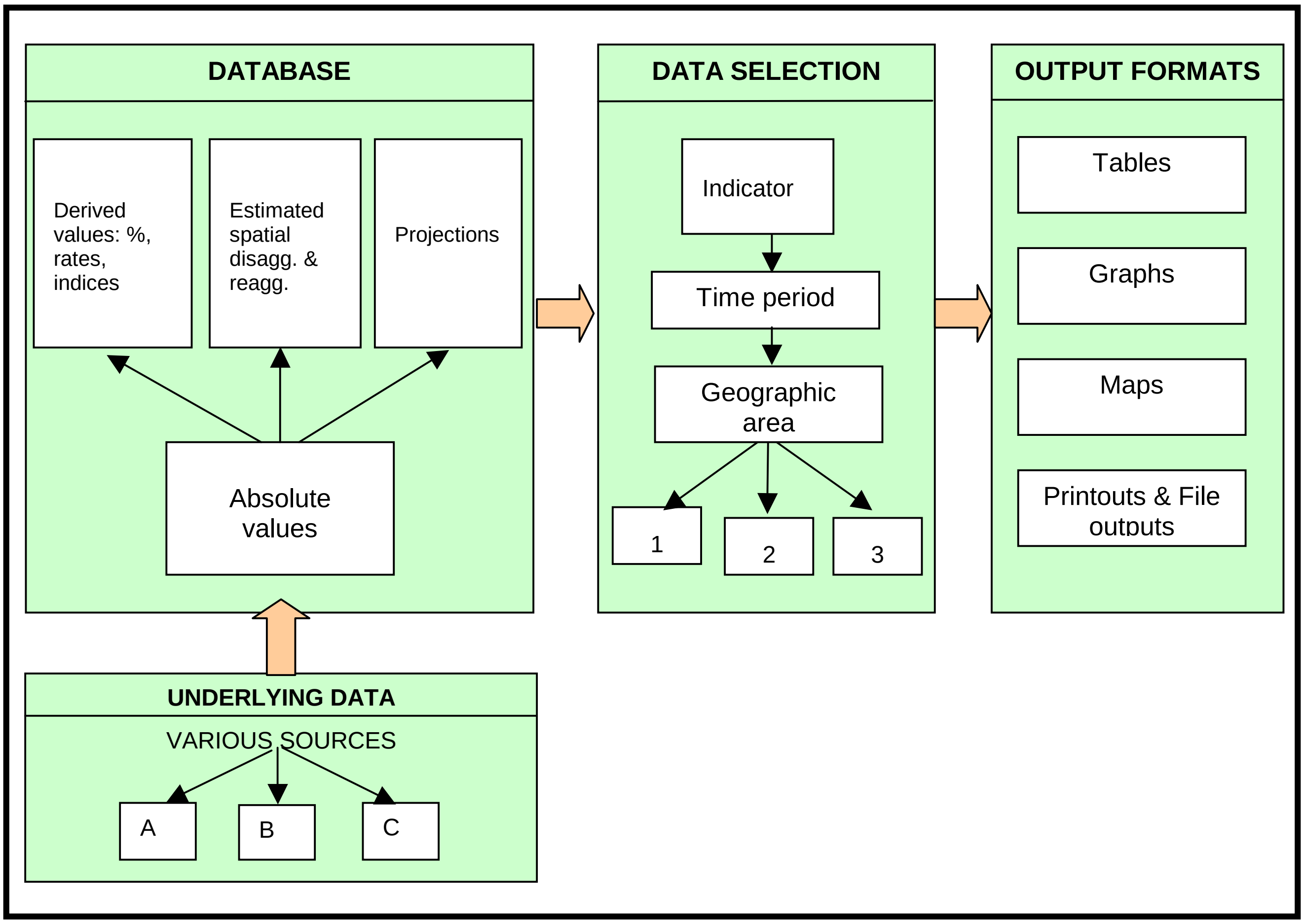
Indicator	**Categories**	**Timespan**	**Geographic detail**
Gross geographic product	Major sectors	1972-1997	Magisterial districts
Labour distribution	Employment/un-employment Major sectors	1980, 1991, 1994	Magisterial districts
Electricity consumption	Economic sectors, domestic	1988-1997	Local authority area, service council area
Electricity connections	Economic sectors, domestic	1988-1997	Local authority area, service council area
Remuneration*	Economic sectors	1993-1998	Magisterial districts
Turnover*	Economic sectors	1993-1998	Magisterial districts
Number of firms*	Economic sectors	1992-1998	Magisterial districts
Tax revenue	Company, Personal, VAT	1992-1997	Tax office area
Buildings completed	Residential, office, shops, industrial	1991-1996	Local authority area, service council area
Telephone connections	Business, residence	1998 1976-1997	Magisterial district Province
Vehicle sales	Commercial, passenger	1980-1997	Towns

* Figures complete for totals, but incomplete for economic sectors

On-line documentation is provided which gives information on:

- The definition of an indicator
- How the figures were obtained
- How reliable the figures are
- How complete the figures are
- To what detail the figures are available
- What the relevance or limitations of the figures are for analytical purposes.

Diagram 1: Overview of Economic Information System



3. Examples of utilisation

- A user can select a main area for analysing the spatial variations of an indicator. Within that area, any level of geographic detail, i.e. magisterial district level or town level in the case of data relating to a local authority area can be assessed.
- It is possible to compare changes over time between different areas. This may indicate whether patterns of economic activity are changing, for example that it is growing in one area and declining in another area, which will have an impact on, for example, human settlement and the demand for water.
- A user can select more than one indicator to ascertain how the trends of the different indicators are correlated in different areas or over time. If indicators are correlated, there may be a causal relationship between the two, or it may reveal that changes in both indicators are a consequence of some other factor. If these causal relationships can be determined, it may also become known whether the causal factors are changing permanently or temporarily, which will inform the user whether there should be a long-term planning response or not.

APPENDIX C LEGAL ASPECTS

Comprising:

Appendix C.1 Permit data from DAM SAFETY DATABASE

Appendix C.2 Example of PCPOLMAN DATABASE

Appendix C.3 Section 56/3 permits

APPENDIX C.1

DAM SAFETY DATABASE

(Example of section 9 and 13 permits)

	Section 9b authorisations grant permission to farmers to build dams >250 000 m^3 or for abstractions or diversions > 110 l/sec.							
	DWAF No.	**Dam Name**	**Magisterial District**	**RIVER**	**Gross capacity ($x10^3m^3$)**	**Dam used for**	**Permit No.**	**Permit Conditions**
1	12/2/C111-43	SONGLOED	ERMELO	HOLBANK SPRUIT	210	IRRIGATION	?	?
2	12/2/C111-46	BLACKWOOD	ERMELO	ONVERWAG SPRUIT	850	IRRIGATION		
3	12/2/C111-48	WATERWESE	VOLKSRUST	PERDEWATER SPRUIT	200	IRRIGATION		
4	12/2/C111-58	GOEDEHOOP	AMERSFOORT	KLEIN VAAL RIVER/RIVIER TR.	925	IRRIGATION		
5	12/2/C111-59	EARLY GREEN	AMERSFOORT	KLEIN VAAL RIVER/RIVIER TR.	224	IRRIGATION		
6	12/2/C111-64	JAN GREYLING	WAKKERSTROOM	KLEIN VAAL RIVER/RIVIER TR.	380	IRRIGATION		
7	12/2/C111-65	WELGELEGEN	ERMELO	NOULANE SPRUIT TR. OF VAAL RIVER	230	IRRIGATION		
8	12/2/C112-40	MIDDELPLAAT	ERMELO	KAFFER SPRUIT TR.	302	IRRIGATION		
9	12/2/C112-41	KRANSPOORT	ERMELO	KAFFER SPRUIT TR.	200	IRRIGATION		
10	12/2/C112-42	DRIEHOEK	ERMELO	KLEIN-KAFFER SPRUIT TR.	866	POLLUTION CONTROL		
11	12/2/C112-49	BRAKFONTEIN	ERMELO	RHENOSTERLOOP RIVER/RIVIER TR.	455	IRRIGATION		
12	12/2/C112-53	OU IRRIGATIONS	ERMELO	RENOSTERLOOP RIVER/RIVIER	298	IRRIGATION		
13	12/2/C112-54	TEERPAD IRRIGATIONS	ERMELO	RENOSTERLOOP RIVER/RIVIER TR.	237	IRRIGATION		
14	12/2/C112-56	ROOI JAN	ERMELO	RENOSTERLOOP RIVER/RIVIER	490	IRRIGATION		
15	12/2/C112-59	HAMELFONTEIN DAM NO 1	ERMELO	RENOSTERLOOP RIVER/RIVIER	225	IRRIGATION		
16	12/2/C114-35	STOCKYARD EVAPORATION	STANDERTON	LEEU SPRUIT TR.	605	POLLUTION CONTROL		
17	12/2/C114-36	VERBLYDEN	STANDERTON	BOESMAN SPRUIT	320	IRRIGATION		
18	12/2/C114-37	KARTAGO	STANDERTON	BRAK SPRUIT TR.	950	IRRIGATION		
19	12/2/C114-47	POORTJIE	STANDERTON	POORJIE RIVER/RIVIER	260	IRRIGATION		
20	12/2/C121-37	PAARDEFONTEIN	STANDERTON	WOLWE SPRUIT	250	IRRIGATION		
21	12/2/C123-31	MODDERFONTEIN	BALFOUR	MOL SPRUIT TR.	1110	IRRIGATION		
22	12/2/C132-09	ALLANVALE	VREDE	WILDEMAN SPRUIT	113305	IRRIGATION		
23	12/2/C211-19	PEET GELDENHUYSDAM	NIGEL	SUIKERBOSRANT RIVER/RIVIER TR.	250	IRRIGATION		
24	12/2/C211-23	TWEEFONTEIN	BALFOUR	SUIKERBOSRANT RIVER/RIVIER TR.	160	IRRIGATION		
25	12/2/C213-19	TEVREDE BOERDERY NO.1-	HEIDELBERG	SUIKERBOSRAND RIVER/RIVIER TR.	472	INSUFFICIENT INFORMATION		
26	12/2/C213-20	TEVREDE BOERDERY NO.2-	HEIDELBERG	SUIKERBOSRAND RIVER/RIVIER TR	350	IRRIGATION		
27	12/2/C222-31	POORTJIE	VANDERBIJLPARK	KLEIN-RIET SPRUIT	637	IRRIGATION		
63	12/2/C800-18	MENIN	BETHLEHEM	LIEBENBERGSVLEI RIVER/RIVIER TR.	691	IRRIGATION		

	Section 9b authorisations grant permission to farmers to build dams >250 000 m^3 or for abstractions or diversions > 110 l/sec.							
	DWAF No.	**Dam Name**	**Magisterial District**	**RIVER**	**Gross capacity ($x10^3m^3$)**	**Dam used for**	**Permit No.**	**Permit Conditions**
64	12/2/C801-41	RAINFALL	HARRISMITH	WILGE RIVER/RIVIER TR.	528	IRRIGATION		
65	12/2/C801-45	NESSHURST	HARRISMITH	FRASER'S SPRUIT TR.	347	IRRIGATION		
66	12/2/C801-47	SILOE	HARRISMITH	WILGE RIVER/RIVIER	500	IRRIGATION		
67	12/2/C801-48	SARCLET	HARRISMITH	RIET SPRUIT	1080	IRRIGATION		
68	12/2/C801-50	DU PLESSISDAL	HARRISMITH	-	314	INSUFFICIENT INFORMATION		
69	12/2/C801-51	SUMMERSLIE	HARRISMITH	MODDER SPRUIT TR.	271	IRRIGATION		
70	12/2/C802-38	ALLUVIAAL RANDT	HARRISMITH	RIBBOKSPRUIT TR.	244	IRRIGATION		
71	12/2/C802-39	NUGGET	HARRISMITH	RIBBOKSPRUIT	271	IRRIGATION		
72	12/2/C804-39	ALPHA	FRANKFORT	LANG SPRUIT TR.	236	INSUFFICIENT INFORMATION		
73	12/2/C805-42	BIETJIE-WATER	REITZ	LANG SPRUIT	581	IRRIGATION		
74	12/2/C805-45	VERGELEGEN	REITZ	KALOEM SPRUIT TR.	433	IRRIGATION		
75	12/2/C805-46	BLYDSCHAP	REITZ	CORNELIS RIVER/RIVIER	509	IRRIGATION		
76	12/2/C805-61	MIEMIESRUST	BETHLEHEM	AS RIVER/RIVIER TR.	419	IRRIGATION		
77	12/2/C805-62	BOSTON A	BETHLEHEM	AS RIVER/RIVIER TR.	414	IRRIGATION		
	Note:	**? Data not readily apparent**			**131599**			

Section 13 authorisations: Permission to municipalitities or local councils to build dams >125 000m^3 or for abstractions or diversions > 5 000 m^3/day.

	DWAF No:	Dam Name	Magisterial District	RIVER	Gross capacity ($10^6 m^3$)	Dam used for	Permit No.	Permit conditions
1	12/2/C110-13	BETHAL	BETHAL	BLESBOK SPRUIT	909	RECREATIONAL USE	?	?
2	12/2/C110-14	DOUGLASDAM	ERMELO	KLEIN-KAFFER SPRUIT TR.	1770	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
3	12/2/C110-16	WILLEM BRUMMER	ERMELO	LIT/KLN KAFFER SPRUIT	5800	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
4	12/2/C111-28	AMERSFOORT	AMERSFOORT	SKULP SPRUIT	992	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
5	12/2/C111-41	CAMDEN POWER STATION RAW WATER RESERVOIR NO. 1	ERMELO	-	231	KOMBINASIE - MUNISIPAAL EN/OF NYWERHEIDS EN IRRIGATION		
6	12/2/C112-57	PET	ERMELO	KLEIN DRINKWATER SPRUIT	168	IRRIGATION		
7	12/2/C113-35	MORGENZON-DORPS	ERMELO	OS SPRUIT	810	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
8	12/2/C113-44	SKOONWATER	VOLKSRUST	GEELKLIPSPRUIT	245	INDUSTRIAL USE		
9	12/2/C113-45	ROUWATER	VOLKSRUST	GEELKLIPSPRUIT	622	INDUSTRIAL USE		
10	12/2/C121-55	WITPOORT FARM	BALFOUR	GROOT SPRUIT TR.	140	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
11	12/2/C123-32	GROOTVLEI POWER STATION TERMINAL RESERVOIRS 1 & 2	BALFOUR	-	320	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
12	12/2/C130-01	BALFOUR	VOLKSRUST	SAND SPRUIT TR.	336	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
13	12/2/C130-02	SCHUILHOEK	VOLKSRUST	SAND SPRUIT TR.	386	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
14	12/2/C130-03	VREDE	VREDE	SPRUITSONDERDRIF	1420	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
15	12/2/C133-08	OU VREDE-DORPS	VREDE	SPRUITSONDERDRIF RIVER/RIVIER	150	IRRIGATION		
16	12/2/C210-02	PETRUS VAN DER MERWE HAARHOFF	HEIDELBERG	SUIKERBOSRANT RIVER/RIVIER	575	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
17	12/2/C210-03	STERKFONTEIN	VEREENIGING	SUIKERBOSRANT RIVER/RIVIER TR.	190	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
18	12/2/C212-43	RYNFIELD NO.1- MEER	BENONI	BLESBOK SPRUIT TR.	1152	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
19	12/2/C212-44	MIDDEL MEER	BENONI	BLESBOK SPRUIT TR.	765	FLOOD CONTROL		
20	12/2/C212-45	HOMESTEAD MEER	BENONI	BLESBOK SPRUIT TR.	908	FLOOD CONTROL		
21	12/2/C212-46	KLEINFONTEIN MEER	BENONI	BLESBOK SPRUIT	1173	FLOOD CONTROL		
22	12/2/C212-48	ASTON LAKE	SPRINGS	DWARS-IN DIE-VLEI	3200	IRRIGATION		
23	12/2/C212-51	NIGEL	NIGEL	NIGELSPRUIT	1600	FLOOD CONTROL		
24	12/2/C212-56	VLAKFONTEIN RESERVOIR	BENONI	-	421	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
25	12/2/C212-58	BENONI NO 3 RESERVOIR	BENONI	-	122	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
26	12/2/C212-59	BRAKPAN NO 2 RESERVOIR	BRAKPAN	-	122	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
27	12/2/C212-60	BRAKPAN NO 3 RESERVOIR	BRAKPAN	-	200	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
28	12/2/C213-22	FOREBAY RESERVOIR	VEREENIGING	VAAL RIVER/RIVIER	694	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		

	Section 13 authorisations: Permission to municipalitities or local councils to build dams >125 000m³ or for abstractions or diversions > 5 000 m³/day.							
	DWAF No:	**Dam Name**	**Magisterial District**	**RIVER**	**Gross capacity (10^6m^3)**	**Dam used for**	**Permit No.**	**Permit conditions**
29	12/2/C221-27	KLIPSPRUIT	JOHANNESBURG	HARRINGTON SPRUIT	419	POLLUTION CONTROL		
30	12/2/C221-45	ORLANDO POWER STATION	JOHANNESBURG	KLIP SPRUIT TR.	790	INLIGTING ONBREEK		
31	12/2/C221-46	OLIFANTSVLEI CONTACT	JOHANNESBURG	KLIP RIVER/RIVIER TR.	1000000	INLIGTING ONBREEK		
32	12/2/C221-52	KLIPRIVIERSBERG NO 1 RESERVOIR	JOHANNESBURG	-	587	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
33	12/2/C221-53	KLIPRIVIERSBERG NO 2 RESERVOIR	JOHANNESBURG	-	650	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
34	12/2/C221-54	MEYER'S HILL RESERVOIR	JOHANNESBURG	-	274	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
35	12/2/C221-57	MEREDALE	JOHANNESBURG	-	122	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
36	12/2/C221-60	MEREDALE NO 2	JOHANNESBURG	-	200	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
37	12/2/C231-59	BLYVOORUITZICHT RETURN WATER DAM NO. 7	OBERHOLZER	WONDERFONTEIN SPRUIT	131	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
38	12/2/C231-76	DRIEFONTEIN RESERVOIR	OBERHOLZER	-	124	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
39	12/2/C232-08	VAAL BARRAGE (WAS C230-08)	VANDERBIJLPARK	VAAL RIVER/RIVIER	55444	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
40	12/2/C232-42	SHAFT FRESH WATER DAM NO. 1	POTCHEFSTROOM	LEEU SPRUIT	203	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
65	12/2/C800-04	GERRANDS	BETHLEHEM	GERRAND SPRUIT	1347	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
66	12/2/C800-14	SAULSPOORT	BETHLEHEM	LIEBENBERGSVLEI	18800	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
67	12/2/C800-16	LOCH ATHLONE	BETHLEHEM	JORDAAN RIVER/RIVIER	3740	RECREATIONAL USE		
68	12/2/C800-20	REITZ REWARD	REITZ	LIEBENBERGSVLEI RIVIER/RIVER TR.	225	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
69	12/2/C800-23	GIBSON	HARRISMITH	WILGE RIVER/RIVIER TR.	543	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
70	12/2/C805-38	GELUK BUITELOOP-OPGAAR	REITZ	LIEBENBERGSVLEI RIVER/RIVIER	480	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
71	12/2/C805-39	GELUK	REITZ	LIEBENBERGSVLEI	240	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE		
72	12/2/C805-44	MIDDELPUNT	REITZ	KALOEM SPRUIT	650	SUPPLY FOR MUNICIPALITY USE &/OR INDUSTRIAL USE	?	?
	Note:	**? Data not readily apparent**			1110390			

Section 13 authorisations grant permission to industry to build dams >150 000 m^3 or for abstractions > 150m^3/day.

DWAF No.	Dam Name	Magisterial District	RIVER	Gross capacity (x $10^6 m^3$)	Dam used for	Permit No.	Permit Conditions
12/2/C111-41	CAMDEN POWER STATION RAW WATER RESERVOIR NO. 1	ERMELO	-	231	KOMBINASIE - MUNISIPAAL EN/OF NYWERHEIDS EN IRRIGATION	?	?
12/2/C111-74	TORBANITE DAM - NEW NUMBER - OLD NUMBER WAS X101-42	ERMELO	VAAL RIVER/RIVIER TR.	1200	IRRIGATION		
12/2/C112-43	NOOITGEDACHT	ERMELO	KLEIN-KAFFER SPRUIT TR.	170	IRRIGATION		
12/2/C113-40	ASH DUMP DAM NO. 1	VOLKSRUST	OFF CHANNEL STORAGE DAM	269	BESOEDELINGSBEHEER		
12/2/C113-44	SKOONWATER	VOLKSRUST	GEELKLIPSPRUIT	245	NYWERHEIDSGEBRUIK		
12/2/C113-45	ROUWATER	VOLKSRUST	GEELKLIPSPRUIT	622	NYWERHEIDSGEBRUIK		
12/2/C114-39	TUTUKA POWER STATION TERMINAL RESERVOIRS NO. 1 & 2	STANDERTON	LEEU SPRUIT	875	BESOEDELINGSBEHEER		
12/2/C114-43	TUTUKA CLEAN WATER DAM NORTH	STANDERTON	-	500	IRRIGATION		
12/2/C121-34	WINKELHAAK-EVANDER	STANDERTON	GROOT SPRUIT	1650	ONTSPANNING		
12/2/C123-32	GROOTVLEI POWER STATION TERMINAL RESERVOIRS 1 & 2	BALFOUR	-	320	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C210-03	STERKFONTEIN	VEREENIGING	SUIKERBOSRANT RIVER/RIVIER TR.	190	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C212-49	FLORARCADIA	HEIDELBERG	HOL SPRUIT	350	IRRIGATION		
12/2/C212-56	VLAKFONTEIN RESERVOIR	BENONI	-	421	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C212-57	NORTHRIDGE RESERVOIR	GERMISTON	-	90	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C212-58	BENONI NO 3 RESERVOIR	BENONI	-	122	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C212-59	BRAKPAN NO 2 RESERVOIR	BRAKPAN	-	122	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C212-60	BRAKPAN NO 3 RESERVOIR	BRAKPAN	-	200	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C212-61	ALEXANDER	SPRINGS	BLESBOKSPRUIT	5056	ONTSPANNING		
12/2/C213-22	FOREBAY RESERVOIR	VEREENIGING	VAAL RIVER/RIVIER	694	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-48	CINDERELLA	BOKSBURG	DIXIE SPRUIT	1536	ONTSPANNING		
12/2/C221-52	KLIPRIVIERSBERG NO 1 RESERVOIR	JOHANNESBURG	-	587	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-53	KLIPRIVIERSBERG NO 2 RESERVOIR	JOHANNESBURG	-	650	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-54	MEYER'S HILL RESERVOIR	JOHANNESBURG	-	274	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-55	FOREST HILL NO 2 RESERVOIR	JOHANNESBURG	-	90	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-56	FOREST HILL NO 3 RESERVOIR	JOHANNESBURG	-	114	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		

Section 13 authorisations grant permission to industry to build dams >150 000 m^3 or for abstractions > 150m^3/day.							
DWAF No.	**Dam Name**	**Magisterial District**	**RIVER**	**Gross capacity (x $10^6 m^3$)**	**Dam used for**	**Permit No.**	**Permit Conditions**
12/2/C221-57	MEREDALE	JOHANNESBURG	-	122	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-58	LANGERAND NO 1 RESERVOIR	VEREENIGING	-	112	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C221-60	MEREDALE NO 2	JOHANNESBURG	-	200	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C222-26	PETER WRIGHT	WESTONARIA	RIET SPRUIT	1950	BESOEDELINGSBEHEER		
12/2/C223-26	LETHABO POWER STATION RAW WATER RESERVOIRS NO. 1 & 2	VEREENIGING	-	443	BESOEDELINGSBEHEER		
12/2/C223-43	SASOLBURG RESERVOIR	SASOLBURG	-	103	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C231-42	DONALDSON	WESTONARIA	WONDERFONTEIN SPRUIT	460	ONTSPANNING		
12/2/C231-59	BLYVOORUITZICHT RETURN WATER DAM NO. 7	OBERHOLZER	WONDERFONTEIN SPRUIT	131	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C231-76	DRIEFONTEIN RESERVOIR	OBERHOLZER	-	124	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C232-08	VAAL BARRAGE (WAS C230-08)	VANDERBIJLPARK	VAAL RIVER/RIVIER	55444	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C232-42	SHAFT FRESH WATER DAM NO. 1	POTCHEFSTROOM	LEEU SPRUIT	203	WATERVOORSIENING VIR MUNISIPALE EN/OF NYWERHEIDSGEBRUIK		
12/2/C232-45	SHAFT COFFER DAM NO. 1	POTCHEFSTROOM	LEEU SPRUIT	492	VLOEDBEHEER		
12/2/C232-51	DEELKRAAL	POTCHEFSTROOM	WONDERFONTEIN SPRUIT	148200	ONTSPANNING		
12/2/C800-15	KRANSFONTEIN	BETHLEHEM	TIERKLOOF RIVER/RIVIER	264	IRRIGATION		
Note:	**? This data not readily apparent**			**224562**			

APPENDIX C.2

PCPOLMAN DATABASE (Example of permits)

Data from PCPOLMAN database (DWAF, Water Quality Section)

SOME ABSTRACTION AND DISCHARGE PERMITS

Permit no	File no	Name	Drainage region	PERMIT STATUS	QUAT (FLOW TYPE)	FLOW	ABS/DISCHARGE	Annual abs/disc TOTAL FLOW(m³)	TIME	Daily abs/disc FLOW(m³)
1464B	B33/2/310/53	Majuba Power-station,Volksrust	Buffels River	0	C110/00/E001	FLOW	D	1398000	D	3830
937 B	B33/2/1600/22	Amersfoort Municipality		0	C110/00/V001	FLOW	D	62050	D	0
1402B	B33/2/310/124	Raad OP Plaaslike Bestuursaangeleenthede		0	C110/00/V002	FLOW	A	200000	D	548
				0	C110/00/V002	FLOW	D	7300	D	20
595 N	B33/2/310/40	Toga Linings (Pty) Limited:Standerton		0	C110/10/D002	FLOW	A	480200	D	1600
1040N	B33/2/310/25	Food and Nutritional products (Pty) Ltd(Standerton		0	C110/10/D002	FLOW	A	368400	D	1200
801 N	B33/2/310/30	Early Farm (Pty) Ltd Standerton		0	C110/10/D002	FLOW	A	312100	D	1230
766 N	B33/2/310/4	Wooltextile Manufacturers (Pty) Limited		0	C110/10/D002	FLOW	A	309600	D	1000
1284N	B33/2/310/77	Nasionale Sorghumbier Brouerye		0	C110/10/D002	FLOW	A	69264	D	222
1178N	B33/2/310/61	South Highveld Bottling (Pty) Ltd (Standerton)		0	C110/10/D002	FLOW	A	46100	D	230
486 N	B33/2/200/59	Food And Nutritional Products		0	C110/19/D004	FLOW	A	182500	D	800
1165N	B33/2/310/60	National Co-operative Dairies Limited,Ermelo		0	C110/20/D001	FLOW	A	208000	D	705
1348N	B33/2/310/53	Eskom,Standerton		0	C111/00/Q001	FLOW	A	912500	D	2500
769 B	33/2/310/1	Ermelo City Council		0	C112/00/E001	FLOW	D	2074200	D	5683
639 B	B33/2/200/1	City Council Of Bethal		0	C113/00/E001	FLOW	D	3011250	D	7500
1777B	16/2/7/C114/C74	New Denmark Colliery,Standerton		0	C114/00/B011	FLOW	D	807000	D	2210
1434N	B33/2/0310/074	New Denmark Colliery (AMCoAL)Slagkraal 353 IS		0	C114/00/B011	FLOW	A	680500	D	1864
1611B	B33/2/310/45	Eskom,Standerton		0	C114/00/C031	FLOW	D	2737500	D	7500
				0	C114/00/E001	FLOW	D	642400	D	1760
734 B	33/2/310/2	Standerton Municipality		0	C114/00/E002	FLOW	D	109500	0	
1777B	16/2/7/C114/C74	New Denmark Colliery,Standerton		0	C114/00/E003	FLOW	D	53700	D	0
				0	C114/00/E004	FLOW	D	766500	D	2000
1777B	16/2/7/C114/C74	New Denmark Colliery,Standerton		0	C114/00/E005	FLOW	D	146000	D	0
1611B	B33/2/310/45	Eskom,Standerton		0	C114/00/E006	FLOW	D	365000	D	1000
1079B	B33/2/310/30	Early Bird Farm (Pty) Ltd		0	C114/00/L001	FLOW	A	261070	0	
1777B	16/2/7/C114/C74	New Denmark Colliery,Standerton		0	C114/00/L002	FLOW	D	23400	D	0
				0	C114/00/L003	FLOW	D	83070	D	228
1611B	B33/2/310/45	Eskom,Standerton		0	C114/00/L003	FLOW	D	73000	D	200
1611B	B33/2/310/45	Eskom,Standerton		0	C114/00/X052	FLOW	D	547500	D	1500
854 N	B33/2/310/47	Sasol Fertilizers (Pty) Ltd		0	C121/00/B003	FLOW	A	693500	D	2850
691 B	B33/2/310/28	Sasol Two (Pty) Limited		0	C121/00/E001	FLOW	D	8833000	D	55000
				0	C121/00/E002	FLOW	D	8833000	D	55000
1449B	B33/2/31/0/63	Embalenhle Municipality		0	C121/00/E003	FLOW	D	1892000	D	5190
802 B	B33/2/310/36	Secunda Collieries (Secunda)		0	C121/00/E004	FLOW	D	1643000	0	
709 B	33/2/310/10	Brakpan Mines Limited		0	C121/00/E005	FLOW	D	456250	D	650
1598B	B33/2/310/28	Sasol Nywerhede (Edms.) Beperk		0	C121/00/E006	FLOW	D	0	D	1
691 B	B33/2/310/28	Sasol Two (Pty) Limited		0	C121/00/E007	FLOW	D	8833000	D	55000
				0	C121/00/E010	FLOW	D	456250	D	1250
676 B	33/2/310/5	Winkelhaak Mines Limited		0	C121/00/H001	FLOW	D	2322400	D	6363
820 B	33/2/322/9	Evander Township Limited		0	C121/00/L001	FLOW	D	30000	0	
802 B	B33/2/310/36	Secunda Collieries (Secunda)		0	C121/00/N001	FLOW	D	0	D	315

1455N	B33/2/310/28	Sasol Nywerhede (Edms.) Beperk		0	C121/00/Q020	FLOW	A	73000	D	0
1598B	B33/2/310/28	Sasol Nywerhede (Edms.) Beperk		0	C121/00/R001	FLOW	D	82350	D	0
				0	C121/00/R004	FLOW	D	0	D	1
1405B	B33/2/310/75	Nthorwane Dorpskomitee		0	C121/00/V002	FLOW	D	26300	D	72
709 B	33/2/310/10	Brakpan Mines Limited		0	C121/00/V003	FLOW	D	186000	D	0
454 B	B33/2/310/12	Kinross Mines Limited		0	C121/00/V006	FLOW	D	26020000	D	0
676 B	33/2/310/5	Winkelhaak Mines Limited		0	C121/00/V008	FLOW	D	1105900	D	3030
				0	C121/00/V009	FLOW	D	975640	D	2673
565 B	33/2/310/24	Messrs Ferco Beleggings (Edms) Beperk		0	C123/00/L002	FLOW	D	402000	D	1100
399 B	33/2/310/13	Springfield Collieries Limited		0	C123/00/P001	FLOW	D	353000	D	967
1235B	B33/2/310/52	Municipality Van Memel		0	C132/00/L001	FLOW	D	30000	D	73
608 B	B33/2/310/3	Municipality Of Vrede		0	C133/00/L001	FLOW	D	126000	D	315
747 N	B33/2/322/185	East Rand Gold And Uranium Company Limited : Ergo		0	C210/00/A001	FLOW	A	0	D	1
847 N	B33/23/321/22	Eskort Bacon Co-operative Limited: Heidelberg		0	C210/04/D002	FLOW	A	221000	D	1150
1056N	B33/2/321/55	Rembrandt-Tabakvervaardigingskoperasie Van Suid Af		0	C210/04/D002	FLOW	A	182000	D	830
1109N	B33/2/322/259	Salcast (Pty) Ltd;Lincoln Rd Benoni Industrial Sit		0	C210/06/D006	FLOW	A	65200	D	240
1060N	B33/2/321/54	Chloride S.A. Limited (Benoni South)		0	C210/06/D006	FLOW	A	59500	D	250
1303N	B33/2/321/81	Iscor Limited,Pretoria		0	C210/06/D006	FLOW	A	50000	D	175
747 N	B33/2/322/185	East Rand Gold And Uranium Company Limited : Ergo		0	C210/07/D007	FLOW	A	3650000	D	10000
406 N	33/2/322/171	Hippo Quarries (Pty) Ltd: Brakpan		0	C210/07/D007	FLOW	A	26640	D	74
1267N	B33/2/321/51	Nigel Bottling Industries (Pty) Ltd		0	C210/09/D001	FLOW	A	250000	D	1000
686 N	B33/2/321/48	Hanni & Sons Leather and Glove Factory (Pty) Ltd		0	C210/09/D001	FLOW	A	160000	D	660
747 N	B33/2/322/185	East Rand Gold And Uranium Company Limited : Ergo		0	C210/09/D001	FLOW	A	0	D	1
				0	C210/10/B004	FLOW	D	5250000	D	15000
1335B	B33/2/321/42	Aluminium Chemicals (Pty) Ltd		0	C210/10/B008	FLOW	D	139000	D	380
747 N	B33/2/322/185	East Rand Gold And Uranium Company Limited : Ergo		0	C210/10/B010	FLOW	A	219000	D	600
529 N	33/2/321/7	Sappi Fine Papers (Pty) Limited,Enstra		0	C210/10/D003	FLOW	D	9125000	D	25000
747 N	B33/2/322/185	East Rand Gold And Uranium Company Limited : Ergo		0	C210/10/D003	FLOW	A	1861500	D	5100
630 N	B33/2/321/23	Zinc Corporation of S.A. Limited		0	C210/10/D003	FLOW	A	1678800	D	4600
418 N	33/2/321/20	Enstra Mill,Springs		0	C210/10/D003	FLOW	A	864000	D	3273
1199N	B33/2/321/1	Irvin And Johson Ltd (Springs)		0	C210/10/D003	FLOW	A	839000	D	3200
212 N	33/2/321/2	South African Board Mills Limited	KZN	0	C210/10/D003	FLOW	A	494040	0	
275 N	33/2/121/32	Van Leer Packaging (Pty) Limited,Springs		0	C210/10/D003	FLOW	A	180703	D	750
89 N	B33/2/321/3	Boart Hardmetals		0	C210/10/D003	FLOW	A	180000	D	620
1184N	B33/2/321/42	Aluminium Chemicals (Pty) Ltd: Springs		0	C210/10/D003	FLOW	A	164300	D	450
369 N	B33/2/321/30	Pilkington Flat Glass S.A. (Pty) Limited		0	C210/10/D003	FLOW	A	113000	D	350
1208N	B33/2/321/78	Randtoria Breweries (Springs)		0	C210/10/D003	FLOW	A	86300	D	280
363 N	B33/2/321/31	Acoustical Fibreglass Insulation (MNFG) (PTY) Ltd		0	C210/10/D003	FLOW	A	80000	D	220
1211N	B33/2/321/56	Kellogg Company Of (S.A) Springs(PTY) LTD		0	C210/10/D003	FLOW	A	66300	D	240
1201N	B33/2/321/79	Maksal Tubes,Springs		0	C210/10/D003	FLOW	A	60600	D	174
1091N	B33/2/321/46	Ultra High Pressure Units (Pty) Ltd: SPRINGS		0	C210/10/D003	FLOW	A	43200	D	180
1046N	B33/2/321/40	Raleigh Cycles (South Africa)Springs		0	C210/10/D003	FLOW	A	7950	D	40
				0	C210/13/D004	FLOW	A	0	D	650
503 B	B33/2/321/32	Balfour Municipality		0	C211/00/L001	FLOW	D	160000	D	440
1026N	B33/2/321/58	Karan Estates(Elandsfontein Farm 412;Heidelberg)		0	C212/00/A001	FLOW	A	230000	D	0
				0	C212/00/C012	FLOW	A	0	D	1
1491B	B33/2/321/5	Municipality of Heidelberg		0	C212/00/E001	FLOW	D	1806750	D	4500
252 B	33/15/2/2	Brakpan Municipality		0	C212/00/E003	FLOW	D	672500	D	1843

APPENDIX C.3

Section 56/3 permits

ABSTRACTIONS FROM VAAL GWS

Data checked by Mrs K Broere, DWAF, GWS, Room 631 (Sedibeng)

Permit Type	River	Quat	Source	User	Allocation Number	Amount (m^3/annum)		Sector	Date issued	Source of data
Section 56 (3)*	**Vaal**	**C12L / C83M**	**Vaal GWS - Vaal Dam**	**Rand Water**	**60/16/2/91**	**1260000000**	**Water board**	**Res. / Ind. / Inst**	**?**	**DWAF"includes free allocation"**
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal River	A Websted	2/2/16/89/8	2555	Domestic	Agric	11/7/1989	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal River	MG Bremmer	53/2/10/1608/86	2592	Domestic	Agric	10/22/1986	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	HJ Verster	132/16/2/83	8000	Domestic	Res. / rec. / agric.	9/26/1983	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	CH Duvenhage	Permit 223	10181	Domestic	Agric	10/8/1957	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	LP Korsten	2/2/16/91/9	2592	Domestic	Domestic / agric.		DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	A Casey	2/2/16/92/1	2592	Domestic	Domestic / agric.		DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	P Maher	2/2/16/92/2	2592	Domestic	Domestic / agric.		DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	Francesco co Piccolo	2/2/16(179)	2592	Domestic	Domestic / agric.		DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River (Deneysville)	Groen Oewers	4/16/2/97	12000	Domestic	Domestic	2/7/1997	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	JG Meyer	53/154/82	3650	Domestic	Agric.	11/22/1984	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	SP du Plessis	56/154/83	3600	Domestic	Dom. / agric.		DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	C. van H Theunissen	49/154/88	3650	Domestic	Dom. / agric.	4/20/1988	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	J le Roux Bredenkamp	S2/154/89	3650	Domestic	Dom. / agric.	5/30/1989	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	N Claassen	S4/154/89	3650	Domestic	Dom. / agric.	5/30/1989	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	SJ Roets	S15/154/89	3600	Domestic	Dom. / agric.	5/30/1989	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	GJS Janse van Vuuren	S27/154/89	3600	Domestic	Dom. / agric.	5/30/1989	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	JJ Steyn	S1/154/90	3600	Domestic	Dom. / agric.		DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River (Barrage area?)	BA van Donwe	103/16/2/82	1800	Domestic	Domestic	10/5/1982	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	PW Gough	2/2/16/94/8	2592	Domestic	Dom. / Agric		DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	GP Danks	2/2/16/94/10	2592	Domestic	Dom. / Agric		DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Barrage)	Clavadel River Lodge	22/16/2/97	8000	Domestic	Irrigation	6/12/1997	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	CW Smith	2/2/16/89/6	2555	Domestic	Domestic	5/17/1989	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	BA Stuart	2/2/16/89/4	2555	Domestic	Domestic	5/17/1989	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	Nessie Oppie Loch	2/2/16/89/7	2555	Domestic	Domestic	9/26/1989	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	M Jurgens	3/16/2/98	2592	Domestic	Domestic	1/15/1998	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	MJ Lamberti	2/2/16/90/1	2555	Domestic	Agric	3/23/1990	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	G Wolf	2/2/16/90/3	2555	Domestic	Domestic	9/17/1990	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	JM Ferreira	2/2/16/90/4	2555	Domestic	Domestic	9/17/1990	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	D Perry	2/2/16/90/5	2592	Domestic	Domestic	10/16/1990	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	D. Da Silva	17/16/2/98	2592	Domestic	Domestic	6/18/1998	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	S Iovino	2/2/16/91/1	2952	Domestic	Domestic	1/21/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	TD Ray	30/2/10/1608/86	2592	Domestic	Dom. / agric	5/2/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	TF Stubbs	2/2/16/91/2	2595	Domestic	Domestic	1/25/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	Reg Wepener Investments	2/2/16/91/8	2592	Domestic	Domestic	8/22/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	S Oberholzer (Rivabello Properties)	2/2/16/91/10	2592	Domestic	Domestic	10/1/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	MJ Gaade	S2/2/16/91/12	2592	Domestic	Domestic	12/5/1991	DWAF
Section 56 (3)	Vaal Rive	C22K	Vaal GWS - Vaal River (Vanderbylpark)	CJ Theunissen	116/16/2/82	1500	Domestic	Dom. / Agric	10/27/1982	DWAF
Section 56 (3)	Vaal Rive	C22K	Vaal GWS - Vaal River (Vanderbylpark)	GPB Loggenberg	49/16/2/84	2500	Domestic	Domestic	4/18/1984	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	HN Krog	52/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	JW Surman	51/2/10/1608/86	2592	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	GC Baars investments	50/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	AJ Frey	47/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	BVJ Benjamin	45/2/10/1608/86	2592	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	DP Scott	43/2/10/1608/86	2592	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	PWL Pieterse	41/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	CW Jordaan	40/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF

ABSTRACTIONS FROM VAAL GWS

Data checked by Mrs K Broere, DWAF, GWS, Room 631 (Sedibeng)

Permit Type	River	Quat	Source	User	Allocation Number	Amount (m^3/annum)		Sector	Date issued	Source of data
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	AO Nissen	39/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	AR Willows-Munro	38/2/10/1608/86	2555	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	V Olivier	34/2/10/1608/86	2592	Domestic	Dom. / Agric.	10/22/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	Loch Vaal Club	68/2/10/1608/87	2665	Domestic	Dom. / Agric.	1/20/1987	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal Barrage	KG Cloutman (Loch Vaal Hotel)	65/2/10/1608/87	2701	Domestic	Dom. / Agric.	1/20/1987	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Miravaal	CIK Family Trust	72/2/10/1608/87	2592	Domestic	Dom. / Agric.	4/14/1987	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Miravaal	PJ Viljoen	2/2/16/91/4	2595	Domestic	Domestic	5/24/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	"EK & Jy" - Brisley & Du Tiot	2/2/16/91/5	2592	Domestic	Domestic	6/11/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Loch Vaal	RC Astrup	2/2/16/91/6	2595	Domestic	Domestic	6/11/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	H. Steenkamp	2/2/16/92/4	2592	Domestic	Domestic	11/12/1992	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	The Gander Foundation (E. Gander)	2/2/16/92/5	2592	Domestic	Domestic	11/12/1992	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	Damlight (Pty) Ltd	2/2/16/92/6	2592	Domestic	Domestic	11/13/1992	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	MW van der Merwe	2/2/16/93/3	2592	Domestic	Domestic	1/21/1993	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Lochvaal)	JC van Rooyen	2/2/16/93/2	2592	Domestic	Domestic	1/21/1993	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Lochvaal)	B. Kennedy	2/2/16/93/1	2592	Domestic	Domestic	1/21/1993	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	CE Basson	2/2/16/92/7	2592	Domestic	Domestic	12/8/1992	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Lochvaal)	Loch Vaal Kennels	2/2/16/93/5	2592	Domestic	Domestic	6/28/1993	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	GF van Zyl	2/2/16/93/7	2592	Domestic	Domestic	10/20/1993	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	JC Coetzee	2/2/16/93/4	2592	Domestic	Domestic	6/2/1993	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Lochvaal)	GR Prevett	S3/16/94	2590	Domestic	Domestic	4/12/1994	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Lochvaal)	GR Prevett	2/2/16/94/1	2592	Domestic	Domestic	4/25/1994	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Lochvaal)	CH Swanepoel	2/2/16/94/3	2592	Domestic	Domestic	5/16/1994	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	Financial Acquisition Services	2/2/16/94/5	2592	Domestic	Domestic	6/2/1994	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbylpark)	Marivaal Investments	2/2/16/94/4	2592	Domestic	Domestic	6/2/1994	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	N Cloete	59/2/10/1608/86	2592	Domestic	Dom. / Agric.	11/3/1986	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	AE van der Merwe	S2/16/94	2590	Domestic	Domestic	4/17/1994	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	AE van der Merwe	2/2/16/94/2	2592	Domestic	Domestic	4/25/1994	DWAF
Section 56 (3)	Vaal	C23L	Vaal GWS - Vaal River (Potchefstroom)	M & E Lombard	B2/2/16(299)/96/	2500	Domestic	Dom. / Agric		DWAF
Section 56 (3)	Vaal	C23L	Vaal GWS - Vaal River (Potchefstroom)	Vetmesting Cooperative	20/16/2/23	365000	Domestic	Industrial	1/14/1983	DWAF
Section 56 (3)	Vaal	C83M	Vaal GWS - Vaal River (Heilbron)	DJ Heming (Race track)	83/16/2/92	42000	Domestic	Institutional	11/23/1992	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam	Oranjeville Village Management Board	Agreement No. 5	590707	Instituition	Municipal	7/12/1938	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam	Dept: Transport & Public Works	2/16/2/98	75000	Instituition	Residential	1/15/1998	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam	SA Fishing Organisation	275/11/77	3000	Instituition	Recreational	10/28/1977	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam	Rand Afrikaanse University	64/11/89	10000	Instituition	Institutional	5/30/1989	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam (Groeteiland)	National Intellengence Service	64/16/2/94	10000	Instituition	Institutional	12/1/1994	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam (Koppiesfontein)	Cormorant Bay Home Owners	57/16/2/95	1200	Instituition	Residential	10/9/1995	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	Vaaloewerdorp: Western Gauteng Servic	25/16/2/96	330000	Instituition	Residential	5/16/1996	DWAF
Section 56 (3)	Vaal	C83M	Vaal GWS - Vaal Dam	Correctional Services : Frankfort	59/16/2/93	6000	Instituition	Inst. / Irr.	9/8/1993	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River (Vereeniging)	Groenpunt Prison - Commandant	6/12/2/90	1000000	Institution	Dom. / Agric.	1/18/1990	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal River	Vaal River Mining Co.	6/16/2/85	3000	Mine	Mining	1/24/1985	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal River	HPH Pistorius - Quarry	67/16/2/86	1500	Mine	Mining	?	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River	Coalbrook Coaliery - SASOL	Agreement	24889350	Mine	Industry (mine close	4/5/1951	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	HPH Pistorius	67/16/2/86	1500	Mine	Quarry - Ind.	7/15/1986	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	WN Frost - Quarry	52/16/2/87	5000	Mine	Quarry - Ind.	4/27/1987	DWAF
Section 56 (3)	Vaal	C23L	Vaal GWS - Vaal River (Pochhefstroom)	Anglo American Prospecting	55/16/2/93	7200	Mine	Mining - Ind.	8/26/1993	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal River	Villiers Municipality	28/16/2/94	800000	Mun/ind	Residential	7/8/1994	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam	Jim Fouche Holiday Resort	54/16/2/91	200000	Mun/ind	Res + recreational	8/12/1991	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam	Waterhaven Properties (Pty) Ltd	11/3/1977	6000	Mun/ind	Dom. + irr.	1/11/1977	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal River (Frankfort)	PEC Mienie	125/16/2/83	60000	Mun/ind	Industry	10/17/1983	DWAF

ABSTRACTIONS FROM VAAL GWS

Data checked by Mrs K Broere, DWAF, GWS, Room 631 (Sedibeng)

Permit Type	River	Quat	Source	User	Allocation Number	Amount (m^3/annum)		Sector	Date issued	Source of data
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam (Balfour)	Waterhaven Properties	36/16/2/93	25000	Mun/ind	Res. / Ind.	5/19/1993	DWAF
Section 56 (3)	Vaal	C12L	Vaal GWS - Vaal Dam (Balfour)	Early Bird Farm	111/16/2/89	64632	Mun/ind	Ind. - Battery hens	11/13/1989	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Rietspruit (Hidelburg)	Ready Mix Materials	14/16/2/94	180000	Mun/ind	Industry	2/9/1994	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Vaal River	Raad op Plaaslike Bestuur	72/16/2/92	330000	Mun/ind	Construction - expir	**9/15/1992**	DWAF
Section 56 (3)	Vaal	C22F	Vaal GWS - Deneysville pipeline	Rockplan (Pty) Ltd	S10/154/91	3600	Mun/ind	?	7/10/1991	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River	Sasol Municipality	Permit 1085	49458	Mun/ind	Recreational / Inst.	11/20/1970	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Barrage)	Constone Reef	141/16/2/81	91250	Mun/ind	Res. / Ind. - expired	10/16/1981	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	Riverside Holiday Inn	91/16/2/88	20000	Mun/ind	Irrigation	8/17/1988	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	Paula Properties CC	2/2/16/94/9	2592	Mun/ind	Dom. / Agric		DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal Barrage	S. Bothma & Son Transport	121/16/2/88	10000	Mun/ind	Industrial	10/25/1988	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	EP Rosseau	72/16/2/84	9600	Mun/ind	Industry	6/11/1984	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	Eureka Nursery	141/16/2/84	24000	Mun/ind	Industry	12/17/1984	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Sasolburg)	CJ Terblanche Investments	92/16/2/86	120000	Mun/ind	Industry	9/15/1986	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Sasolburg)	Leeuw's Transport	57/16/2/87	60000	Mun/ind	Industry	5/4/1987	DWAF
Section 56 (3)	Vaal	C22K	Vaal GWS - Vaal River (Vanderbijlpark)	Rimba Investments - Vaaloewer vakansie	73/16/2/92	35000	Mun/ind	Municipal	9/15/1992	DWAF
Section 56 (3)	**Vaal**	**C23C**	**Vaal GWS - Vaal River (Parys)**	**Parys Municipality**	**52/16/2/89**	**11814324**	**Mun/ind**	**Municipal**	**3/21/1989**	**DWAF**
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River	Vredefort Municipality	117/16/2/87	470000	Mun/ind	Municipal	11/17/1987	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	PC van Rensburg	123/16/2/89	7000	Mun/ind	Industry	12/5/1989	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	Sandy's Sand	57/16/2/90	60000	Mun/ind	Industry	8/31/1990	DWAF
Section 56 (3)	Vaal	C23C	Vaal GWS - Vaal River (Parys)	PC van Rensburg	66/16/2/84	16800	Mun/ind	Industry	5/24/1984	DWAF
Section 56 (3)	Vaal	C23K	Vaal GWS - Vaal River	Kearns & Churns	Permit 15	191150	Mun/ind	Industrial	1/8/1957	DWAF
Section 56 (3)	Vaal	C83M	Vaal GWS - Vaal River	Nebo Resort	Agreement 1	30660	Mun/ind	Municipal	2/18/1975	DWAF
Section 56 (3)	Vaal	C83M	Vaal GWS - Vaal River (Middle Vaal)	Eastern Tvl Kalkverskaffers	107/16/2/83	18250	Mun/ind	Mining		DWAF
Section 56 (3)	Vaal	C83M	Vaal GWS - Vaal Dam	Heilbron Municipality	Agreement	750000	Mun/ind	Municipal	6/7/1976	DWAF
Section 56 (3)	Vaal	C83M	Vaal Dam	Heilbron Municipality	42/154/83	8000	Mun/ind	Municipal		DWAF
Section 56 (3)*						**1303023619**				

Note: **Formerly Section 6 of the Vaal River Development Scheme, 34 (Act 38 of 1934)**

APPENDIX D LAND USE DATA

Comprising:

Appendix D.1 Irrigation land use

Appendix D.2 Urban area

APPENDIX D.1

IRRIGATION LAND USE DATA

(Summary data and quaternary data)

(Crop area data from WSAM, Irrigation sub-model)

WMA 8: UPPER VAAL WMA **IRRIGATION WATER REQUIREMENTS**

Version 2: 17 May 2001

CATCHMENT	Crop area data: Total harvested area	Total Green area	Quota data: GUIDELINE QUOTA	CALCULATE CROP WATER USE - 1995	Gross requirement [est]: TOTAL WATER REQUIREMENT (SAPWAT)	TOTAL WATER REQUIREMENT FOR 1995	GUIDELINE QUOTA REQ.	TOTAL ACTUAL WATER REQUIREMENT AT 1:50 YR ASSURANCE	Returns: RETURN FLOW AT 1:50 YR ASS
	aIHAi+aIMAi+aILAi	aISai	Table 8.2	Table 8.2	oITRo [WSAM]	Tab: 8.2	Tab: 8.2	gIARo	EST. ONLY
Units	km^2	km^2	[m^3/ha/a]	[m^3/ha/a]	[$10^6 m^3$/a]	[$10^6 m^3$/a]	[$10^6 m^3$/a]	[$10^6 m^3$/a]	%
Ref: Vaal River Irrigation Study	Table: 7.2	Tab: 8.2 & 7.2	Tab: 8.2						
Upstream of Grootdraai [controlled]	42.9	42.9	6100	5840	25.1	25.1	26.2	21.7	10%
[Vaal Dam catchment GWCA (d/s Grootdraai Dam); Waterval River & Vaal Dam GWCA]									
Grootdraai to Vaal Dam [all controlled]	38.9	29.9	6100	5560 to 5590	19.8	16.7	18.2	6.9	10%
C13 (Klip)	0.0	0.0	n/a	n/a	0.0	0.0	0.0	0.0	0%
[Wilge River Irrig area 1 & 2 and Liebensbergvlei area]				dry year					
Wilge [all controlled]	56.3	55.2	6100/ 8130 / 8640	3354 to 5788	28.2	20.6	34.5	17.8	10%
[Suikerbosrant River [incl. Blesbokspruit]				dry year					
Suikerbosrand [all controlled]	25.4	25.4	6100	3263	8.8	8.3	15.5	7.2	10%
Klip River [all controlled]	32.0	26.7	6100	4461	14.3	11.9	16.3	10.3	10%
Vaal dam and Vaal barrage [all controlled]	38.0	38.0	6100	3389 to 3734	19.0	13.3	23.2	1.5	10%
Vaal River GWCA; Rietpoort IB & Koppieskraal IB; Mooi River GWS									
Barrage to Mooi [scheduled / controlled]	25.6	25.7	6100 / 7700	6482 to 9302	23.5	19.2	21.4	8.0	10%
[Mooi River GWS; Klipdrift Settlement MB; Vyfhoek South MB]									
Mooi [all controlled]	46.1	45.8	5875 / 7700	7732 to 8926	43.6	34.4	31.3	40.3	10%
TOTAL [SS]	305.3	289.6	5875 to 8640		182.3	149.4	186.5	113.7	10% or 11.4
Total scheduled irrigation	62.6		5875 to 7700	3263 to 9302	DWAF data	Actual req.		DWAF data	

Notes:

Irrigation area data taken from Vaal Irrigation Study (PC000/00/21599); Table 7.2 and 8.2 etc.

Total harvested area = total crop area in Table 7.2

Total green or field area = total irrig area in Table 7.2 & 8.2; this area used to calculate irrig req.

DWAF data from UPPER VAAL 2.XLS; 5621IRRIGATION (worksheet)

Total controlled / scheduled irrigation

Quaternary catchment	Crop Irrigated	Economic value	SAPWAT crop factor	Harvested Area (km^2)	Conveyance loss factor (Refer to section 5.6.3)	Application efficiency	Leaching factor (Refer to section 5.6.4)
Wilge key area:							
C81E	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.1	0.1	0.79	1
C81E	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.8	0.1	0.79	1
C81E	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.3	0.1	0.79	1
C81K	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.1	0.1	0.79	1
C81K	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.8	0.1	0.79	1
C81K	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.3	0.1	0.79	1
C82C	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.1	0.1	0.79	1
C82C	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.8	0.1	0.79	1
C82C	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.3	0.1	0.79	1
C82G	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.1	0.1	0.79	1
C82G	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.8	0.1	0.79	1
C82G	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.3	0.1	0.79	1
C82H	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.1	0.1	0.79	1
C82H	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.8	0.1	0.79	1
C82H	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.3	0.1	0.79	1
C83C	Potato	Medium	Line Nr (37)*(1.00)	2.5	0.1	0.78	1
C83C	Stone fruit - fresh (peaches, plums, apricots, etc.)	High	Line Nr (4)*(1.00)	1.63	0.1	0.78	1
C83C	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (36)*(1.00)	0.3	0.1	0.78	1
C83C	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	2.65	0.1	0.78	1
C83C	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.78	1
C83F	Potato	Medium	Line Nr (37)*(1.00)	2.5	0.1	0.78	1
C83F	Stone fruit - fresh (peaches, plums, apricots, etc.)	High	Line Nr (4)*(1.00)	1.63	0.1	0.78	1
C83F	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (36)*(1.00)	0.3	0.1	0.78	1
C83F	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	2.65	0.1	0.78	1
C83F	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.78	1
C83G	Potato	Medium	Line Nr (37)*(1.00)	2.5	0.1	0.78	1
C83G	Stone fruit - fresh (peaches, plums, apricots, etc.)	High	Line Nr (4)*(1.00)	1.63	0.1	0.78	1
C83G	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (36)*(1.00)	0.3	0.1	0.78	1
C83G	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	2.65	0.1	0.78	1
C83G	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.78	1
C83H	Potato	Medium	Line Nr (37)*(1.00)	2.5	0.1	0.78	1
C83H	Stone fruit - fresh (peaches, plums, apricots, etc.)	High	Line Nr (4)*(1.00)	1.63	0.1	0.78	1
C83H	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (36)*(1.00)	0.3	0.1	0.78	1
C83H	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	2.65	0.1	0.78	1
C83H	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.78	1
C83M	Kikuyu	Low	Line Nr (8)*(1.00)	0.5	0.1	0.79	1
C83M	Lucerne	Low	Line Nr (9)*(1.00)	0.04	0.1	0.79	1
C83M	Potato	Medium	Line Nr (37)*(1.00)	0.77	0.1	0.79	1
C83M	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	1.1	0.1	0.79	1
C83M	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.18	0.1	0.79	1
C83M	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.08	0.1	0.79	1
Total:				**55.19**			
Grootdraai Key area:							
C11B	Kikuyu	Low	Line Nr (8)*(1.00)	4.12	0.1	0.75	1
C11B	Lucerne	Low	Line Nr (9)*(1.00)	0.51	0.1	0.75	1
C11B	Potato	Medium	Line Nr (37)*(1.00)	0.26	0.1	0.75	1
C11B	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.26	0.1	0.75	1
C11B	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.43	0.1	0.75	1
C11D	Kikuyu	Low	Line Nr (8)*(1.00)	4.12	0.1	0.75	1
C11D	Lucerne	Low	Line Nr (9)*(1.00)	0.26	0.1	0.75	1
C11D	Potato	Medium	Line Nr (37)*(1.00)	0.51	0.1	0.75	1
C11D	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.26	0.1	0.75	1
C11D	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.43	0.1	0.75	1
C11E	Kikuyu	Low	Line Nr (8)*(1.00)	4.12	0.1	0.75	1
C11E	Lucerne	Low	Line Nr (9)*(1.00)	0.51	0.1	0.75	1
C11E	Potato	Medium	Line Nr (37)*(1.00)	0.26	0.1	0.75	1
C11E	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.26	0.1	0.75	1
C11E	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.43	0.1	0.75	1
C11J	Kikuyu	Low	Line Nr (8)*(1.00)	4.12	0.1	0.75	1
C11J	Lucerne	Low	Line Nr (9)*(1.00)	0.51	0.1	0.75	1
C11J	Potato	Medium	Line Nr (37)*(1.00)	0.26	0.1	0.75	1
C11J	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.26	0.1	0.75	1
C11J	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.43	0.1	0.75	1
C11L	Kikuyu	Low	Line Nr (8)*(1.00)	4.12	0.1	0.75	1
C11L	Lucerne	Low	Line Nr (9)*(1.00)	0.51	0.1	0.75	1
C11L	Potato	Medium	Line Nr (37)*(1.00)	0.26	0.1	0.75	1
C11L	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.26	0.1	0.75	1
C11L	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.43	0.1	0.75	1
Total:				**42.9**			
Grootdraai to Vaal Dam key area:							
C11M	Kikuyu	Low	Line Nr (8)*(1.00)	0.7	0.1	0.79	1
C11M	Lucerne	Low	Line Nr (9)*(1.00)	0.02	0.1	0.79	1
C11M	Potato	Medium	Line Nr (37)*(1.00)	1.1	0.1	0.79	1
C11M	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	1.58	0.1	0.79	1
C11M	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (56)*(1.00)	0.26	0.1	0.79	1
C11M	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.53	0.1	0.79	1
C12B	Kikuyu	Low	Line Nr (8)*(1.00)	0.7	0.1	0.79	1
C12B	Lucerne	Low	Line Nr (9)*(1.00)	0.02	0.1	0.79	1
C12B	Potato	Medium	Line Nr (37)*(1.00)	1.1	0.1	0.79	1
C12B	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	1.58	0.1	0.79	1
C12B	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (56)*(1.00)	0.26	0.1	0.79	1
C12B	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.53	0.1	0.79	1
C12D	Kikuyu	Low	Line Nr (8)*(1.00)	0.26	0.1	0.75	1

Quaternary catchment	Crop Irrigated	Economic value	SAPWAT crop factor	Harvested Area (km^2)	Conveyance loss factor (Refer to section 5.6.3)	Application efficiency	Leaching factor (Refer to section 5.6.4)
C12D	Lucerne	Low	Line Nr (9)*(1.00)	0.01	0.1	0.75	1
C12D	Potato	Medium	Line Nr (37)*(1.00)	0.39	0.1	0.75	1
C12D	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	0.55	0.1	0.75	1
C12D	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.09	0.1	0.75	1
C12D	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.75	1
C12E	Kikuyu	Low	Line Nr (8)*(1.00)	0.26	0.1	0.75	1
C12E	Lucerne	Low	Line Nr (9)*(1.00)	0.01	0.1	0.75	1
C12E	Potato	Medium	Line Nr (37)*(1.00)	0.39	0.1	0.75	1
C12E	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	0.55	0.1	0.75	1
C12E	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.09	0.1	0.75	1
C12E	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.75	1
C12F	Kikuyu	Low	Line Nr (8)*(1.00)	0.26	0.1	0.75	1
C12F	Lucerne	Low	Line Nr (9)*(1.00)	0.01	0.1	0.75	1
C12F	Potato	Medium	Line Nr (37)*(1.00)	0.39	0.1	0.75	1
C12F	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	0.55	0.1	0.75	1
C12F	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.09	0.1	0.75	1
C12F	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.75	1
C12G	Kikuyu	Low	Line Nr (8)*(1.00)	0.26	0.1	0.75	1
C12G	Lucerne	Low	Line Nr (9)*(1.00)	0.01	0.1	0.75	1
C12G	Potato	Medium	Line Nr (37)*(1.00)	0.39	0.1	0.75	1
C12G	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	0.55	0.1	0.75	1
C12G	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.09	0.1	0.75	1
C12G	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.55	0.1	0.75	1
C12H	Kikuyu	Low	Line Nr (8)*(1.00)	0.7	0.1	0.79	1
C12H	Lucerne	Low	Line Nr (9)*(1.00)	0.02	0.1	0.79	1
C12H	Potato	Medium	Line Nr (37)*(1.00)	1.1	0.1	0.79	1
C12H	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	1.58	0.1	0.79	1
C12H	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (56)*(1.00)	0.26	0.1	0.79	1
C12H	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	1.53	0.1	0.79	1
C12L	Kikuyu	Low	Line Nr (8)*(1.00)	0.96	0.1	0.79	1
C12L	Lucerne	Low	Line Nr (9)*(1.00)	0.05	0.1	0.79	1
C12L	Potato	Medium	Line Nr (37)*(1.00)	1.45	0.1	0.79	1
C12L	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.05	0.1	0.79	1
C12L	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.35	0.1	0.79	1
C12L	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	2.05	0.1	0.79	1
Total:				**29.88**			
Total irrigation in Vaal catchment u/s Vaal Dam:				**72.78**			
Total irrigation in Vaal catchment u/s Vaal Dam & Wilge:				**127.97**			
Suikerbos key area:							
C21A	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.81	0.1	0.79	1
C21A	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.42	0.1	0.79	1
C21B	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.81	0.1	0.79	1
C21B	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.42	0.1	0.79	1
C21C	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.81	0.1	0.79	1
C21C	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.42	0.1	0.79	1
C21E	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.81	0.1	0.79	1
C21E	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.42	0.1	0.79	1
C21F	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.81	0.1	0.79	1
C21F	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.42	0.1	0.79	1
C21G	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	3.81	0.1	0.79	1
C21G	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.42	0.1	0.79	1
Total:				**25.38**			
Klip key area:							
C22C	Potato	Medium	Line Nr (37)*(1.00)	0.89	0.1	0.79	1
C22C	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	5.04	0.1	0.79	1
C22C	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	2.96	0.1	0.79	1
C22D	Potato	Medium	Line Nr (37)*(1.00)	0.89	0.1	0.79	1
C22D	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	5.04	0.1	0.79	1
C22D	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	2.96	0.1	0.79	1
C22E	Potato	Medium	Line Nr (37)*(1.00)	0.89	0.1	0.79	1
C22E	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	5.04	0.1	0.79	1
C22E	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	2.96	0.1	0.79	1
Total:				**26.67**			
Vaal Barrage key area:							
C22F	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	4.42	0.1	0.79	1
C22F	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	4.54	0.1	0.79	1
C22F	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	4.42	0.1	0.79	1
C22H	Stone fruit - fresh (peaches, plums, apricots, etc.)	High	Line Nr (4)*(1.00)	1.13	0.1	0.79	1
C22H	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	4.51	0.1	0.79	1
C22J	Stone fruit - fresh (peaches, plums, apricots, etc.)	High	Line Nr (4)*(1.00)	1.13	0.1	0.79	1
C22J	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	4.51	0.1	0.79	1
C22K	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	4.42	0.1	0.79	1
C22K	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	4.54	0.1	0.79	1
C22K	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	4.42	0.1	0.79	1
Total:				**38.04**			
Vaal d/s of Barrage key area:							
C23C	Kikuyu	Low	Line Nr (8)*(1.00)	1.34	0.2	0.75	1
C23C	Lucerne	Low	Line Nr (9)*(1.00)	2.03	0.2	0.75	1
C23C	Potato	Medium	Line Nr (37)*(1.00)	0.05	0.2	0.75	1
C23C	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	2.34	0.2	0.75	1
C23C	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.31	0.2	0.75	1
C23L	Kikuyu	Low	Line Nr (8)*(1.00)	4.21	0.15	0.75	1
C23L	Lucerne	Low	Line Nr (9)*(1.00)	6.59	0.15	0.75	1

Quaternary catchment	Crop Irrigated	Economic value	SAPWAT crop factor	Harvested Area (km^2)	Conveyance loss factor (Refer to section 5.6.3)	Application efficiency	Leaching factor (Refer to section 5.6.4)
C23L	Potato	Medium	Line Nr (55)*(1.00)	0.79	0.15	0.75	1
C23L	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	7.1	0.15	0.75	1
C23L	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.26	0.15	0.75	1
C23L	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.48	0.15	0.75	1
Total:				**25.5**			
Mooi key area:							
C23G	Kikuyu	Low	Line Nr (8)*(1.00)	3.62	0.15	0.7	1
C23G	Lucerne	Low	Line Nr (9)*(1.00)	5.82	0.15	0.7	1
C23G	Potato	Medium	Line Nr (37)*(1.00)	0.79	0.15	0.7	1
C23G	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	5.13	0.15	0.7	1
C23G	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	High	Line Nr (55)*(1.00)	0.04	0.15	0.7	1
C23G	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.48	0.15	0.7	1
C23H	Kikuyu	Low	Line Nr (8)*(1.00)	3.62	0.15	0.7	1
C23H	Lucerne	Low	Line Nr (9)*(1.00)	5.82	0.15	0.7	1
C23H	Potato	Medium	Line Nr (37)*(1.00)	0.79	0.15	0.7	1
C23H	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	5.13	0.15	0.7	1
C23H	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	High	Line Nr (55)*(1.00)	0.04	0.15	0.7	1
C23H	Winter staple crops (wheat, barley, etc.)	Low	Line Nr (34)*(1.00)	0.48	0.15	0.7	1
C23K	Kikuyu	Low	Line Nr (8)*(1.00)	3.15	0.2	0.66	1
C23K	Lucerne	Low	Line Nr (9)*(1.00)	2.47	0.2	0.66	1
C23K	Summer staple crops (maize, groundnut, soya and other beans, etc.)	Low	Line Nr (32)*(1.00)	5.5	0.2	0.66	1
C23K	Vegetables -green bean, brassicas, cucurbits, pea, onion, tomato, lettuce, carrot, etc	Medium	Line Nr (55)*(1.00)	0.04	0.2	0.66	1
Total:				**42.92**			
Total irrigation in Vaal catchment d/s Vaal Dam:				**158.51**			
Total irrigation in WMA:				**286.48**			

APPENDIX D.2

URBAN AREAS

Urban areas in the Upper Vaal WMA

Quaternary	Urban centre	Urban area km^2	Runoff coefficient for paved areas	Proportion of impervious area
Grootdraai key area:				
C11B	**Ermelo TLC**	14	0.84	0.125
C11F	**Ermelo TLC**	14	0.84	0.125
Total:		**28**		
Grootdraai to Vaal Dam key area:				
C11M	**Standerton TLC**	12	0.84	0.125
C12D	**Highveld Ridge TLC (Secunda; Evander; Kinross; Trichardt etc.)**	21	0.84	0.125
Total:		**33**		
C13 key area:				
Total:	**No significant urban areas**	**0**		
Suikerbosrand key area:				
C21B	**Balfour TLC**	5.6	0.84	0.18
C21D	**Benoni; Brakpan and Springs TLCs**	79.7	0.84	0.22
C21E	**Springs & Nigel TLCs**	36.1	0.84	0.18
C21F	**Hidelberg TLC**	7	0.84	0.26
C21G	**Vereeniging TLC**	4	0.84	0.13
Total:		**132.4**		
Klip key area:				
C22A	**Greater Johannesburg MLC**	169	0.84	0.26
C22B	**Greater Johannesburg MLC; Germiston; Boksburg & Alberton TLC**	147.6	0.84	0.26
C22C	**Germinston & Boksburg TLC**	33	0.84	0.26
C22D	**Greater Johannesburg MLC & Germiston TLC**	40.9	0.84	0.26
C22E	**Vereeniging TLC (Meyerton)**	5.4	0.84	0.26
Total:		**395.9**		
Vaal Dam to Barrage key area:				
C22F	**Vereeniging (Eastern Vaal Metro)**	26.8	0.84	0.26
C22H	**Vereeniging (Eastern Vaal Metro) & Vanderbijlpark (Western Vaal Metro)**	50.3	0.84	0.26
C22J	**Vanderbijlpark (Western Vaal Metro)**	3.5	0.84	0.26
C22K	**Sasolburg & Vanderbijlpark TLCs**	39.3	0.84	0.15
Total:		**119.9**		
Vaal d/s Barrage key area:				

Urban areas in the Upper Vaal WMA

Quaternary	Urban centre	Urban area	Runoff coefficient	Proportion of
		km^2	for paved areas	impervious area
Total:	**No significant urban areas**	**0**		
Mooi key area:				
C23D	**Westonaria TLC & part of Carltonville; Randfontein & Krugersdorp TLCs**	115	0.84	0.125
C23E	**Carltonville TLC**	18	0.84	0.125
C23H	**Potchefstroom TLC**	22	0.84	0.125
Total:		**155**		
Wilge key area:				
C81E	**Harrismith TLC**	14	0.84	0.125
C81F	**Phutdatjhaba (Witsieshoek) TLC**	104	0.84	0.125
C83C	**Bethlehem TLC**	48	0.84	0.125
C83J	**Frankfort TLC**	5	0.84	0.125
Total:		**171**		
Total urbanised area in WMA:		**1035.2**		

Source of data:

1. **Water Research Commission (1994) Surface Water Resources of South Africa : 1990; WRC Report No. 298/2.1/94, Volume II, Appendices, Appendix 5.4**
2. **DWAF (1997) Hydrology of the Vaal Barrage Catchment; VRSAU Report No. PC000/00/16396, Table 2.8**

APPENDIX E WATER RELATED INFRASTRUCTURE

Comprising:

APPENDIX E.1

WEIR DETAILS

Weir name	River name	Full supply gross storage capacity (10^6 m^3)	Full supply surface area (km^2)
Matsoku Weir			
Heidelberg Weir	Blesbokspruit		
Rietvlei	Blesbokspruit		
Uitvlugt Weir	Blesbokspruit		
K21 gauging Weir	Klip		
Sterkfontein	Klip		
Fredriksdal Weir	Liebenbergsvlei		
Liebenbergsvlei Weir	Liebenbergsvlei		
Hoogekraal/Kromdraai	Mooi		
Witrand Weir	Mooi		
R6 with a crump Weir	Rietspruit		
Suikerbosrand Weir	Suikerbosrand		
Taaibosspruit Weir	Taaibosspruit		
Annie’s rust Weir	Vaal		
Engelbrechtsdrift Weir	Vaal		
Klipplaat drift Weir	Vaal		
Lindequesdrift Weir	Vaal		
Vaal Barrage	Vaal	53.710	13.04
Lethabo Weir	Vaal Barrage		
Brandrift/Roodebank	Waterval		
Ballingtomp Weir	Wilge		
Frankfort Weir	Wilge		
Blaubank Weir	Wonderfonteinspruit		

APPENDIX E.2

RESERVOIR DETAILS

Name of reservoir	Storage capacity (Ml)	Name of reservoir	Storage capacity (Ml)
Airfield (RW)	50.44	Arlington (4)	
Barnardsvlei (RW)	95.97	Benoni (RW)	179.67
Bethlehem (9)		Blyvooruitzicht (RW)	22.79
Brakfontein (RW)		Brakpan (RW)	167.06
Buffelshoek (RW)		Cornelia	
Daleside (RW)	45.43	Deneysville (2)	
Driefontein (RW)	124.35	Edenville (6)	
Forest Hill (3, RW)	228.24	Fouriesburg (4)	
Frankfort		Germsiton (RW)	90.94
Harrismith (6)		Hartebeeshoek (RW)	99.32
Heilbron (RW)		Isando (RW)	
Kestell (3)		Klipfontein (2, RW)	298.07
KlipRiviersberg (RW)	587.43	Knoppiesfontein	
Krugersdorp (4, RW)	186.84	Lakeside?	2.110
Langerand (RW)	111.96	Libanon (RW)	22.74
Memel (2)		Meredale (RW)	122.43
Meyers Hill (RW)		Modder East (RW)	273.21
Northmead (RW)		Northridge (RW)	90.08
Parys (4)		Phuthaditjhaba	
Reitz (3)		Roodepoort (RW)	45.43
Rosendal (3)		Sasolburg (RW)	103.42
Selcourt (RW)	22.71	Swartwater?	4.380
Tembisa (RW)		Tweeling (3)	
Villiers		Vlakfontein (2, RW)	421.24
Vrede	1.546	Vredefort (3)	
Warden (3)		Waterkloof (RW)	
Waterval(2, RW)	107.10	Weltevreden (RW)	
Wildebeestfontein (3, RW)	119.59	Willem Brummer	5.80
Winburg (3)		Witpoortjie (2, RW)	120.59

Notes:

1. The bulk storage reservoirs listed are mainly reinforced concrete.
2. The figure within the bracket indicates the amount of reservoirs existing in the particular town stated (source: Water Affairs document: 1st Order Strategy to Develop Community Water Supply & Sanitation).
3. RW denotes a Rand Water pump station.

4. There are also a number of station reservoirs as follows (all figures in Ml):

•Eikenhof (No. 1 & 2)	40.06
•Mapleton	19.96
•Palmiet (No 1 & 2)	46.30
•Vereeniging	27.28
•Zwartkopjes	20.10

APPENDIX E.3

PUMPSTATION DETAILS

Name of Pumpstation	**Raw or treated water**	**Peak rated design pumping capacity (m^3/s)**	**Static head (m)**
Allanridge			
Balkfontein Inlet and High Pressure			
Bloemendal (RW)			
De Werf			
Delport		0.20	
Eikenhof (RW)			
Eskom Vaal River			
Grootdraai		6.21	56
Grootfontein		6.83	
Houtkop (RW)			
Koppie Alleen			
Lethabo Weir			
Mapleton (RW)			
Palmiet (RW)			
Parys		0.09	100
Roodepoort (RW)			
Saaiplaas			
Tutuka		3.00	117
Vaal River			
Vereeniging (RW)	Treated	21.40	
Zuikerbosch (RW)	Treated	43.29	
Zuurbekom (RW)			
Zwartkopjes (RW)			

Note:
1.RW denotes a Rand Water pumpstation
2.* denotes head at full capacity .. Static head not known

APPENDIX E.4

WASTEWATER TREATMENT WORKS DETAILS

Name of Wastewater treatment Works	Position		Peak rated design flow capacity (Ml/day)	Treatment process description	Effluent disposal process
	Longitude	Latitude			
Ancor WCW	26°15'58"	28°28'57"	13.50		Discharge into the Blesbokspruit
Benoni WCW	26°12'37"	28°18'53"	18	Activated sludge	Discharge into the Benoni canal
Bethal STW				Bio filters & Acivated sludge	
Bethlehem WCW				Activated sludge & Bio filters	Discharge into Jordaan
Bickley WCW	26°26'40"	28°26'52"	3.59	Bio filters & Activated sludge	Discharge into the Blesbokspruit
Blyvooruitzicht Gold Mines WCW	26°23'15"	27°23'25"			Discharge into the Wonderfonteinspruit
Bushkoppies	26°18'35"	27°56'10"	200	Removal of biological phosphate and nitrogen, maturation ponds	Discharge into the Harringtonspruit
Carletonville (Oberholzer?)	26°09'50"	27°21'30"		Biological filtration system, activated sludge and oxidation dam	Discharge into the Wonderfonteinspruit
Daveyton WCW	26°08'14"	28°27'47"	16	Conventional	Discharge into the Blesbokspruit
Deelkraal Mine's	26°28'20"	27°18'00"			Discharge into the Loopspruit
Dekema	26°19'35"	28°10'00"	36	Bio filters & Activated sludge	Discharge into the Natalspruit
Doornfontein Gold Mine WCW	26°24'35"	27°19'50"			Discharge into the Wonderfonteinspruit
Elandsrand	26°27'45"	27°21'45"			Varkenslaagtespruit
Ermelo STW	26°30'	29°59'		Activated Sludge, Bio systems & air blowing system	Discharge into the Klein drinkwaterspruit
Flip Human	26°10'51"	27°46'14"	45	Activated-sludge systems	Discharge into the Wonderfonteinspruit
Fochville WCW				Activated sludge	Discharge into the Loopspruit
Goudkoppies	26°16'25"	27°55'30"	150	Biological nutrient removal Pocess and chlorination	Discharge into the Harringtonspruit (1998)

Name of Wastewater treatment Works	Position		Peak rated design flow capacity (Ml/day)	Treatment process description	Effluent disposal process
	Longitude	Latitude			
Grundlingh WCW	26°23'66"	28°28'14"	2.71	Bio filters & Activated sludge	Discharge into Nigel Dam
Hannes van Niekerk				Activated-sludge systems	Discharge into the Wonderfonteinspruit
Harrismith STW (1)			3.90	Biofilter/Activated sludge	Discharged into the Wilge River
Tshiame STW (Harrismith 2)					
Heidelberg WCW	26°32'23"	28°19'44"	5.56	Bio fiilters	Discharge into the Blesbokspruit
Jan Smuts WCW	26°13'18"	28°22'27"	9	Bio filters & Activated sludge	Discharge into Jan Smuts Dam
JP Marais WCW	26°10'08"	28°23'42"	21	Bio filters & Activated sludge	Discharge into the Benoni canal
Khutsong	26°21'11"	27°18'32"			Discharge into the Wonderfonteinspruit
Klerksdorp	26°53'80"	26°37'10"	21.9	Activated sludge	Discharged into the Schoonspruit
Kloof Mine WCW				Mturation ponds	No discharge proved
Kroonstad STW				Activated sludge & biological seep beds	
Leeudoorn Mine WCW			4		Discharge into the Loopspruit
Leeuwkuil					
McComb WCW	26°12'49"	28°27'53"	9	Activated sludge	Discharge into the Benoni canal
Meyerton	26°34'30"	28°58'30"			Discharge into the Fouriespruit
Olifantsvlei	26°19'05"	27°53'55"	80	Etended aeration and chemical removal of phosphate	Discharge into the Klip River
Palmietfontein					
Parys STW				Biological filters	
Potchefstroom	26°44'50"	27°05'40"	23.75	Biological filtration + Activated-sludge	Discharge into the Wonderfonteinspruit
Randfontein					?

Name of Wastewater treatment Works	Position		Peak rated design flow capacity (Ml/day)	Treatment process description	Effluent disposal process
	Longitude	Latitude			
Ratanda WCW	26°09'34"	28°28'36"			
Rondebult	26°17'45"	28°13'20"	36	Activated sludge	Discharge into the Natalspruit
Rynfield WCW	26°09'34"	28°28'36"	13	Activated sludge	Discharge into the Benoni canal
Standerton STW	26°57'27"	29°13'56"		None	Discharge into the Vaal river
Standerton (Sakhile)	26°57'27"	29°13'56"		None	Discharge into the Vaal river
Tsakane WCW	26°22'35"	28°21'58"	7.72	Bio filters & Activated sludge	Discharge into the Kaydalespruit
Vlakplaats	26°21'15"	28°11'00"	83	Activated sludge	Discharge into the Natalspruit
Waterval	26°26'30"	28°05'45"	105	Activated sludge	Discharge into the Klip River
Wedela	26°29'13"	27°22'30"			Discharge into the Loopspruit
Welgedacht (new works proposed)			100		
Welverdiend	26°22'17"	27°15'21"			Discharge into the Wonderfonteinspruit
West Driefontein					Discharge into the Loopspruit
Western Deep Levels Mine WCW	26°27'00"	27°25'30"			Re-use

APPENDIX E.5

BOREHOLES DETAILS

Name	Quaternary	Abstraction ($10^6 m^3$ pa)
Zuurbekom (boreholes utilised by RW)	C22A	Approx. 3.65 (10Ml/day)

APPENDIX E.6

PIPELINE DETAILS

Description of pipelines	Position (Latitude, Longitude)	Flow direction	Peak rated design flow capacity ($10^6 m^3$)	Gravity or rising main	Diameter (mm)	Pipe material	Raw or treated water
Rand Water – Vereeniging pumpstation to Sasolberg to Heilbron	Refer to GIS system	To Heilbron		Pumping	376 to 1295	Prestressed concrete to Steel	Treated
Rand Water – Zuurbekom pumpstation to Libanon and Blyvooruitzicht reservoirs and Khutsong	Refer to GIS system	To Blyvooruitzicht and Khutsong		Gravity	324 to 610	Steel	Treated
Rand Water – Zwartkoppies through the Pretoria area to Hartebeespoort, Mamelodi and Soshanguve	Refer to GIS system	To Hartebeespoort, Mamelodi and Soshanguve		Gravity	450 to 900	Steel	Treated
Rand Water – Zwartkoppies to Bloemendal pumpstation to Wildebeestfontein reservoir.	Refer to GIS system	To Wildebeestfontein		Gravity	460 to 1200	Steel	Treated
Rand Water – Zwartkoppies to Rustenburg	Refer to GIS system	To Rustenburg		Gravity	610 to 1000	Steel	Treated
Grootdraai – Vlakfontein			10	Rising main	2x1824	steel	
Grootfontein – Knoppiesfontein			10 combined	2 Rising mains	2x1824	steel	
Bossiesspruit Dam to Sasol			10.23 combined	2 Gravity	2x1580	steel	
Vaal Dam to Deneysville							
Vaal Dam to Grootvlei Power Station							

Description of pipelines	Position (Latitude, Longitude)	Flow direction	Peak rated design flow capacity ($10^6 m^3$)	Gravity or rising main	Diameter (mm)	Pipe material	Raw or treated water
Grootdraai Dam to Sasol II							
Zaaihoek – Majuba at Elandspoort	27°09'45" 29°52'42"						
Grootdraai Dam to Tutuka Power Station							

Note: For Rand Water from the Vereeniging and Zuikerbosch offtakes to Daleside reservoir and on the Zwartkoppies pumpstation there are numerous pumping mains (steel, concrete and prestressed concrete) ranging in size from 560mm to 2135 mm. Details in the table cover pipelines from the Zwartkoppies pumpstation

APPENDIX E.7

CANAL DETAILS

(Information not readily available)

APPENDIX E.8

HAZARDOUS WASTE SITES

Name of waste site	Location	Classification of waste
Felstrust solid waste	Close to Elsburgspruit	
Lottering solid wast	Close to Elsburgspruit	
Old Wadeville solid waste	Close to Elsburgspruit	

APPENDIX F WATER REQUIREMENTS

Comprising:

Appendix F.1	Ecological status classes
Appendix F.2	Ecological flow requirements
Appendix F.3	Livestock and game details
Appendix F.4	Transfers details
Appendix F.5	Strategic bulk user and other bulk user details
Appendix F.6	Mine details
Appendix F.7	Power Station details
Appendix F.8	Urban details
Appendix F.9	Assurance of supply to water users

APPENDIX F.1

ECOLOGICAL STATUS CLASS INDEX

QUATERNARY	PROVINCE	RIVERS	EISC	DEMC	PESC	BEST AEMC
C11A	MPUMALANGA	Vaal	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11B	MPUMALANGA	Vaal	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11C	MPUMALANGA	Klein Vaal	LOW	CLASS D: LARGE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C11D	MPUMALANGA	Klein Vaal (Rietspruit)	LOW	CLASS D: LARGE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C11E	MPUMALANGA	Rietspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11F	MPUMALANGA	Kaffirspruit (after confluence with Kleinkaffirspruit and Brakspruit)	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11G	MPUMALANGA	Kaffirspruit	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11H	MPUMALANGA	Blesbokspruit (Knopkieriesspruit?)	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11J	MPUMALANGA	Vaal	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11K	MPUMALANGA		MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C11L	MPUMALANGA	Grootdraai dam	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT
C11M	MPUMALANGA	Vaal (downstream from Crootdraai)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C12A	GAUTENG	Venterspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12B	GAUTENG	Vaal (main)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12C	GAUTENG	Vaal (main)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12D	MPUMALANGA	Waterval (Kleinspruit)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C12E	MPUMALANGA	Rietspruit	LOW	CLASS D: LARGE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL

C12F	MPUMALANGA	Waterval (Kleinspruit)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12G	MPUMALANGA	Waterval (Kleinspruit)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C12H	GAUTENG	Vaal (main)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12J	MPUMALANGA	Unamed trib.	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12K	MPUMALANGA	Molspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C12L	GAUTENG	Vaal (Vaal dam backwater portion)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C13A	FREE STATE	Sandspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C13B	FREE STATE	Sandspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C13C	FREE STATE	Seekoevlei	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL
C13D	FREE STATE	Klip (after confluence with Modderspruit/Gansvleispruit system)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C13E	FREE STATE	Komandospruit	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL
C13F	FREE STATE	Klip (after confluence with Komandospruit)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C13G	FREE STATE	Spruitsonderdrif	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS B: LARGELY NATURAL	CLASS B: LARGELY NATURAL
C13H	FREE STATE	Klip (after confluence with Spruitsonderdrif)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C21A	GAUTENG	Suikerbosrand	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C21B	GAUTENG	Suikerbosrand	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C21C	GAUTENG	Suikerbosrand	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C21D	GAUTENG	Blesbokspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C21E	GAUTENG	Blesbokspruit	HIGH	CLASS B: SMALL RISK	CLASS D: LARGELY	CLASS C: MODERATELY MODIFIED

				ALLOWED	MODIFIED	
C21F	GAUTENG	Blesbokspruit (downstream from Heidelberg)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C21G	GAUTENG	Suikerbosrand	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C22A	GAUTENG	(below confluence point)-Klipriver?	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS D: LARGELY MODIFIED
C22B	GAUTENG	Natalspruit	LOW	CLASS D: LARGE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS D: LARGELY MODIFIED
C22C	GAUTENG	Rietspruit (after confluence with Natalspruit)	LOW	CLASS D: LARGE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS D: LARGELY MODIFIED
C22D	GAUTENG	Klip	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT
C22E	GAUTENG	Klip	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS D: LARGELY MODIFIED
C22F	GAUTENG	Vaal (downstream from Vaal dam)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C22G	GAUTENG	Taaibosspruit (FOR PESC, TAKE C83L)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C22H	GAUTENG	Rietspruit?? (before confluence with Vaal)= C22C	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C22J	GAUTENG	Leeuspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C22K	GAUTENG	Vaal (Barrage portion)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C23A	GAUTENG	Vaal	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C23B	GAUTENG	Vaal	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C23C	GAUTENG	Vaal (Parys)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C23D	NORTH WEST	Mooirivierloop??	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C23E	NORTH WEST	Mooirivierloop	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C23F	NORTH WEST	Skoonspruit main stem	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C23G	NORTH WEST	Mooi (upstream from Boskop)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL
C23H	NORTH WEST	Mooi (just before confluence with Loopspruit)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS C: MODERATELY MODIFIED
C23J	NORTH WEST	Loopspruit (above Klipdrif dam)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS B: LARGELY NATURAL

C23K	NORTH WEST	Loopspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS B: LARGELY NATURAL
C23L	GAUTENG	Vaal (downstream from Parys)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS D: LARGELY MODIFIED	CLASS D: LARGELY MODIFIED
C81A	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81B	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81C	FREE STATE	Nuwejaarsspruit (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81D	FREE STATE	Sterkfontein Dam	INVALID ENTRIES	WRONG ENTRY	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT
C81E	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81F	FREE STATE	Elands (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81G	FREE STATE	Elands (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81H	FREE STATE	Elands (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81J	FREE STATE	Vaalbanks (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81K	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81L	FREE STATE	Meul (Wilge trib.)	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C81M	FREE STATE	Meul (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82A	FREE STATE	Cornelis (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82B	FREE STATE	Cornelis (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82C	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY	CLASS C: MODERATELY MODIFIED

					MODIFIED	
C82D	FREE STATE	Rus se Spruit (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82E	FREE STATE	Holspruit (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82F	FREE STATE	Grootspruit (Wilge trib.)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82G	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C82H	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83A	FREE STATE	Ash	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS E - F: NOT AN ACCEPTABLE CLASS
C83B	FREE STATE	Jordaans (copied from C83D)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83C	FREE STATE	Liebenbergsvlei	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS E - F: > CLASS E NOT ATTAINABLE IN 5 YR - USE CLASS D AS DEFAULT
C83D	FREE STATE	Tierkloof	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83E	FREE STATE	Tierkloof	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83F	FREE STATE	Liebenbergsvlei	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS E - F: NOT AN ACCEPTABLE CLASS
C83G	FREE STATE	Liebenbergsvlei	HIGH	CLASS B: SMALL RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS D: LARGELY MODIFIED
C83H	FREE STATE	Libenbergsvlei	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS E - F: NOT AN ACCEPTABLE CLASS	CLASS D: LARGELY MODIFIED
C83J	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83K	FREE STATE	Kromspruit	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83L	FREE STATE	Klipriver	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED
C83M	FREE STATE	Wilge (main stem)	MODERATE	CLASS C: MODERATE RISK ALLOWED	CLASS C: MODERATELY MODIFIED	CLASS C: MODERATELY MODIFIED

APPENDIX F.2

ECOLOGICAL FLOW REQUIREMENT

(This data is not readily available)

APPENDIX F.3

LIVESTOCK AND GAME DETAILS

Conversion of mature Livestock and Game Populations to Equivalent Large Stock Units (ELSU) (DWAF, Circular 14/98).

Livestock species:	**Number per ELSU**	**Game species:**	**Number per ELSU**
Cattle	0.85	Black Wildebeeste	3.3
Sheep	6.5	Blou Wildebeeste	2.4
Goats	5.8	Blesbuck	5.1
Horses	1	Buffalo	1
Donkeys / mules	1.1	Eland	1
Pigs	4	Elephant	0.3
		Gemsbok	2.2
		Giraffe	0.7
		Hippopotamus	0.4
		Impala	7
		Kudu	2.2
		Nyala	3.3
		Ostrich	2.7
		Red Hartebeest	2.8
		Roan Antelope	2
		Sable Antelope	2
		Southern Reedbuck	7.7
		Springbok	10.3
		Tsessebe	2.8
		Warthog	5
		Waterbuck	2.4
		Rhinoceros	0.4
		Zebra	1.6

Appendix F.3 LARGE STOCK UNITS		
Quaternary catchment	**Equivalent Large stock units (ELSU)**	**Daily Water requirement (l/ELSU/d)**
Wilge key area:		
C81A	16,385	45
C81B	24,958	45
C81C	10,764	45
C81D	8,328	45
C81E	27,978	45
C81F	8,781	45
C81G	16,675	45
C81H	15,585	45
C81J	17,009	45
C81K	15,644	45
C81L	34,478	45
C81M	47,543	45
C82A	24,715	45
C82B	21,469	45
C82C	15,490	45
C82D	25,195	45
C82E	17,908	45
C82F	9,429	45
C82G	21,684	45
C82H	30,221	45
C83A	22,795	45
C83B	7,591	45
C83C	26,378	45
C83D	14,696	45
C83E	17,777	45
C83F	34,242	45
C83G	31,054	45
C83H	26,004	45
C83J	10,904	45
C83K	29,786	45
C83L	51,354	45
C83M	59,473	45
Total:	**742,293**	**742293**
ELSU annual req. (million cubic meters/a):		**12.20**
Grootdraai key area:		
C11A	36,075	45
C11B	26,865	45
C11C	13,689	45
C11D	17,591	45
C11E	51,776	45
C11F	46,752	45
C11G	21,693	45
C11H	199,937	45
C11J	44,417	45
C11K	20,127	45
C11L	39,297	45
Total:	**518,219**	
ELSU annual req. (million cubic meters/a):		**8.52**
Grootdraai to Vaal Dam key area:		
C11M	32,755	45
C12A	9,421	45
C12B	15,938	45
C12C	25,129	45
C12D	47,501	45

Appendix F.3 LARGE STOCK UNITS		
Quaternary catchment	**Equivalent Large stock units (ELSU)**	**Daily Water requirement (l/ELSU/d)**
C12E	20,486	45
C12F	33,475	45
C12G	21,210	45
C12H	14,495	45
C12J	16,947	45
C12K	15,889	45
C12L	31,209	45
Total:	**284,455**	
ELSU annual req. (million cubic meters/a):		**4.68**
C13 key area:		
C13A	21,299	45
C13B	26,258	45
C13C	22,496	45
C13D	25,316	45
C13E	12,057	45
C13F	14,360	45
C13G	8,447	45
C13H	13,144	45
Total:	**143,377**	
ELSU 1995 req. (million cubic meters/a):		**2.36**
ELSUs - u/s Vaal Dam	**946,051**	
ELSUs - u/s Vaal Dam & Wilge	**1,688,344**	
ELSU req. - u/s Vaal Dam (mcm/a)		**15.55**
ELSU req. - u/s Vaal Dam & Wilge (mcm/a)		**27.75**
Suikerbos key area:		
C21A	23,389	45
C21B	14,170	45
C21C	14,344	45
C21D	5,391	45
C21E	17,306	45
C21F	13,249	45
C21G	4,854	45
Total:	**92,703**	
ELSU 1995 req. (million cubic meters/a):		**1.52**
Klip key area:		
C22A	6,352	45
C22B	2,696	45
C22C	7,557	45
C22D	1,388	45
C22E	139	45
Total:	**18,132**	
ELSU 1995 req. (million cubic meters/a):		**0.30**
Vaal Barrage key area:		
C22F	8,347	45
C22G	44,385	45
C22H	7,453	45
C22J	19,166	45
C22K	17,004	45
Total:	**96,355**	
ELSU 1995 req. (million cubic meters/a):		**1.58**
Vaal below Vaal Barrage:		
C23A	15,748	45

Appendix F.3 LARGE STOCK UNITS

Quaternary catchment	Equivalent Large stock units (ELSU)	Daily Water requirement (l/ELSU/d)
C23B	25,554	45
C23C	37,387	45
C23L	45,587	45
Total:	**124,276**	
ELSU 1995 req. (million cubic meters/a):		**2.04**
Mooi key area:		
C23D	9,110	45
C23E	20,974	45
C23F	19,385	45
C23G	21,669	45
C23H	17,723	45
C23J	34,839	45
C23K	15,767	45
Total:	**139,467**	
ELSU 1995 req. (million cubic meters/a):		**2.29**
ELSUs - d/s Vaal Dam	**470,933**	
ELSU req. - d/s Vaal Dam (mcm/a)		**7.74**
ELSUs - Free State Province	**1,029,663**	
ELSUs - Mpumalanga Province	**810,930**	
ELSUs - Gauteng Province	**161,685**	
ELSUs - North West Province	**156,998**	
Total ELSUs - Upper Vaal WMA	**2,159,277**	
Total ELSU Req. - Upper Vaal WMA (mcm/a)		**35.49**

LIVESTOCK AND GAME DATA FOR MAGISTERIAL DISTRICTS IN THE UPPER VAAL WMA

(Figures from 1990 Food Survey Report by Department of Agric (Glen) & CSS survey of 1988 (where necessary)

		(DOA)	(DOA)	(DOA)	(CSS)	(CSS)	(DOA)	(CSS)	(CSS)	(Unadjusted)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(DOA)	(unadjusted)
PROVINCE	**DISTRICT**	**CATTLE**	**SHEEP**	**GOATS**	**GOATS**	**PIGS**	**Horses, mules & donkeys**	**HORSES**	**MULES/ DONKEYS**	**LIVESTOCK**	**Gemsbok**	**Kudu**	**Spring-buck**	**Bles-buck**	**Black Wildebeeste**	**Blue Wildebeeste**	**Eland**	**Impala**	**Waterbuck**	**Zebra**	**Hartebees**	**GAME**
FREE STATE	**Bethlehem***	73695	118398	746	**2245**	249	0	**674**	**242**	**195503**				12	4							**16**
FREE STATE	**Frankfort**	98920	319794	0	**3025**	0	0	**517**	**26**	**422282**												**0**
FREE STATE	**Harrismith**	216440	424772	**3669**	2444	0	**4540**	1073	112	**649421**			78	194		25	4	115	4	4		**424**
FREE STATE	**Heilbron***	165886	232972	0	0	427	0	**357**	**29**	**399671**												**0**
FREE STATE	**Parys**	21954	32389	0	**223**	142	**258**	49	0	**54966**												**0**
FREE STATE	**Reitz**	79233	168540	**754**	533	498	**1150**	323	18	**250175**												**0**
FREE STATE	**Sasolburg**	31073	40036	0	0	6394	0	**75**	**0**	**77578**												**0**
FREE STATE	**Vrede**	59976	208095	0	**3781**	683	0	**1428**	**81**	**274044**				700								**700**
FREE STATE	**Vredefort***	31512	45125	**2598**	430	150	0	**41**	**0**	**79426**												**0**
GAUTENG	**Alberton**	0	0	0	0	0	0	0	0	**0**												**0**
GAUTENG	**Benoni***	0	0	0	0	0	0	**10**	**0**	**10**												**0**
GAUTENG	**Boksburg**	0	0	0	0	0	0	**78**	**0**	**78**												**0**
GAUTENG	**Brakpan***	0	0	0	0	0	0	0	0	**0**												**0**
GAUTENG	**Germiston**	0	0	0	0	0	0	0	0	**0**												**0**
GAUTENG	**Heidelberg**	28000	17731	**959**	0	11701	25	**169**	**0**	**58560**												**0**
GAUTENG	**Johannesburg***	28105	8074	0	0	0	0	**44**	**0**	**36223**												**0**
GAUTENG	**Nigel**	19635	23259	**230**	0	2987	**154**	97	0	**43144**												**0**
GAUTENG	**Oberholzer***	12520	3630	**150**	0	0	**100**	24	0	**16400**												**0**
GAUTENG	**Randfontein***	0	0	0	0	0	0	**58**	**0**	**58**												**0**
GAUTENG	**Roodepoort***	0	0	0	0	5696	0	0	0	**5696**												**0**
GAUTENG	**Springs**	0	0	0	0	0	0	0	0	**0**												**0**
GAUTENG	**Vanderbijlpark**	19225	20390	**840**	0	4593	**530**	38	0	**45578**				250								**250**
GAUTENG	**Westonaria**	7378	7070	**494**	0	0	**253**	0	0	**15195**												**0**
MPUMALANGA	**Amersfoort**	35232	231736	**2813**	0	247	**1583**	377	31	**271611**												**0**
MPUMALANGA	**Balfour**	0	0	0	0	652	0	**332**	**35**	**1019**												**0**
MPUMALANGA	**Bethal**	117670	383670	**9450**	5196	3070	0	**389**	**16**	**514265**				1000								**1000**
MPUMALANGA	**Delmas***	3800	3454	0	0	1258	**100**	59	0	**8612**												**0**
MPUMALANGA	**Ermelo***	121500	496500	0	384	1453	0	**1229**	**134**	**621066**				2140	105							**2245**
MPUMALANGA	**Highveld Ridge***	20000	80000	0	0	517	0	**99**	**13**	**100629**												**0**
MPUMALANGA	**Standerton**	133000	219100	0	0	2596	279	**570**	**68**	**355334**												**0**
MPUMALANGA	**Volksrust***	43545	146768	0	**5196**	434	0	**552**	**105**	**196600**												**0**
NORTH WEST	**Potchefstroom**	89963	61970	**2900**	1929	32346	**19460**	238	16	**206639**				1000								**1000**
	TOTAL	**1458262**	**3293473**	**25603**	**25386**	**76093**	**28432**	**8900**	**926**	**4899783**	**0**	**0**	**78**	**5296**	**109**	**25**	**4**	**115**	**4**	**4**	**0**	**5635**

APPENDIX F.4

TRANSFER DETAILS

Inter-Basin Transfers

From quat	To quat	From sector	To sector	Description of transfer	Maximum Capacity (Million cubic metres per annum)	1995 (Million cubic metres per annum)
V11L	C22F*	SRD	SRD	Dummy transfer from Spioekop to take into account of non-firm yield abstractions at Driel.	174.0	174.0
V11J	C22F*	SRD	SRD	Tukela - Vaal transfer from Driel to Driekloof which spills to Sterkfontein and Vaal Dam.	580.0	580.0
V31B	C11L	SRD	SRD	INTERBASIN TRANSFER FROM Zaaihoek Dam to Vaal catchment (Perdewaterspruit).	52.4	49.8
W51B	C11L	SRD	SRD	INTERBASIN TRANSFER FROM Usutu catchment [Heyshope Dam] to Grootdraai subcatchment	63.0	59.9
W53B	C11B	SRD	SSO	INTERBASIN TRANSFER FROM Usutu catchment to 'mothballed' Camden P/s for maintenance operations & 3rd party users.	0.8	0.8
V31B	C13A	SRD	SSB	Transfer to Majuba P/s - construction phase (capacity includes allowance for future growth)	2.2	2.2
Total imports into Vaal WMA:					872.4	866.6
Exports (from Vaal catchment u/s Vaal Dam to other WMA's)						
C13A	V31B	SRD	SSU	Inter-Basin transfer - from Schuilhoek & Balfour Dams [Vaal WMA] to Volksrust TLC [upper Tugela]	0.3	0.3
C11L	B11E	SRD	SSB	Interbasin transfer from Grootdraai Dam to Olifants catchment for Matla Power Station	35.4	35.4
Total exports					35.7	35.7
Exports (from Vaal catchment d/s Vaal Dam to other WMA's)						
C22F	A21B	SRD	SSU	Rand Water transfer to Kempton Park/Tembisa	32.7	32.6
C22F	A21C	SRD	SSU	From Vaal Barrage to Johannesburg North [Crocodile WMA]	146.6	142.3
C22F	A21C	SRD	SSU	Rand Water transfer to Lethabong MLC	10.1	9.8
C22F	A21C	SRD	SSU	Rand Water transfer to Midrand MLC	13.9	13.5
C22F	A21D	SRD	SSU	Rand Water Transfer to Krugersdorp TLC	21.7	21.4
C22F	A21D	SRD	SSM	Rand Water transfer to Randfontein Estates Gold Mine	3.5	3.5
C22F	A21F	SRD	SSU	Inter WMA transfer by Rand Water from Vaal Dam to Randfontein TLC	9.6	9.6
C22F	A21K	SRD	SSM	Rand Water transfer to Western Platinum Mines	9.2	9.2
C22F	A22F	SRD	SSM	Rand Water transfer to mines in the region	30.0	23.1
C22F	A22H	SRD	SSM	Rand Water transfer to mines in the region	20.0	16.4
C22F	A22H	SRD	SSU	Rand Water transfer to Rustenburg	15.8	15.8
C22F	A23D	SRD	SSU	Rand Water transfer to Greater Pretoria MC	141.0	127.2
C22F	A23K	SRD	SSU	Rand Water transfer to Garankuwa Industrial Area	4.0	4.0
C22F	A23K	SRD	SSU	Rand Water transfer to Mabopane and Garankuwa	13.2	13.2
C22F	C70C	SRD	SSU	Transfers from Vaal Dam to Heilbron [Rand Water has taken over bulk supply in 1998 via Sasolburg]	0.9	0.9
Total:					472.2	441.5
Total Exports out of WMA:					507.9	477.3

Inter-Basin Transfers

From quat	To quat	From sector	To sector	Description of transfer	Maximum Capacity (Million cubic metres per annum)	1995 (Million cubic metres per annum)
Within basin transfers (u/s Vaal Dam Area):						
C11L	C11K	SRD	SSO	Escom transfer from Grootdraai Dam to 3rd parties around Tutuka Power station	0.5	0.4
C11L	C11K	SRD	SSB	Escom Transfer from Grootdraai Dam to Tutuka Power station	34.2	34.2
C11L	C11K	SRD	SSM	Transfer by Escom from Grootdraai Dam to colliery that supplies coal to Tutuka Power Station - strategic bulk user	1.0	0.9
C11L	C12D	SRD	SSO	Grootdraai Dam to Sasol II/III/IV	90.5	86.3
C12L	C12H	SRD	SSU	Transfer from Vaal Dam to Villiers TLC	0.4	0.4
C12L	C12K	SRD	SSO	Escom Transfer from Vaal Dam to 'mothballed' Grootvlei Powerstation for maintenance use & 3rd parties	2.1	2.0
C81F	C81G	SRD	SSU	Transfer from Metsi Matso Dam to Kestell TLC	0.2	0.2
Total:					128.8	124.5
Transfer from Vaal Dam to u/s Vaal Dam area						
C22F	C11H	SRD	SSU	Rand Water transfer from Vaal Dam via Secunda to Bethal TLC	3.2	3.2
C22F	C12D	SRD	SSM	Rand Water transfers from Vaal Dam to Leslie & Bracken Gold mines & to Twisdraai	0.3	0.3
C22F	C12D	SRD	SSU	Rand Water transfers Highveld Ridge TLC [Secunda, Kinross, Trichardt etc.]	11.7	11.7
Total					15.2	15.2
Within basin transfers (d/s Vaal Dam Area):						
C22F	C22G	SRD	SSU	Transfer from Vaal Dam to Denysville via DWAF pipeline	0.5	0.5
C22F	C22J	SRD	SSO	Transfers from Barrage [Vaal Dam] to Iscor [raw & purified water]	24.0	22.9
C22F	C22K	SRD	SSO	Transfer from Vaal Barrage to Sasol I [water from Vaal Dam]	29.2	27.9
Total (excluding Rand Water)					53.8	51.3
Within basin transfers (d/s Vaal Dam Area): (Rand Water only)						
C22A	C23E	SSG	SSU	Rand Water transfers from Zuurbekom boreholes [10 Ml/day] to Carletonville	3.7	3.7
C22F	C21D	SRD	SSU	Rand Water transfer from Vaal Dam to Benoni & Brakpan TLC's	54.2	54.2
C22F	C21D	SRD	SSM	Rand Water transfers from Vaal Dam to East Daggafontein and Grootvlei Gold Mines	0.2	0.2
C22F	C21E	SRD	SSU	Rand Water transfer from Vaal Dam to Nigel & Springs TLCs	37.3	37.3
C22F	C21F	SRD	SSU	Rand Water transfer from Vaal Dam to Heidelberg TLC	3.8	3.8
C22F	C22A	SRD	SSU	Rand Water to Johannesburg South MLC	204.9	200.7
C22F	C22B	SRD	SSM	Rand Water transfer from Vaal Dam to ERPM gold mine	0.6	0.6
C22F	C22B	SRD	SSU	Rand Water transfer from Vaal Dam to Greater Germinston; Alberton & Boksburg TLCs [East Rand]	105.5	105.5
C22F	C22D	SRD	SSM	Rand Water transfer from Vaal Barrage to Durban Roodepoort Deep Gold mine	0.1	0.1
C22F	C22H	SRD	SSM	Rand Water tansfer from Vaal Dam to Western Areas Gold Mine	0.4	0.4

Inter-Basin Transfers

From quat	To quat	From sector	To sector	Description of transfer	Maximum Capacity (Million cubic metres per annum)	1995 (Million cubic metres per annum)
C22F	C22J	SRD	SSU	Rand Water transfer to Western Vaal Metro [Vanderbijlpark	21.4	21.4
C22F	C22K	SRD	SSU	Rand Water transfer of water from Vaal Dam to Sasolburg	20.4	20.4
C22F	C23D	SRD	SSU	Rand Water transfer of water from Vaal Dam to Westonaria TLC	3.6	3.6
C22F	C23D	SRD	SSM	Rand Water transfers from Vaal Dam to Libanon	1.1	1.1
C22F	C23E	SRD	SSU	Rand Water transfer of bulk water from Vaal Dam to Carltonville TLC	2.0	2.0
C22F	C23E	SRD	SSM	Rand Water transfers from Vaal river to Elandsrand	1.7	1.7
C22F	C23J	SRD	SSM	Rand Water transfers from Vaal Dam to Kloof and Deelkraal Gold Mines	0.9	0.9
C22F	C23J	SRD	SSU	Rand Water transfer from Vaal Dam to Fochville & Wedela TLCs	3.4	3.4
Total:					465.2	461.0
Effluent transfers (imported, exported):						
A21D	C23D	URF	SRD	From Crocodile WMA: Krugersdorp effluent returned to Flip Human STW	3.7	3.5
C12D	B11D	URF	SRD	To Olifants WMA: Effluent returns from Kinross & Trichardt [Highveld Ridge TLC] to Trichardtspruit	0.6	0.5
C21D	C21F	URF	SRD	Transfer of sewage returns from Brakpan [Tsakane STW] to Blesbokspruit	2.8	2.7
C21D	C22B	URF	SRD	Transfer of sewage from Brakpan TLC [Vlakplaats STW] to Natalspruit	2.1	2.0
C22A	C22D	URF	SRD	Transfer of Greater Johannesburg effluent to Klip River via Bushkoppies STW	69.3	65.8
C22F	C22E	URF	SRD	Effluent exported from Vereeniging MLC to Klip River via Meyerton STWs	1.4	1.3
C22B	C22C	URF	SRD	Greater Germinston & Alberton export sewage to Rietspruit system via Waterval STW	23.7	22.5
C22F	C22J	URF	SRD	Effluent from Vereening Metro [Sebokeng] via Sebokeng STW to Rietspruit	3.5	3.3
C22K	C23B	URF	SRD	Effluent from Sasol 1 STW from Sasolburg & Polyfin to Vaal River [below Barrage]	10.6	10.1
C22K	C23B	ORF	SRD	Effluent from Sasol 1 via Sasol 1 STW to Vaal River [below Barrage]	6.7	6.4
Total:					124.4	118.2

APPENDIX F.5

STRATEGIC BULK USER AND OTHER BULK USER DETAILS

1995 Strategic bulk user details.

Strategic bulk user	Location	Main activity	Source of water	On-site requirement ($10^6 m^3/a$)	Returns flow ($10^6 m^3/a$)	River
Eskom: Tutuka Power Station	North of Grootdraai Dam	Power generation	Grootdraai Dam (pipeline)	32.52	0.90	Leeuspruit
Eskom: Majuba Power Station	Near Perdekop	Power generation (construction phase)	Zaaihoek Dam	2.09	0.00	None known
Eskom Lethabo Power Station	South of Vereeniging	Power generation	Vaal Dam	34.71	0.00	None known

1995 Other bulk user details.

Bulk user	Main activity	Source of water	Bulk requirements ($10^6 m^3/a$)	Return flows ($10^6 m^3/a$)	River
Sasol 2 and 3	Coal to oil refinery	Grootdraai Dam (pipeline)	85.96	5.48	Waterval River via Sasol STW
Sasol 1	Coal to oil refinery	Vaal Dam	27.76	10.4	Vaal River via Sasol 1 STW
Iscor	Steel production	Vaal Dam (raw & purified water)	22.84	7.99	Great Rietspruit
Eskom: Camden Power Station +3rd parties	Mothballed – maintenance supply	Jericho Dam - Usutu WMA	0.76		-
Eskom: Tutuka 3rd parties	3rd party supply	Grootdraai Dam (pipeline)	0.432		No known returns
Eskom: Grootvlei Power Station & 3rd parties]	Mothballed – maintenance	Pipeline from Vaal Dam	1.98		Molspruit
Eskom: Lethabo 3rd parties	3rd party supply	Vaal Dam	0.755		No known returns
Eskom:Kragbron (Highveld / Taaibos) & 3rd parties	Mothballed – maintenance	Vaal R.	0.75		-
Early Bird (Bo-Vaalriver)	Chicken Farm	Vaal	0.096		No known returns
Early Bird (Waterval river)	Chicken Farm	Waterval	0.033		No known returns
Karan Estates	Feedlot	Suikerbosrand	0.570		No known returns
Ready Mix Materials	Cement	Rietspruit	0.210		No known returns
Small users - Vaal Barrage [direct]	Semi-urban	Vaal Barrage	0.085		No known returns
Small industrial users - Vaal Barrage [direct]	Steel works	Vaal	0.789		No known returns
Rand Water - small consumers	Semi-urban; institutional (Spoornet etc); industries	Vaal Dam	6.750		No known returns
Groenpunt Prison	Insitutional	Vaal	0.853		No known returns
Vaal Marina	Recreational	Vaal Dam	0.182	-	No known returns

APPENDIX F.6

MINE DETAILS

Province	Mine	Location	Source of water	Bulk requirement (10^{6m3}/a)	Mine pumpage & effluent disc. (10^{6m3}/a)	Destination river
MP	Volkrust area - mines [coal]	Near Majuba P/station	From Eskom	from P/station	0.024	Schulpspruit
MP	Bethal area - mines [coal]	Near Bethal	not applicable - from TLC	from TLC	0.264	Blesbok
MP	Tutuka Colliery	Near P/station	Grootdraai Dam	0.902	0.323	Leeuspruit
MP	Leslie & Bracken; Winkelhaak; Twisdraai, Brandspruit etc.	Secunda area	Vaal Dam [Rand W]	0.33	1.25	Waterval River
GP	East Daggafontein [Anglo gold)	Brakpan/Springs	Blesbokspruit - direct	2.18	0	-
GP	East Daggafontein [Anglo gold)	Brakpan/Springs	Vaal Dam [Rand W]	0.11	0	-
GP	ERGO Daggafontein	Springs	Blesbokspruit - direct	0.42	0	-
GP	Grootvlei Gold Mine - mine pumpage	Springs	Vaal	0.11	45.66	Blesbokspruit [started 95/96]
GP	Durban Roodepoort Deep Gold Mine	Roodepoort [Jhb]	Vaal Dam [Rand W]	0.12	5.63	Klip River
GP	ERPM [mining stopped mid 1999]	Boksburg	Vaal Dam [Rand W]	0.62	8.1	Elsburgspruit
GP	Glen Douglas Dolomite Mine	Near Meyerton	From TLC	0	1.26	Klip River
GP	Western Areas Gold Mine	Westonaria	Vaal Dam [Rand W]	0.34	13.41	Great Rietspruit [Leeuspruit]
GP	Libanon / Venterspost Gold Mine	S of Westonaria	Vaal Dam [Rand W]	0.19	6.94	Lower Wonderfontein Spruit
GP	Randfontein Estates Gold Mine	Randfontein	Vaal Dam [Rand W]	0.49	0	ceased pumpage 1994/95
GP	West Rand Consolidated & Palmiet Ferrochrome	Randfontein	Vaal Dam [Rand W]	0.41	4.38	Upper Wonderfontein spruit
NW	Elandsrand Gold	Cartonville area	Vaal Dam [Rand W]	0.36	0.55	Wonderfontein spruit

Province	Mine	Location	Source of water	Bulk requirement (10^{6m3}/a)	Mine pumpage & effluent disc. (10^{6m3}/a)	Destination river
	Mining Co					
GP	Anglo Gold (Western Deep Levels)	Carletonville	Vaal Dam [Rand W]	0.66	0.8	Wonderfontein spruit
GP	Anglo Gold (Western Deep Levels)	Carletonville			10.95	Loopspruit
GP	Blyvooruitzicht Gold Mine (Durban Roodepoort Deep)	Carletonville	Vaal Dam [Rand W]	0.22	3.11	Wonderfontein spruit
GP	West Driefontein Gold Mine (Goldfields)	Carletonville	Vaal Dam [Rand W]	0.17	12.41	Wonderfontein spruit
GP	West Driefontein Gold Mine (Goldfields)	Carletonville			0	Loopspruit
NW	Doornfontein GM	SW of C'ville	Vaal Dam [Rand W]	TLC	2.56	Wonderfontein spruit
NW	East Driefontein Gold Mine	Carletonville area	Vaal Dam [Rand W]	0.24	0	-
GP	Kloof Gold Mine (Goldfields)	Carletonville / Potchefstroom	Vaal Dam [Rand W]	0.61	3.65	Loopspruit
GP	Leeudoorn Gold Mine	Carletonville / Potchefstroom	Vaal	0	0.15	Loopspruit
NW	Deelkraal	Carletonville / Potchefstroom	Vaal	0.3	1.28	Loopspruit

Note1: Since 1995 some mine names have changed and current names are out of date.
Note 2: Sources of data:

- Council of Geoscience, SAMADABA (?) database
- VRSAU reports for Upper Vaal; Vaal Barrage and Middle Vaal;
- Blesbok report;
- Mooi report;
- Rand Water data etc.

APPENDIX F.7

POWER STATIONS DETAILS

(Eskom operational and mothballed stations and municipal stations)

Operational Eskom Power Stations

Description	Lethabo	Majuba	Tutuka
Quaternary	C22F	C13A	C11K
Location Latitude Longitude	26º44’25” 27º58’30”	27º06’07” 29º46’10”	26º46’45” 29º20’17”
Rated Capacity (MW net)	3558	1836 **(1)**	3510
Load Factor (Average annual %) **(3)**	66%	7%	50%
Specific water consumption (l/kWh)	1.83	0.16 **(2)**	1.93
Assurance of water supply	99.5%	99.5%	99.5%
Water Demand ($10^6 m^3/a$) **(4)**	37.67	0.18	29.69

Note:

(1) Only three dry-cooled units commissioned.
(2) 3 x 612 MW @0.16 l/kWhr, 3 x 669 MW @ 1.80 l/kWhr.
(3) Projected load factors for 1999.
(4) Calculated as follows: Rated capacity x (hours/year) x load factor x specific water consumption.

Mothballed power stations (coal)

Description	Camden	Grootvlei
Quaternary	C11B	C12K
Location Latitude	26º36’45” S	26º46’05” S
Longitude	30º05’10” E	29º29’45” E
Rated Capacity (MW net)	1520	1130
Load Factor (Average annual %)	0%	0%
Specific water consumption (l/kWhr)	2.30	2.12
Assurance of water supply	99.5%	99.5%

Power stations (coal) operated by local councils

(None in study area)

APPENDIX F.8

URBAN USER DETAILS AND TRENDS

(Trend analysis)
(Per capita usage per residential category for urban areas)
(Consumption factors for urban areas)

TRENDS IN WATER USE IN THE UPPER VAAL WMA

It is essential to examine trends in the various water use sectors. This is particularly important to the urban water use sector as this sector has been most dynamic in recent years. Table F.8.1 indicates historic trends in water allocation amongst the various water use sectors.

TABLE F.8.1: HISTORIC TREND AND MOST RECENT PERCENTAGE DISTRIBUTION OF WATER AMONGST THE FOREMOST WATER USE SECTORS

YEAR	ECOLOGY AND FORESTRY	AGRICULTURE	URBAN SECTOR	REMARKS
1975	-	75	25	Ecology sector not recognised yet
1985	10	65	25	
1995	20	50	30	

Note:Urban sector represents the residential, public, commercial, industrial and mining categories.

The actual contributions from the data capture process on the water use of numerous TLCs in the study area enabled only limited analysis of specific variables. The variables well surveyed, which indicate certain trends, are as follows:

- type and size of dwelling and land size/income structure
- composition of area serviced
- water supply standards
- water losses

Residential land and residential house sizes are declining as illustrated in Table F.8.2. subsequently the domestic water use for indoor and outdoor purposes is also declining.

TABLE F.8.2: TRENDS IN URBAN RESIDENTIAL HOUSE AND LAND SIZES.

YEAR	RESIDENTIAL LAND (M^2)	RESIDENTIAL HOUSE SIZE (M^2)	REMARKS
1980	1275	190	House with water and sewer connection
1985	1050	150	do. Do
1990	950	175	do. Do
1995	900 (estimate)	150 (estimate)	Housing developed under RDP criteria

NOTE: Source of information: Housing Trust (1993)

The large water services providers are currently using the following unit water use values in the development of water services infrastructure as shown in the following Table F.8.3.

TABLE F.8.3: DESIGN UNIT WATER VALUES USED FOR THE INFRASTRUCTURE DEVELOPMENT.

USER'S INCOME LEVEL	UNIT RANGE (KL/STAND/DAY)	UNIT RANGE (KL/HECTARE/DAY)	AVERAGE VALUES FROM DMS SURVEY (KL/UNIT/DAY)
Upper income	1.150 – 2.150	-	1.55 (erf >500m^2)
Middle income	0.650 – 1.150	-	0.75 (erf >500m^2)
Low income	0.400 – 0.600	-	1.25 (high density)
Wet. Industries		40 – 65	
Dry industries		30 – 40	19.0 (light industry)

Source of information: TLC guidelines for development of municipal infrastructure.

From the survey carried out on major TLC's situated in the study area, it has been determined that there are seven distinct water services categories to be dealt with. Table F.8.4 illustrates 1995 distribution patterns according to seven water services categories.

TABLE F.8.4: TYPICAL WATER SERVICES SITUATION IN THE STUDY AREA IN 1995.

CATEGORIES OF DOMESTIC USAGE	DWELLING AND WATER SUPPLY CATEGORY	TYPE OF SANITATION SERVICES	PERCENTAGE BREAKDOWN (%)
1,2,3,4	In-house connection	Full water and waterborne sewerage	27
5	Yard taps (metered and unmetered) Communal standpipes	Water connection only	31
6	Backyard shacks	No water connection, communal tap	16
7	Informal/inadequate	None	26

The current management functions of the TLCs and MTCs are stated in the general Proclamation No. 35, 1995 under Section 8(20) read with Section 10(1) of the Local Government Transition Act, 1993 (Act No. 209 of 1993). This Act determines bulk supply of water as one of the powers and duties of the town and metropolitan councils.

The water and sanitation departments of each council are to provide a continuous and reliable supply of bulk water of specified quality for distribution in order to meet the needs of communities.

Summary on urban water use trends

It must be stressed that the trends in development of urban water services in this WMA are much more complex in comparison to some of the other WMA's. There are many factors, which are influencing this process. The bottom line is that this WMA is almost entirely dependent on imported water from other WMA's. However, the Vaal River System infra-structural facility, of which is the Upper Vaal's water service system is an integral part, supplies water directly or indirectly (as return flows) to users in other WMA's.

The growth for urban water supplies in the province increased between 1985 and 1995 about one and half times as shown in Table F.8.5 . However, the general short-term trend experienced in very recent years, indicate very low or negative growth for water in some locations. This is most likely on account of significant decline in mining activities in this WMA. Table F.8.5 gives the trends of source of water supply over a 10 year period from 1985 to 1995.

TABLE F.8.5: TRENDS IN WATER SUPPLIES FROM VARIOUS SOURCES IN 1995

SOURCE OF WATER	WATER SUPPLIES 1985 ($10^6 m^3$/ANNUM)	WATER SUPPLIES 1995 ($10^6 m^3$/ANNUM)	INCREASE OVER 10 YEARS (%)	REMARKS
Local surface and Groundwater	28.6	44.0	154	
Bulk external supply	44.8	63.8	142	
Bulk and local water sources	4.9	7.8	159	RDP systems
Total for all supplies	78.3	115.6	148	

Note: Source of information - Barta

The typical characteristics of urban/peri-urban water services situation in this WMA is related to an absence of strong rural water use component in comparison to other WMA's. An exception to this trend is the large rural community in QwaQwa. Water services information from these areas is not readily available.

A significant water services development in this WMA is taking place primarily in the former constituent townships. These townships are now integrated under TLCs and MTCs jurisdiction.

The constraints influencing this WMA's urban/metropolitan water services trends are primarily of the natural, socio-economic and institutional nature. The technical and to some extent environmental restraints also play an important but somewhat secondary role. The water services development and management in this WMA is subjected primarily to the constraints as follows:

- stochastic distribution of precipitation,
- evaporation exceeding precipitation due to highly variable temperature
- patterns (i.e. peak demand variability in water supply)
- high population growth rate (some 2,4% p.a.) and unabated population influx of rural population,
- competition for financial resources between established and growing new communities,

- culture of non-payment for services rendering to a slow-down in maintenance and expansion of existing water services infrastructure,
- direct and indirect subsidisation of least contributing communities,
- ongoing restructuring of local government management structures causing serious discontinuity in development of needed services,
- a pure monopoly of potable water supply of a single water services provider taking over of the entire market demand,
- a fragmentation in management of metropolitan water supply and wastewater
- reclamation causing a lack of interest in a conjunctive management actions,
- a crisis management approach to water services development in an absence of an overall metropolitan master plan,
- a huge demand for electrical energy due to large volumes of water pumped over long distances and excessive pumping heads,
- inadequate methods used in determining of metropolitan demand for water and capacity expansion and timing,
- the demand management principles overlooked in sizing of new capacity,
- inconsistent technology transfer by the metropolitan authorities,
- non-methodological financial management by the metropolitan stakeholders in absence of asset management practices,
- unattended urban hydrology problems with regard to contaminated urban runoff and excessive pumpage of mineralised mining waters.

Most of the above listed constraints contribute directly or indirectly to the present trends in management and development of water services in this WMA. It is anticipated that by means of new water legislation on the background of a wider Local Government Transition Act specifying implementation of the Integrated Development Planning (IDP) principles, many above mentioned constraints will eventually be eliminated.

APPENDIX F.9

ASSURANCE OF SUPPLY TO USERS IN WMA

(Data on assurance supplied by DWAF and used in WSAM to determine 1:50 yr assurace quantites)

UPPER VAAL WMA									
			Per capita consumption per residential category (l/capita/day)						
Quaternary	Transitional Council	Cat1_SS	Cat2_SS	Cat3_SS	Cat4_SS	Cat5_SS	Cat6_SS	Cat7_SS	Direct : Indirect
Grootdraai key area:									
C11A	BREYTEN / KWAZANELE	320	320	160	90	10	6	90	72 % : 28 %
C11E	AMERSFOORT	125	125	62	35	4	2	35	72 % : 28 %
C11F	ERMELO / WESSELTON	165	165	82	46	5	3	46	65 % : 35 %
C11H	BETHAL	331	331	165	94	10	5	94	72 % : 28 %
C11H	MORGENZON / SIVUKILE	320	320	160	90	10	6	90	72 % : 28 %
C11L	PAARDEKOP / SIYAZENZELA	320	320	160	90	10	6	90	72 % : 28 %
Pattern of usage:		264	264	132	74	8	5	74	
Grootdraai to Vaal Dam key area:									
C11M	STANDERTON / SAKHILE	360	360	180	101	11	7	101	58 % : 42 %
C12C	CORNELIA / NTSWANATSATSI	320	320	160	90	10	6	90	72 % : 28 %
C12D	HIGHVELD RIDGE	256	256	128	72	8	5	72	58 % : 42 %
C12E	CHARL CILLIERS / THUTHUKANI	320	320	160	90	10	6	90	72 % : 28 %
C12G	GREYLINGSTAD / NTHORWANE	320	320	160	90	10	6	90	72 % : 28 %
C12H	VILLIERS / QALABOTJHA	249	249	125	70	8	5	70	72 % : 28 %
Pattern of usage:		304	304	152	86	10	6	86	
Klip (C13) key area:									
C13C	MEMEL / ZAMANI	297	297	149	84	9	6	84	72 % : 28 %
C13G	VREDE / THEMBALIHLE	275	275	137	77	9	5	77	72 % : 28 %
Pattern of usage:		286	286	143	81	9	6	81	
Suikerbosrant key area:									
C21B	BALFOUR	303	303	151	85	9	6	85	72 % : 28 %
C21D	BENONI	221	221	111	62	7	4	62	58 % : 42 %
C21D	BRAKPAN	307	307	153	86	10	6	86	58 % : 42 %
C21E	NIGEL / DUDUZA	175	175	87	50	5	3	50	58 % : 42 %
C21E	SPRINGS / KWATHEMA / VISCHKUIL	436	436	218	123	14	8	123	58 % : 42 %
C21F	HEIDELBERG / RATANDA	270	270	135	76	8	5	76	58 % : 42 %
Pattern of usage:		285	285	143	80	9	5	80	
Klip key area:									
C22A	JOHANNESBURG METRO (South)	306	306	153	86	14	10	86	58 % : 42 %
C22B	ALBERTON	283	283	141	80	9	5	80	58 % : 42 %
C22B	BOKSBURG	228	228	114	64	7	4	64	58 % : 42 %
C22B	GERMISTON / KATLEHONG	320	320	160	90	10	6	90	58 % : 42 %
Pattern of usage:		284	284	142	80	10	6	80	
Vaal Dam to Barrage key area:									
C22F	VEREENIGING / KOPENONG METRO	138	138	69	39	4	3	39	72 % : 28 %
C22G	DENEYSVILLE / REFENGKGOTSO	254	254	127	72	8	5	72	72 % : 28 %
C22J	WESTERN VAAL METRO	191	191	95	54	6	4	54	58 % : 42 %

UPPER VAAL WMA									
			Per capita consumption per residential category (l/capita/day)						
Quaternary	Transitional Council	Cat1_SS	Cat2_SS	Cat3_SS	Cat4_SS	Cat5_SS	Cat6_SS	Cat7_SS	Direct : Indirect
C22K	SASOLBURG / ZAMDELA	464	464	232	130	15	9	130	37 % : 63 %
Pattern of usage:		262	262	131	74	8	5	74	
Vaal Barrage to Mooi confluence key area:									
C23C	PARYS / TUMAHOLE	386	386	193	108	12	7	108	72 % : 28 %
C23C	VREDEFORT / MOKWALLO	277	277	138	78	9	5	78	72 % : 28 %
C23L	RENOVAAL	320	320	160	90	10	6	90	72 % : 28 %
Pattern of usage:		328	328	164	92	10	6	92	
Mooi key area:									
C23D	WESTONARIA	116	116	58	32	3	2	32	80 % : 20 %
C23E	CARLETONVILLE / KHUTSONG	96	96	48	27	3	2	27	58 % : 42 %
C23H	POTCHEFSTROOM / IKAGENG	355	355	177	100	11	5	100	72 % : 28 %
C23J	FOCHVILLE / KOKOZI	355	355	177	100	11	7	100	72 % : 28 %
C23J	WEDELA	320	320	160	90	10	6	90	72 % : 28 %
Pattern of usage:		248	248	124	70	8	4	70	
Wilge key area:									
C81E	HARRISMITH / 42ND HILL / TSIAME	259	259	129	72	8	5	72	60 % : 40 %
C81F	PHUTHADITJHABA	320	320	160	90	10	6	90	72 % : 28 %
C81G	KESTELL / TLHOLONG	320	320	160	90	10	6	90	72 % : 28 %
C82B	WARDEN / EZENZELENI	396	396	198	111	12	7	111	72 % : 28 %
C83C	BETHLEHEM	372	372	186	105	12	7	105	58 % : 42 %
C83G	REITZ / PETSANA	357	357	179	100	11	7	100	72 % : 28 %
C83H	TWEELING / MAFAHLANENG	320	320	160	90	10	6	90	72 % : 28 %
C83J	FRANKFORT	292	292	146	82	9	5	82	58 % : 42 %
C83M	ORANJEVILLE / METSIMAHOLO	295	295	148	83	9	6	83	72 % : 28 %
		326	326	163	91	10	6	91	
Pattern of usage for Upper Vaal		290	290	145	81	9	5	81	
Default pattern of usage [Markdata]		320	320	160	90	10	6	90	
		90%	90%	90%	90%	91%	91%	90%	

Upper Vaal WMA: Urban consumption parameters

	Direct consumption - Residential categories							Indirect cons.	
Quaternary	fUL1i	fUL2i	fUL3i	fUL4i	fUL5i	fUL6i	fUL7i	fULIi	Urban centre, source of potable water and comments
Grootdraai key area:									
C11A	1	1	1	1	1	1	1	1	Breyten TLC (Torbenite Dam) - no known sewage returns to system.
C11E	1	1	1	1	1	1	1	1	Amersfoort TLC (Amersfoort Dam) - no known returns
C11F	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Ermelo TLC (Douglas & Brummer Dams) - returns to Kleindrinkwaterspruit.
C11H	0.45	0.2	0.35	0.8	1	1	0.5	0.342	Bethal (Rand Water) & Morgenzon TLCs - returns by Bethal to Blesbokspruit.
C11L	1	1	1	1	1	1	1	1	Paardekop TLC (boreholes)- no known returns
Note:	**No changes for large TLC's; smaller TLC's no known returns; factors adjusted to 100 % consumption.**								
Grootdraai to Vaal Dam key area:									
C11M	0.45	0.2	0.35	1	1	1	0.5	0.486	Standerton TLC (Vaal River) - returns to Vaal River
C12C	1	1	1	1	1	1	1	1	Cornelia TLC (boreholes)- no known returns
C12D	0.45	0.2	0.35	1	1	1	0.5	0.445	Highveld Ridge TLC (Rand Water) - Secunda & Evander return to Blesbokspruit. Trichardt & Kinross returns to Trichardtspruit (Olifants WMA).
C12E	1	1	1	1	1	1	1	1	Charl Cilliers TLC - no known returns
C12G	1	1	1	1	1	1	1	1	Greylingstad TLC (boreholes) - no known returns
C12H	1	1	1	1	1	1	1	1	Villiers TLC (Vaal Dam) - no known returns
Note:	**No changes for large TLC's; smaller TLC's no known returns; factors adjusted to 100 % consumption.**								
C13 key area:									
C13C	1	1	1	1	1	1	1	1	Memel TLC (Klip River & boreholes) - no known returns
C13G	1	1	1	1	1	1	1	1	Vrede TLC (Spruitsonderdrif River)- no known returns
Note:	**No large TLC's; smaller TLC's no known returns; factors adjusted to 100 % consumption.**								
Suikerbosrand key area:									
C21B	1	1	1	1	1	1	1	1	Balfour TLC (Blesbokspruit) - no known returns
C21D	0.45	0.2	0.35	**1**	1	1	0.5	0.5	Benoni & Brakpan TLC (Rand Water) - returns to upper Blesbokspruit; to lower Blesbokspruit (C21F) & Natalspruit (C22B).
C21E	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Springs & Nigel TLCs (Rand Water) - returns to Blesbokspruit via Bickley; Grundling; McComb; Ancor & Sappi Enstra STWs.
C21F	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Heidelburg TLC (Rand Water) - returns to lower Blesbokspruit
Note:	**No major adjustments, Benoni and Brakpan increased consumption to 100% in residential cetegory 4.**								
Klip key area:									
C22A	**0.25**	**0.1**	**0.15**	**0.4**	**1**	**1**	**0.1**	0.24	**Johannesburg South MLC (Rand Water); returns to Klip system; reduced consumption by 20 %.**
C22B	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Greater Germinston; Boksburg & Alberton MLCs (Rand Water) - returns from Vlakplaats; Dekema; Rondebult & Waterval [C22C] STWs to Rietspruit system.
Note:	**Consumption parameters reduced in Johannesburg - may recieve sewage from the Crocodile WMA, even with split.**								
Vaal Dam to Vaal Barrage:									
C22F	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Vereeniging or Eastern Vaal MLC (Rand Water) - returns to Vaal system from Meyerton; Leeukuil; Rietspruit & Sebokeng STWs.
C22F*	0.45	0.2	0.35	0.8	1	1	0.5	0.35	Vaal Dam dummy catchment

Upper Vaal WMA: Urban consumption parameters

	Direct consumption - Residential categories							Indirect cons.	
Quaternary	**fUL1i**	**fUL2i**	**fUL3i**	**fUL4i**	**fUL5i**	**fUL6i**	**fUL7i**	**fULIi**	**Urban centre, source of potable water and comments**
C22G	1	1	1	1	1	1	1	1	Deneysville TLC (Vaal Dam) - no known returns (diffused locally to evaporation ponds)
C22H	0.45	0.2	0.35	0.8	1	1	0.5	0.336	No urban centre
C22J	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Western Vaal Metro (Rand Water) - returns to Greater Rietpruit via Rietspruit & Sebokeng STWs.
C22K	0.45	0.2	0.35	0.8	1	1	0.5	0.357	Sasolburg MLC (Rand Water) - sewage returns from Sasol 1 STW to Vaal River below Barrage (C23B).
Note:	**No changes for large TLC's; smaller TLC's no known returns; factors adjusted to 100 % consumption.**								
Barrage to Mooi confl:									
C23C	0.45	0.2	0.35	**1**	1	1	0.5	0.352	Parys & Vredefort TLCs (Vaal River)- returns to Vaal R from Parys only.
C23L	1	1	1	1	1	1	1	1	Renovaal TLC (Vaal River) - no returns
Note:	**Parys returns water but not Vredefort - impacts on fUL4i only**								
Mooi key area:									
C23D	0.45	0.2	0.35	0.5	1	1	0.5	0.336	Westonaria TLC (Rand Water) - returns to upper Wonderfonteinspruit.
C23E	0.45	0.2	0.35	0.8	1	1	0.5	0.336	Carltonville TLC (Rand Water) - returns to Wonderfonteinspruit.
C23H	**0.35**	**0.2**	**0.25**	**0.6**	**1**	**1**	**0.1**	**0.336**	**Potchefstroom TLC (Mooi River) - returns to Mooi River; reduced consumption by 10 %.**
C23J	0.45	0.2	0.35	0.8	1	1	0.5	0.468	Fochville & Wedela TLCs (Rand Water) - returns to Loopspruit.
Note:	**Potchefstroom, data available, consumption reduced in most categories; no other adjustments**								
Wilge key area:									
C81E	0.45	0.2	0.35	**0.6**	1	1	0.5	0.345	Harrismith TLC (Wilge River) - returns to Nuwejaarspruit.
C81F	0.45	0.2	0.35	0.8	1	1	0.5	0.365	Phuthaditjhaba (Sedibeng Water from Metsi Matso & Fika Patso Dams) - returns to Elands River
C81G	1	1	1	1	1	1	1	1	Kestell TLC (Sedibeng Water & boreholes) - no known returns.
C82B	1	1	1	1	1	1	1	1	Warden TLC (Cornelius River) - no known returns.
C83C	0.45	0.2	0.35	**1**	1	1	0.5	0.336	Bethlehem TLC (Dams on Liebensbergvlei Rivers) - returns to Jordan River.
C83G	1	1	1	1	1	1	1	1	Reitz TLC (Liebensbergspruit) - no known returns
C83H	1	1	1	1	1	1	1	1	Tweeling TLC - no known returns
C83J	1	1	1	1	1	1	1	1	Frankfort TLC (Wilge River) - no known returns (oxidation dams).
C83M	1	1	1	1	1	1	1	1	Oranjeville TLC (Vaal Dam) - negligible returns.
Note:	**Harrismith and Bethlehem; consumption reduced/ increased in residential category 4; no other adjustments.**								

User Category	ParameterName_ol	Parameter	50%	80%	90%	95%	98%	99%	99.5%	99.8%	99.9%
Bulk - Strategic (on-site)	SBS	oBSRi	0	0	0	0	**20**	**80**	**0**	0	0
Bulk - Mining (on-site)	MBS	oBMRi	0	0	0	0	50	50	0	0	0
Bulk - Other (on-site)	OSB	oBOOi	0	0	0	20	50	30	0	0	0
Direct Urban category 1	PC1	oUC1i	0	0	0	50	20	30	0	0	0
Direct Urban category 2	PC2	oUC2i	0	0	0	50	20	30	0	0	0
Direct Urban category 3	PC3	oUC3i	0	0	0	30	40	30	0	0	0
Direct Urban category 4	PC4	oUC4i	0	0	0	0	20	80	0	0	0
Direct Urban category 5	PC5	oUC5i	0	0	0	0	0	100	0	0	0
Direct Urban category 6	PC6	oUC6i	0	0	0	0	0	100	0	0	0
Direct Urban category 7	PC7	oUC7i	0	0	0	20	30	50	0	0	0
Indirect Urban use	IUR	oUIRi	0	0	0	20	30	50	0	0	0
Irrigation high income	IRH	oIHRo	0	20	20	30	30	0	0	0	0
Irrigation medium income	IRM	oIMRo	0	35	30	20	15	0	0	0	0
Irrigation low income	IRL	oILRo	0	50	40	10	0	0	0	0	0
Rural per capita demand	RPC	gRPCi	0	0	0	0	0	100	0	0	0
Rural Livestock consumption	LSW	oRSRi	0	0	0	0	20	80	0	0	0
Rural Irrigation subsistence	RIR	oRIRo	0	0	0	0	20	80	0	0	0
Per capita volume used for su	PIR	oRICi	0	0	20	30	30	20	0	0	0
			Probability of supply%								
1:2 assurance factor	fY50i	1.23	50								
1:5 assurance factor	fY05i	1.23	80								
1:10 assurance factor	fY10i	1.22	90								
1:20 assurance factor	fY20i	1.113	95								
1:100 assurance factor	fYC1i	0.93	99								
1:200 assurance factor	fYD5i	0.88	99.5								
1:500 assurance factor	fYD2i	0.78	99.8								
	e.g. for rural domestic use if use =100 Mm^3/a in 1995 the adjusted value will be 100/fYC1i = 107.527										
	fY05i	fY10i	fY20i	fY50i	fYC1i	fYD1i	fYD2i	fYD5i			
Min	1.121	1.12	1.06	1.121	0.847	0.593	0.711	0.72			
10Percentile	1.164	1.162	1.083	1.164	0.905	0.634	0.76	0.826			
25Percentile	1.188	1.186	1.093	1.188	0.922	0.645	0.774	0.857			
Median	1.227	1.224	1.113	1.227	0.935	0.655	0.785	0.881			
75Percentile	1.299	1.295	1.139	1.299	0.945	0.662	0.794	0.899			
Max	1.654	1.647	1.355	1.654	0.962	0.673	0.808	0.93			

ASSURANCE OF SUPPLY FOR VARIOUS USER CATEGORIES

APPENDIX G WATER RESOURCES

Comprising:

Appendix G.1 Details of postulated dam storages

Appendix G.2 Sediment load per quaternary

Appendix G.3 Groundwater Resources of South Africa

Appendix G.4 Potential vulnerability of surface water and groundwater to microbial contamination.

Appendix G.5 Water quality database

APPENDIX G.1

DETAILS OF POSTULATED DAM STORAGES

Quat.	MAP	MAE	Hydro	Adj. MAR	Postulated dams		Actual dams storage (106m3)		
Number	(mm)	(S - mm)	zone	(106m3)	(%MAR)	(106m3)	Capacity	Farm	Total
C11A	743	1450	D	48.59	200	97.17	0.00	4.31	4.31
C11B	705	1400	D	31.50	200	63.00	0.00	3.60	3.60
C11C	765	1400	D	36.90	200	73.80	0.00	2.85	2.85
C11D	702	1400	D	21.52	200	43.05	0.00	2.87	2.87
C11E	697	1400	D	64.73	200	129.45	0.00	2.93	2.93
C11F	705	1450	D	50.15	200	100.30	0.00	13.59	13.59
C11G	659	1450	D	17.23	200	34.47	0.00	2.05	2.05
C11H	664	1500	F	71.97	200	143.94	0.00	3.87	3.87
C11J	658	1450	D	47.38	200	94.75	0.00	2.00	2.00
C11K	633	1520	F	18.06	200	36.13	0.00	3.22	3.22
C11L	675	1450	D	49.67	200	99.34	363.00	2.49	365.49
C11M	637	1500	D	37.15	200	74.31	0.00	2.80	2.80
				494.85		**989.71**	**363.00**	**46.58**	**409.58**
C12A	614	1475	D	21.85	200	43.71	0.00	1.27	1.27
C12B	631	1520	D	21.91	200	43.82	0.00	1.33	1.33
C12C	605	1500	D	26.99	200	53.98	0.00	1.36	1.36
C12D	667	1580	F	58.01	200	116.01	0.00	7.25	7.25
C12E	641	1540	F	28.99	200	57.98	0.00	2.99	2.99
C12F	635	1570	F	44.66	200	89.31	0.00	6.54	6.54
C12G	640	1550	F	32.53	200	65.06	0.00	3.13	3.13
C12H	618	1550	F	13.48	200	26.95	0.00	1.80	1.80
C12J	615	1540	F	12.99	200	25.97	0.00	1.27	1.27
C12K	657	1580	F	22.93	200	45.86	0.00	2.70	2.70
C12L	648	1600	F	38.58	200	77.16	0.00	1.47	1.47
				322.91		**645.81**	**0.00**	**31.11**	**31.11**
C13A	779	1400	D	51.40	200	102.79	0.00	2.24	2.24
C13B	683	1400	D	31.07	200	62.15	0.00	1.52	1.52
C13C	724	1400	D	54.02	200	108.04	0.00	2.06	2.06
C13D	698	1400	D	49.61	200	99.22	0.00	1.52	1.52
C13E	699	1400	D	33.59	200	67.19	0.00	1.52	1.52
C13F	692	1450	D	29.81	200	59.62	0.00	1.63	1.63
C13G	674	1430	D	21.67	200	43.33	0.00	2.97	2.97
C13H	628	1470	D	19.97	200	39.95	0.00	1.47	1.47
				291.14		**582.28**	**0.00**	**14.94**	**14.94**
C21A	674	1600	F	28.61	200	57.22	0.00	1.17	1.17
C21B	697	1600	C	10.52	200	21.04	0.00	2.38	2.38
C21C	674	1600	C	9.21	200	18.42	0.00	2.75	2.75
C21D	698	1625	C	10.50	200	21.01	0.00	7.03	7.03
C21E	691	1625	C	14.16	200	28.32	0.00	7.26	7.26
C21F	704	1625	C	10.44	200	20.88	0.00	1.01	1.01
C21G	667	1625	C	8.89	200	17.79	0.00	1.81	1.81
				92.34		**184.68**	**0.00**	**23.41**	**23.41**
C22A	695	1650	C	22.60	200	45.20	0.00	3.55	3.55
C22B	691	1630	C	16.28	200	32.56	0.00	1.98	1.98
C22C	684	1625	C	18.67	200	37.33	0.00	2.09	2.09
C22D	701	1650	C	14.73	200	29.45	0.00	0.92	0.92
C22E	669	1625	C	19.55	200	39.10	0.00	1.48	1.48
C22F	655	1650	C	11.95	200	23.89	0.00	2.34	2.34
C22G	613	1600	C	18.41	200	36.82	0.00	0.00	0.00

Quat.	MAP	MAE	Hydro	Adj. MAR	Postulated dams		Actual dams storage (106m3)		
C22H	639	1650	C	11.08	200	22.15	0.00	4.43	4.43
C22J	633	1650	C	15.66	200	31.32	0.00	1.58	1.58
C22K	644	1625	C	11.41	200	22.82	0.00	2.40	2.40
				160.32		**320.64**	**0.00**	**20.77**	**20.77**
C23A	612	1600	E	5.19	200	10.38	0.00	3.18	3.18
C23B	619	1625	E	14.60	200	29.19	7.36	1.59	8.95
C23C	609	1650	E	22.82	200	45.63	1.24	2.76	4.00
C23D	664	1650	A	15.46	100	15.46	0.00	3.64	3.64
C23E	631	1675	A	16.89	100	16.89	5.82	1.79	7.61
C23F	605	1700	A	37.40	100	37.40	0.00	1.75	1.75
C23G	597	1700	A	14.45	100	14.45	0.00	0.72	0.72
C23H	604	1700	A	10.70	100	10.70	14.42	2.60	17.02
C23J	620	1670	E	20.70	200	41.40	13.79	3.42	17.21
C23K	607	1675	E	8.40	200	16.80	0.00	2.44	2.44
C23L	612	1700	E	26.30	200	52.60	0.00	2.00	2.00
				192.90		**290.90**	**42.62**	**25.89**	**68.51**
C81A	882	1350	D	52.16	200	104.32	0.00	0.77	0.77
C81B	763	1350	D	47.41	200	94.83	0.00	1.80	1.80
C81C	730	1320	D	18.22	200	36.44	0.00	1.12	1.12
C81D	735	1310	D	14.85	200	29.70	2616.95	0.00	2616.95
C81E	658	1360	D	28.58	200	57.16	0.00	2.91	2.91
C81F	892	1300	B	81.79	200	163.58	0.00	5.07	5.07
C81G	722	1310	B	22.20	200	44.40	0.00	0.77	0.77
C81H	638	1350	D	14.31	200	28.62	0.00	0.77	0.77
C81J	612	1410	D	12.03	200	24.06	0.00	0.77	0.77
C81K	623	1410	D	11.81	200	23.62	0.00	0.77	0.77
C81L	740	1350	D	58.11	200	116.22	0.00	0.77	0.77
C81M	662	1370	D	48.95	200	97.90	0.00	0.77	0.77
				410.42		**820.85**	**2616.95**	**16.29**	**2633.24**
C82A	670	1400	D	29.32	200	58.64	0.00	1.28	1.28
C82B	660	1420	D	22.53	200	45.06	0.00	0.77	0.77
C82C	646	1430	D	14.47	200	28.94	0.00	0.85	0.85
C82D	623	1440	D	19.66	200	39.31	0.00	1.02	1.02
C82E	666	1440	D	28.58	200	57.16	0.00	0.77	0.77
C82F	639	1450	D	18.26	200	36.52	0.00	0.77	0.77
C82G	655	1450	D	24.40	200	48.80	0.00	0.77	0.77
C82H	614	1490	D	23.12	200	46.25	0.00	1.01	1.01
				180.33		**360.67**	**0.00**	**7.24**	**7.24**
C83A	692	1350	B	28.65	200	57.30	17.08	1.98	19.06
C83B	668	1380	B	7.93	200	15.86	0.00	7.76	7.76
C83C	663	1440	B	22.79	200	45.58	0.00	3.37	3.37
C83D	650	1410	B	12.49	200	24.99	0.00	2.88	2.88
C83E	654	1450	B	10.92	200	21.84	0.00	2.62	2.62
C83F	637	1480	D	27.26	200	54.51	0.00	3.63	3.63
C83G	647	1460	D	23.91	200	47.82	0.00	3.68	3.68
C83H	646	1480	D	19.42	200	38.85	0.00	2.62	2.62
C83J	641	1510	D	7.27	200	14.53	0.00	0.88	0.88
C83K	635	1520	F	26.74	200	53.48	0.00	1.27	1.27
C83L	641	1550	F	40.06	200	80.13	0.00	1.27	1.27
C83M	639	1580	F	50.19	200	100.38	2537.00	1.27	2538.27
				277.64		**555.28**	**2554.08**	**33.23**	**2587.31**

Quat.	MAP	MAE	Hydro	Adj. MAR	Postulated dams		Actual dams storage (106m3)		
TOTALS				**3915.28**		**4750.82**	**5576.65**	**219.46**	**5796.12**

APPENDIX G.2

SEDIMENT LOAD PER QUATERNARY

Quat. number	Gross area (km^2)	Net area (km^2)	Sediment region	Erodibilty index	Sediment ($t/km^2/a$)	Sediment yield (t/a)	Sediment vol (10^6 m^3)	Volume (%MAR)
C11A	721	721	3	6	153.34	110558	0.111	0.228
C11B	536	536	3	6	153.34	82190	0.082	0.261
C11C	450	450	3	6	153.34	69003	0.069	0.187
C11D	373	373	3	6	153.34	57196	0.057	0.266
C11E	1157	1157	3	7	153.34	177414	0.178	0.275
C11F	931	931	3	7	153.34	142760	0.143	0.285
C11G	433	433	3	7	153.34	66396	0.067	0.386
C11H	1104	1104	3	7	153.34	169287	0.170	0.236
C11J	1002	1002	3	7	153.34	153647	0.154	0.325
C11K	340	340	3	7	153.34	52136	0.052	0.289
C11L	948	948	3	7	153.34	145366	0.146	0.293
C11M	796	796	3	7	153.34	122059	0.122	0.329
	8791	**8791**				**1348012**	**1.351**	**0.273**
C12A	485	485	3	7	153.34	74370	0.075	0.341
C12B	479	479	3	7	153.34	73450	0.074	0.336
C12C	666	666	3	7	153.34	102124	0.102	0.379
C12D	899	899	3	7	153.34	137853	0.138	0.238
C12E	498	498	3	7	153.34	76363	0.077	0.264
C12F	835	835	3	7	153.34	128039	0.128	0.287
C12G	571	571	3	7	153.34	87557	0.088	0.270
C12H	355	355	3	7	153.34	54436	0.055	0.405
C12J	344	344	3	7	153.34	52749	0.053	0.407
C12K	479	479	3	7	153.34	73450	0.074	0.321
C12L	887	887	3	7	153.34	136013	0.136	0.353
	6498	**6498**				**996403**	**0.998**	**0.309**
C13A	595	595	3	7	153.34	91237	0.091	0.178
C13B	616	616	3	7	153.34	94457	0.095	0.305
C13C	837	837	3	8	153.34	128346	0.129	0.238
C13D	896	896	3	7	153.34	137393	0.138	0.278
C13E	603	603	3	8	153.34	92464	0.093	0.276
C13F	611	611	3	7	153.34	93691	0.094	0.315
C13G	435	435	3	8	153.34	66703	0.067	0.308
C13H	589	589	3	7	153.34	90317	0.090	0.453
	5182	**5182**				**794608**	**0.796**	**0.273**
C21A	707	707	3	7	153.34	108411	0.109	0.380
C21B	431	431	3	6	153.34	66090	0.066	0.629
C21C	438	438	3	6	153.34	67163	0.067	0.731
C21D	446	446	3	6	153.34	68390	0.069	0.652
C21E	629	629	3	6	153.34	96451	0.097	0.682
C21F	427	427	3	6	153.34	65476	0.066	0.628
C21G	463	463	3	6	153.34	70996	0.071	0.800
	3541	**3541**				**542977**	**0.544**	**0.589**
C22A	548	548	3	6	153.34	84030	0.084	0.373
C22B	392	392	3	6	153.34	60109	0.060	0.370
C22C	465	465	3	6	153.34	71303	0.071	0.383

Quat. number	Gross area (km^2)	Net area (km^2)	Sediment region	Erodibilty index	Sediment ($t/km^2/a$)	Sediment yield (t/a)	Sediment vol (10^6 m^3)	Volume (%MAR)
C22D	345	345	3	6	153.34	52902	0.053	0.360
C22E	532	532	3	6	153.34	81577	0.082	0.418
C22F	440	440	3	7	153.34	67470	0.068	0.566
C22G	831	831	3	7	153.34	127426	0.128	0.694
C22H	454	454	3	6	153.34	69616	0.070	0.630
C22J	669	669	3	6	153.34	102584	0.103	0.656
C22K	434	434	3	7	153.34	66550	0.067	0.585
	5110	**5110**				**783567**	**0.785**	**0.490**
C23A	258	258	3	7	153.34	39562	0.040	0.764
C23B	701	701	3	7	153.34	107491	0.108	0.738
C23C	1069	1069	3	6	153.34	163920	0.164	0.720
C23D	510	510	3	6	153.34	78203	0.078	0.507
C23E	850	633	3	6	153.34	97064	0.097	0.576
C23F	1324	1001	3	1	153.34	153493	0.154	0.411
C23G	613	613	3	7	153.34	93997	0.094	0.652
C23H	451	451	3	7	153.34	69156	0.069	0.648
C23J	890	890	3	6	153.34	136473	0.137	0.661
C23K	396	396	3	6	153.34	60723	0.061	0.724
C23L	1211	1211	3	7	153.34	185695	0.186	0.707
	8273	**7733**				**1185778**	**1.188**	**0.616**
C81A	382	382	3	9	82	31324	0.031	0.060
C81B	576	576	3	9	82	47232	0.047	0.100
C81C	250	250	3	9	82	20500	0.021	0.113
C81D	195	195	3	9	82	15990	0.016	0.108
C81E	643	643	3	8	153.34	98598	0.099	0.346
C81F	689	689	3	9	82	56498	0.057	0.069
C81G	435	435	3	9	82	35670	0.036	0.161
C81H	358	358	3	8	153.34	54896	0.055	0.384
C81J	392	392	3	8	153.34	60109	0.060	0.501
C81K	359	359	3	8	153.34	55049	0.055	0.467
C81L	795	795	3	8	153.34	121905	0.122	0.210
C81M	1093	1093	3	8	153.34	167601	0.168	0.343
	6167	**6167**				**765372**	**0.767**	**0.187**
C82A	582	582	3	8	153.34	89244	0.089	0.305
C82B	493	493	3	8	153.34	75597	0.076	0.336
C82C	353	353	3	8	153.34	54129	0.054	0.375
C82D	572	572	3	8	153.34	87710	0.088	0.447
C82E	623	623	3	8	153.34	95531	0.096	0.335
C82F	484	484	3	8	153.34	74217	0.074	0.407
C82G	581	581	3	8	153.34	89091	0.089	0.366
C82H	783	783	3	7	153.34	120065	0.120	0.520
	4471	**4471**				**685583**	**0.687**	**0.381**
C83A	746	746	3	9	82	61172	0.061	0.214
C83B	251	251	3	9	82	20582	0.021	0.260
C83C	828	828	3	8	153.34	126966	0.127	0.558
C83D	465	465	3	8	153.34	71303	0.071	0.572
C83E	426	426	3	8	153.34	65323	0.065	0.599

Quat. number	Gross area (km^2)	Net area (km^2)	Sediment region	Erodibilty index	Sediment (t/km^2/a)	Sediment yield (t/a)	Sediment vol (10^6 m^3)	Volume (%MAR)
C83F	875	875	3	8	153.34	134173	0.134	0.493
C83G	695	695	3	8	153.34	106571	0.107	0.447
C83H	547	547	3	8	153.34	83877	0.084	0.433
C83J	222	222	3	7	153.34	34041	0.034	0.469
C83K	548	548	3	7	153.34	84030	0.084	0.315
C83L	826	826	3	7	153.34	126659	0.127	0.317
C83M	1100	1100	3	7	153.34	168674	0.169	0.337
	7529	**7529**				**1083371**	**1.086**	**0.391**
TOTALS	**55 562**	**55 022**				**818 5671**	**8.202**	**0.339**

APPENDIX G.3

GROUND WATER RESOURCES OF SOUTH AFRICA

GROUND WATER RESOURCES OF SOUTH AFRICA

1. BACKGROUND

The Department of Water Affairs and Forestry (DWAF) has decided to conduct a Water Situation Assessment Study for South Africa to give a broad overview of national water requirements and water resources. These studies will enable the DWAF to utilize the Water Situation Assessment Model (WSAM), to assist in the decision making process when doing long term water resources planning.

WSM (Pty) Ltd was appointed to undertake the Situation Assessment Study of the Ground Water Resources of South Africa. This study took the form of a desk study evaluating all relevant existing data and reports at a reconnaissance level. The study area consists of all the quaternary sub-catchments of South Africa and the adjoining sub-catchments of the neighbouring states.

This report gives the findings of the study.

2. STUDY OBJECTIVES

The objective of the study is mainly to provide quantitative information on the Ground Water Resources on a quaternary catchment basis for the whole of South Africa for input into the WSAM. The information provided will consist of the following, viz :-

- ground water resource potential or harvest potential
- ground water resources available to be exploited or exploitation potential
- interaction between ground water and surface water ie the portion of ground water that contributes to stream flow (base flow)
- present ground water use
- a ground water balance identifying quaternary catchments where over exploitation occurs as well as catchments having a potential for increased ground water development
- ground water quality evaluation, determining the portion of ground water which is potable

3. METHODOLOGY

This study is a reconnaissance study making use of existing available information.

The quantification of the ground water resources is probably one of the most difficult aspects of ground water to access. Information on recharge to the ground water systems, storage capacity of the ground water systems, the hydraulic conductivity and thickness of these ground water systems, the interaction with surface water and water quality is required. Once the ground water resources are quantified a ground water balance is set up, comparing the resource with the existing use, to determine areas of over exploitation and identify areas which have a potential for further ground water exploitation. These parameters have been evaluated and the methodology is given below.

3.1 Harvest Potential

The evaluation of the mean annual recharge and storage on a national scale has been done by Vegter, 1995. This information together with a rainfall reliability factor (20^{th} percentile precipitation divided by the median precipitation), which gives an indication of the possible drought length, has been utilized by Seward and Seymour, 1996, to produce the Harvest Potential of South Africa.

The Harvest Potential is defined as the maximum volume of ground water that may be abstracted per area without depleting the aquifers. The Harvest Potential as determined by Seward and Seymour, 1996 has been used as the starting point for the determination of the Ground Water Resources of South Africa.

3.2 Exploitation Potential

It is however not possible to abstract all the ground water available. This is mainly due to economic and/or environmental considerations. The main contributing factor is the hydraulic conductivity or transmissivity of the aquifer systems. As no regional information is available, a qualitative evaluation has been done using available borehole yield information, as there is a good relationship between borehole yield and transmissivity.

The average borehole yield was determined for each quaternary catchment using information available from the National Ground Water Database and the borehole database of the Chief Directorate Water Services. Where no information was available, the average of the tertiary catchment was used. The average yields were then divided into 5 groups and an exploitation factor allocated to each group as follows, viz: -

AVERAGE BOREHOLE YIELD	EXPLOITATION FACTOR
>3,0 ℓ/s	0,7
1,5 – 3,0 ℓ/s	0,6
0,7 – 1,5 ℓ/s	0,5
0,3 – 0,7 ℓ/s	0,4
<0,3 ℓ/s	0,3

This factor was then multiplied by the Harvest Potential of each quaternary catchment to obtain the exploitation potential. The exploitation potential is considered to be a conservative estimate of the groundwater resources available for exploitation.

3.3 Ground Water, Surface Water Interaction

In order to avoid double counting the water resources, the interaction between Surface and Ground Water needs to be quantified. At a workshop held at the DWAF where ground and surface water specialists were represented, it was agreed that the baseflow, be regarded as the portion of water common to both ground and surface water for the purposes of this study.

- ***Baseflow***

  The baseflow has been considered as that portion of ground water which contributes to the low flow of streams. Baseflow can therefore be regarded as that portion of the total water resource that can either be abstracted as ground water or surface water. The baseflow in this study is defined as the annual equivalent of the average low flow that is equaled or exceeded 75% of the time during the 4 driest months of the year. The baseflow has been calculated by Schultz and Barnes, 2001.

- ***Baseflow factor***

  The baseflow factor gives an indication of the portion of ground water which contributes to base flow and has been calculated by dividing the baseflow by the Harvest Potential.

  If baseflow = 0, then ground water does not contribute to baseflow and the baseflow factor is therefore also = 0.

  If baseflow ▲◄ harvest potential then all ground water can be abstracted as surface water and the baseflow factor is therefore ▲◄ 1. As the contribution of the Harvest Potential to baseflow cannot be greater than the Harvest Potential, the baseflow factor has therefore been corrected to equal 1 where it was > 1.

- ***Impact of Ground Water Abstraction on Surface Water Resources***

  The impact that ground water abstraction will have on surface water resources has been evaluated qualitatively by using the corrected baseflow factor ie,

  - negligible where corrected baseflow factor is = 0
  - low where the corrected baseflow factors is ≤ 0,3
  - moderate where the corrected baseflow factor is ≤ 0,8
  - high where the corrected baseflow factor is > 0,8

- ***Contribution of Ground Water to the Total Utilization Water Resource***

This assessment of the interaction of groundwater and the base flow component of the surface water can however, not be used directly to determine the additional contribution of groundwater abstraction to the total utilizable water resource without also taking account of the effect of surface water storage capacity and the reduction in surface water runoff that is caused by the increase of groundwater recharge (induced recharge) that results from groundwater abstraction. For the purpose of this water resources assessment the proportion of the utilizable groundwater not contributing to the base flow of the surface water that can be added to the utilizable surface water to estimate the total utilizable resources has therefore been ignored.

3.4 Existing Ground Water Use

Data on existing ground water use was not readily accessible especially the main use sectors, viz agriculture and mining. Available borehole information was thus utilized to give a first estimate.

This was done by adding all the estimated yields or blow yields of all the boreholes for an 8 hr/day pumping period, 365 days per year.

Ground Water use was also evaluated from work done by Jane Baron (Baron and Seward, 2000). The use was evaluated for the following sectors, ie

- Municipal Use

  This data was obtained from a study done by DWAF in 1990 with additional information obtained from DWAF hydrogeologists and town clerk /engineers.

- Rural Use

  Rural use was estimated from the DWAF, Water Services Database linking water source to population and allowing for 25 ℓ/capita/day.

- Livestock use

  The number of equivalent large livestock units per quaternary catchment was taken from the WSAM and multiplied by 45 ℓ/day and then multiplied by the % reliance on ground water obtained from the Glen College Food Survey (1990).

- Irrigation Use

  The total irrigation use per quaternary catchment was taken from the WSAM. This use was then multiplied by the % reliance on ground water obtained from the Glen College Food Survey (1990).

The total use was determined by summation of the municipal, rural, livestock and irrigation use. It must be noted that information on mining and industrial use was not available and has not been included in the total use.

Workshops held in each of the Water Management Area's by the Water Resources Situation Assessment teams, provided local input to the water use numbers. These numbers were then adjusted by applying a factor to the Baron & Seward (2000) number to give the final ground water use figures.

3.5 Ground Water Balance

The Ground Water Balance was calculated for each quaternary catchment to determine the extent to which the ground water resources have been developed. This was done by means of comparing the values of Harvest Potential and Exploitation Potential with adjusted ground water use (Baron and Seward, 2000).

The following scenario's were mapped, viz :-

- If the total use was greater than the Harvest Potential then the catchment was considered to be over utilized.

- If the total use was greater than the Exploitation Potential but less than the Harvest Potential then the catchment was considered to be heavily utilized.

- If the total use was less than the Exploitation Potential but greater than 66% of the Exploitation Potential then the catchment was considered to be moderately utilized.

- If the total use was less than 66% of the Exploitation Potential the catchment was considered under utilized.

3.6 Water Quality

The ground water quality is one of the main factors affecting the development of available ground water resources. Although there are numerous problems associated with water quality, some of which are easily remediated, total dissolved solids (TDS), nitrates (NO_3 as N) and fluorides (F) are thought to represent the majority of serious water quality problems that occur.

The water quality has been evaluated in terms of TDS and potability. The information was obtained from WRC Project K5/841 (Simonic 2000). The mean TDS together with the highest value, lowest value and range is given for each catchment where analyses were available. Where no analyses were available an estimate of the mean was made using Vegters Maps (Vegter, 1995). The potability evaluation done by Simonic (Simonic, 2000) was based on the evaluation of chloride, fluoride, magnesium, nitrate, potassium, sodium, sulfate and calcium using the Quality of Domestic Water Supplies, Volume I (DWAF, 1998).

The TDS is described in terms of a classification system developed for this water resources situation assessment. The uses that were taken into account were domestic use and irrigation. It was assumed that if the water quality met the requirements for domestic and irrigation use it would in most cases satisfy the requirements of other uses. The South African Water Quality Guidelines for the Department of Water Affairs and Forestry (1996) for these two uses were combined into a single classification system as shown in Table 3.6.1

TABLE 3.6.1: CLASSIFICATION SYSTEM FOR MINERALOGICAL WATER QUALITY

Colour Code	Description	TDS Range (mg/l)
Blue	Ideal water quality	<260
Green	Good water quality	260 – 600
Yellow	Marginal water quality	601 – 1 800
Red	Poor water quality	1 801 – 3 400
Purple	Completely unacceptable water quality	>3 400

The portion of the ground water resources considered potable has been calculated as that portion classified as ideal, good and marginal (Class 0, 1 and 2) according to the Quality of Domestic Water Supplies, Volume I (DWAF, 1998). Water classified as poor and unacceptable has been considered **not** potable.

In catchments where no information was available estimates of the portion potable were made using Vegters maps (Vegter 1995).

4. DATA LIMITATIONS

It must be noted that this evaluation was done using existing available information. The evaluation is based on the harvest potential map which was derived from interpretations of limited existing information on recharge and a very broad qualitative assessment of storage capacity. The comparison of base flow with the harvest potential indicates that the harvest potential could be significantly underestimated in the wetter parts of the country. It is thought that this is due to an under estimation of the storage capacity.

Although yield data on some 91 000 boreholes was used the accuracy of this data in some instances is questionable, as it was not known whether the yield was a blow yield estimated during drilling, or a yield recommended by a hydrogeologist from detailed pumping test results. In general, however, the yields do highlight areas of higher and lower yield potential such as the dolomite areas but in some areas such as catchment W70 appear to grossly underestimate the yield. Underestimation of the yield would negatively impact on the calculation of exploitation potential.

Information on ground water use was obtained mainly from indirect qualitative evaluations. Further, mining and industrial use was not available and was therefore not included in the total usage. This could have a significant effect on the ground water balance in specifically the gold mining areas.

Water quality data should also only be used to give regional trends. In many catchments data at only a few sample points were available. As a catchment could be underlain by numerous different lithologies, a large range in water quality can occur. The samples used in the analysis could thus be non representative of the catchment as a whole.

In general this study should be seen as a first quantitative estimate of the ground water resources of South Africa.

5. OVERVIEW OF THE GROUND WATER RESOURCES OF SOUTH AFRICA

In over 90% of the surface area of South Africa, ground water occurs in secondary openings such as pores in weathered rock and faults, fractures, fissures and dissolution channels in so-called hard rock. These rocks consist of igneous, metamorphic and sedimentary rocks and range in age from Jurassic (± 140 x 10^6 yrs) to Swazian (3 750 x 10^6 yrs).

In the remaining 10% of the surface area of South Africa ground water occurs in primary openings ie intergranular pores in mainly unconsolidated classic rocks. These rocks are generally recent in age (< 65 x 10^6 yrs) and consist of the Kalahari beds, the alluvial strip along some rivers and cenozoic deposits fringing the coast line, mainly in Northern Kwa Zulu Natal and the Southern and Western Cape.

The total Harvest Potential for South Africa has been calculated as 19 100 x $10^6 m^3$/a and varies from less than 0,5 mm/a in quaternary catchment D82J to more than 352 mm/a in quaternary catchment W12J.

Borehole yields vary considerably. The highest boreholes yields (up to 100 ℓ/s) have been found in the Malmani Dolomites. Other high borehole yielding (> 10 ℓ/s) lithostratigraphic units include the Table Mountain Quartsites of the Southern Cape, Basement Granites in the Pietersburg Dendron and Coetzerdam area, coastal deposits along Northern Natal, the eastern southern and western Cape, and alluvial deposits along certain sections of some of the major rivers such as the Limpopo River.

Moderate to good yields (> 5 ℓ/s) are found in the Letaba Basalt formation and where the Ecca has been intruded by dolerite dykes and sheets.

The total exploitation potential for South Africa has been calculated as 10 100 x $10^6 m^3$/a and varies from less than 0,2 mm/a in quaternary catchment D82G to more than 211 mm/a in quaternary catchment W12J.

The ground water use, excluding mines and industries, has been estimated to be some 1 040 x $10^6 m^3$/a and is concentrated in a few isolated areas.

The ground water balance shows that in general ground water is underutilized except for a few areas where over or heavy utilization occurs.

The extreme north western parts of South Africa show the poorest quality with TDS > 20 000 mg/ℓ. The higher rainfall eastern parts have the best water quality, TDS < 100 mg/ℓ. The potability ranges between 0% in the extreme north-western parts of South Africa and 100% in the central and eastern areas. The main problems being brackish water and high nitrates and fluorides.

APPENDIX G.4

POTENTIAL VULNERABILITY OF SURFACE WATER AND GROUNDWATER TO MICROBIAL CONTAMINATION

WATER RESOURCES SITUATION ASSESSMENTS

DEPARTMENT: WATER AFFAIRS & FORESTRY
DIRECTORATE: WATER RESOURCE PLANNING

POTENTIAL VULNERABILITY OF SURFACE WATER & GROUNDWATER TO MICROBIAL CONTAMINATION

AUGUST 2001

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SUMMARY

This report forms part of the Water Resources Situation Assessments undertaken for the Department of Water Affairs and Forestry. Information is provided on the potential microbial contamination of surface water and groundwater resources in South Africa.

For surface water, initial mapping information was taken from the National Microbiological Monitoring Program where priority contaminated areas were identified and mapped. As part of this project, it was necessary to produce a surface contamination map for the whole country. A national surface faecal contamination map was produced using population density and sanitation type available from DWAF databases. A three category rating system was used (low, medium and high) to describe the surface faecal contamination. This information was delineated on a quaternary catchment basis for the whole country.

For groundwater, the first step involved the development of a groundwater vulnerability map using the depth to groundwater, soil media and impact of the vadose zone media. A three category rating system was used (least, moderate, most) to describe the ease with which groundwater could be contaminated from a source on the surface. The second step involved using the surface contamination and aquifer vulnerability maps to derive a groundwater contamination map. The derived map shows the degree of faecal contamination that could be expected of the groundwater for all areas in South Africa.

Conclusions and recommendations

- Maps were produced that provide an overall assessment of potential microbial contamination of the surface water and groundwater resources of South Africa.

- Spatial resolution of the maps is based on a quaternary catchment scale. It is recommended that these maps are not used to derive more detailed spatial information.

- Once sufficient microbial data are available, it is recommended that the numerical methods, and their associated assumptions, be checked, and the maps replotted where necessary.

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ACKNOWLEDGEMENT

The support of Mr Julian Conrad of Environmentek, CSIR for providing the GIS DRASTIC coverages. His help is fully acknowledged and appreciated.

GLOSSARY

Aquifer	Strata, or a group of interconnected strata, comprising of saturated earth material capable of conducting groundwater and of yielding usable quantities of groundwater to boreholes
Contamination	Introduction into the environment of an anthropogenic substance
DRASTIC	Numerical method that describes groundwater characteristics, using: water depth, recharge, aquifer media, soil media, topography, impact on vadose zone, and conductivity
Faecal	Material that contains bodily waste matter derived from ingested food and secretions from the intestines, of all warm-blooded animals including humans
Fitness for use	Assessment of the quality of water based on the chemical, physical and biological requirements of users
Groundwater	Subsurface water occupying voids within a geological stratum
Microbial	Microscopic organism that is disease causing
Ratio	Mathematical relationship defined by dividing one number by another number
Rating	Classification according to order, or grade
Vadose zone	Part of the geological stratum above the saturated zone where voids contain both air and water
Vulnerability	In the context of this report, it is the capability of surface water or groundwater resources to become contaminated

1. INTRODUCTION

The purpose of the Water Resources Situation Assessments is to prepare an overview of the water resources in South Africa. This will take account of the availability and requirements for water, as well as deal with issues such as water quality. The country has been divided into nineteen water management areas. Eight separate studies are being carried out within catchment boundaries that roughly approximate provincial borders. Once these studies have been completed, all information will also be synthesized into a single report for the whole country.

This report describes the method used to prepare a series of maps that show the microbial rating of surface water and groundwater resources in South Africa. Maps are produced at a quaternary catchment scale. It is intended that the appropriate portions of the maps be incorporated into each of the Water Management Area reports.

The microbial information provided in this report is intended for planning purposes, and is not suitable for detailed water quality assessment. The maps provide a comparative rating of the faecal contamination status of the surface water and groundwater resources in South Africa.

This report contains five sections:

- Section One: Introduction
- Section Two: Mapping of surface contamination
- Section Three: Mapping Groundwater Resources
- Section Four: Conclusions and Recommendations
- Section Five: References

2. MAPPING SURFACE WATER RESOURCES

2.1 Background

The water resources of South Africa have come under increasing influence from faecal contamination as a result of increased urban development and lack of appropriate sanitation. Due to increased use of contaminated water for domestic consumption, people are at serious risk of contracting water-borne disease (e.g. gastroenteritis, salmonellosis, dysentery, cholera, typhoid fever and hepatitis). The Department of Water Affairs and Forestry (DWAF) is the custodian of the national water resources and should ensure *fitness for use* of the water resources. Thus, the Department has developed a monitoring system to provide the necessary management information to assess and control the health hazard in selected areas. This project is called the National Microbiological Monitoring Programme (NMMP).

As part of the NMMP, a screening exercise was carried out to determine the number of catchments that experience faecal contamination. A short-list of tertiary catchment areas was compiled. Data from the database of the Directorate: Water Services Planning of DWAF was used to prioritize catchments to assess the overall health hazard (see Figure 1).

Ratings for land use activity were assigned using the method developed by Goodmin & Wright (1991), IWQS (1996), and Murray (1999). Ratings for land and water use were combined to establish an overall rating. Water use was considered to have a higher effect than the land use so that a 60:40 weighting was used (see Equation 1).

$$OR = 0.4\ TLU + 0.6\ TWU \qquad .... (1)$$

Where OR = Area Rating (no units)
TLU = Total land use rating for area (no units)
TWU = Total water use rating for area (no units)

Each area was assigned a rating to indicate low (1), medium (2) or high (3) potential risk to users in the catchment area. The following values were used to designate each class:

Low	OR = 0 to 1000	
Medium	OR = 1001 to100 000	
High	OR > 100 000	.......(2)

Figure 1 shows the surface faecal contamination map for priority rated catchments in South Africa.

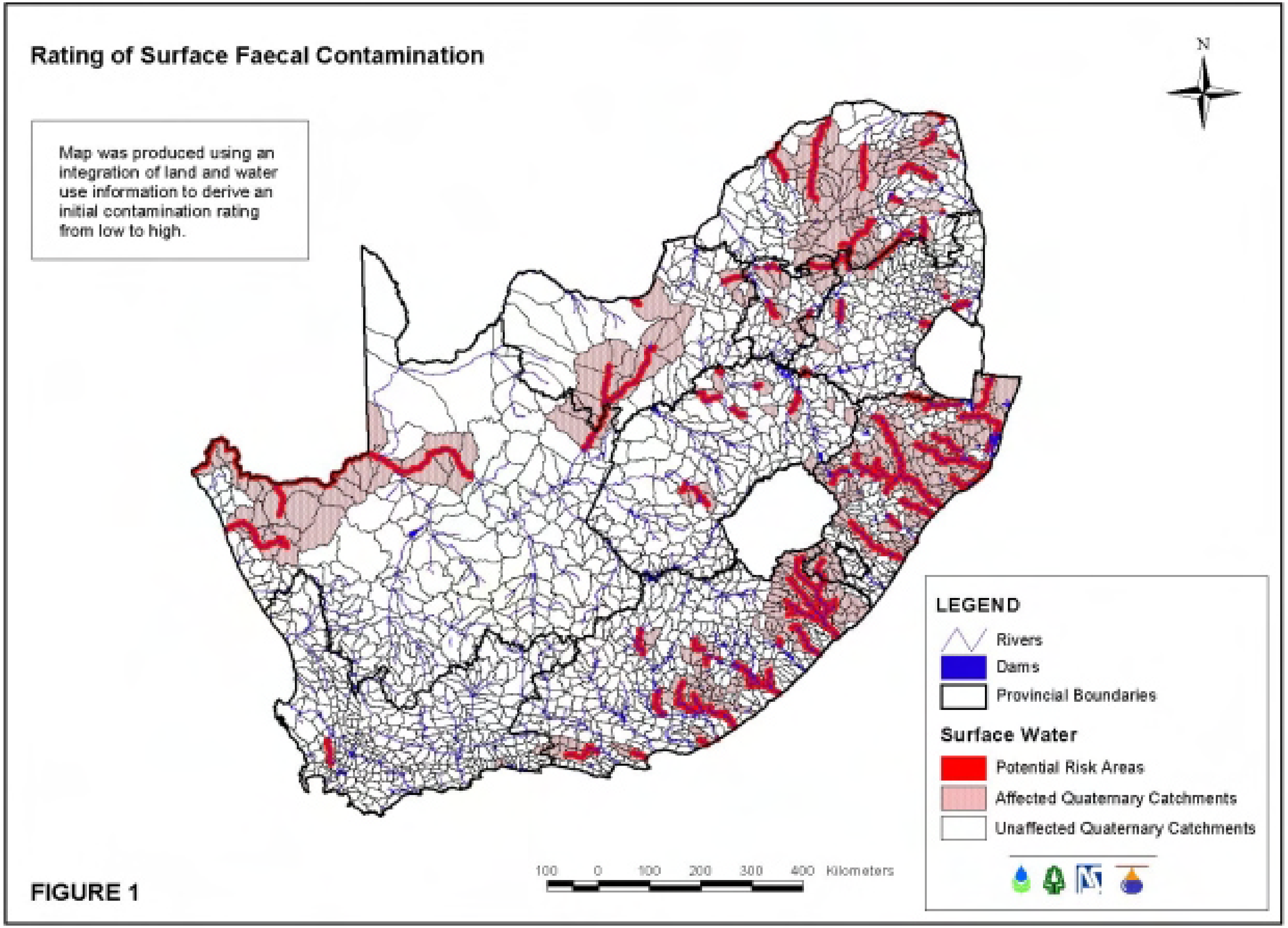

Rating of Surface Faecal Contamination
Map was produced using an integration of land and water use information to derive an initial contamination rating from low to high.
N
LEGEND
Rivers
Dams
Provincial Boundaries
Surface Water
Potential Risk Areas
Affected Quaternary Catchments
Unaffected Quaternary Catchments
100 0 100 200 300 400 Kilometers

FIGURE 1

2.2 Surface faecal contamination

Figure 2 shows the potential surface faecal contamination map, developed using average population density (for a quaternary) and degree of sanitation (Venter, 1998). The land use rating is given by:

$$LU = SA + PD \qquad \text{........ (3)}$$

Where LU = Land use rating per settlement (no units)
SA = No/poor sanitation rating (no units)
PD = Population Density rating (no units)

Land use rankings for quaternary catchments were determined by calculating the total ratings of all settlements within a particular quaternary catchment, given by:

$$TLU = (LU_n) \qquad \text{........ (4)}$$

Where TLU = Total land use rating per quaternary catchment
LU_n = Land use rating for n settlements, per quaternary

Each quaternary catchment was allocated a low (1), medium (2) and high (3) priority rating used to map the information using GIS. Classes were designated by the following values:

Low = $TLU < 1000$
Medium = $1000 < TLU < 3000$
High = $TLU > 3000$ .... (5)

2.3 Results: GIS Surface Water Mapping

Figure 1 was plotted on GIS by firstly assembling the national coverages for the quaternary catchments, rivers and dams. The data described above were processed using the following method:

The quaternary catchments were shaded according to whether they were considered potential risk areas or not (refer to Equations 1 & 2).

Within the quaternaries at risk, the rivers were buffered and shaded red to indicate the risk to potential surface water users.

Figure 2, the potential surface faecal contamination map, was produced as follows:

The ratings (TLU) were distributed into intervals (refer to Equations 5 and 6).

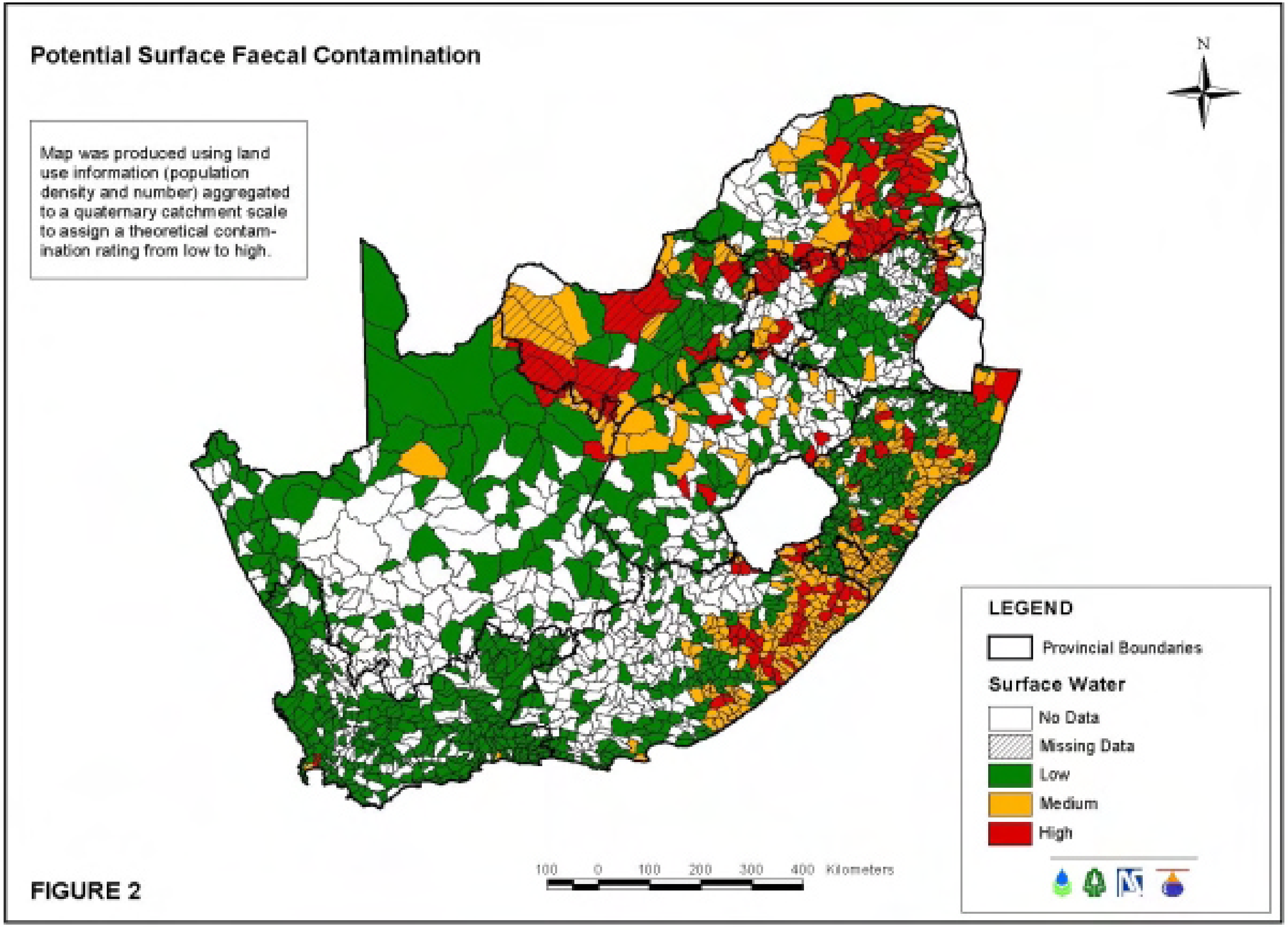

Potential Surface Faecal Contamination
N
Map was produced using land use information (population density and number) aggregated to a quaternary catchment scale to assign a theoretical contamination rating from low to high.
LEGEND
Provincial Boundaries
Surface Water
No Data
Missing Data
Low
Medium
High
100 0 100 200 300 400 Kilometers

FIGURE 2

The quaternary catchments were then shaded according to these rating intervals indicating areas of Low, Medium or High Risk, see below.

Low	Green	TLU < 1000	
Medium	Yellow	1000 < TLU < 3000	
High	Red	TLU > 3000	.... (6)

Quaternary catchments with no data were unshaded.

Quaternary catchments containing missing data were hatched.

3. MAPPING GROUNDWATER RESOURCES

3.1 Background

Groundwater is an important national water resource that plays an important role in meeting water requirements in remote areas. This is particularly true in areas where rainfall is low and surface water resources are scarce.

Microbial contamination of groundwater increases in high population density areas and areas with inadequate sanitation. Approximately three quarters of the population of South Africa do not have access to adequate sanitation.

Considerable work has already been carried out to map the groundwater resources in South Africa. Examples include: the national Groundwater Resources of the Republic of South Africa map produced by Vegter (1995) for the Water Research Commission (WRC), regional 1: 500 000 scale hydrogeological maps produced by DWAF, the national groundwater vulnerability map prepared by Reynders & Lynch (1993) and the aquifer classification map of Parsons & Conrad (1998). Figure 3 shows the vulnerability map used by Parsons & Conrad (1998). The existing work, particularly the vulnerability map (Figure 3), has therefore been used as a basis for assessing the potential of microbial contamination of groundwater systems.

3.2 Method

It is recognised that certain aquifers are more vulnerable to contamination than others. The DRASTIC method (Aller *et al.*, 1985) is a well-known and studied method of assessing aquifer vulnerability to contamination. Reynders & Lynch (1993) and Lynch *et al*. (1994, 1997) prepared a national scale aquifer vulnerability map using DRASTIC that was revised by Parsons & Conrad (1998) using additional data (see Figure 3).

DRASTIC is a weighting, and rating, technique that considers seven factors when estimating the groundwater vulnerability. Factors are geologically and geohydrologically based. Controls relating to the magnitude or severity of the pollution source are not considered. DRASTIC factors are shown in Table 1.

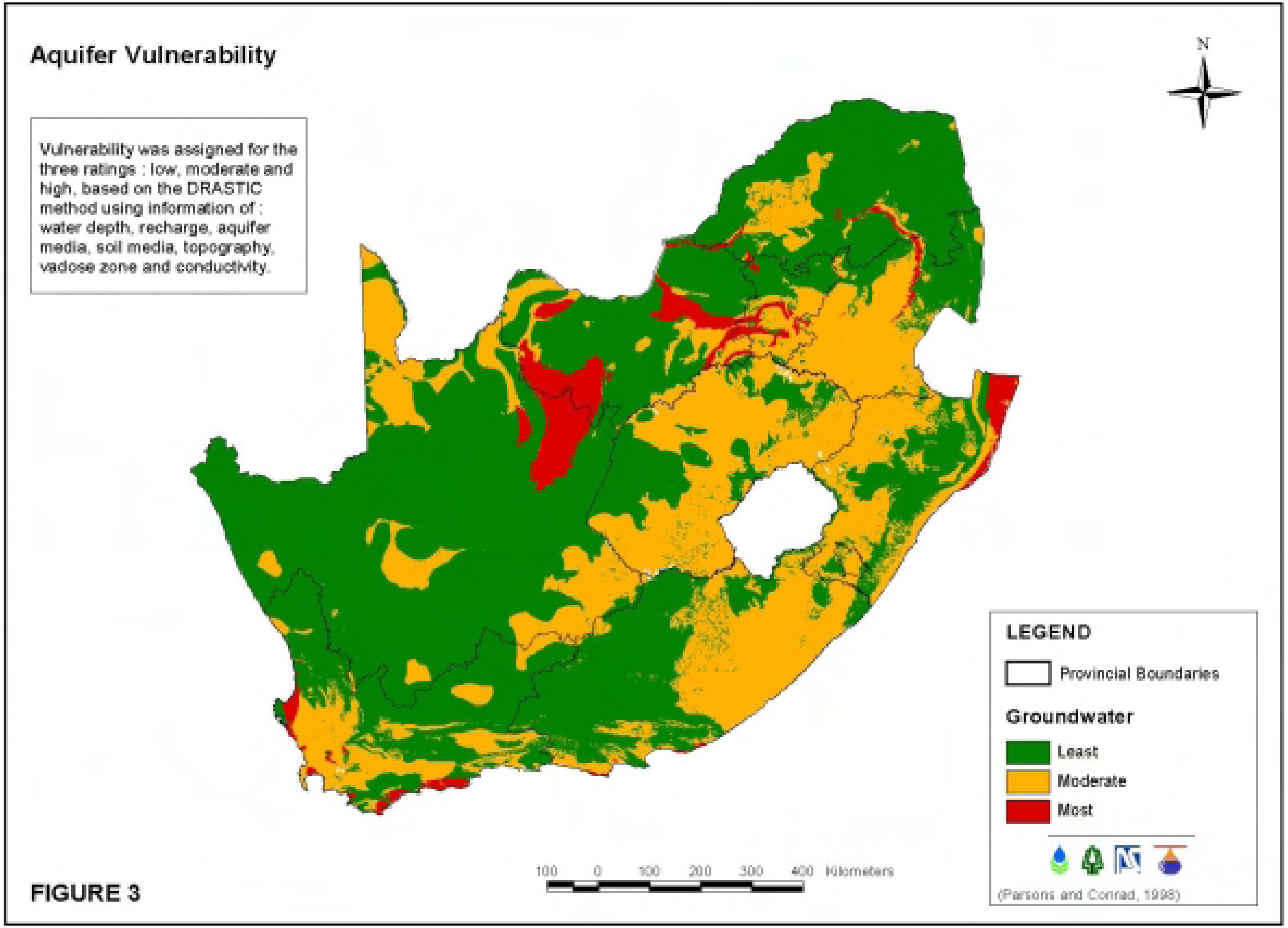

Aquifer Vulnerability
Vulnerability was assigned for the three ratings : low, moderate and high, based on the DRASTIC method using information of : water depth, recharge, aquifer media, soil media, topography, vadose zone and conductivity.
N
100 0 100 200 300 400 Kilometers
LEGEND
Provincial Boundaries
Groundwater
Least
Moderate
Most
(Parsons and Conrad, 1998)

FIGURE 3

TABLE 1: FACTORS USED BY DRASTIC

D	Depth to water
R	(net) Recharge
A	Aquifer media
S	Soil media
T	Topography (slope)
I	Impact of the vadose zone media
C	Conductivity (hydraulic) of the aquifer

Each factor was weighted according to its relative importance (Aller *et al.*, 1985). Using a set of tables, a rating is assigned based on prevailing conditions. A relative DRASTIC index (I) is derived using the following formula, with higher index values showing greater groundwater vulnerability:

$$I = D_R D_W + R_R R_W + A_R A_W + S_R S_W + T_R T_W + I_R I_W + C_R C_W \quad ..... (7)$$

where: I = index rating

$_R$ is the rating for each factor, and

$_W$ is the weighting for each factor.

DRASTIC was also developed to assess the vulnerability to pesticide contamination (Aller *et al.*, 1985). In this case, those factors that play an important role in defining vulnerability to pesticide contamination are assigned higher weights.

In the case of microbial contamination, other factors are more important in terms of aquifer vulnerability to microbial contamination. Travel time in the vadose zone is recognised as an important control in this regard (Xu & Braune, 1995; Wright, 1995; DWAF, 1997). It was hence decided to assess aquifer vulnerability to microbial contamination in terms of D, S and I (i.e. all factors that relate to the vadose zone). [1]

The weighting and rating technique used by DRASTIC was followed in the current study, adopting the weights used by the pesticide DRASTIC. Using the following formula, the highest possible index value is 140 and the lowest value is 14,

$$\text{Index} = 5\,D_R + 5\,S_R + 4\,I_R \quad .... (8)$$

It must be noted that (1) the value of the index is relative, (2) the factors used in the index were considered by the team to have the greatest influence in assessing the potential for microbial contamination at the surface entering underlying aquifers.

[1] A similar approach was used by Xu & Braune (1995) where they used the factors D, A and S, and used the weightings assigned by DRASTIC and not Pesticide DRASTIC.

3.3 Aquifer vulnerability map

Three DRASTIC groundwater coverages were used to produce an indication of vulnerability of groundwater contamination, namely, depth to groundwater, soil media and vadose.

Each grid element on the DRASTIC coverages was allocated a rating, that was multiplied by a weighting factor (Depth = 5, Soil = 5, Vadose = 4) to produce a score. These three coverages were intersected and their scores added to produce a relative index for each point on the resulting coverage. An additional assumption was applied that assigned a low vulnerability to all areas with a Depth score of less than or equal to 2. This was used to account for deep infiltration of groundwater (over 35 metres) where long residence time and filtration will reduce the degree of contamination.

The relative index (RI) obtained for each grid allowed for grouping into high, medium and low categories. However, setting the intervals for the three categories proved difficult because of sensitivity to the interval chosen. A large percentage of indices fell in the interval of 60 to 80. It was thus decided to use the interval of 70 to 85 to allow for equal distribution between high, medium and low vulnerability areas (see Figure 4), namely:

Low	Green	RI < 70	
Medium	Yellow	70 < RI < 85	
High	Red	RI > 85	.... (9)

To illustrate the sensitivity to the interval chosen the map was replotted using two further intervals of 60-90 and 65-90 (see Figure 5).

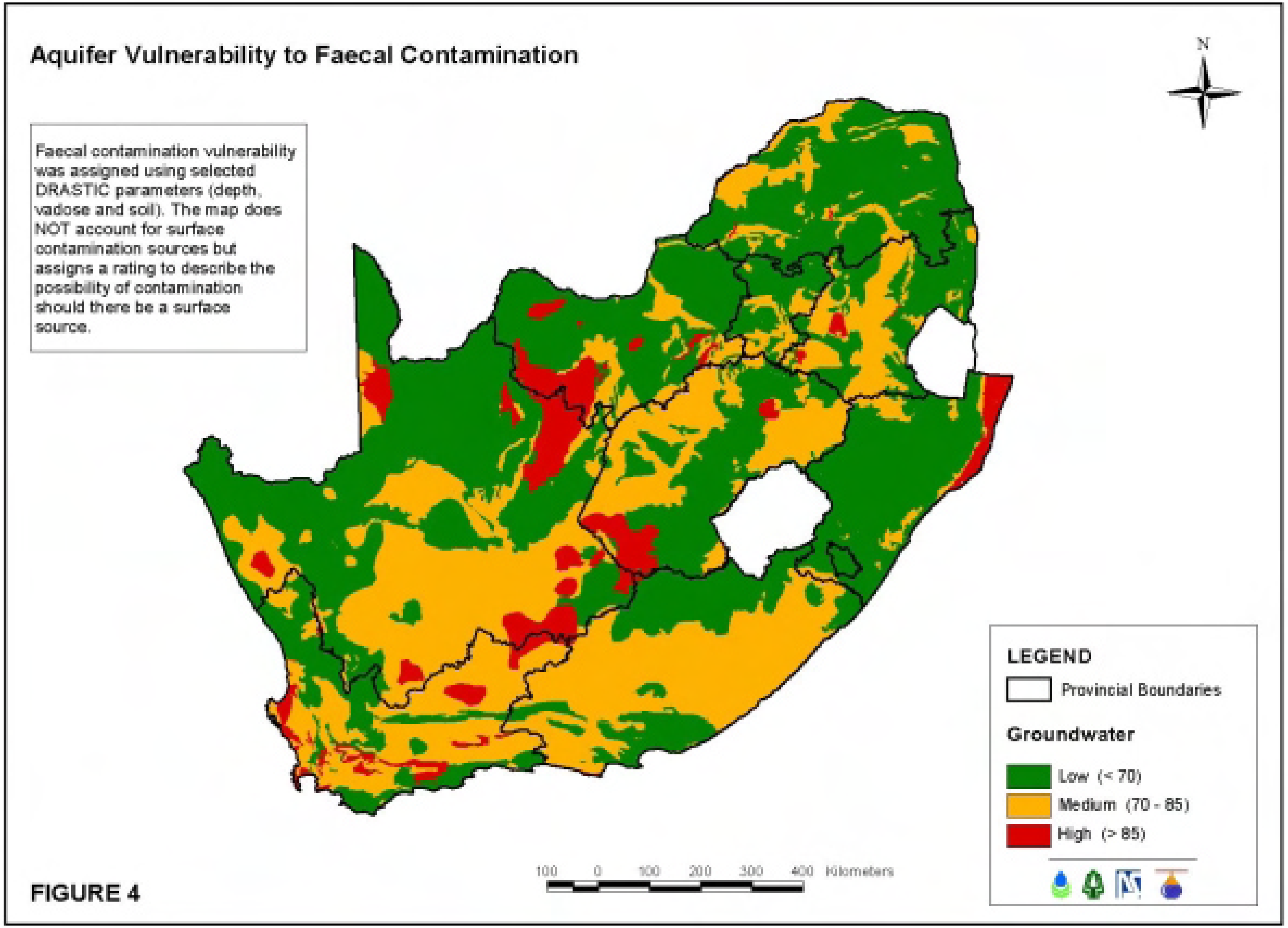
Because of attenuation mechanisms that control microbial contamination entering the subsurface, it was considered conceptually correct to only consider D, S and I. Comparison of Figures 3 and 4 shows remarkable similarity and confirms that the vulnerability *per se* is largely controlled by the three factors (D, S and I), which promotes confidence in the resultant microbial contamination vulnerability map.

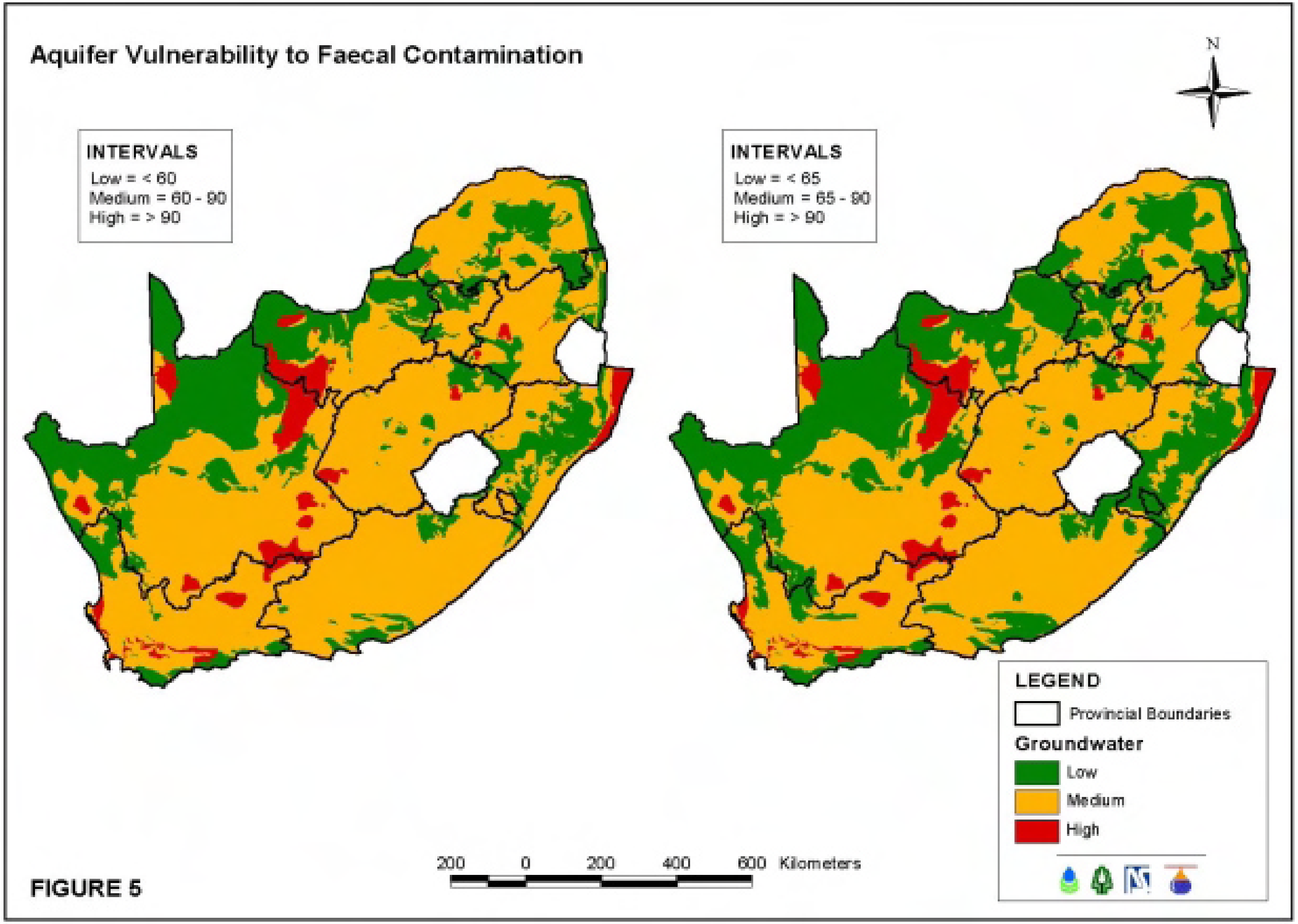
A limitation of the study is the inability to validate results obtained. Little information is available regarding groundwater microbial contamination. Monitoring data, from selected areas, should be collected to assess the validity of the vulnerability assessment presented in this report.

3.4 Groundwater faecal contamination

Figure 2 (*Potential Surface Faecal Contamination)* and Figure 4 (*Aquifer vulnerability to Faecal Contamination)* maps were intersected to produce a combined *Risk of Faecal Contamination of Aquifers* map on a quaternary basis, see Figure 6.

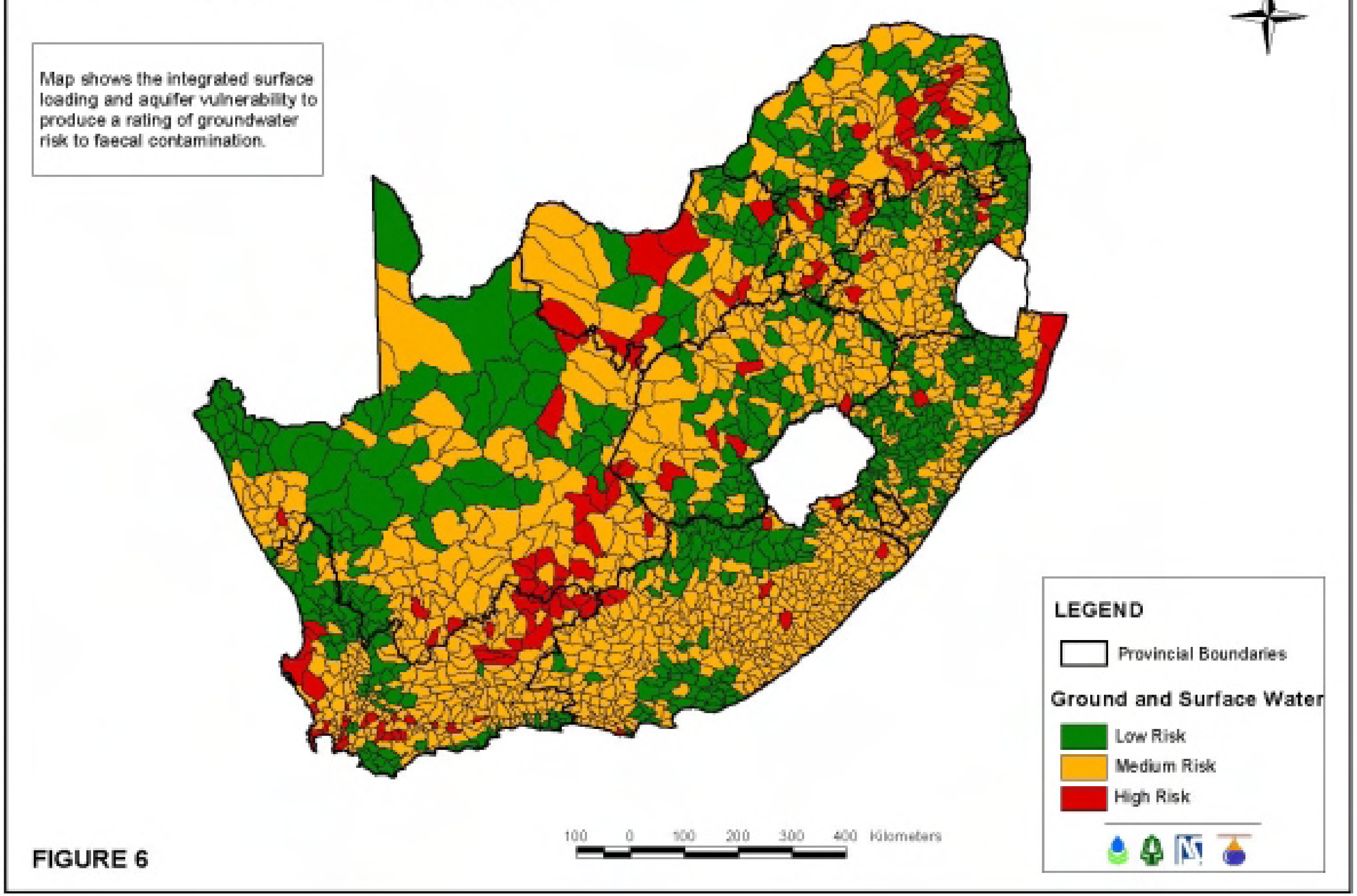
A total rating score was calculated for each quaternary (e.g. two medium risk areas and one high risk area gives 2 + 2 + 3). This total was then divided by the total number of different risk areas present in each quaternary to produce an average risk value. Each quaternary catchment was shaded according to this average risk value.


Aquifer Vulnerability to Faecal Contamination
Faecal contamination vulnerability was assigned using selected DRASTIC parameters (depth, vadose and soil). The map does NOT account for surface contamination sources but assigns a rating to describe the possibility of contamination should there be a surface source.
N
LEGEND
Provincial Boundaries
Groundwater
Low (< 70)
Medium (70 - 85)
High (> 85)
100 0 100 200 300 400 Kilometers
FIGURE 4



Aquifer Vulnerability to Faecal Contamination

FIGURE 5



Rating of Faecal Contamination of Aquifers

FIGURE 6

4. CONCLUSIONS & RECOMMENDATIONS

- A series of maps (and their associated GIS coverages) have been produced to show the potential microbial contamination of surface water and groundwater resources in South Africa.

- Maps are produced on a quaternary catchment scale. Where more detailed spatial information is required, alternative methods should be used.

- Once sufficient microbial data are available, it is recommended that the numerical methods are calibrated, and the maps replotted.

- The surface water and groundwater maps should be used in the assessments of water quality for each water management area.

5. REFERENCES

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APPENDIX G.5

WATER QUALITY DATABASE

WATER QUALITY DATA BASE

	Natural conditions:		Urban returns:			Strategic returns:			Other bulk user returns:		
Quaternary catchment	Virgin MAR ($10^6 m^3$) (oMARi)	Average TDS of natural runoff (oTSNi)	Increase in TDS as a result of urban use (oISUi)	Urban effluent returns ($10^6 m^3$)	TLC and river	Increase in TDS as a result of strategic industry use (oISSi)	Return flows by Strategic users ($10^6 m^3$)	Remark	Increase in TDS as a result of other bulk use (oISOi	Return flows by Other Bulk users ($10^6 m^3$)	Remark
Grootdraai key area:											
C11A	48.6	109	350	0.0	Breyten TLC						
C11B	31.5	109									
C11C	36.9	109									
C11D	21.5	109									
C11E	64.7	109									
C11F	50.1	109	387	1.3	Ermelo TLC: Kleindrinkwaterspruit						
C11G	17.2	109									
C11H	72	110	350	1.6	Bethal TLC: Blesbokspruit.						
C11J	47.4	109									
C11K	18.1	136				1000	1.0	Tutuka p/s			
Grootdraai to Vaal Dam key area:											
C11L	49.7	109	350	0.0	Paardekop TLC						
C11M	37.2	94	350	2.4	Standerton TLC: Vaal River; default used.						
C12A	21.83	94									
C12B	21.94	94									
C12C	26.97	94	350	0.0	Cornelia TLC						
C12D	57.98	127	254	4.8	Highveld Ridge TLC: Waterval River				1000	5.1	Sasol II/ III: Blesbokspruit
C12E	28.99	94	350	0.0	Charl Cilliers TLC: no returns						
C12F	44.65	94									
C12G	32.52	94	350	0.0	Greylingstad TLC: no returns						
C12H	13.48	94	350	0.0	Villiers TLC: no returns						
C12J	12.96	94									
C12K	22.93	94							1000	0.6	Grootvlei p/s: Molspruit
C12L	38.58	94									
Klip (C13) key area:											
C13A	51.39	118									
C13B	31.06	118									
C13C	54.02	118	350	0.0	Memel TLC: no returns						
C13D	49.6	118									
C13E	33.58	118									
C13F	29.81	118									
C13G	21.68	94	350	0.0	Vrede TLC						
C13H	19.97	100									
Suikerbosrant key area:											
C21A	28.62	113									
C21B	10.52	113	350	0.0	Balfour TLC: no returns						
C21C	9.21	113									
C21D	10.5	113	250	18.0	Benoni & Brakpan TLCs: Blesbokspruit						
C21E	14.17	113	600	20.3	Springs & Nigel TLCs: Blesbokspruit						
C21F	10.44	113	308	2.0	Heidelburg & Tskane TLC: Blesbokspruit						
C21G	8.89	159									
Klip (C22) key area:											
C22A	23.68	113	162	67.5	Greater Johannesburg Metro (south): Klipspruit						
C22B	17.06	113	565	30.9	Germinston; Alberton; Boksburg; Benoni Metros: Elsburgspruit & Natalspruit						
C22C	19.58	113	495	21.0	Germinston & Alberton Metros: Natalspruit						
C22D	15.43	113	250	65.0	Greater Johannesburg: Klip River						
C22E	20.49	159	265	2.1	Meyerton [part of Vereeniging]: Klip River						
Vaal Dam to Barrage key area:											
C22F	11.94	159	491	3.9	Eastern Vaal Metro (Vereeniging): Vaal R.				267	0.2	Lethabo & Kragbron p/s & associated 3rd parties: Vaal R.
C22F*	0	0	0								
C22G	18.41	159	350	0.0	Deneysville TLC: no returns						
C22H	11.08	113									
C22J	15.66	113	228	14.6	Eastern [Vereeniging] & Western [Vanderbijlpark] Metros: Returns to Greater Rietspruit				822	7.5	ISCOR: Vaal River
C22K	11.4	159									
Barrage to Mooi confluence key area:											
C23A	5.22	231									
C23B	14.68	231	702	9.5	Sasolburg TLC: Vaal River				654	7.8	Sasol 1: Vaal River
C23C	22.95	231	105	1.6	Parys TLC: Vaal River						
C23L	32.71	206									
Mooi key area:											
C23D	10.52	575	307	1.8	Westonaria TLC: Upper Wonderfonteinspruit						
C23E	15.43	575	124	2.8	Carltonville TLC: Wonderfonteinspruit						
C23F	37.69	315									
C23G	9.83	575									
C23H	7.95	206	263	6.6	Potchefstroom TLC: Mooi R.						
C23J	21.08	176	252	1.4	Fochville & Wedela TLCs: Loopspruit						
C23K	10.48	176									

WATER QUALITY DATA BASE

	Natural conditions:		Urban returns:			Strategic returns:			Other bulk user returns:		
Quaternary catchment	Virgin MAR ($10^6 m^3$) (oMARi)	Average TDS of natural runoff (oTSNi)	Increase in TDS as a result of urban use (oISUi)	Urban effluent returns ($10^6 m^3$)	TLC and river	Increase in TDS as a result of strategic industry use (oISSi)	Return flows by Strategic users ($10^6 m^3$)	Remark	Increase in TDS as a result of other bulk use (oISOi	Return flows by Other Bulk users ($10^6 m^3$)	Remark
Wilge key area:											
C81A	51.92	119									
C81B	47.23	119									
C81C	18.11	119									
C81D	18.12	50									
C81E	28.45	119	199	1.2	Harrismith TLC: Wilge R.						
C81F	81.4	119	199	1.9	Phuthaditjhaba: Elands R. .						
C81G	22.07	119		0.0	Kestell TLC: No returns						
C81H	14.22	119									
C81J	11.95	119									
C81K	11.73	119									
C81L	57.86	119									
C81M	48.77	119									
C82A	29.19	119									
C82B	22.44	119	350	0.0	Warden TLC: no returns						
C82C	14.37	119									
C82D	19.58	119									
C82E	28.45	119									
C82F	18.19	119									
C82G	24.27	119									
C82H	23.03	119									
C83A	28.53	119									
C83B	7.92	119									
C83C	22.66	119	453	3.6	Bethlehem TLC: Jordan R.						
C83D	12.47	119									
C83E	10.85	119									
C83F	27.13	119									
C83G	23.83	119	350	0.0	Reitz TLC: no returns.						
C83H	19.36	119	350	0.0	Tweeling TLC: no returns						
C83J	7.26	119	350	0.0	Frankfort TLC: no returns						
C83K	26.71	94									
C83L	40.04	94									
C83M	50.2	94	350	0.0	Oranjeville TLC: neglible						

	WATER QUALITY DATA BASE							
	Mining returns:				Rural returns:		Other data:	
Quaternary catchment	TDS concentration in groundwater discharge (oTFMi)	Increase in TDS as a result of mining water use (oISMi)	Mine Groundwater decant/dewatering ($10^6 m^3$) (oBMGi)	Remark	Increase in TDS as a result of rural water use	Return flows rural Bulk users ($10^6 m^3$)	Ratio between salt load in return flow to load in water supply (oPSIi)	Reservoir spill TDS/supply TDS (oPSPi)
Grootdraai key area:								
C11A	3000	1000					0.47	0.87
C11B							0.47	0.87
C11C							0.47	0.87
C11D							0.47	0.87
C11E							0.47	0.87
C11F							0.47	0.87
C11G							0.47	0.87
C11H	3000		0.264	Coal mines near Bethal: BlesbokspruitCalibration - Upper Vaal Catchment			0.64	0.87
C11J							0.47	0.87
C11K	3000		0.323	Coal mines associated with Tutka p/s: Leeuspruit			0.64	0.87
Grootdraai to Vaal Dam key area:								
C11L							0.47	0.87
C11M							0.53	0.87
C12A							0.53	0.87
C12B							0.53	0.87
C12C							0.53	0.87
C12D	3000		1.25	Secunda coal mines & gold mines: Waterval R			0.63	0.87
C12E							0.53	0.87
C12F							0.53	0.87
C12G							0.53	0.87
C12H							0.53	0.87
C12J							0.53	0.87
C12K							0.53	0.87
C12L							0.53	0.87
Klip (C13) key area:								
C13A	3000		0.024	Coal mines near Volksrust: Schulpspruit			0.53	0.87
C13B							0.53	0.87
C13C							0.53	0.87
C13D							0.53	0.87
C13E							0.53	0.87
C13F							0.53	0.87
C13G							0.53	0.87
C13H							0.53	0.87
Suikerbosrant key area:								
C21A							0.2	0.5
C21B							0.2	0.5
C21C							0.2	0.5
C21D							0.2	0.5
C21E	3572	7058	45.66	Grootvlei GM: Blesbokspruit			0.2	0.5
C21F							0.2	0.5
C21G							0.2	0.5
Klip (C22) key area:								
C22A							0.2	0.5

WATER QUALITY DATA BASE

Quaternary catchment	Mining returns: TDS concentration in groundwater discharge (oTFMi)	Increase in TDS as a result of mining water use (oISMi)	Mine Groundwater decant/dewatering (10^6m^3) (oBMGi)	Remark	Rural returns: Increase in TDS as a result of rural water use	Return flows rural Bulk users (10^6m^3)	Other data: Ratio between salt load in return flow to load in water supply (oPSIi)	Reservoir spill TDS/supply TDS (oPSPi)
C22B	3640	4515	8.1	ERPM GM: Elsburgspruit			0.2	0.5
C22C							0.2	0.5
C22D	3823	3823	5.63	Durban Roodepoort Deep GM: Klip River			0.2	0.5
C22E		1000	1.26	Glen Douglas Dolomite Mine: Klip River			0.2	0.5
Vaal Dam to Barrage key area:								
C22F							0.2	0.5
C22F*							0	0.5
C22G							0.2	0.5
C22H	875	997	13.41	Western Area GM: Leeuspruit			0.2	0.5
C22J							0.2	0.5
C22K							0.2	0.5
Barrage to Mooi confluence key area:								
C23A							0.45	0.67
C23B							0.45	0.67
C23C							0.45	0.67
C23L							0.45	0.67
Mooi key area:								
C23D	562	1510	11.32	WestRand Cons & Libanon GM: Wonderfonteinspruit			0.79	0.81
C23E	924	902	18.55	West Driefontein; Western Deep Levels; Blyvooruitzicht & Doornfontein GMs: Wonderfonteinspruit			0.79	0.81
C23F							0.45	0.81
C23G							0.79	0.81
C23H							0.44	0.93
C23J	468	405	16.1	West Driefontein; Western Deep Levels; Kloof; Leeudoorn & Deelkraal GMs: Loopspruit			0.42	0.64
C23K							0.41	0.64
Wilge key area:								
C81A							0.19	0.87
C81B							0.19	0.87
C81C							0.19	0.87
C81D							0.19	0.87
C81E							0.19	0.87
C81F					150	2.2	0.19	0.87
C81G							0.19	0.87
C81H							0.19	0.87
C81J							0.19	0.87
C81K							0.19	0.87
C81L							0.19	0.87

WATER QUALITY DATA BASE

Quaternary catchment	Mining returns: TDS concentration in groundwater discharge (oTFMi)	Increase in TDS as a result of mining water use (oISMi)	Mine Groundwater decant/dewatering ($10^6 m^3$) (oBMGi)	Remark	Rural returns: Increase in TDS as a result of rural water use	Return flows rural Bulk users ($10^6 m^3$)	Other data: Ratio between salt load in return flow to load in water supply (oPSIi)	Reservoir spill TDS/supply TDS (oPSPi)
C81M							0.19	0.87
C82A							0.19	0.87
C82B							0.19	0.87
C82C							0.19	0.87
C82D							0.19	0.87
C82E							0.19	0.87
C82F							0.19	0.87
C82G							0.19	0.87
C82H							0.19	0.87
C83A							0.19	0.87
C83B							0.19	0.87
C83C							0.19	0.87
C83D							0.19	0.87
C83E							0.19	0.87
C83F							0.19	0.87
C83G							0.19	0.87
C83H							0.19	0.87
C83J							0.19	0.87
C83K							0.53	0.87
C83L							0.53	0.87
C83M							0.53	0.87

APPENDIX H

SUPPLEMENTARY INFORMATION

APPENDIX H.1

Data type	Responsible organisation
Afforestation	CSIR
Alien vegetation	CSIR
Industrial, urban and strategic water use	WRSA consultants
Ground Water	WSM Consulting Engineers
Dams	DWAF
Transfer schemes	WRSA consultants
Run-of-river yields	Arcus Gibb
Population	Markdata
Ecological Reserve	IWR, Prof Hughes
Irrigation - Areas and crop types - Efficiency and losses - Evapotraspiration and crop factors	 WRSA consultant WRSA consultant WRP
Storage-draft-frequency curves	WRP

APPENDIX H.2

Default values used in the WRSA reports

Parameter	Description	Default value
fBMLi	Mining losses (factor)	0,1
fBOLi	Other industrial losses (factor)	0,1
fBSLi	Strategic losses (factor)	0,05
fIHCi	Irrigation conveyance losses - High category irrigation (factor)	0,1
fIMCi	Irrigation conveyance losses - Medium category irrigation (factor)	0,1
fILCi	Irrigation conveyance losses - Low category irrigation (factor)	0,1
fIPLi	Irrigation efficiency – Low category irrigation (factor)	0,75
iIPMi	Irrigation efficiency – Medium category irrigation (factor)	0,75
iIPHi	Irrigation efficiency – High category irrigation (factor)	0,75
oRTLi	Rural losses (factor)	0,2

THE DATA AT QUATERNARY CATCHMENT RESOLUTION

For the record – not part of appendix

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D11A	278	278	7	10	203	56434	0.0565	0.0426	255	71024	0.0712	0.0536
D11B	236	236	7	10	203	47908	0.0480	0.0589	255	60294	0.0604	0.0741
D11C	292	292	7	10	203	59276	0.0594	0.0549	255	74601	0.0748	0.0691
D11D	319	319	7	10	203	64757	0.0649	0.0774	255	81499	0.0817	0.0975
D11E	322	322	7	10	203	65366	0.0655	0.1018	255	82266	0.0824	0.1281
D11F	413	413	7	10	203	83839	0.0840	0.0749	255	105514	0.1057	0.0943
D11G	320	320	7	10	203	64960	0.0651	0.1368	255	81755	0.0819	0.1722
D11H	359	359	7	10	203	72877	0.0730	0.1420	255	91718	0.0919	0.1787
D11J	440	440	7	10	203	89320	0.0895	0.1485	255	112412	0.1126	0.1869
D11K	381	381	7	10	203	77343	0.0775	0.1565	255	97339	0.0975	0.1970
0	**3360**	**3360**				**682080**	**0.6834**	**0.0863**		**858423**	**0.8601**	**0.1087**
D12A	369	369	6	13	335	123615	0.1239	0.2878	422	155574	0.1559	0.3622
D12B	385	385	6	13	335	128975	0.1292	0.1969	422	162320	0.1626	0.2478
D12C	343	343	6	13	335	114905	0.1151	0.5597	422	144612	0.1449	0.7044
D12D	355	355	6	12	335	118925	0.1192	0.6649	422	149671	0.1500	0.8368
D12E	712	712	6	12	335	238520	0.2390	0.7200	422	300186	0.3008	0.9062
D12F	803	803	6	13	335	269005	0.2695	0.9797	422	338553	0.3392	1.2330
0	**2967**	**2967**				**993945**	**0.9959**	**0.4791**		**1250916**	**1.2534**	**0.6030**
D13A	475	475	6	13	335	159125	0.1594	0.2239	422	200265	0.2007	0.2817
D13B	533	533	6	13	335	178555	0.1789	0.2420	422	224718	0.2252	0.3046
D13C	517	517	6	13	335	173195	0.1735	0.3160	422	217972	0.2184	0.3977
D13D	635	635	6	13	335	212725	0.2132	0.3679	422	267722	0.2683	0.4630
D13E	1031	1031	6	13	335	345385	0.3461	0.2673	422	434680	0.4355	0.3364
D13F	970	970	6	13	335	324950	0.3256	0.3358	422	408961	0.4098	0.4226
D13G	1125	1125	6	13	335	376875	0.3776	0.7118	422	474311	0.4753	0.8958
D13H	1144	1144	6	13	335	383240	0.3840	1.2843	422	482322	0.4833	1.6163
D13J	1167	1167	6	13	335	390945	0.3917	1.1828	422	492019	0.4930	1.4886

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D13K	397	397	6	13	335	132995	0.1333	0.2641	422	167379	0.1677	0.3324
D13L	682	682	6	13	335	228470	0.2289	0.9037	422	287538	0.2881	1.1373
D13M	678	678	6	13	335	227130	0.2276	1.0546	422	285851	0.2864	1.3272
0	**9354**	**9354**				**3133590**	**3.1399**	**0.4499**		**3943737.7**	**3.9516**	**0.5662**
D14A	764	764	6	12	335	255940	0.2565	1.0205	422	322110	0.3228	1.2843
D14B	324	324	6	13	335	108540	0.1088	1.3492	422	136602	0.1369	1.6981
D14C	722	722	6	13	335	241870	0.2424	1.3106	422	304402	0.3050	1.6494
D14D	680	680	6	13	335	227800	0.2283	1.9450	422	286695	0.2873	2.4479
D14E	663	663	6	13	335	222105	0.2225	2.1580	422	279527	0.2801	2.7159
D14F	541	541	6	13	335	181235	0.1816	1.2767	422	228091	0.2285	1.6067
D14G	605	605	6	13	335	202675	0.2031	1.0383	422	255074	0.2556	1.3068
D14H	697	697	6	13	335	233495	0.2340	1.5790	422	293862	0.2944	1.9872
D14J	515	515	6	13	335	172525	0.1729	1.5681	422	217129	0.2176	1.9735
D14K	634	634	6	13	335	212390	0.2128	1.6937	422	267301	0.2678	2.1316
0	**6145**	**6145**				**2058575**	**2.0627**	**1.4136**		**2590792**	**2.5960**	**1.7790**
D15A	437	437	7	10	203	88711	0.0889	0.0749	255	111646	0.1119	0.0942
D15B	393	393	7	10	203	79779	0.0799	0.0773	255	100405	0.1006	0.0973
D15C	276	276	7	10	203	56028	0.0561	0.1036	255	70513	0.0707	0.1304
D15D	437	437	7	12	203	88711	0.0889	0.0842	255	111646	0.1119	0.1060
D15E	619	619	7	12	203	125657	0.1259	0.1097	255	158144	0.1585	0.1380
D15F	352	352	7	12	203	71456	0.0716	0.2366	255	89930	0.0901	0.2978
D15G	485	485	7	12	203	98455	0.0987	0.3474	255	123909	0.1242	0.4372
D15H	361	361	7	12	203	73283	0.0734	0.4943	255	92229	0.0924	0.6221
0	**3360**	**3360**				**682080**	**0.6834**	**0.1199**		**858422.63**	**0.8601**	**0.1509**
D16A	159	159	7	10	203	32277	0.0323	0.0762	255	40622	0.0407	0.0960
D16B	249	249	7	10	203	50547	0.0506	0.0925	255	63615	0.0637	0.1164
D16C	438	438	7	10	203	88914	0.0891	0.2732	255	111902	0.1121	0.3438
D16D	339	339	7	10	203	68817	0.0690	0.1114	255	86609	0.0868	0.1402
D16E	434	434	7	10	203	88102	0.0883	0.1763	255	110880	0.1111	0.2219
D16F	277	277	7	10	203	56231	0.0563	0.1105	255	70769	0.0709	0.1391
D16G	290	290	7	10	203	58870	0.0590	0.1269	255	74090	0.0742	0.1597
D16H	345	345	7	10	203	70035	0.0702	0.2191	255	88142	0.0883	0.2758

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D16J	374	374	7	10	203	75922	0.0761	0.1584	255	95551	0.0957	0.1993
D16K	329	329	7	10	203	66787	0.0669	0.1116	255	84054	0.0842	0.1404
D16L	533	533	7	10	203	108199	0.1084	0.1819	255	136172	0.1364	0.2290
D16M	753	753	7	10	203	152859	0.1532	0.1152	255	192379	0.1928	0.1450
0	**4520**	**4520**				**917560**	**0.9194**	**0.1369**		**1154782.8**	**1.1571**	**0.1722**
D17A	638	638	7	10	203	129514	0.1298	0.0629	255	162998	0.1633	0.0791
D17B	442	442	7	10	203	89726	0.0899	0.0710	255	112923	0.1131	0.0894
D17C	525	525	7	10	203	106575	0.1068	0.1379	255	134129	0.1344	0.1735
D17D	748	748	7	10	203	151844	0.1521	0.1356	255	191101	0.1915	0.1707
D17E	605	605	7	10	203	122815	0.1231	0.1276	255	154567	0.1549	0.1606
D17F	582	582	7	10	203	118146	0.1184	0.2451	255	148691	0.1490	0.3084
D17G	849	849	7	10	203	172347	0.1727	0.1584	255	216905	0.2173	0.1994
D17H	852	852	7	10	203	172956	0.1733	0.1701	255	217671	0.2181	0.2140
D17J	437	437	7	10	203	88711	0.0889	0.0890	255	111646	0.1119	0.1120
D17K	383	383	7	10	203	77749	0.0779	0.1533	255	97850	0.0980	0.1929
D17L	590	590	7	10	203	119770	0.1200	0.1611	255	150735	0.1510	0.2027
D17M	528	528	7	10	203	107184	0.1074	0.1475	255	134895	0.1352	0.1857
0	**7179**	**7179**				**1457337**	**1.4603**	**0.1241**		**1834111.9**	**1.8378**	**0.1562**
D18A	599	599	7	10	203	121597	0.1218	0.1259	255	153034	0.1533	0.1584
D18B	327	327	7	10	203	66381	0.0665	0.1668	255	83543	0.0837	0.2100
D18C	466	466	7	12	203	94598	0.0948	0.1972	255	119055	0.1193	0.2482
D18D	766	766	7	10	203	155498	0.1558	0.1393	255	195700	0.1961	0.1753
D18E	376	376	7	10	203	76328	0.0765	0.1376	255	96062	0.0963	0.1731
D18F	446	446	7	12	203	90538	0.0907	0.2071	255	113945	0.1142	0.2607
D18G	492	492	7	13	203	99876	0.1001	0.1160	255	125698	0.1259	0.1460
D18H	384	384	7	13	203	77952	0.0781	0.1551	255	98105	0.0983	0.1952
D18J	859	859	7	12	203	174377	0.1747	0.1561	255	219460	0.2199	0.1964
D18K	935	935	7	13	203	189805	0.1902	0.1290	255	238877	0.2394	0.1623
D18L	610	610	7	12	203	123830	0.1241	0.1919	255	155845	0.1562	0.2415
0	**6260**	**6260**				**1270780**	**1.2733**	**0.1486**		**1599323.1**	**1.6025**	**0.1871**
D21A	309	309	6	10	335	103515	0.1037	0.1688	422	130277	0.1305	0.2124
D21B	394	394	6	10	335	131990	0.1323	0.1495	422	166114	0.1664	0.1882

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
D21C	212	212	6	9	335	71020	0.0712	0.2287	422	89381	0.0896	0.2878
D21D	252	252	6	9	335	84420	0.0846	0.2762	422	106246	0.1065	0.3476
D21E	268	268	6	9	335	89780	0.0900	0.3430	422	112991	0.1132	0.4317
D21F	480	480	6	9	335	160800	0.1611	0.4945	422	202373	0.2028	0.6223
D21G	278	278	6	9	335	93130	0.0933	0.4354	422	117208	0.1174	0.5480
D21H	381	381	6	9	335	127635	0.1279	0.3292	422	160633	0.1610	0.4143
D21J	359	359	6	10	335	120265	0.1205	0.1620	422	151358	0.1517	0.2039
D21K	326	326	6	10	335	109210	0.1094	0.1772	422	137445	0.1377	0.2230
D21L	304	304	6	9	335	101840	0.1020	0.2519	422	128169	0.1284	0.3170
0	**3563**	**3563**				**1193605**	**1.1960**	**0.2357**		**1502195.6**	**1.5052**	**0.2967**
D22A	636	636	6	9	335	213060	0.2135	0.5977	422	268144	0.2687	0.7522
D22B	457	457	6	9	335	153095	0.1534	0.4794	422	192676	0.1931	0.6033
D22C	486	486	6	9	335	162810	0.1631	0.3321	422	204902	0.2053	0.4180
D22D	628	628	6	9	335	210380	0.2108	0.5729	422	264771	0.2653	0.7211
D22E	498	498	6	10	335	166830	0.1672	0.3266	422	209962	0.2104	0.4111
D22F	633	633	6	9	335	212055	0.2125	0.4105	422	266879	0.2674	0.5166
D22G	969	969	6	9	335	324615	0.3253	0.6144	422	408540	0.4094	0.7733
D22H	541	541	6	9	335	181235	0.1816	0.5043	422	228091	0.2285	0.6347
D22J	652	652	6	10	335	218420	0.2189	0.3533	422	274890	0.2754	0.4447
D22K	324	324	6	10	335	108540	0.1088	0.3859	422	136602	0.1369	0.4857
D22L	376	376	6	11	335	125960	0.1262	0.5836	422	158525	0.1588	0.7345
0	**6200**	**6200**				**2077000**	**2.0812**	**0.4551**		**2613980.5**	**2.6192**	**0.5728**
D23A	608	608	6	12	335	203680	0.2041	0.5334	422	256339	0.2569	0.6713
D23B	597	597	6	12	335	199995	0.2004	0.4911	422	251701	0.2522	0.6181
D23C	861	861	3	12	82	70602	0.0707	0.1730	103	88855	0.0890	0.2177
D23D	565	565	6	12	335	189275	0.1897	0.8614	422	238210	0.2387	1.0841
D23E	702	702	6	12	335	235170	0.2356	0.8219	422	295970	0.2966	1.0343
D23F	352	352	6	12	335	117920	0.1182	0.6037	422	148407	0.1487	0.7598
D23G	512	512	6	12	335	171520	0.1719	0.6553	422	215864	0.2163	0.8248
D23H	776	776	6	12	335	259960	0.2605	1.3243	422	327169	0.3278	1.6667
D23J	534	534	6	12	335	178890	0.1792	1.1169	422	225140	0.2256	1.4057

Quat. Number	Gross area (km2)	Net area (km2)	Sediment region	Erodibility index	Sediment (t/km2/a)	Sediment yield (t/a)	Sediment vol(MCM)	Volume (%MAR)	*Sediment (t/km2/a)*	*Sediment yield (t/a)*	*Sediment vol(MCM)*	*Volume (%MAR)*
0	**5507**	**5507**				**1627012**	**1.6303**	**0.6465**		**2047654.1**	**2.0517**	**0.8136**
D24A	310	310	6	12	335	103850	0.1041	0.5452	422	130699	0.1310	0.6862
D24B	470	470	6	12	335	157450	0.1578	0.6896	422	198157	0.1986	0.8679
D24C	398	398	6	12	335	133330	0.1336	0.9886	422	167801	0.1681	1.2442
D24D	598	598	6	12	335	200330	0.2007	1.3334	422	252123	0.2526	1.6781
D24E	489	489	6	12	335	163815	0.1641	1.3315	422	206167	0.2066	1.6757
D24F	567	567	6	12	335	189945	0.1903	1.0849	422	239053	0.2395	1.3653
D24G	626	626	6	13	335	209710	0.2101	0.9379	422	263928	0.2645	1.1804
D24H	736	736	6	12	335	246560	0.2471	1.3026	422	310305	0.3109	1.6394
D24J	1032	1032	6	12	335	345720	0.3464	1.6795	422	435101	0.4360	2.1137
D24K	877	877	6	12	335	293795	0.2944	1.7489	422	369752	0.3705	2.2011
D24L	511	511	6	12	335	171185	0.1715	1.8793	422	215443	0.2159	2.3651
0	**6614**	**6614**				**2215690**	**2.2201**	**1.1787**		**2788526.9**	**2.7941**	**1.4834**
D31A	1160	1160	5	12	30	34800	0.0349	0.2128	38	43797	0.0439	0.2678
D31B	996	757	5	13	30	22710	0.0228	0.5438	38	28581	0.0286	0.6844
D31C	677	677	5	12	30	20310	0.0204	0.4541	38	25561	0.0256	0.5715
D31D	1108	833	5	12	30	24990	0.0250	0.2575	38	31451	0.0315	0.3241
D31E	969	969	5	12	30	29070	0.0291	0.3395	38	36586	0.0367	0.4273
0	**4910**	**4396**				**131880**	**0.1321**	**0.3048**		**165975.8**	**0.1663**	**0.3836**
D32A	716	716	5	12	30	21480	0.0215	0.5253	38	27033	0.0271	0.6611
D32B	582	582	5	13	30	17460	0.0175	0.3693	38	21974	0.0220	0.4648
D32C	850	850	5	12	30	25500	0.0256	0.5117	38	32093	0.0322	0.6440
D32D	851	851	5	12	30	25530	0.0256	0.5400	38	32130	0.0322	0.6796
D32E	1157	1157	5	13	30	34710	0.0348	0.9054	38	43684	0.0438	1.1395
D32F	1443	1443	5	13	30	43290	0.0434	0.5841	38	54482	0.0546	0.7351
D32G	1045	1045	5	12	30	31350	0.0314	0.4304	38	39455	0.0395	0.5417
D32H	572	572	5	12	30	17160	0.0172	0.4476	38	21596	0.0216	0.5634
D32J	1114	1041	5	12	30	31230	0.0313	0.5128	38	39304	0.0394	0.6454
D32K	824	824	5	12	30	24720	0.0248	0.4606	38	31111	0.0312	0.5797
0	**9154**	**9081**				**272430**	**0.2730**	**0.5204**		**342863.12**	**0.3435**	**0.6550**
D33A	593	472	5	12	30	14160	0.0142	0.9903	38	17821	0.0179	1.2463
D33B	1018	323	5	12	30	9690	0.0097	1.1770	38	12195	0.0122	1.4813

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D33C	805	520	5	12	30	15600	0.0156	0.9679	38	19633	0.0197	1.2182
D33D	952	311	5	12	30	9330	0.0093	1.4309	38	11742	0.0118	1.8008
D33E	1554	343	5	12	30	10290	0.0103	1.3347	38	12950	0.0130	1.6797
D33F	863	77	5	12	30	2310	0.0023	1.7295	38	2907	0.0029	2.1766
D33G	1406	400	5	12	30	12000	0.0120	1.7610	38	15102	0.0151	2.2163
D33H	1054	468	5	7	80.7	37767.6	0.0378	4.0585	102	47532	0.0476	5.1077
D33J	865	200	5	12	30	6000	0.0060	2.1668	38	7551	0.0076	2.7270
D33K	488	290	5	12	30	8700	0.0087	1.6299	38	10949	0.0110	2.0513
0	**9598**	**3404**				**125847.6**	**0.1261**	**1.6044**		**158383.81**	**0.1587**	**2.0191**
D34A	794	794	5	12	30	23820	0.0239	0.2193	38	29978	0.0300	0.2760
D34B	706	706	5	12	30	21180	0.0212	0.2960	38	26656	0.0267	0.3725
D34C	760	760	5	12	30	22800	0.0228	0.3641	38	28695	0.0288	0.4583
D34D	599	599	5	12	30	17970	0.0180	0.3348	38	22616	0.0227	0.4214
D34E	519	519	5	12	30	15570	0.0156	0.2834	38	19595	0.0196	0.3566
D34F	692	692	5	12	30	20760	0.0208	0.3868	38	26127	0.0262	0.4868
D34G	950	950	5	12	30	28500	0.0286	0.2593	38	35868	0.0359	0.3264
0	**5020**	**5020**				**150600**	**0.1509**	**0.2924**		**189535.61**	**0.1899**	**0.3680**
D35A	254	254	6	12	335	85090	0.0853	1.9440	422	107089	0.1073	2.4465
D35B	260	260	6	13	335	87100	0.0873	2.1655	422	109619	0.1098	2.7253
D35C	943	943	6	13	335	315905	0.3165	2.9344	422	397578	0.3984	3.6931
D35D	586	586	6	13	335	196310	0.1967	3.5307	422	247063	0.2476	4.4435
D35E	312	312	6	13	335	104520	0.1047	2.6773	422	131542	0.1318	3.3695
D35F	557	557	6	12	335	186595	0.1870	2.1607	422	234837	0.2353	2.7193
D35G	552	552	6	13	335	184920	0.1853	3.7217	422	232729	0.2332	4.6839
D35H	498	498	6	12	335	166830	0.1672	2.7651	422	209962	0.2104	3.4800
D35J	1002	1002	5	12	30	30060	0.0301	0.3909	38	37832	0.0379	0.4920
D35K	674	674	5	12	30	20220	0.0203	0.2947	38	25448	0.0255	0.3709
0	**5638**	**5638**				**1377550**	**1.3803**	**2.1929**		**1733697.1**	**1.7372**	**2.7599**
0	0	0										
TOTALS	**99349**	**92568**				**20367562**	**20.4083**	**0.3027**		**25633321**	**25.6846**	**0.3810**

FIGURES


BOTSWANA
NAMIBIA
LIMPOPO
Northern Province
CROCODILE(WEST) AND MARICO
OLIFANTS
Mpumalanga
Gauteng
LOWER VAAL
North West
MIDDLE VAAL
UPPER VAAL
THUKELA
Free State
Kwazulu Natal
LESOTHO
MVOTI TO UMZIMKULU
LOWER ORANGE
Northern Cape
UPPER ORANGE
Atlantic Ocean
OLIFANTS/DOORN
MZIMVUBU TO KIESKAMMA
Eastern Cape
GOURITZ
TSITSIKAMMA
Western Cape
BERG
Indian Ocean
LOCALITY MAP
BASE MAP LEGEND
PREPARED BY
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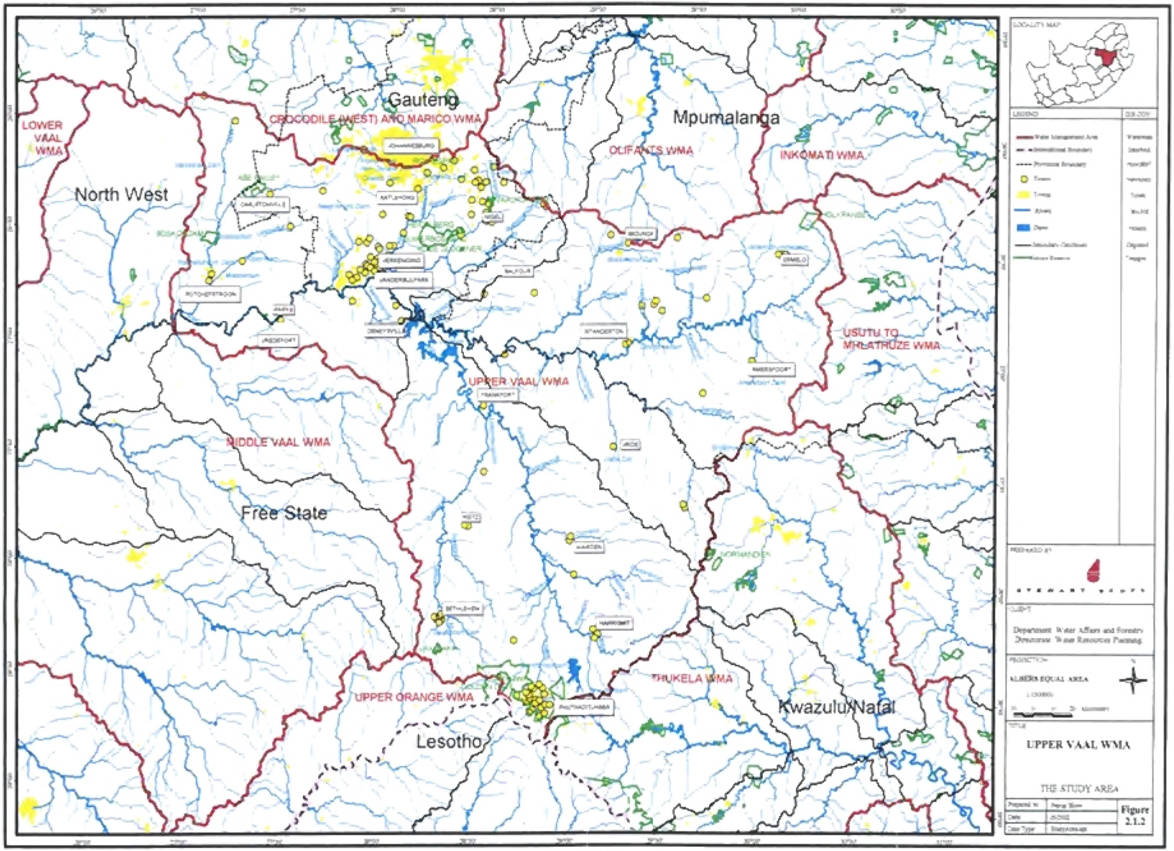
CLIENT
Department Water Affairs and Forestry
Directorate Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
ORANGE RIVER WATERCOURSE
Prepared by Petrus Blom
Date 06/2002
Figure 2.1.1


Gauteng
CROCODILE (WEST) AND MARICO WMA
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
LOWER VAAL WMA
North West
JOHANNESBURG
VEREENIGING
VANDERBIJLPARK
POTCHEFSTROOM
STANDERTON
ERMELO
AMERSFOORT
UPPER VAAL WMA
FRANKFORT
USUTU TO MHLATUZE WMA
MIDDLE VAAL WMA
Free State
REITZ
WARDEN
BETHLEHEM
HARRISMITH
UPPER ORANGE WMA
THUKELA WMA
PHUTHADITJHABA
Kwazulu/Natal
Lesotho
LOCALITY MAP
LEGEND
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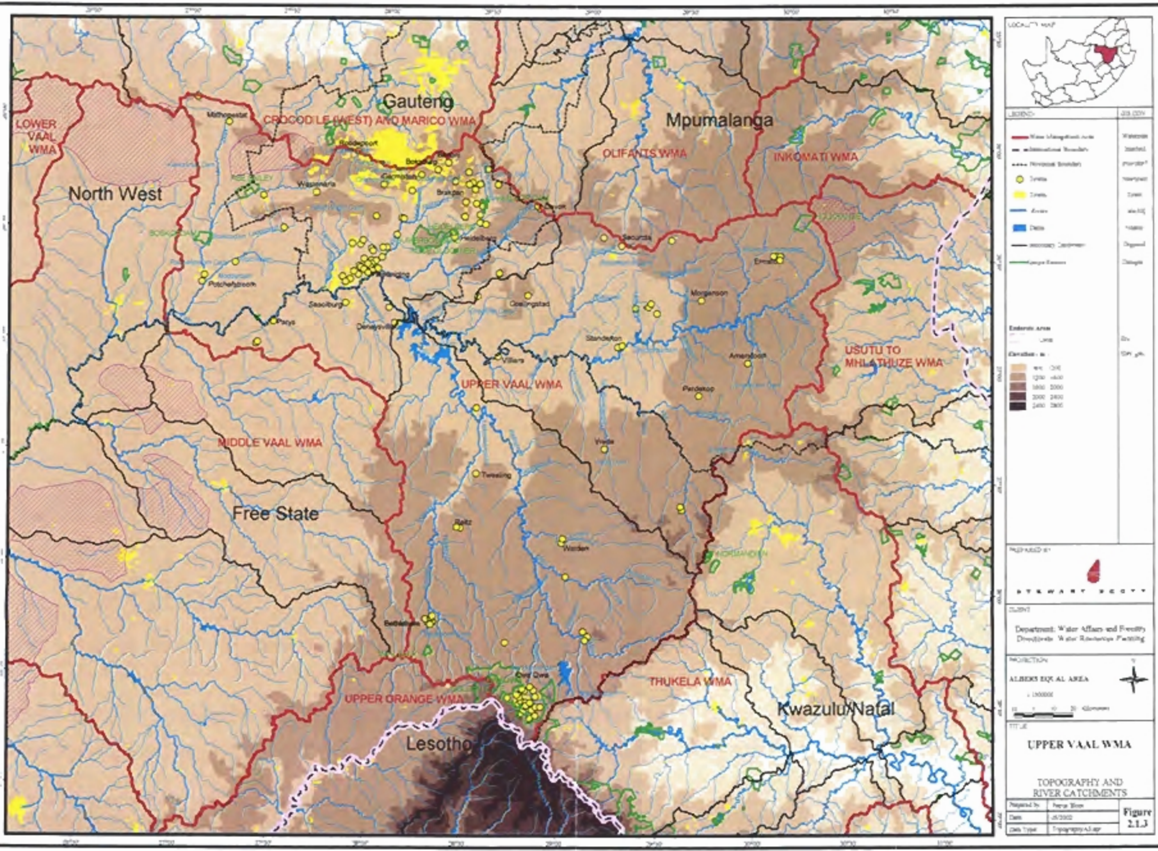
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
UPPER VAAL WMA
THE STUDY AREA
Figure 2.1.2


Gauteng
CROCODILE (WEST) AND MARICO WMA
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
LOWER VAAL WMA
North West
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
Potchefstroom
Heidelberg
Vereeniging
Sasolburg
Parys
Deneysville
Villiers
Standerton
Secunda
Ermelo
Morgenzon
Amersfoort
Volksrust
Vrede
Tweeling
Reitz
Warden
Bethlehem
Qwa Qwa
Brakpan
Boksburg
Germiston
Roodepoort
Benoni
Nigel
Delmas
Carletonville
Westonaria
Randfontein
Greylingstad
Perdekop
Balfour
Kroonstad
Frankfort
Heilbron
Harrismith
Koppies
LOCALITY MAP
LEGEND
Water Management Area
Provincial Boundary
Dams
Secondary Catchment
Protected Areas
Elevation
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
UPPER VAAL WMA
TOPOGRAPHY AND RIVER CATCHMENTS
Figure 2.1.3

Gauteng
Mpumalanga
North West
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
Mooi
Vaaldam to Vaal Barrage
Klip
Suikerbosrand
Barrage to Mooi
Grootdraai to Vaaldam
Grootdraai
Wilge
Klip
Secunda
Standerton
Ermelo
Morgenzon
Amersfoort
Perdekop
Villiers
Tweeling
Reitz
Warden
Bethlehem
Qwa Qwa
Parys
Sasolburg
Heidelberg
Potchefstroom
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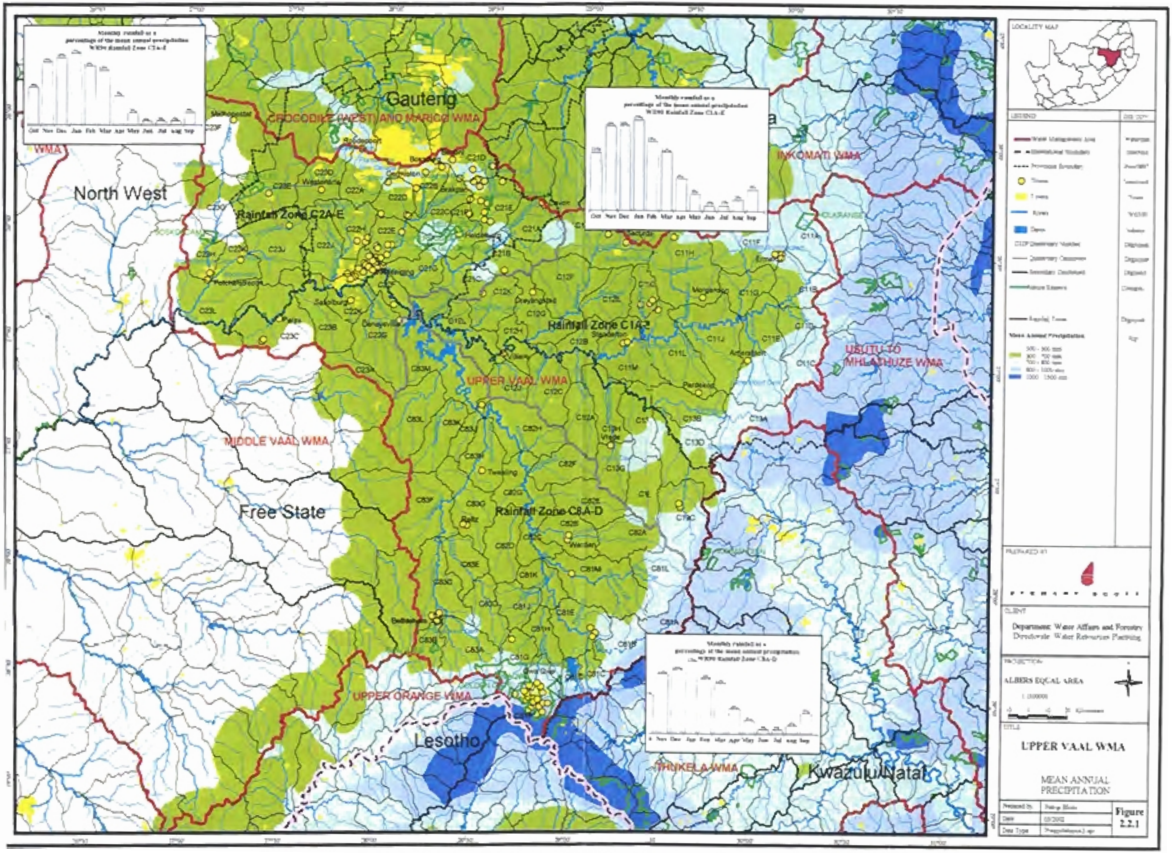
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
HYDROLOGICAL SUBCATCHMENTS
Figure 2.1.4


Gauteng
North West
Free State
Lesotho
Kwazulu/Natal
CROCODILE (WEST) AND MARICO WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
Rainfall Zone C2A-E
Rainfall Zone C1A-E
Rainfall Zone C8A-D
Monthly rainfall as a percentage of the mean annual precipitation
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
LOCALITY MAP
LEGEND
Mean Annual Precipitation
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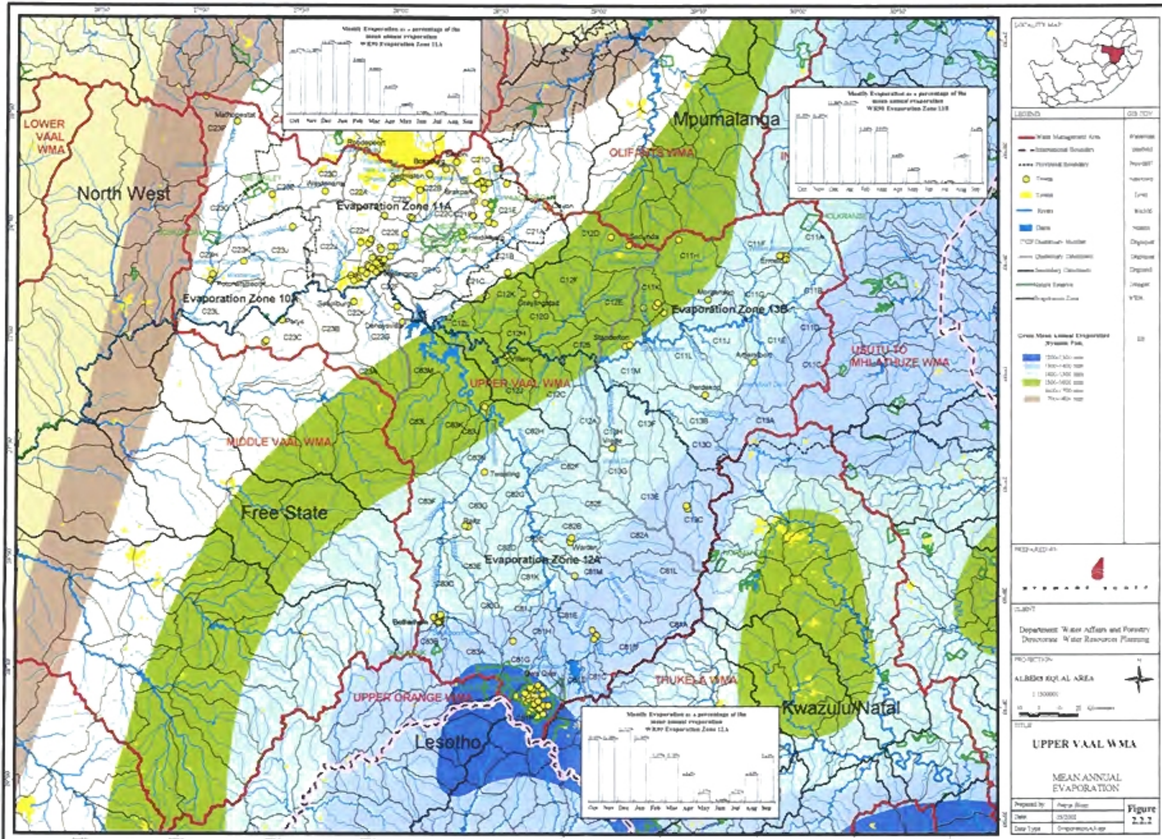
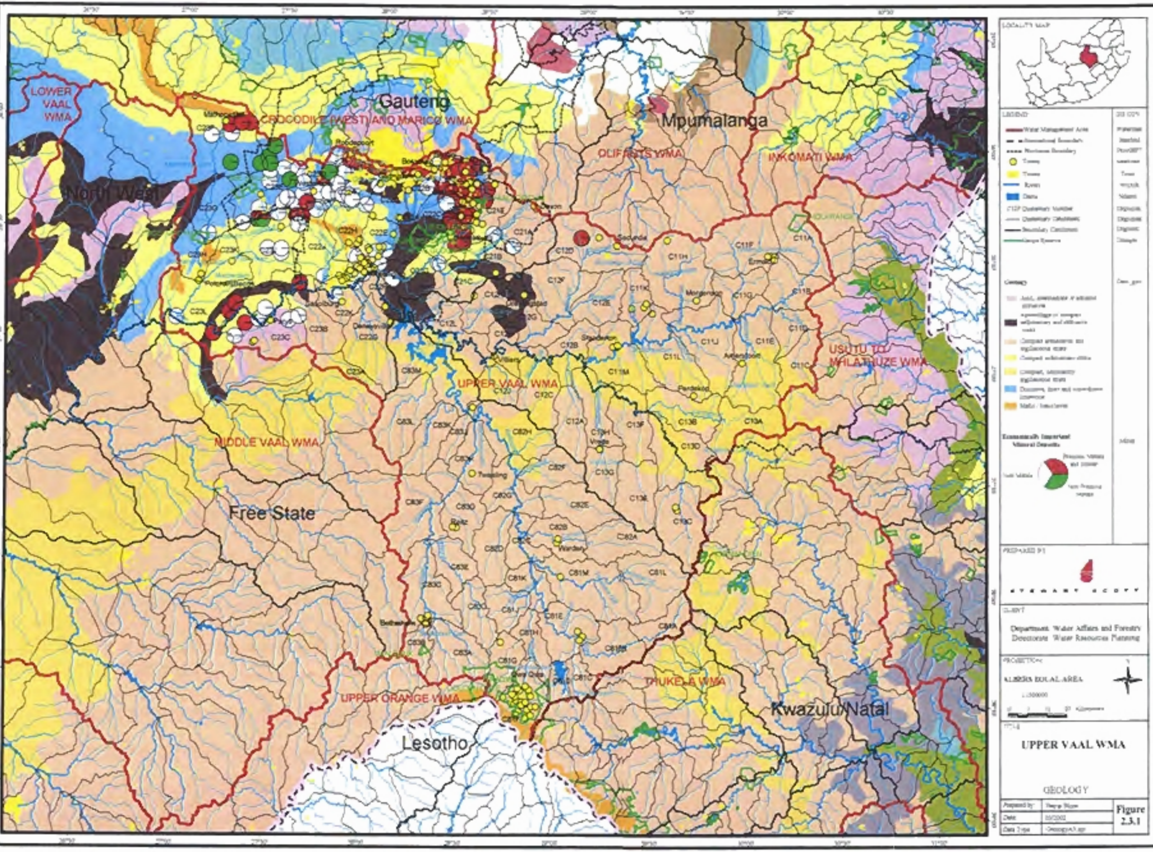
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
MEAN ANNUAL PRECIPITATION
Figure 2.2.1



LOWER VAAL WMA
North West
Mpumalanga
OLIFANTS WMA
Evaporation Zone 11A
Evaporation Zone 10A
Evaporation Zone 13B
Evaporation Zone 12A
UPPER VAAL WMA
MIDDLE VAAL WMA
USUTU TO MHLATHUZE WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
Secunda
Standerton
Bethlehem
LOCALITY MAP
LEGEND
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
MEAN ANNUAL EVAPORATION
Figure 2.2.2



LOWER VAAL WMA
Gauteng
CROCODILE (WEST) AND MARICO WMA
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
North West
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
LOCALITY MAP
LEGEND
Geology
Economically Important Mineral Deposits
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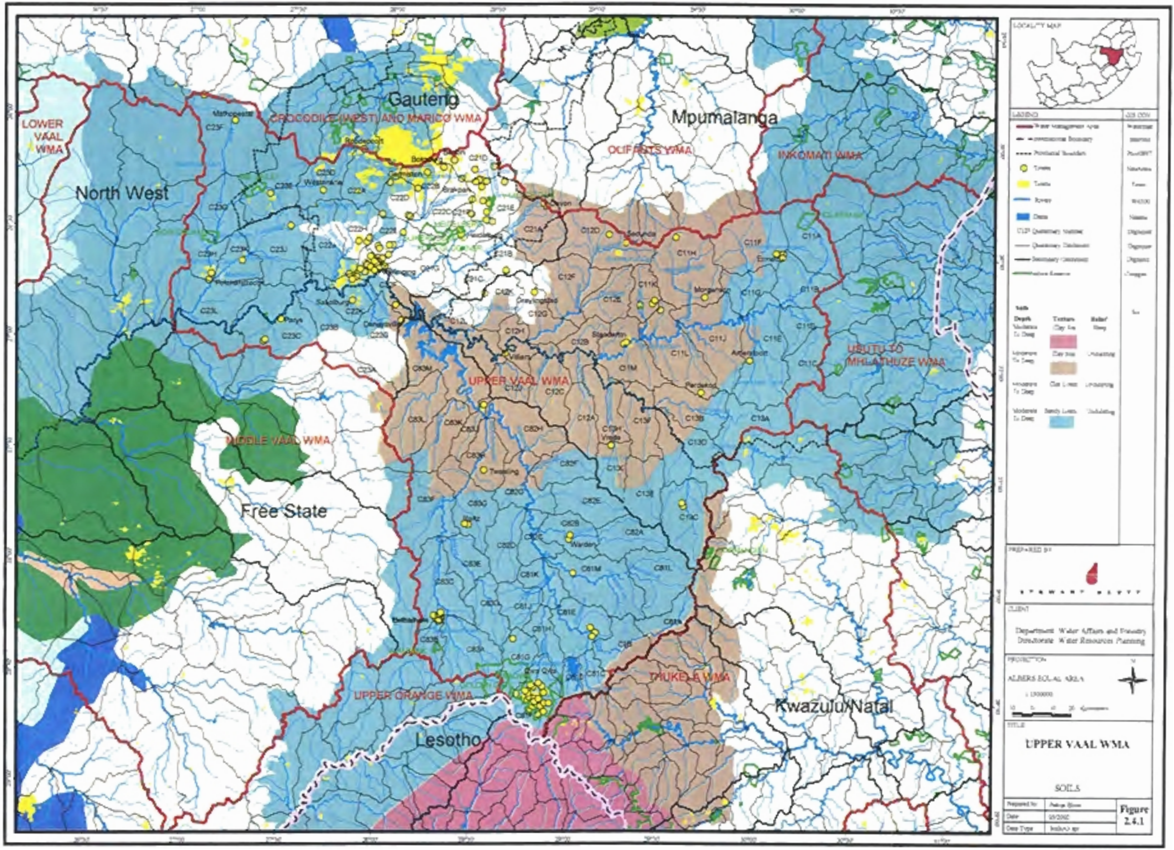
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
GEOLOGY
Figure 2.3.1


LOCALITY MAP
LEGEND
Towns
Rivers
Dams
Soils
Depth
Texture
Relief
Clay Loam
Sandy Loam
Undulating
Gauteng
CROCODILE (WEST) AND MARICO WMA
LOWER VAAL WMA
North West
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
UPPER VAAL WMA
USUTU TO MHLATHUZE WMA
MIDDLE VAAL WMA
Free State
THUKELA WMA
UPPER ORANGE WMA
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Standerton
Villiers
Vrede
Warden
Harrismith
Bethlehem
Parys
Sasolburg
Heidelberg
Brakpan
Westonaria
Potchefstroom
Carletonville
Frankfort
Reitz
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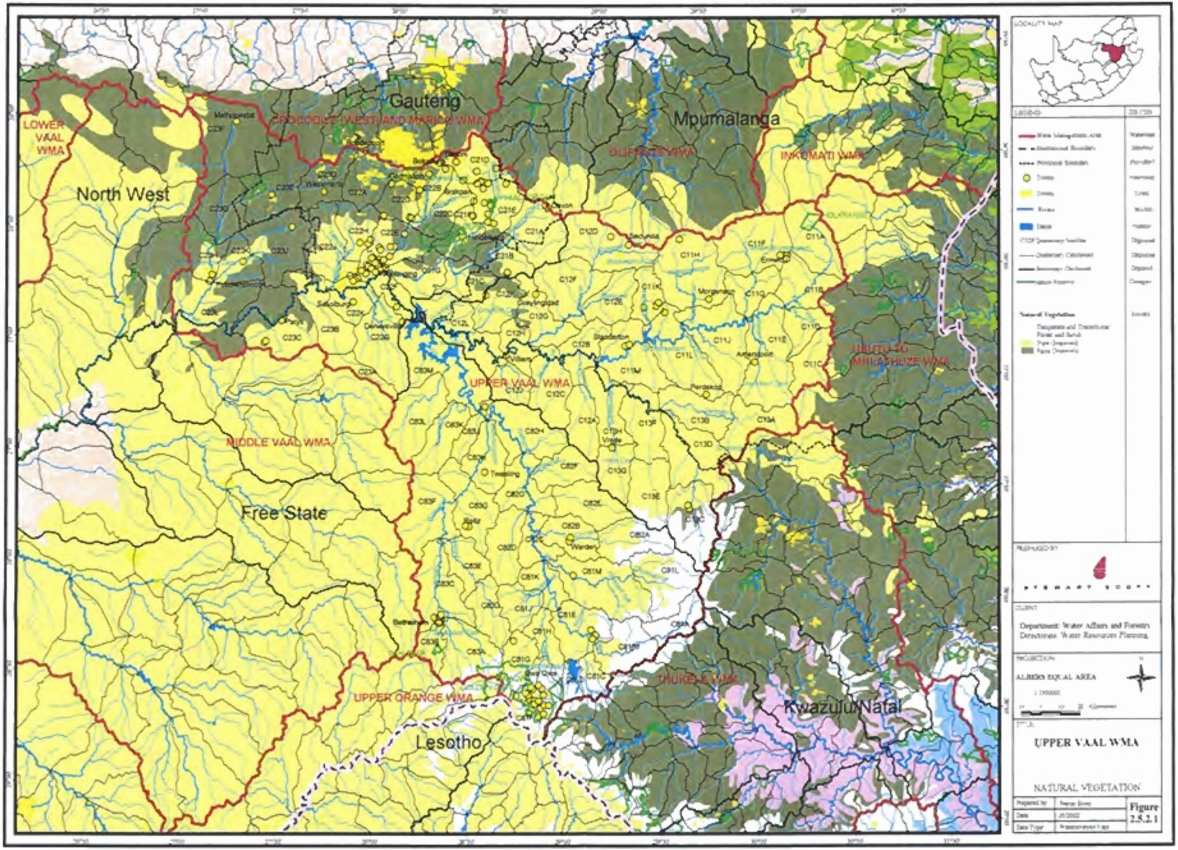
Directorate Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
SOILS
Prepared by
Date
Data Type
Figure 2.4.1



Gauteng
Mpumalanga
North West
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
USUTU TO MHLATHUZE WMA
Secunda
Ermelo
Morgenzon
Standerton
Amersfoort
Perdekop
Greylingstad
Villiers
Vrede
Twistdraai
Reitz
Warden
Bethlehem
Sasolburg
Deneysville
Parys
Potchefstroom
LOCALITY MAP
LEGEND
Natural Vegetation
PREPARED BY
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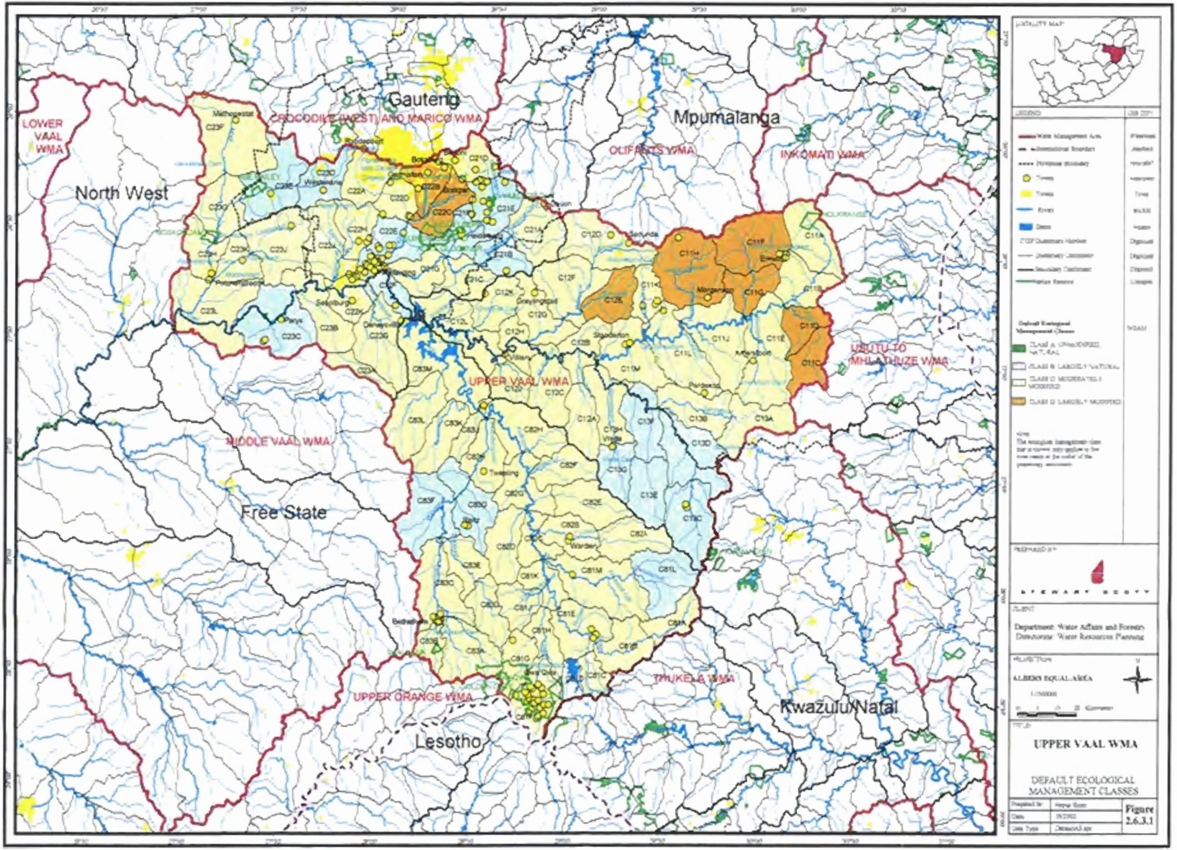
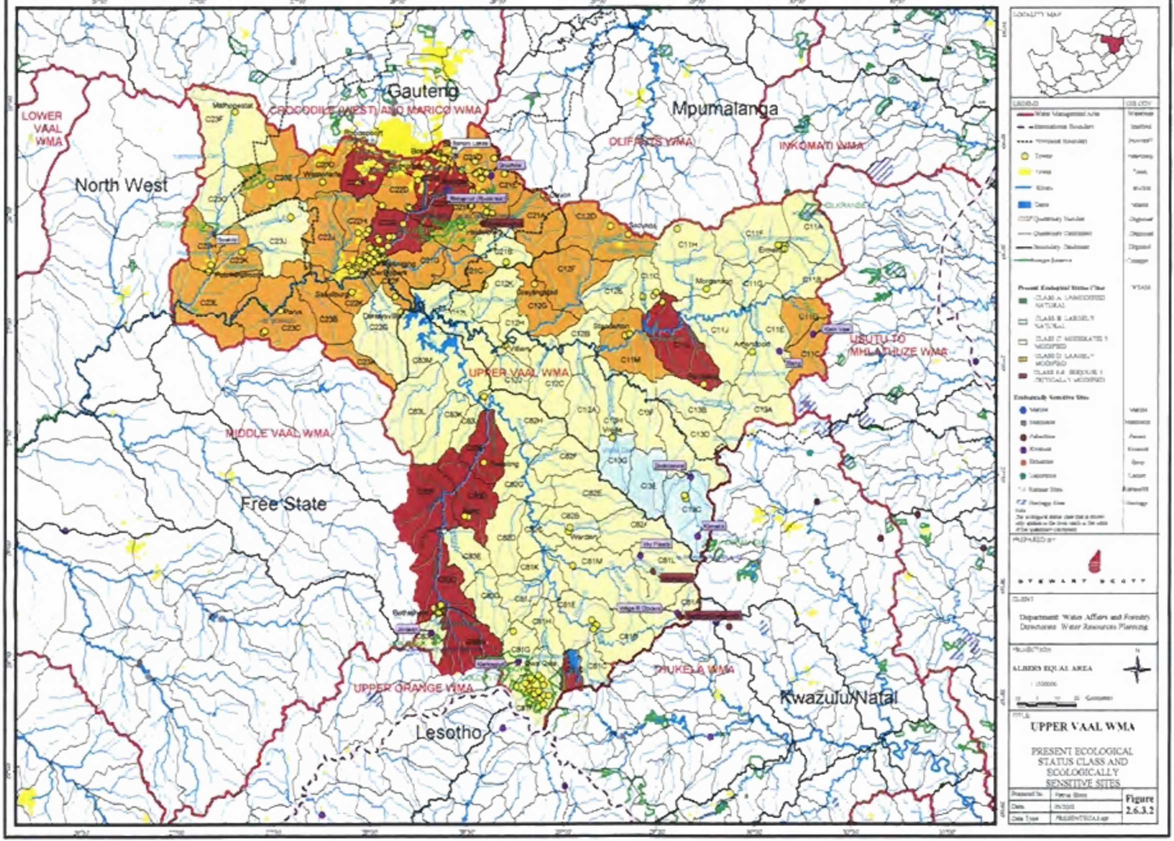
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
UPPER VAAL WMA
NATURAL VEGETATION
Figure 2.5.2.1


Gauteng
CROCODILE (WEST) AND MARICO WMA
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
LOWER VAAL WMA
North West
UPPER VAAL WMA
MIDDLE VAAL WMA
USUTU TO MHLATHUZE WMA
Free State
THUKELA WMA
UPPER ORANGE WMA
Kwazulu/Natal
Lesotho
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
DEFAULT ECOLOGICAL MANAGEMENT CLASSES
Figure 2.6.3.1



Gauteng
CROCODILE (WEST) AND MARICO WMA
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
LOWER VAAL WMA
North West
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
LOCALITY MAP
LEGEND
Present Ecological Status Class
Ecologically Sensitive Sites
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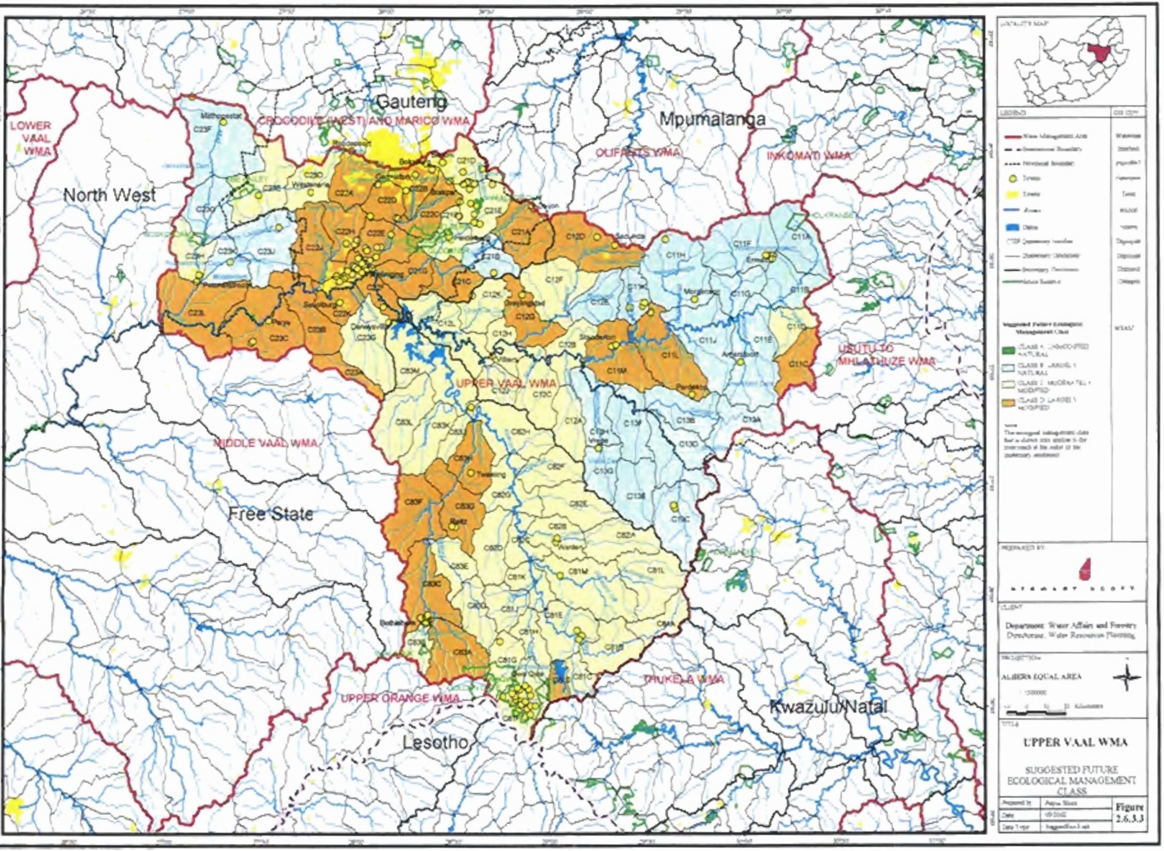
PROJECTION
ALBERS EQUAL AREA
TITLE:
UPPER VAAL WMA
PRESENT ECOLOGICAL STATUS CLASS AND ECOLOGICALLY SENSITIVE SITES
Figure 2.6.3.2



Gauteng
Mpumalanga
North West
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
LOCALITY MAP
LEGEND
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PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
SUGGESTED FUTURE ECOLOGICAL MANAGEMENT CLASS
Figure 2.6.3.3

LOWER VAAL WMA
North West
Gauteng
CROCODILE (WEST) AND MARICO WMA
JOHANNESBURG
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
CARLETONVILLE
NIGEL
SECUNDA
HOLKRANSE
ERMELO
BALFOUR
POTCHEFSTROOM
PARYS
DENEYSVILLE
VREDEFORT
STANDERTON
AMERSFOORT
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
FRANKFORT
MIDDLE VAAL WMA
VREDE
Free State
REITZ
WARDEN
BETHLEHEM
HARRISMITH
THUKELA WMA
UPPER ORANGE WMA
PHUTHADITJHABA
Kwazulu/Natal
Lesotho
LOCALITY MAP
LEGEND
GIS COV
Water Management Area
International Boundary
Provincial Boundary
Towns
Towns
Rivers
Dams
C12F Quaternary Number
Quaternary Catchment
Secondary Catchment
Primary Catchment
Nature Reserve
Population
Rural
Urban
Population
160000
1600000
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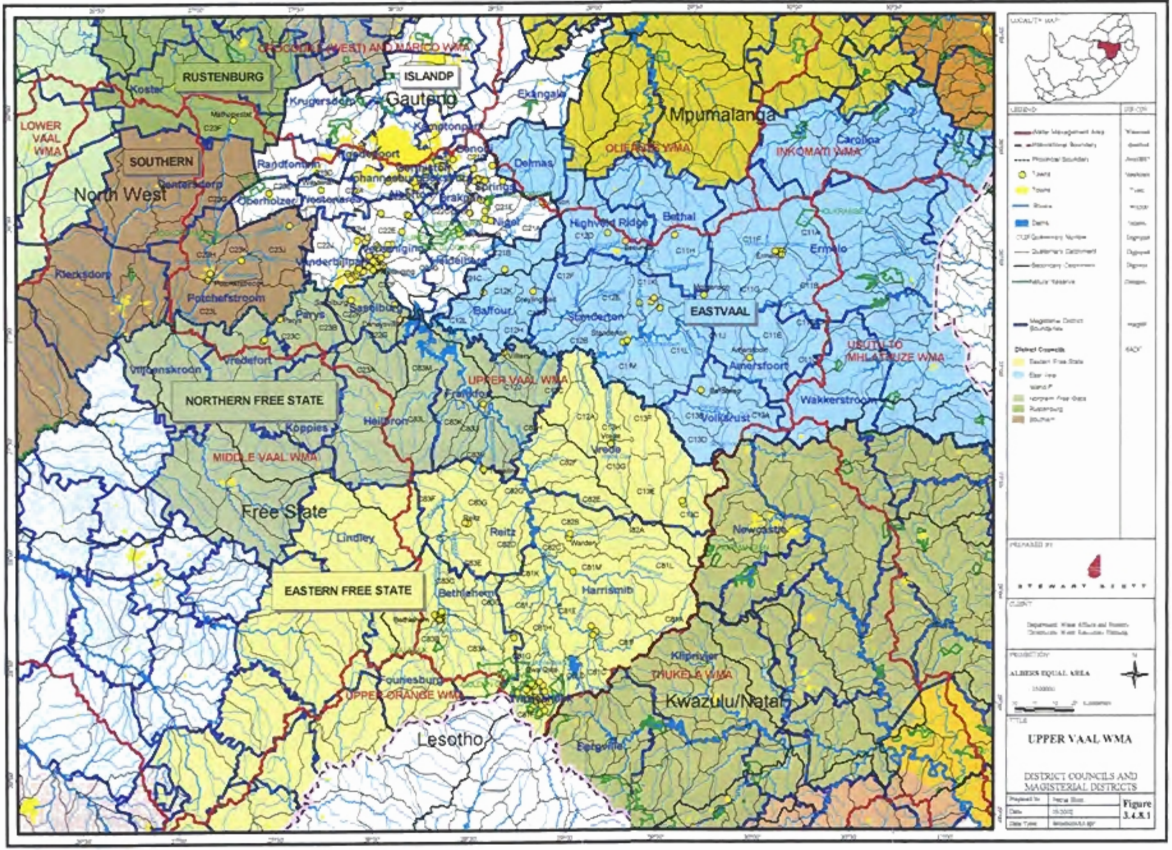
PROJECTION
ALBERS EQUAL AREA
1:1500000
Kilometers
TITLE
UPPER VAAL WMA
POPULATION DISTRIBUTION
Prepared by: Petrus Blom
Date: 05/2002
Data Type: PopulationA3.apr
Figure 3.2.4.1


CROCODILE (WEST) AND MARICO WMA
RUSTENBURG
ISLANDP
Gauteng
Mpumalanga
LOWER VAAL WMA
SOUTHERN
North West
OLIFANTS WMA
INKOMATI WMA
Carolina
Delmas
Bethal
Highveld Ridge
Ermelo
EASTVAAL
Standerton
Balfour
Amersfoort
USUTU TO MHLATUZE WMA
Wakkerstroom
Volksrust
UPPER VAAL WMA
NORTHERN FREE STATE
Vredefort
Viljoenskroon
Koppies
Heilbron
Frankfort
MIDDLE VAAL WMA
Vrede
Free State
Reitz
Lindley
EASTERN FREE STATE
Bethlehem
Harrismith
Newcastle
Klip river
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Parys
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Vanderbijlpark
Vereeniging
Heidelberg
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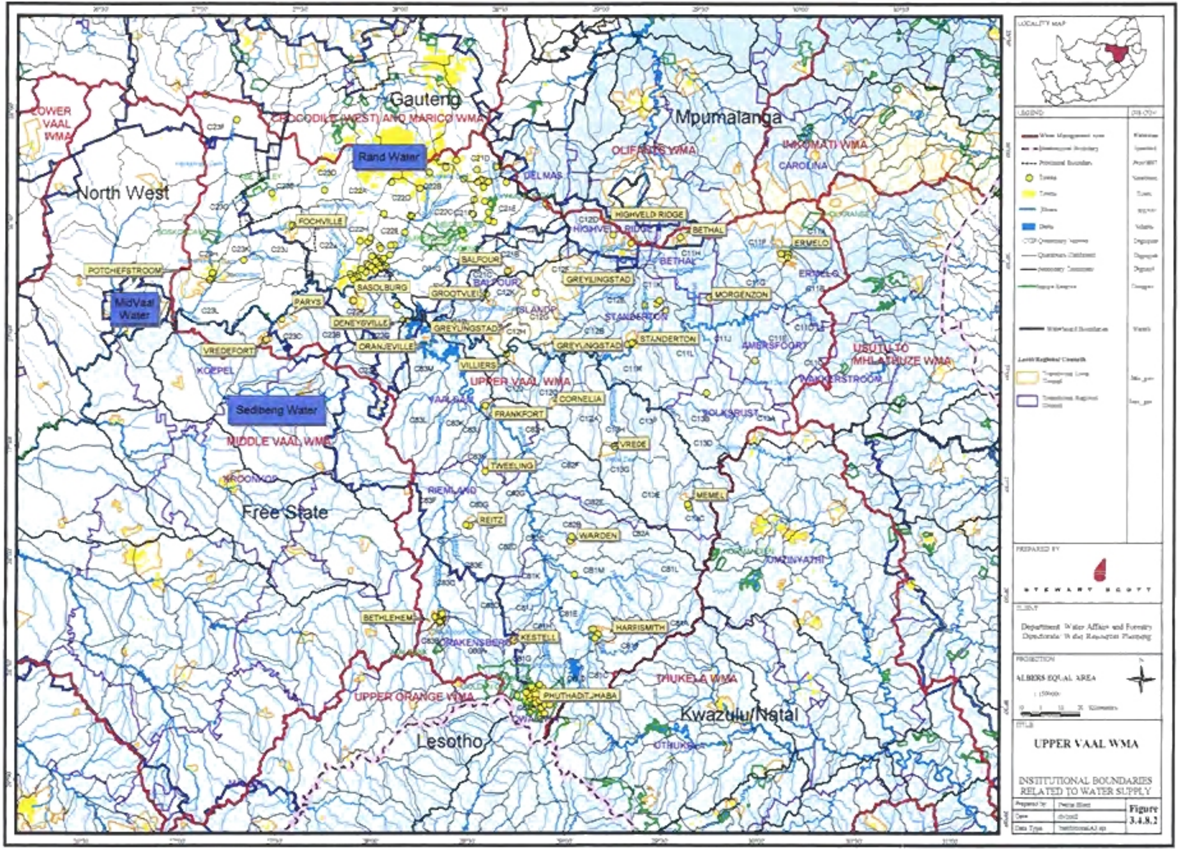
Springs
Brakpan
Benoni
Kempton park
Germiston
Johannesburg
Randfontein
Westonaria
Oberholzer
Krugersdorp
Koster
Ventersdorp
Ekangala
Kliprivier
ALBERS EQUAL AREA
STEWART SCOTT
UPPER VAAL WMA
DISTRICT COUNCILS AND MAGISTERIAL DISTRICTS
Figure 3.4.8.1



Gauteng
Mpumalanga
North West
Free State
Kwazulu/Natal
Lesotho
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CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
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UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
Rand Water
MidVaal Water
Sedibeng Water
FOCHVILLE
POTCHEFSTROOM
SASOLBURG
PARYS
DENEYSVILLE
ORANJEVILLE
VREDEFORT
BALFOUR
GROOTVLEI
GREYLINGSTAD
HIGHVELD RIDGE
BETHAL
ERMELO
MORGENZON
STANDERTON
VILLIERS
CORNELIA
FRANKFORT
VREDE
TWEELING
MEMEL
REITZ
WARDEN
BETHLEHEM
KESTELL
HARRISMITH
PHUTHADITJHABA
DELMAS
CAROLINA
AMERSFOORT
WAKKERSTROOM
VOLKSRUST
KOEPEL
RIEMLAND
UMZINYATHI
LOCALITY MAP
LEGEND
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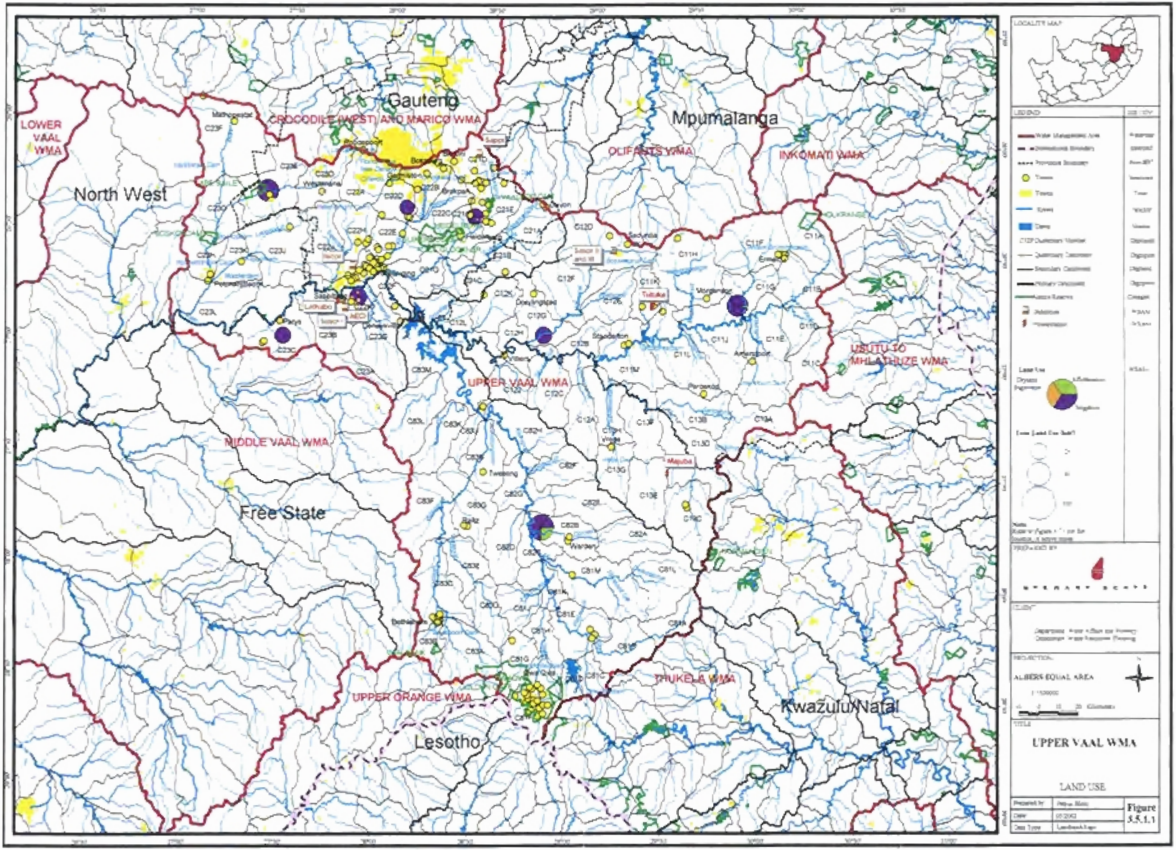
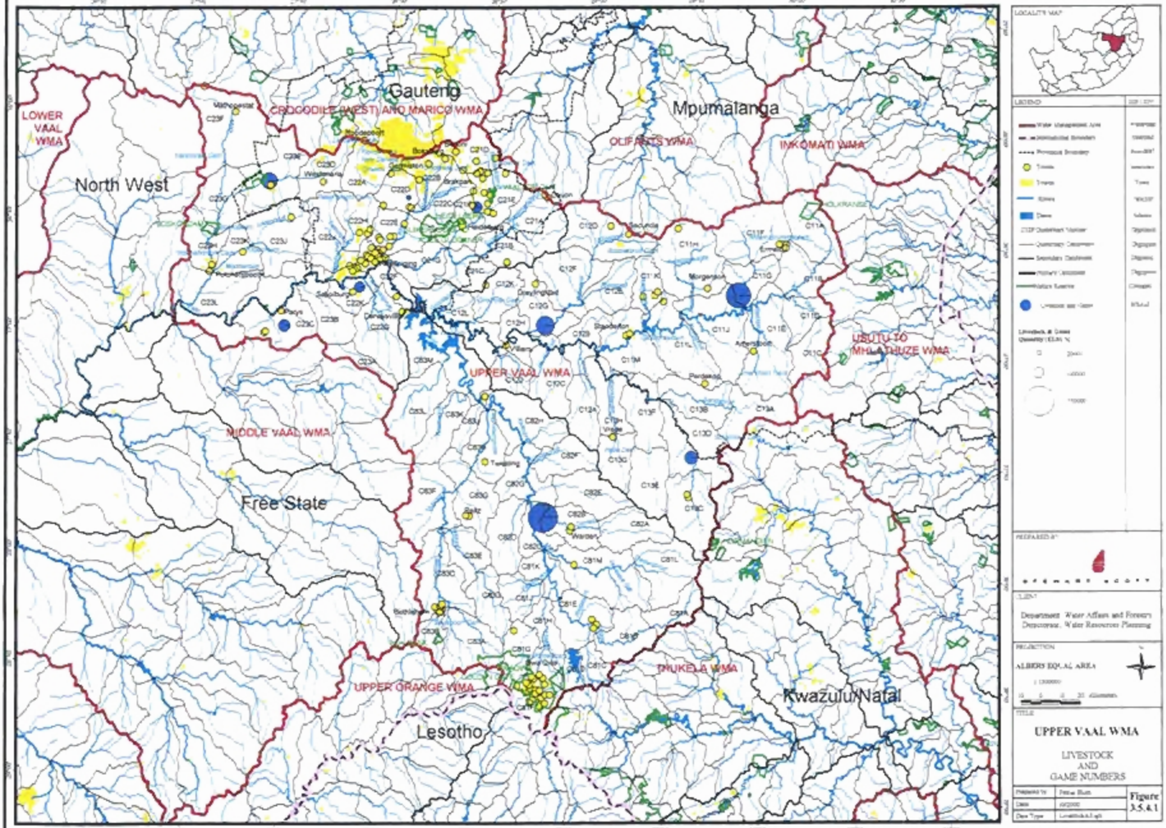
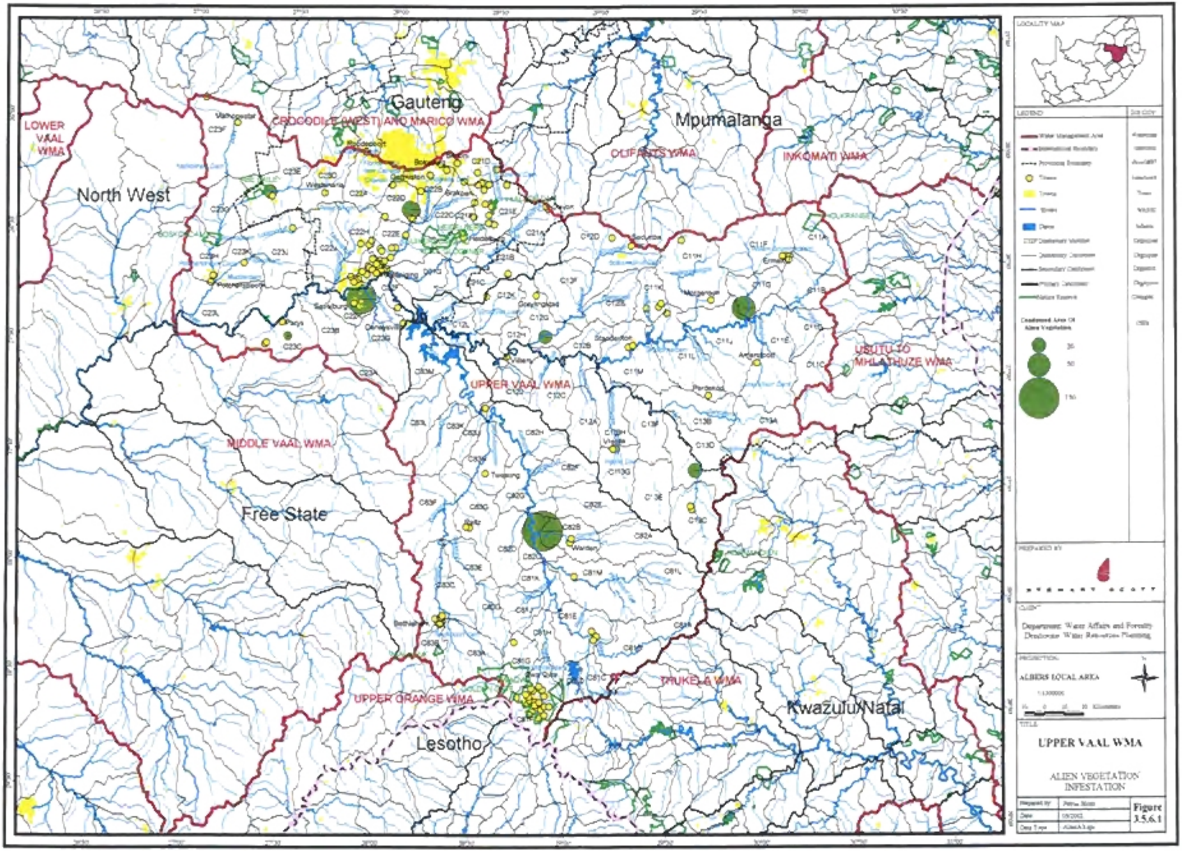
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
INSTITUTIONAL BOUNDARIES RELATED TO WATER SUPPLY
Figure 3.4.8.2



LOCALITY MAP
LEGEND
Gauteng
North West
Mpumalanga
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
PROJECTION:
ALBERS EQUAL AREA
UPPER VAAL WMA
LAND USE
Figure 5.5.1.1


Gauteng
Mpumalanga
North West
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
LOCALITY MAP
LEGEND
PREPARED BY
CLIENT
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
LIVESTOCK AND GAME NUMBERS
Figure 3.5.4.1



Gauteng
Mpumalanga
North West
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
LOCALITY MAP
LEGEND
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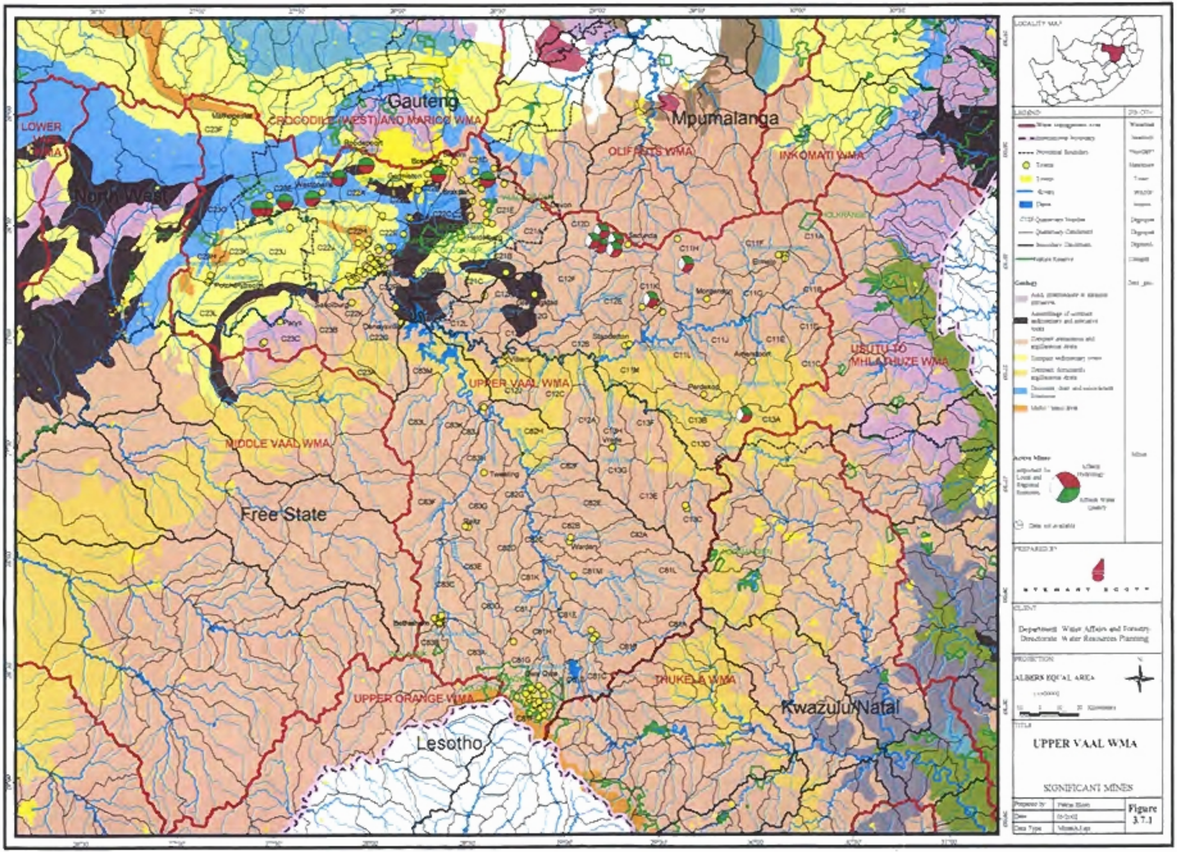
PROJECTION
ALBERS LOCAL AREA
TITLE
UPPER VAAL WMA
ALIEN VEGETATION INFESTATION
Figure 3.5.6.1



LOCALITY MAP
LEGEND
Geology
Active Mines
Gauteng
Mpumalanga
North West
Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
Secunda
Standerton
Parys
Sasolburg
Villiers
Morgenzon
Amersfoort
Perdekop
Ermelo
Vrede
Warden
Bethlehem
Twееling
Potchefstroom
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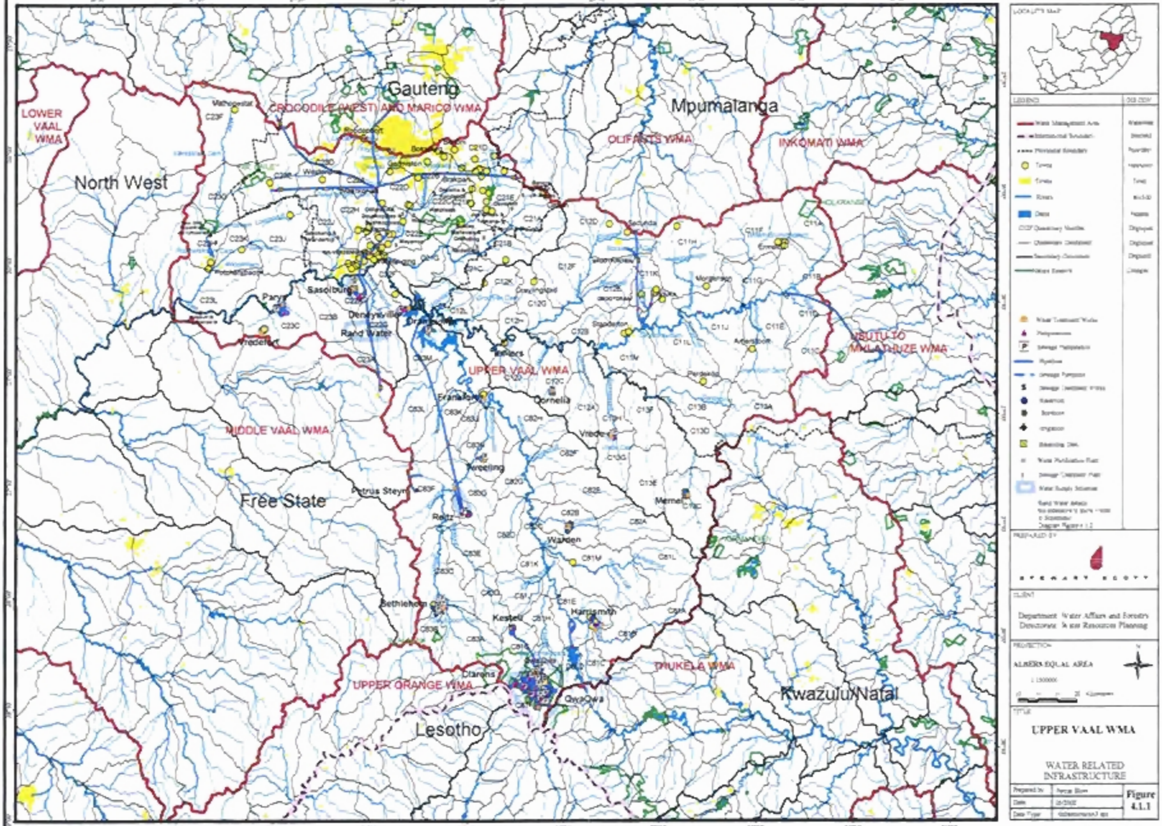
PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
SIGNIFICANT MINES
Figure 3.7.1



Gauteng
CROCODILE (WEST) AND MARICO WMA
LOWER VAAL WMA
North West
Mpumalanga
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
Sasolburg
Parys
Vredefort
Deneysville
Rand Water
Frankfort
Cornelia
Vrede
Tweeling
Petrus Steyn
Reitz
Memel
Warden
Bethlehem
Kestell
Harrismith
Clarens
QwaQwa
Villiers
Secunda
Standerton
Ermelo
Perdekop
LOCALITY MAP
LEGEND
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PROJECTION
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
WATER RELATED INFRASTRUCTURE
Figure 4.1.1

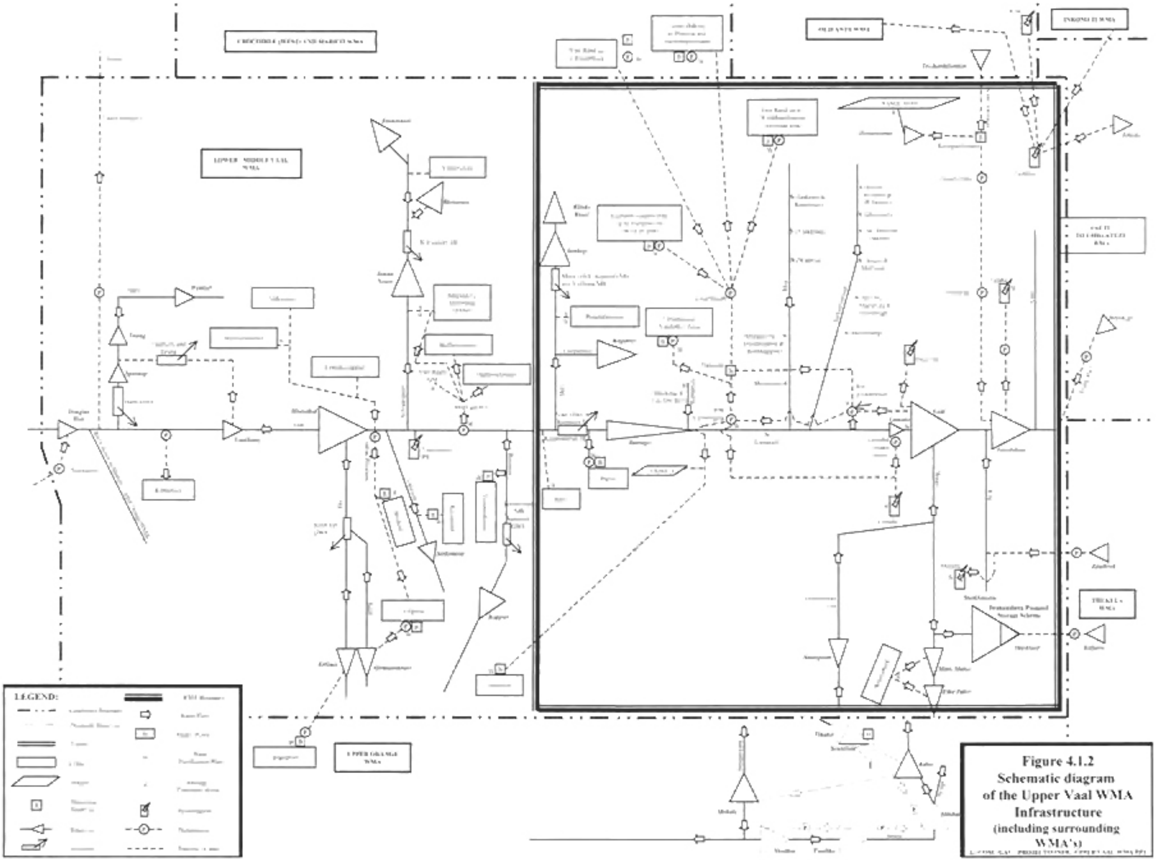
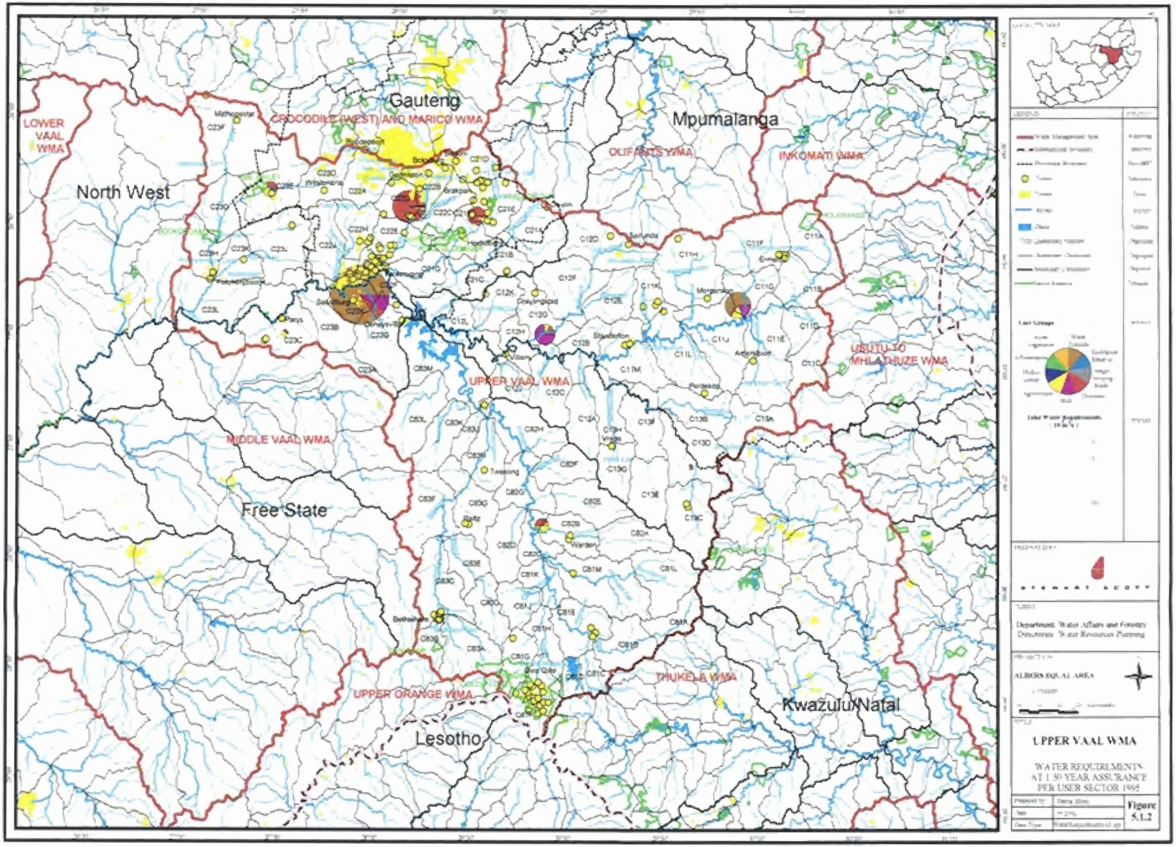


Figure 4.1.2
Schematic diagram of the Upper Vaal WMA Infrastructure (including surrounding WMA's)



Gauteng
Mpumalanga
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Free State
Lesotho
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
Secunda
Standerton
Morgenzon
Ermelo
Amersfoort
Perdekop
Vrede
Villiers
Twesspruit
Reitz
Warden
Bethlehem
Sasolburg
Parys
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
WATER REQUIREMENTS AT 1:50 YEAR ASSURANCE PER USER SECTOR 1995
Figure 5.1.2

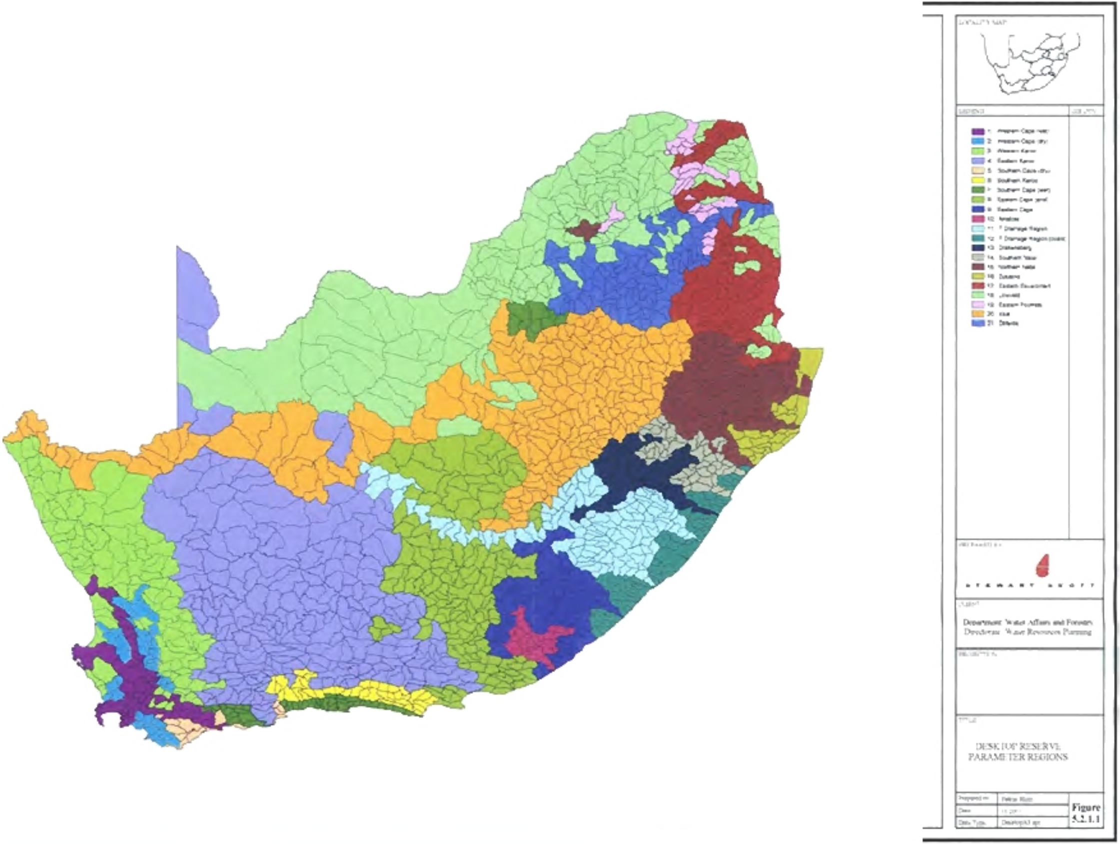
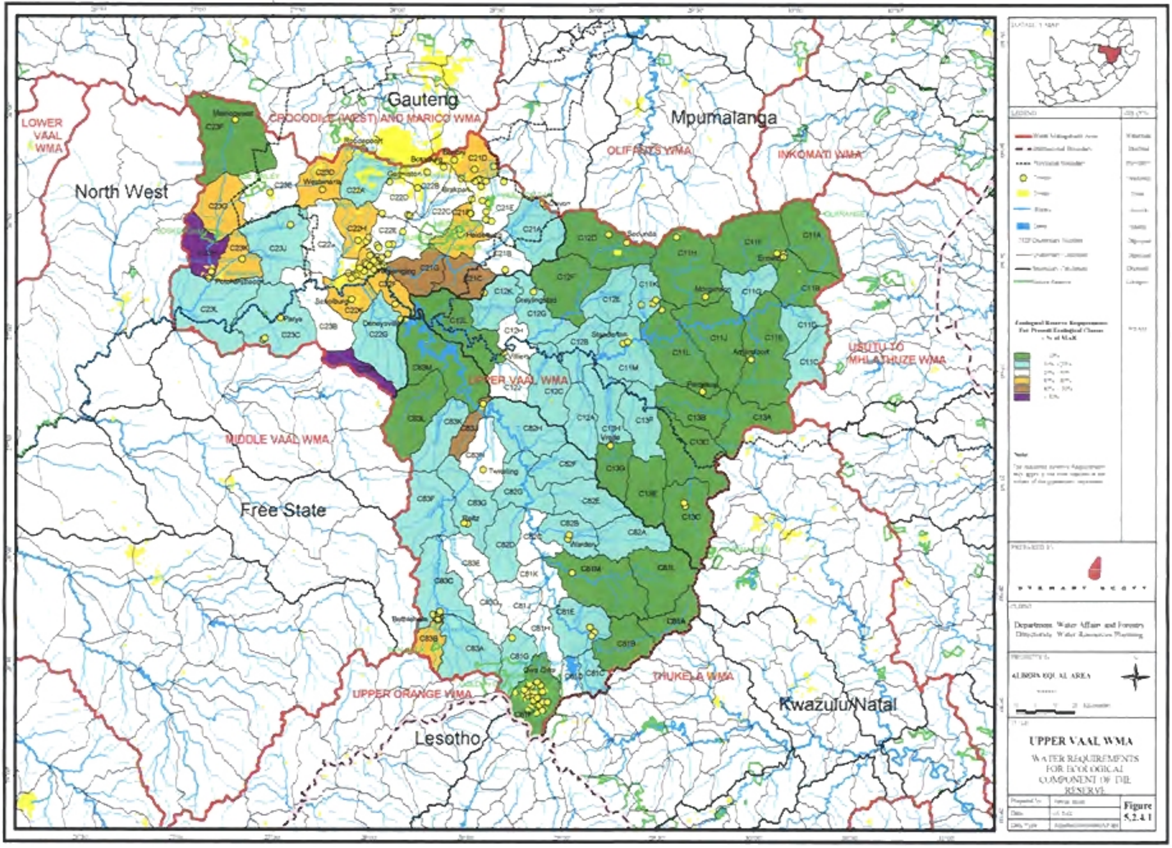


Figure 5.2.1.1

DESKTOP RESERVE PARAMETER REGIONS


Gauteng
CROCODILE (WEST) AND MARICO WMA
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OLIFANTS WMA
INKOMATI WMA
LOWER VAAL WMA
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USUTU TO MHLATHUZE WMA
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Sasolburg
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Note
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ALBERS EQUAL AREA
UPPER VAAL WMA
WATER REQUIREMENTS FOR ECOLOGICAL COMPONENT OF THE RESERVE
Figure 5.2.4.1

FIGURE 5.6.2.1: IRRIGATION WATER REQUIREMENTS 1995

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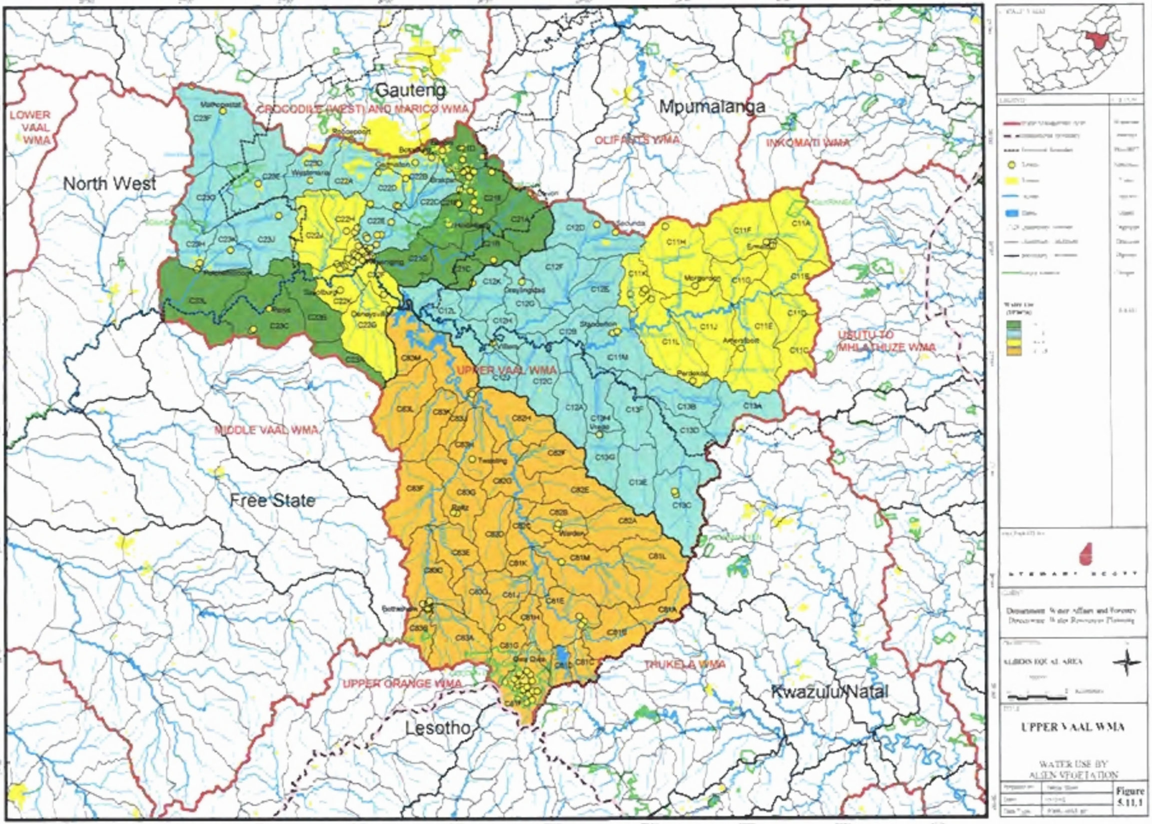

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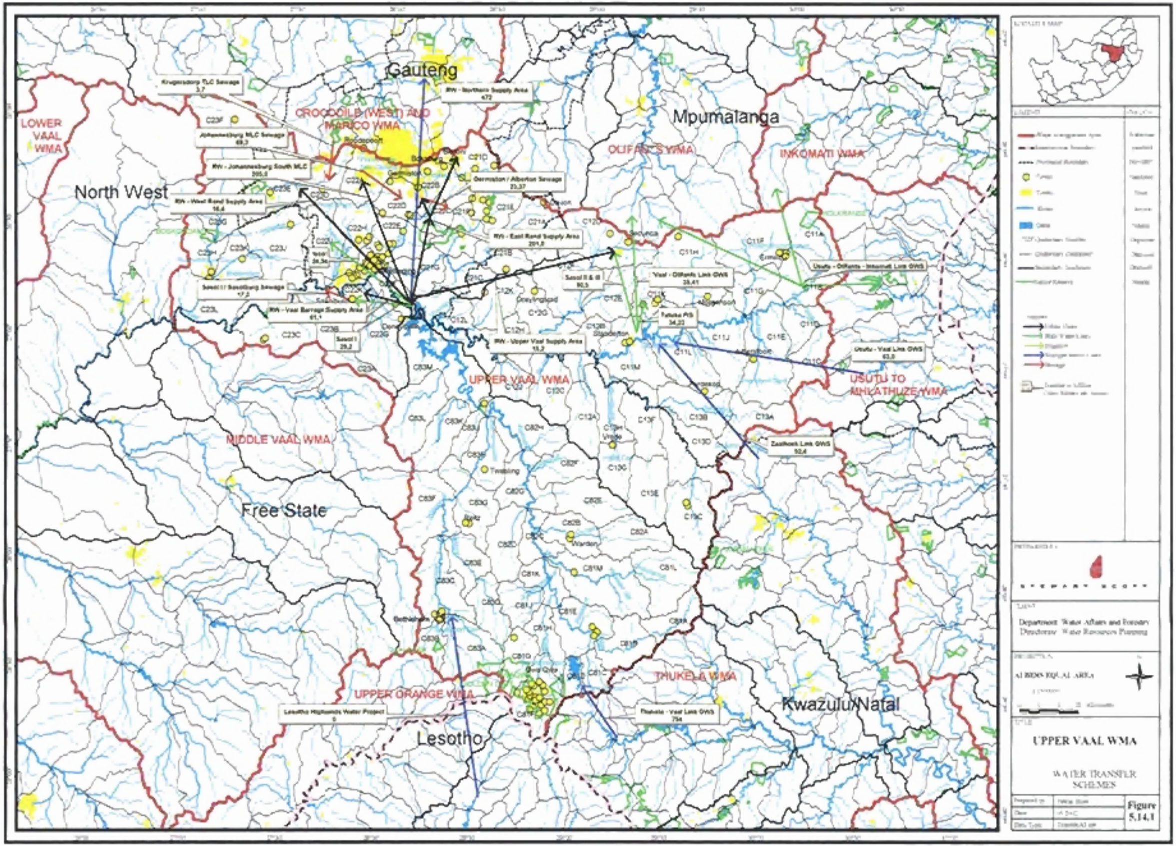
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
ALBERS EQUAL AREA
UPPER VAAL WMA
WATER USE BY ALIEN VEGETATION
Figure 5.11.1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CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
USUTU TO MHLATHUZE WMA
Krugersdorp TLC Sewage 3,7
RW - Northern Supply Area 472
Johannesburg MLC Sewage 69,7
RW - Johannesburg South MLC 205,3
Germiston / Alberton Sewage 23,37
RW - West Rand Supply Area 16,4
RW - East Rand Supply Area 201,8
Sasol I / Sasolburg Sewage 17,2
RW - Vaal Barrage Supply Area 61,1
Sasol I 29,2
Sasol II & III 90,5
Vaal - Olifants Link GWS 25,41
Usutu - Olifants - Inkomati Link GWS
Tutuka P/S 34,33
RW - Upper Vaal Supply Area 15,2
Usutu - Vaal Link GWS 63,0
Zaaihoek Link GWS 52,4
Lesotho Highlands Water Project 0
Thukela - Vaal Link GWS 794
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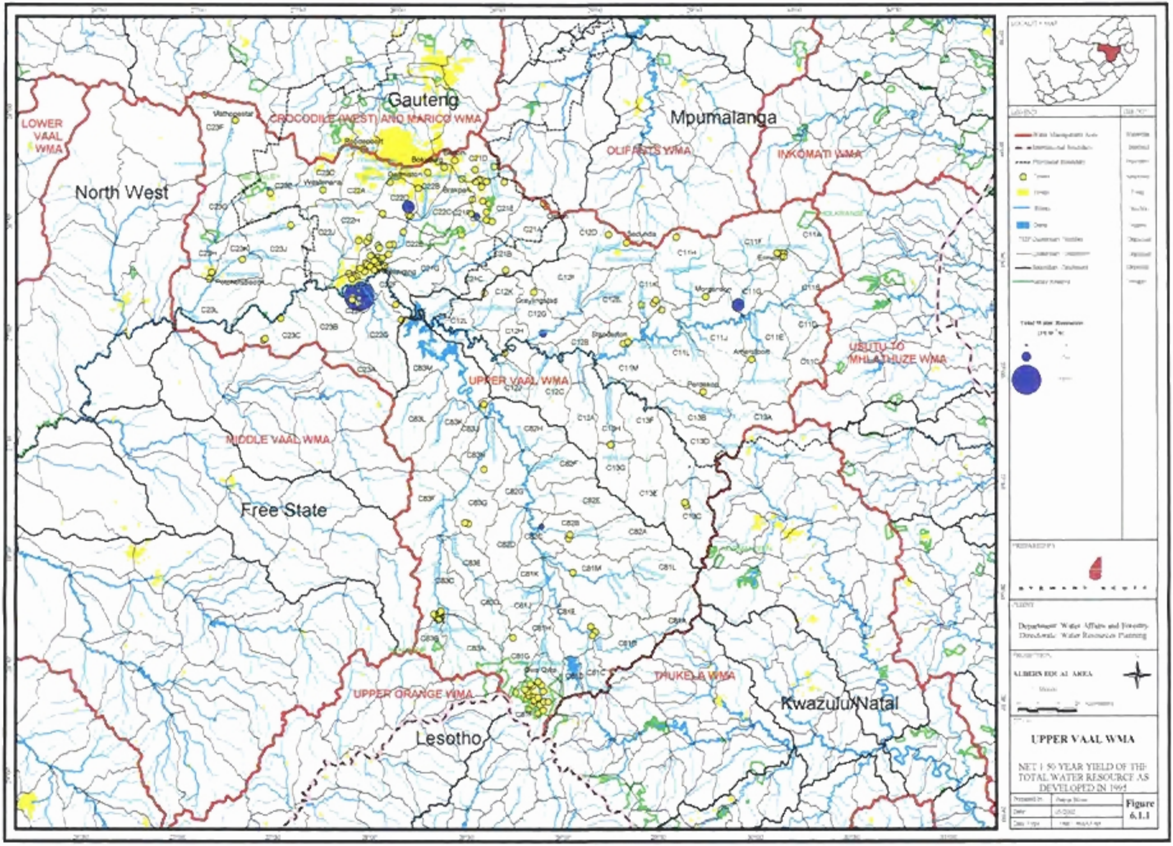
ALBERS EQUAL AREA
UPPER VAAL WMA
WATER TRANSFER SCHEMES
Figure 5.14.1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LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
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MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
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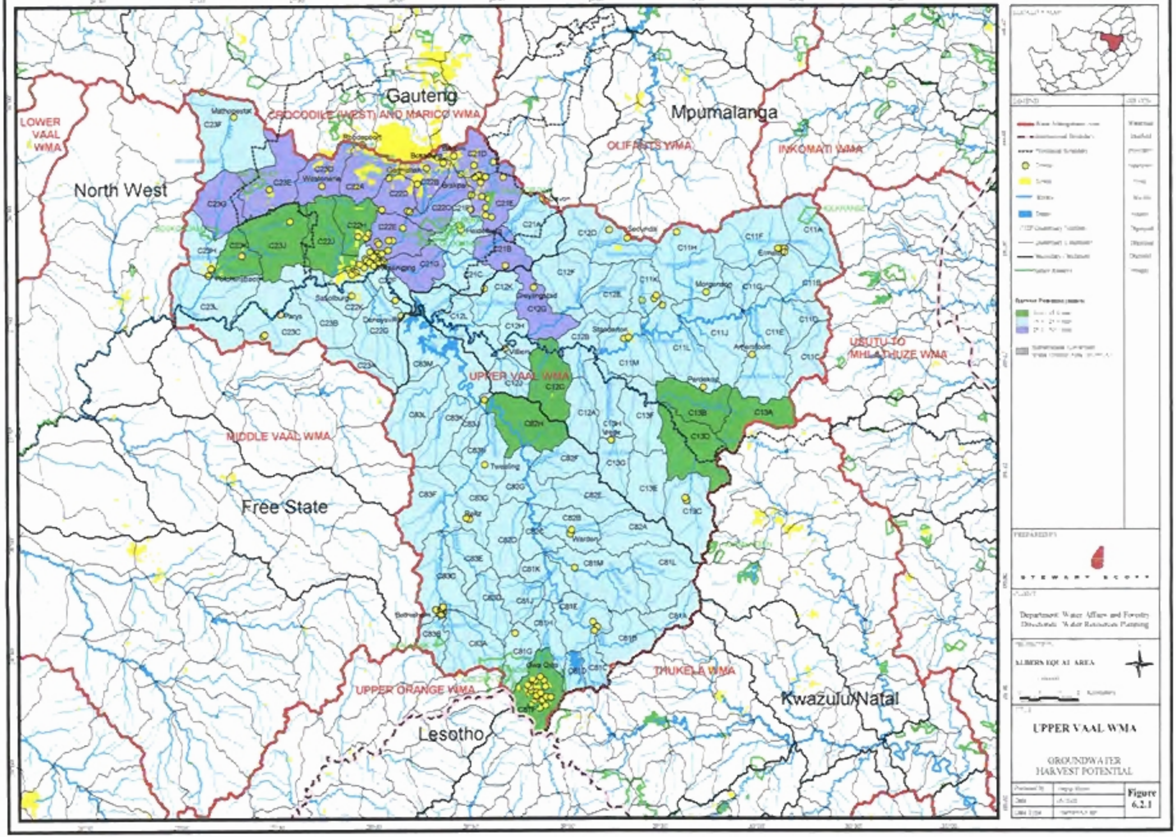
ALBERS EQUAL AREA
UPPER VAAL WMA
NET 1:50 YEAR YIELD OF THE TOTAL WATER RESOURCE AS DEVELOPED IN 1995
Figure 6.1.1



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CROCODILE (WEST) AND MARICO WMA
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LOWER VAAL WMA
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UPPER VAAL WMA
USUTU TO MHLATHUZE WMA
MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
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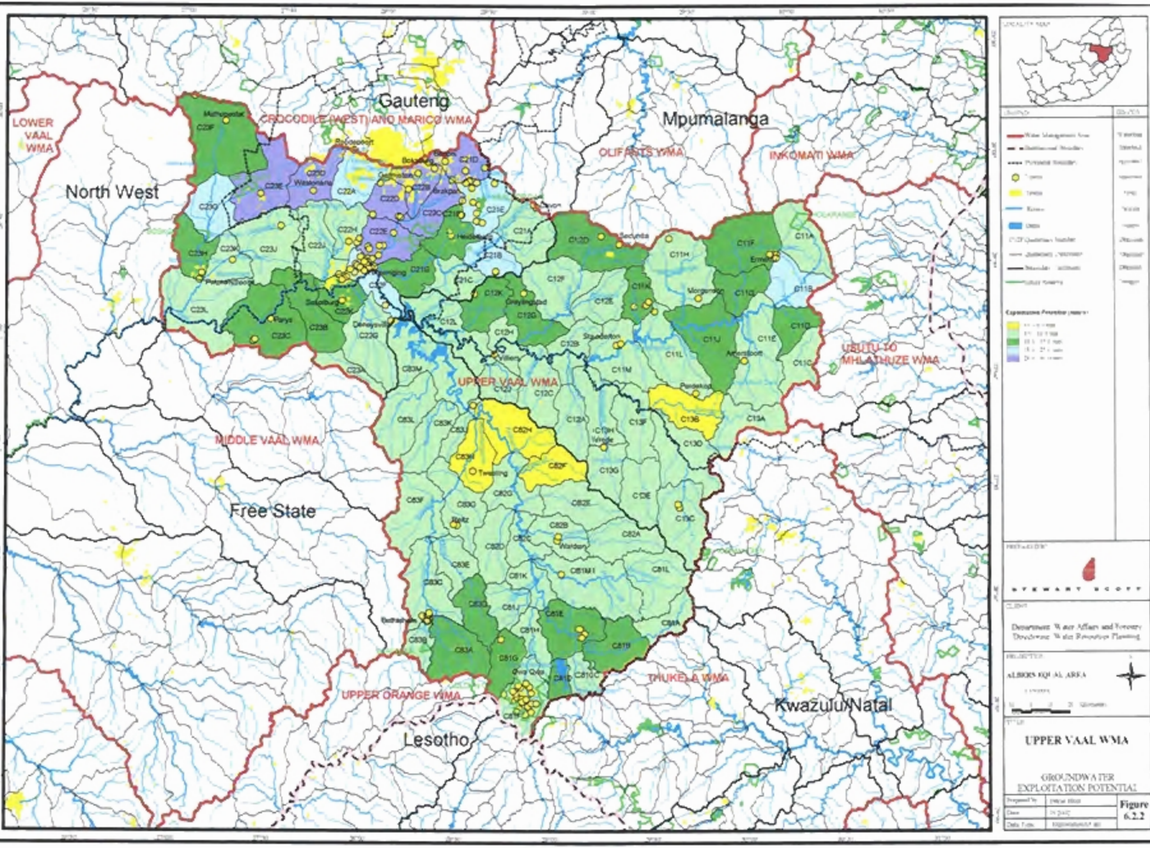
ALBERS EQUAL AREA
UPPER VAAL WMA
GROUNDWATER HARVEST POTENTIAL
Figure 6.2.1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CROCODILE (WEST) AND MARICO WMA
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INKOMATI WMA
LOWER VAAL WMA
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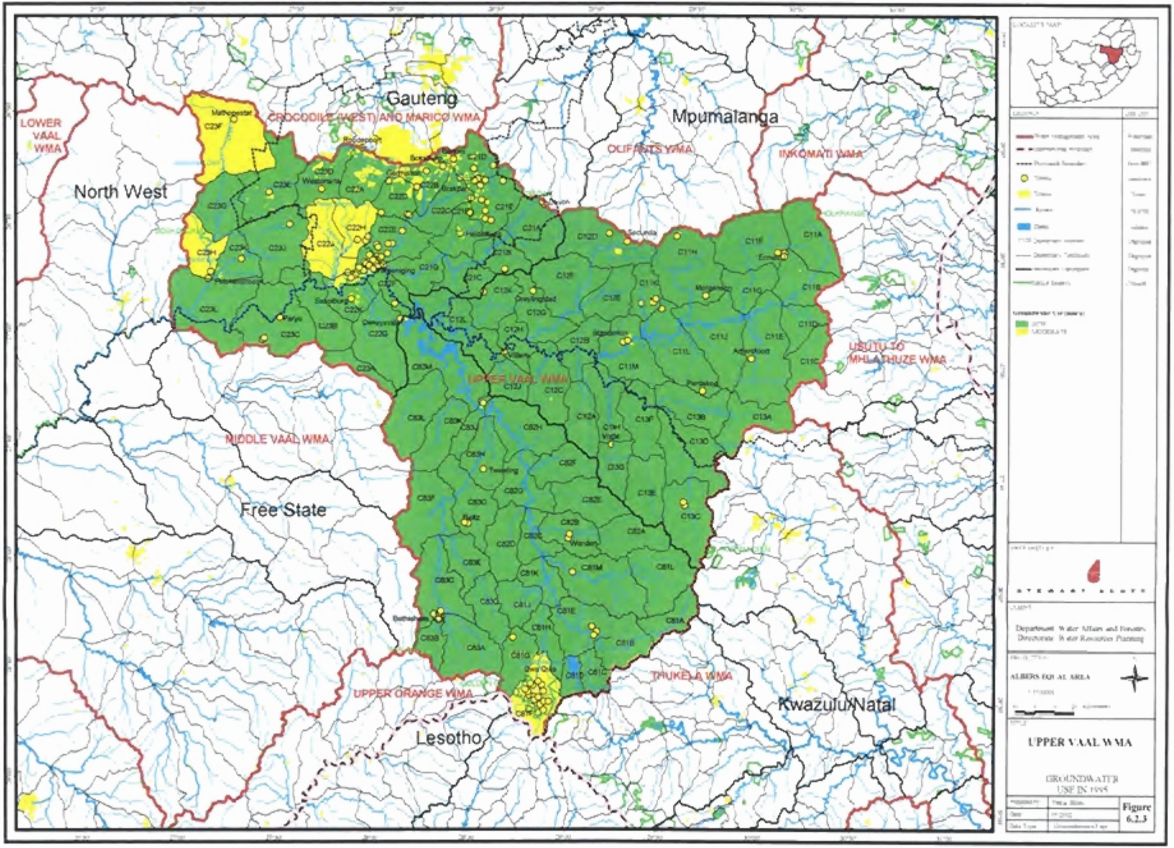
UPPER VAAL WMA
MIDDLE VAAL WMA
USUTU TO MHLATHUZE WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
STEWART SCOTT
UPPER VAAL WMA
GROUNDWATER EXPLOITATION POTENTIAL
Figure 6.2.2



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CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
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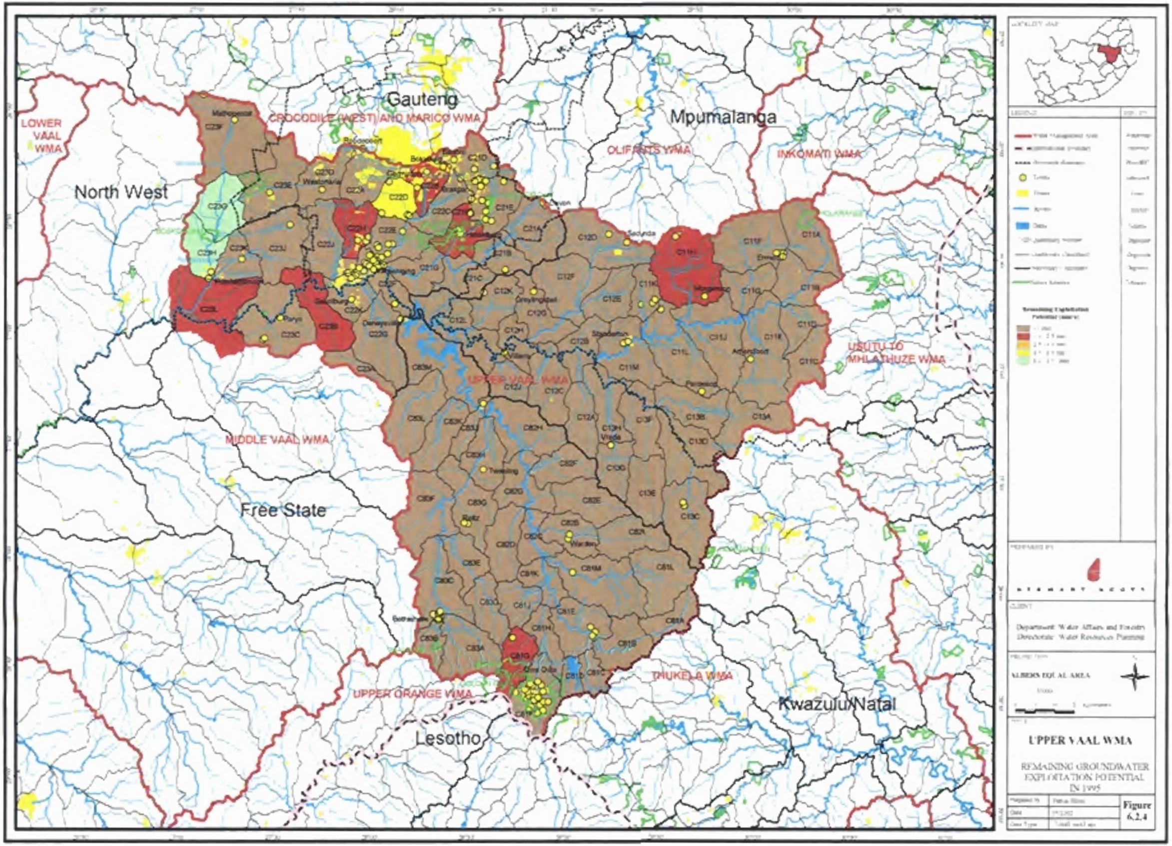
ALBERS EQUAL AREA
UPPER VAAL WMA
GROUNDWATER USE IN 1995
Figure 6.2.3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LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
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UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
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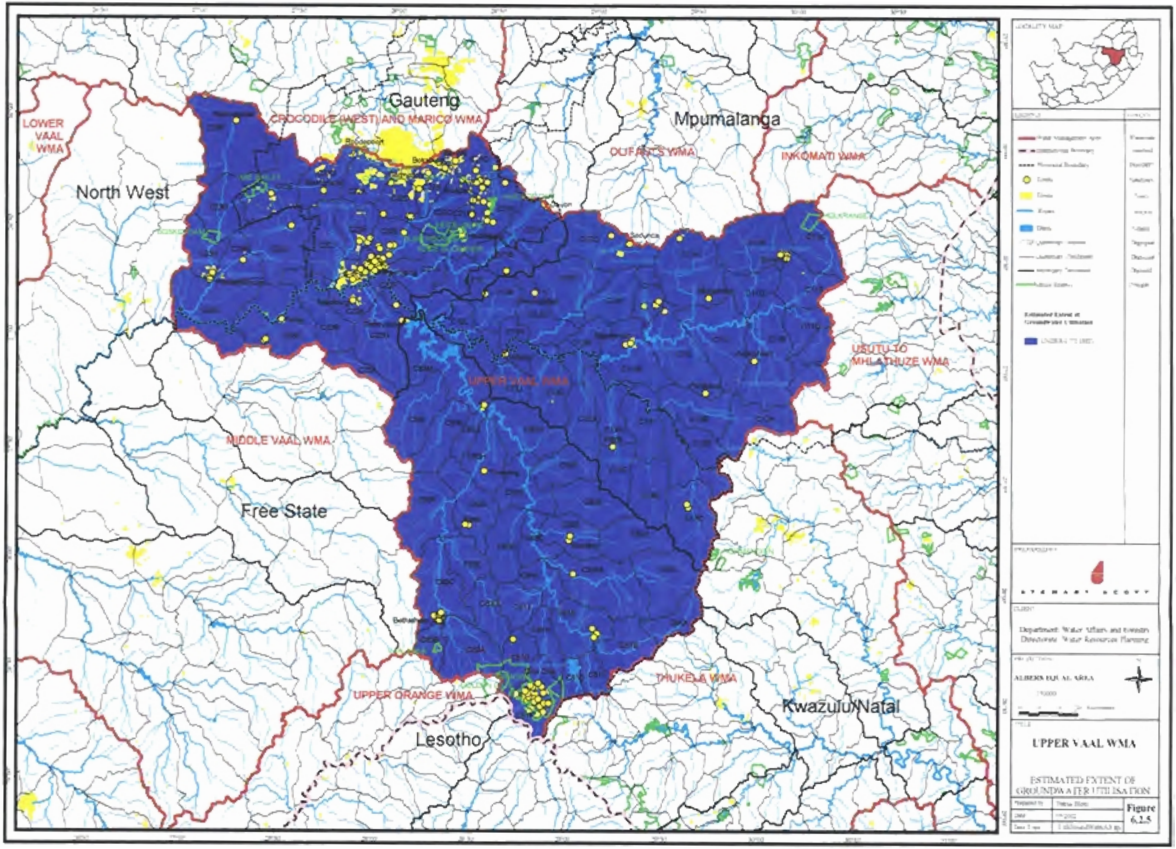
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
REMAINING GROUNDWATER EXPLOITATION POTENTIAL IN 1995
Figure 6.2.4



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CROCODILE (WEST) AND MARICO WMA
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INKOMATI WMA
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UPPER VAAL WMA
MIDDLE VAAL WMA
Free State
THUKELA WMA
UPPER ORANGE WMA
Kwazulu/Natal
Lesotho
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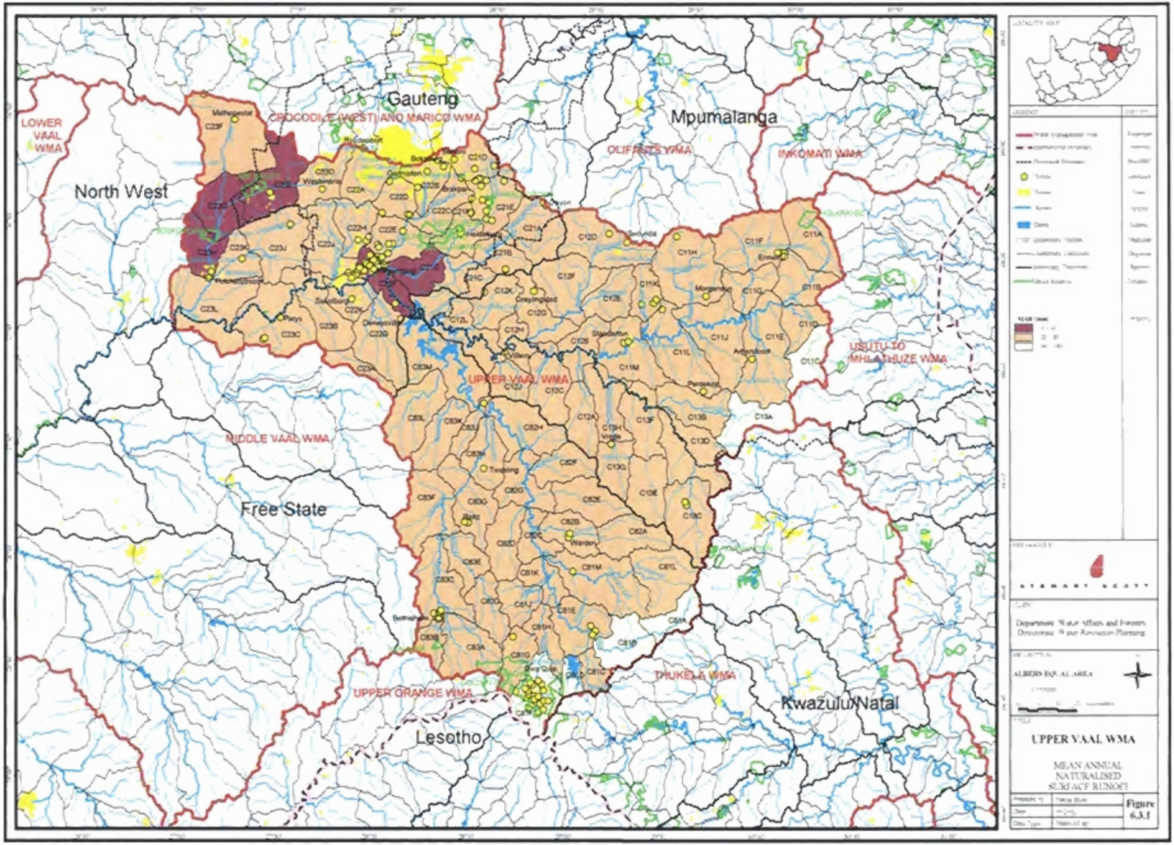
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
ESTIMATED EXTENT OF GROUNDWATER UTILISATION
Figure 6.2.5



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LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
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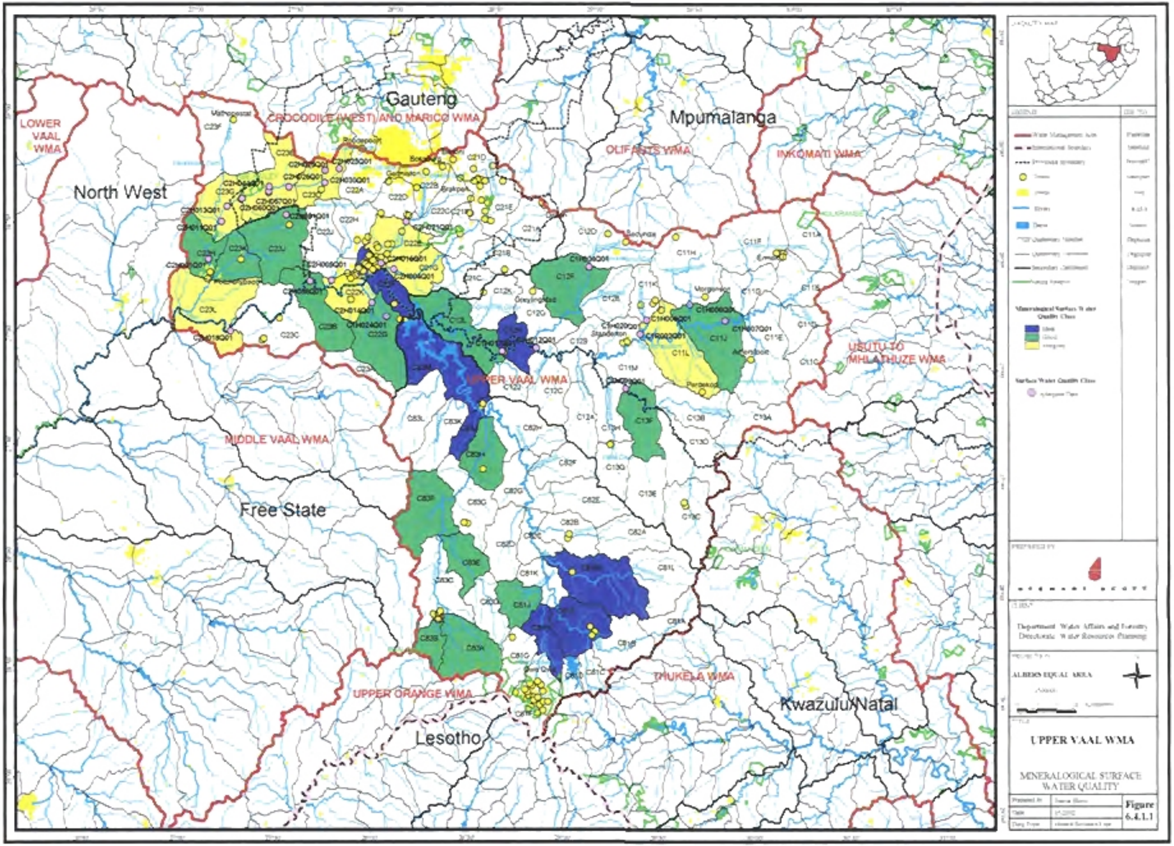
ALBERS EQUAL AREA
UPPER VAAL WMA
MEAN ANNUAL NATURALISED SURFACE RUNOFF
Figure 6.3.1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North West
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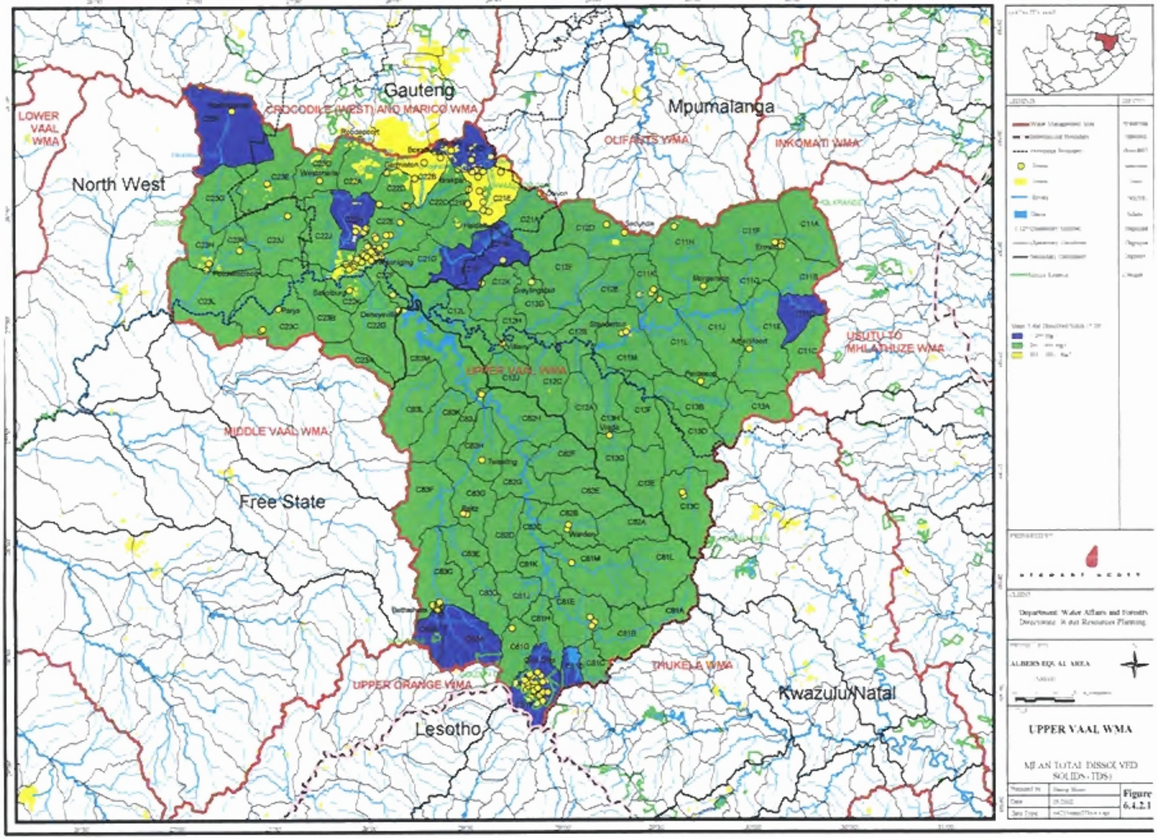
Kwazulu/Natal
LOWER VAAL WMA
CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
USUTU TO MHLATHUZE WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
THUKELA WMA
UPPER ORANGE WMA
ALBERS EQUAL AREA
UPPER VAAL WMA
MINERALOGICAL SURFACE WATER QUALITY
Figure 6.4.1.1


Gauteng
CROCODILE (WEST) AND MARICO WMA
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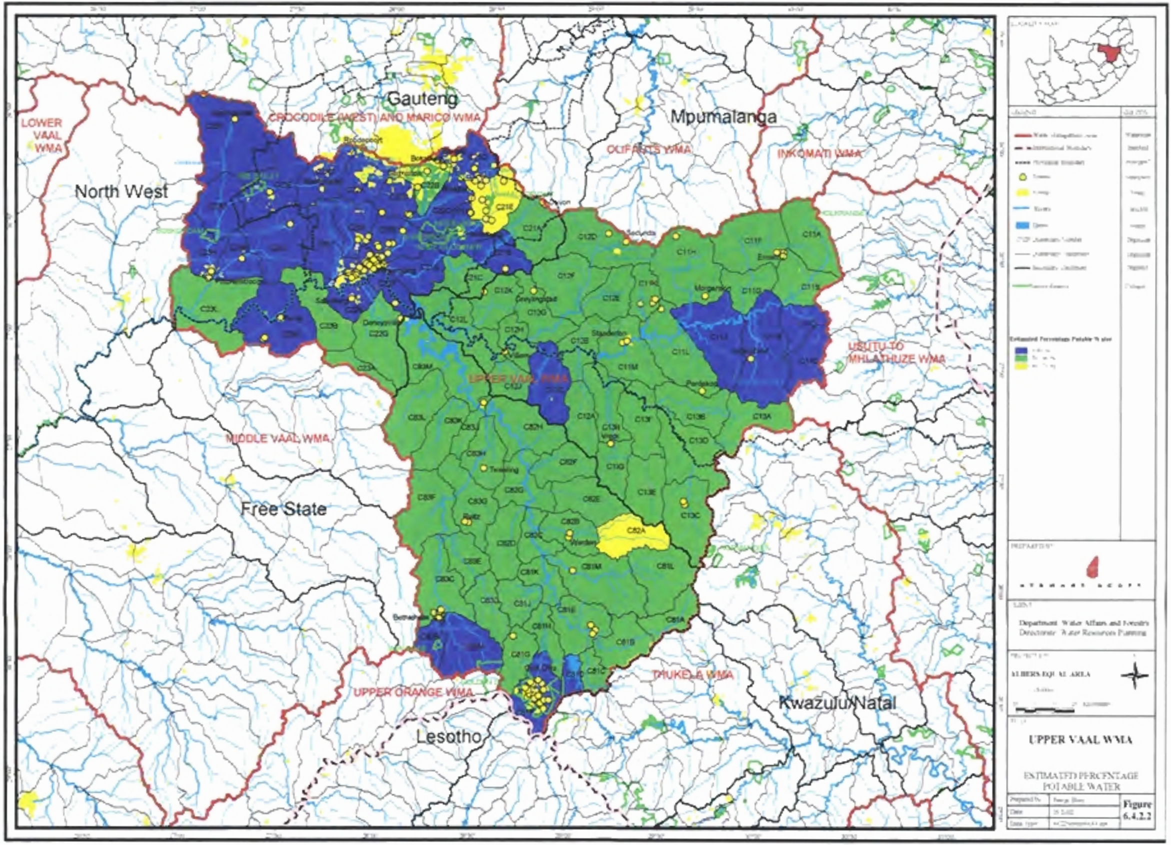
MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
THUKELA WMA
Kwazulu/Natal
Lesotho
Department: Water Affairs and Forestry
ALBERS EQUAL AREA
UPPER VAAL WMA
MEAN TOTAL DISSOLVED SOLIDS (TDS)
Figure 6.4.2.1



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CROCODILE (WEST) AND MARICO WMA
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LOWER VAAL WMA
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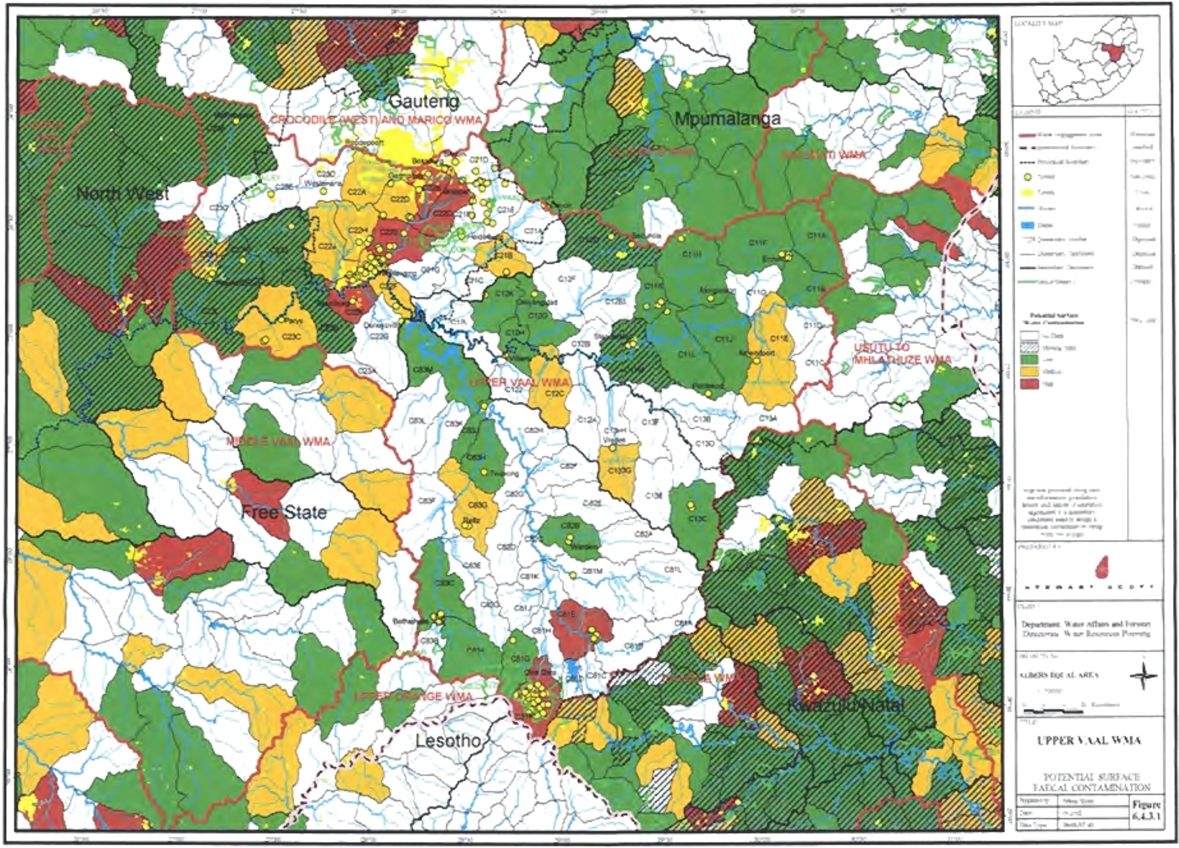
Estimated Percentage Potable Water
Department: Water Affairs and Forestry
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
ESTIMATED PERCENTAGE POTABLE WATER
Figure 6.4.2.2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CROCODILE (WEST) AND MARICO WMA
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MIDDLE VAAL WMA
Free State
UPPER ORANGE WMA
Lesotho
KwaZulu-Natal
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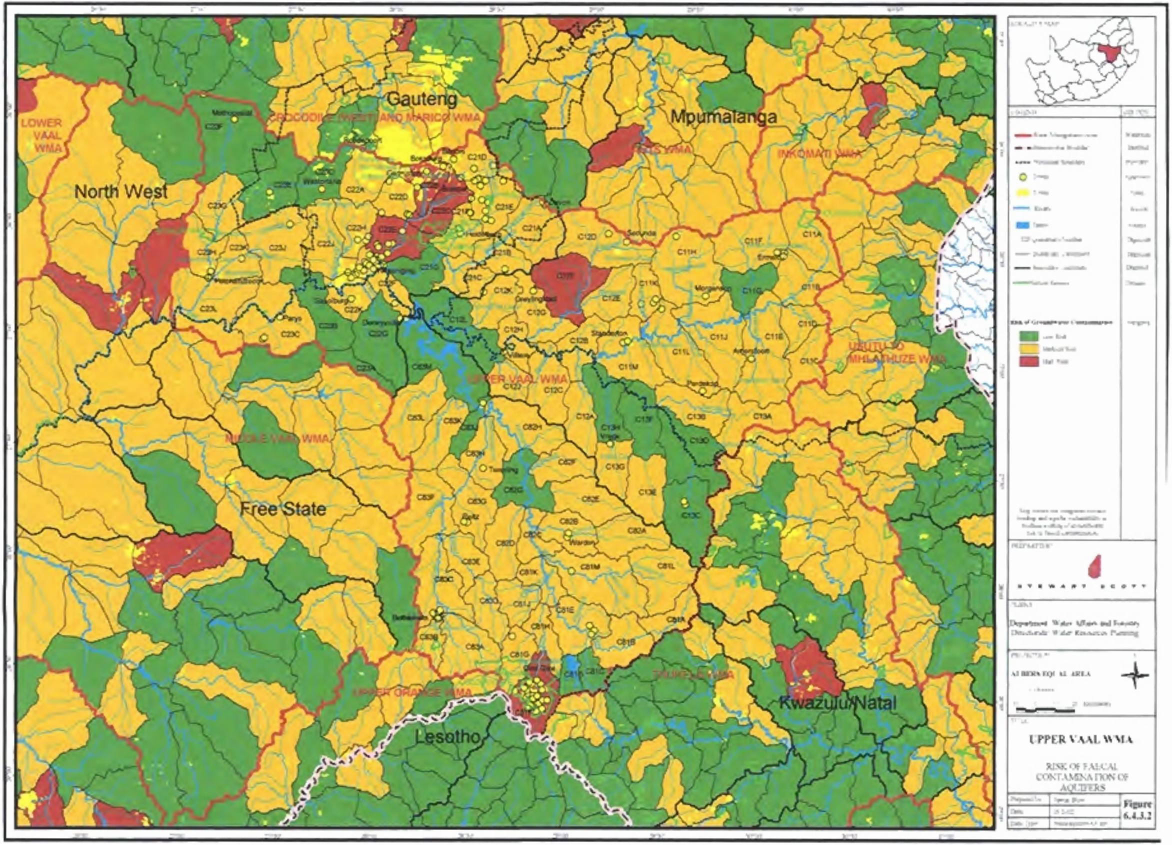
ALBERS EQUAL AREA
UPPER VAAL WMA
POTENTIAL SURFACE FAECAL CONTAMINATION
Figure 6.4.3.1



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CROCODILE (WEST) AND MARICO WMA
INKOMATI WMA
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Standerton
Amersfoort
Villiers
Parys
Warden
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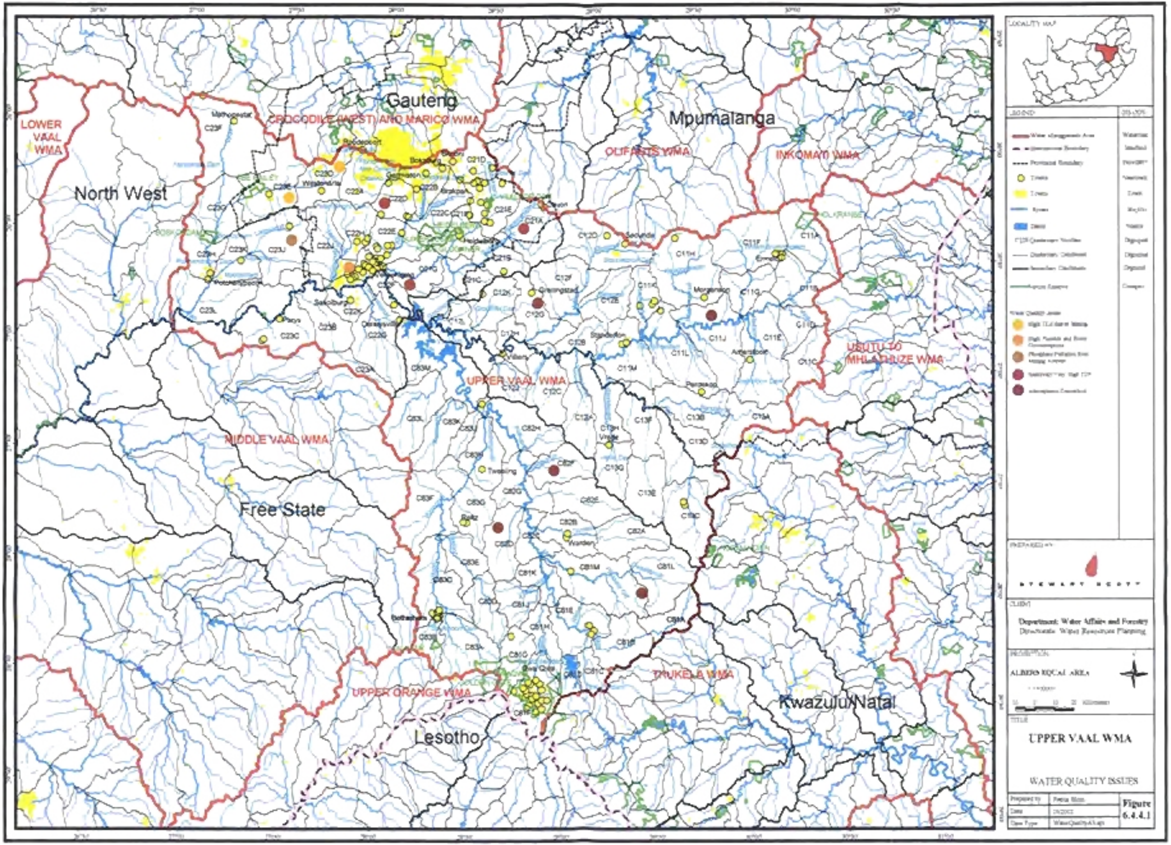
Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
RISK OF FAECAL CONTAMINATION OF AQUIFERS
Figure 6.4.3.2



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Kwazulu/Natal
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CROCODILE (WEST) AND MARICO WMA
OLIFANTS WMA
INKOMATI WMA
UPPER VAAL WMA
MIDDLE VAAL WMA
USUTU TO MHLATHUZE WMA
UPPER ORANGE WMA
THUKELA WMA
LOCALITY MAP
LEGEND
PREPARED BY
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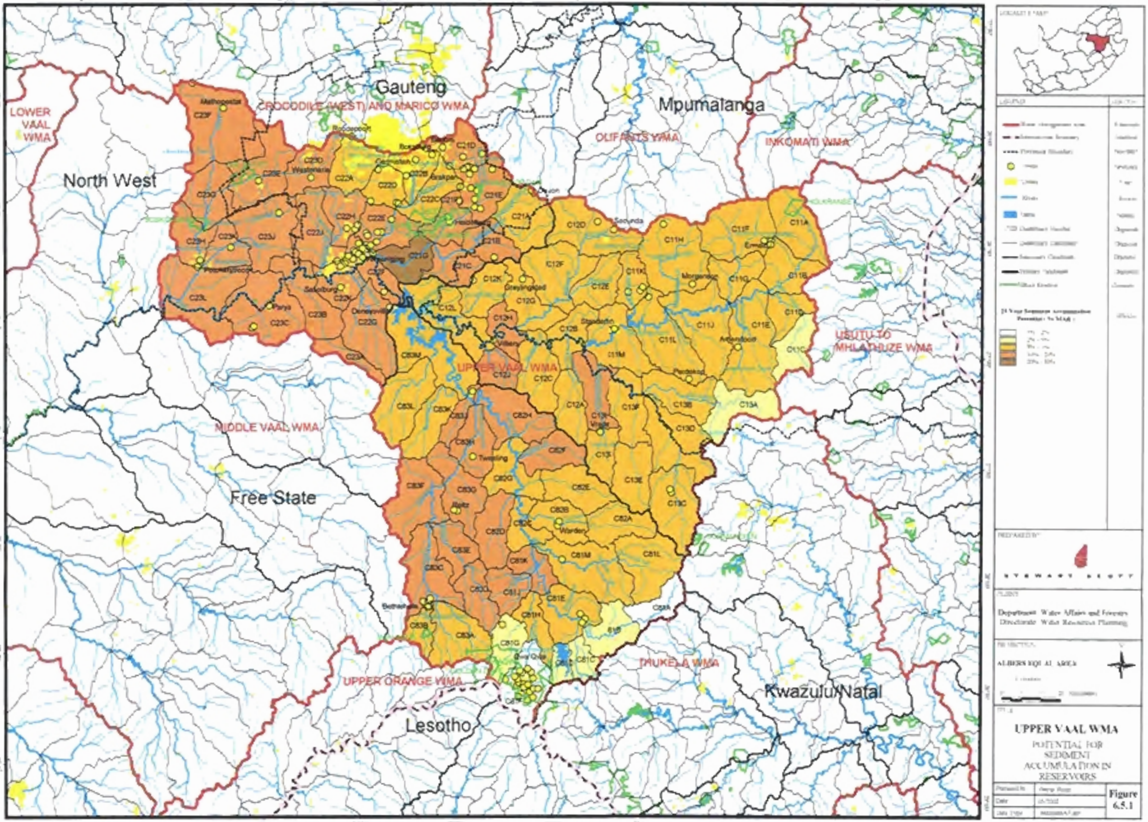
Directorate: Water Resource Planning
ALBERS EQUAL AREA
TITLE
UPPER VAAL WMA
WATER QUALITY ISSUES
Figure 6.4.4.1



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Heidelberg
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Parys
Potchefstroom
Vrede
Bethlehem
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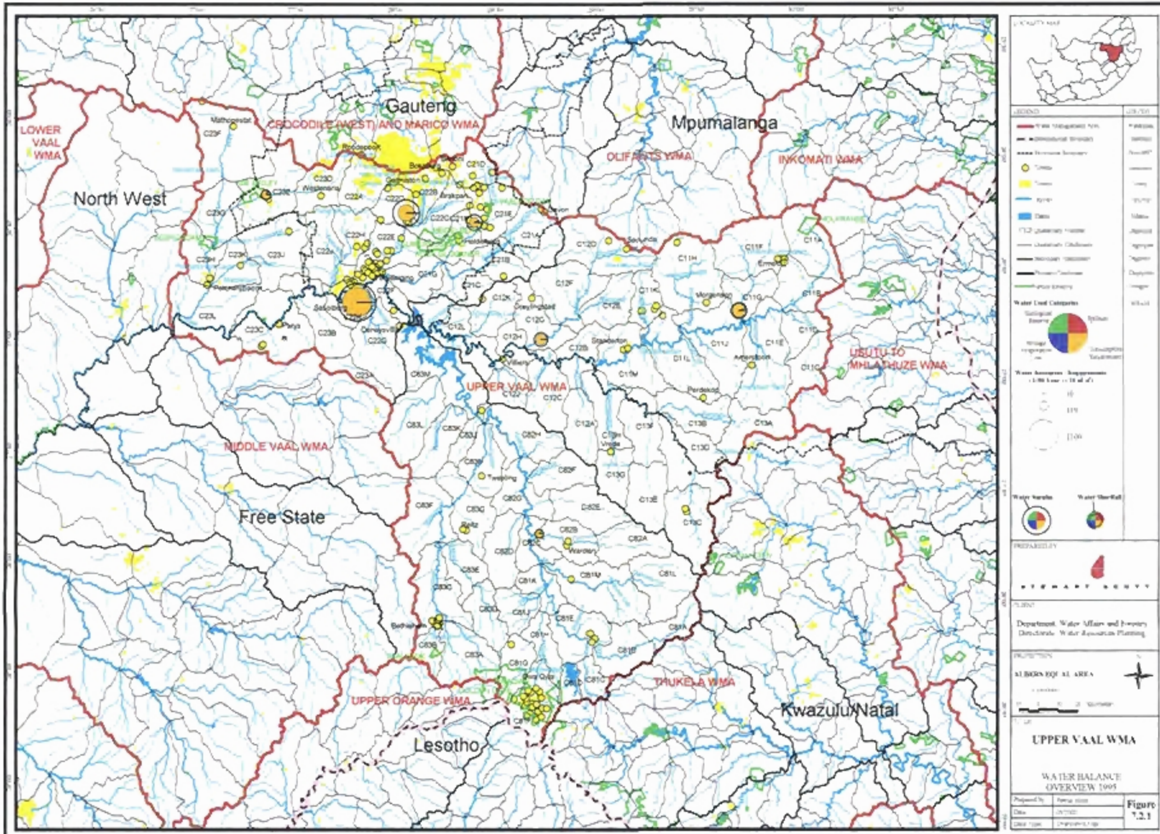
ALBERS EQUAL AREA
UPPER VAAL WMA
POTENTIAL FOR SEDIMENT ACCUMULATION IN RESERVOIRS
Figure 6.5.1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OLIFANTS WMA
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UPPER VAAL WMA
MIDDLE VAAL WMA
UPPER ORANGE WMA
THUKELA WMA
Water Use Categories
Water Surplus
Water Shortfall
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Directorate: Water Resources Planning
ALBERS EQUAL AREA
UPPER VAAL WMA
WATER BALANCE
OVERVIEW 1995
Figure
7.2.1