CHAPTER 2 - SOUTH AFRICA'S WATER SITUATION AND STRATEGIES TO BALANCE SUPPLY AND DEMAND

2.1 INTRODUCTION

South Africa is located in a predominantly semi-arid part of the world. The climate varies from desert and semi-desert in the west to sub-humid along the eastern coastal area, with an average rainfall for the country of about 450 mm per year (mm/a), well below the world average of about 860 mm/a, while evaporation is comparatively high. As a result, South Africa's water resources are, in global terms, scarce and extremely limited. The country has no truly large or navigable rivers, and the combined flow of all the rivers in the country amounts to approximately 49 000 million cubic metres per year (m^3/a), less than half of that of the Zambezi River, the closest large river to South Africa. Groundwater plays a pivotal role in especially rural water supplies. Because of the predominantly hard rock nature of the South African geology, only about 20 per cent of groundwater occurs in major aquifer systems that could be utilised on a large scale.

Due to the poor spatial distribution of rainfall, as shown in Fig. 2.1, the natural availability of water across the country is also highly uneven. This situation is compounded by the strong seasonality of rainfall, as well as high within-season variability, over virtually the entire country. Consequently surface runoff is also highly variable. As a result, stream flow in South African rivers is at relatively low levels for most of the time. The sporadic high flows that do occur limit the proportion of stream flow that can be relied upon to be available for use. These circumstances also have implications for water-related disasters such as floods and droughts (see Part 7 of Chapter 3). To aggravate the situation, most urban and industrial development, as well as some dense rural settlements, have been established in locations remote from large watercourses, dictated either by the occurrence of mineral riches or influenced by the political dispensation of the past. As a result, in several river basins the requirement for water already far exceeds its natural availability, and widely-spread and often large-scale transfers of water across catchments have, therefore, already been implemented in past decades.

Four of South Africa's main rivers are shared with other countries. These are the Limpopo, Inkomati, Pongola (Maputo) and Orange (Senqu) Rivers, which together drain about 60 per cent of the country's land area and contribute about 40 per cent of its total surface runoff (river flow). Approximately 70 per cent of its gross domestic product (GDP) and a similar percentage of the population are supported by water supplied from these rivers, making their judicious joint management of paramount importance to South Africa.

To facilitate the management of water resources, the country has been divided into 19 catchment-based water management areas, which are described in more detail in Part 5 of Chapter 3.

The imbalances between the occurrence of and requirements for water are profoundly evident when comparing some basic parameters presented in this chapter for the different water management areas. Of the 19 water management areas only the Mzimvubu to Keiskamma management area is currently not linked to another management area through inter-catchment transfers. The inter-linking of catchments gives effect to one of the main principles of the National Water Act (the Act), which designates water as a national resource. Eleven of the 19 water management areas share international rivers.

The location and boundaries of the different water management areas, as well as inter-water management area transfers, are shown in Fig. 2.2. Key statistics for each water management area, as well as a concise description of strategic action plans in compliance with section 6(1) of the Act, follow. More detail in this regard can be found in Appendix D**,** where the relationship

Figure 2.1: Rainfall and evaporation

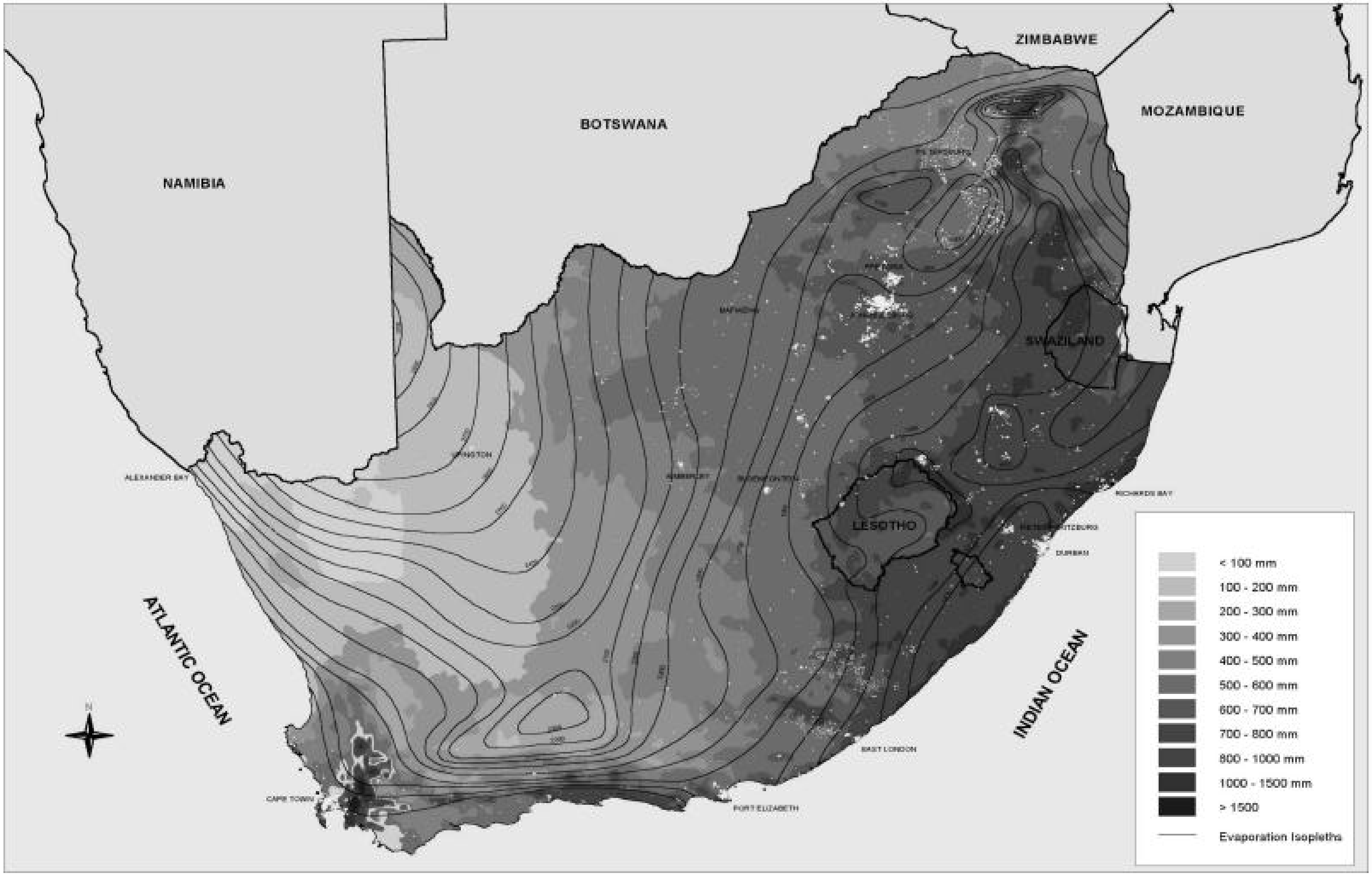
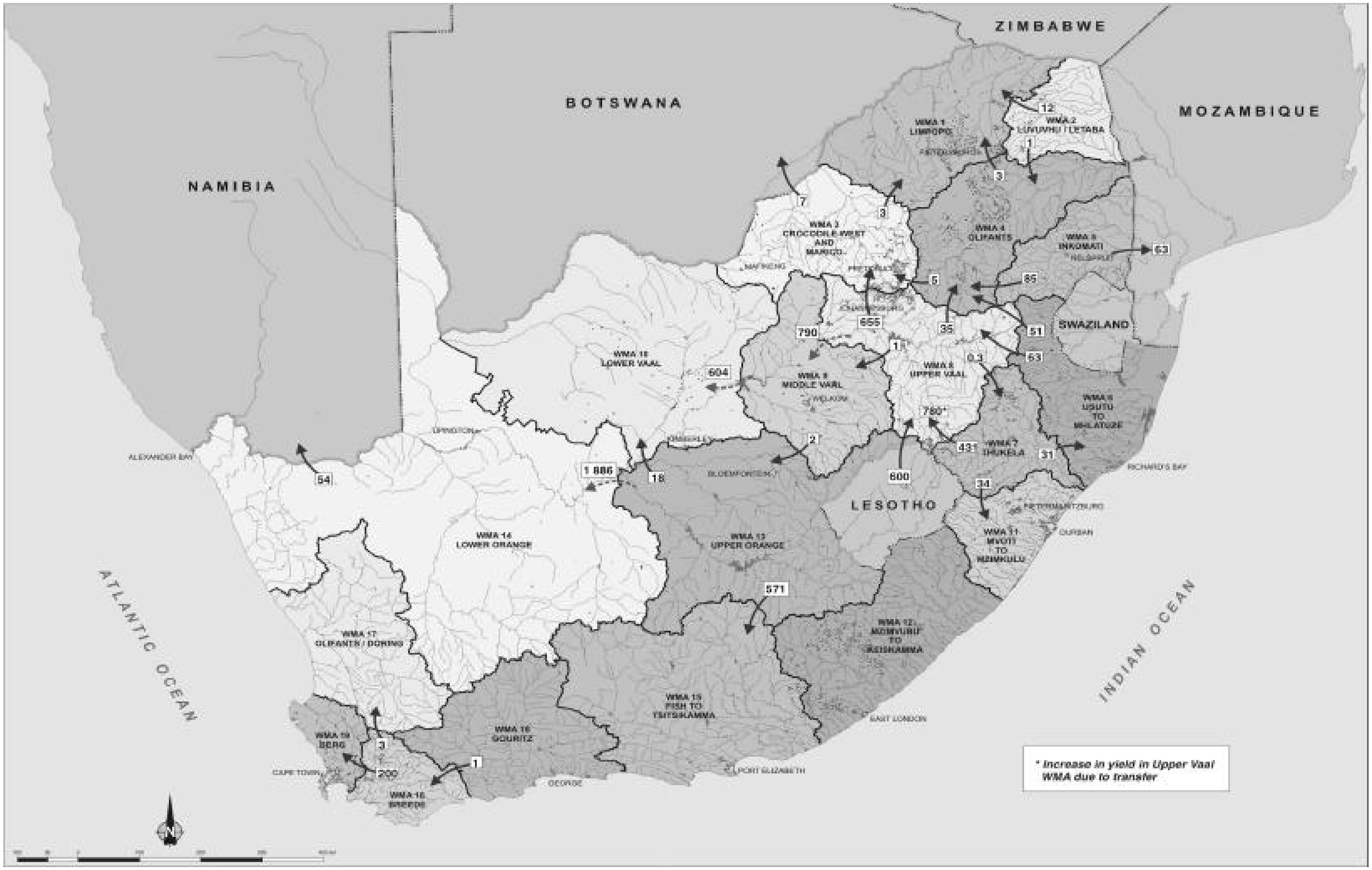


Figure 2.2: Location of water management areas and inter-water management area transfers



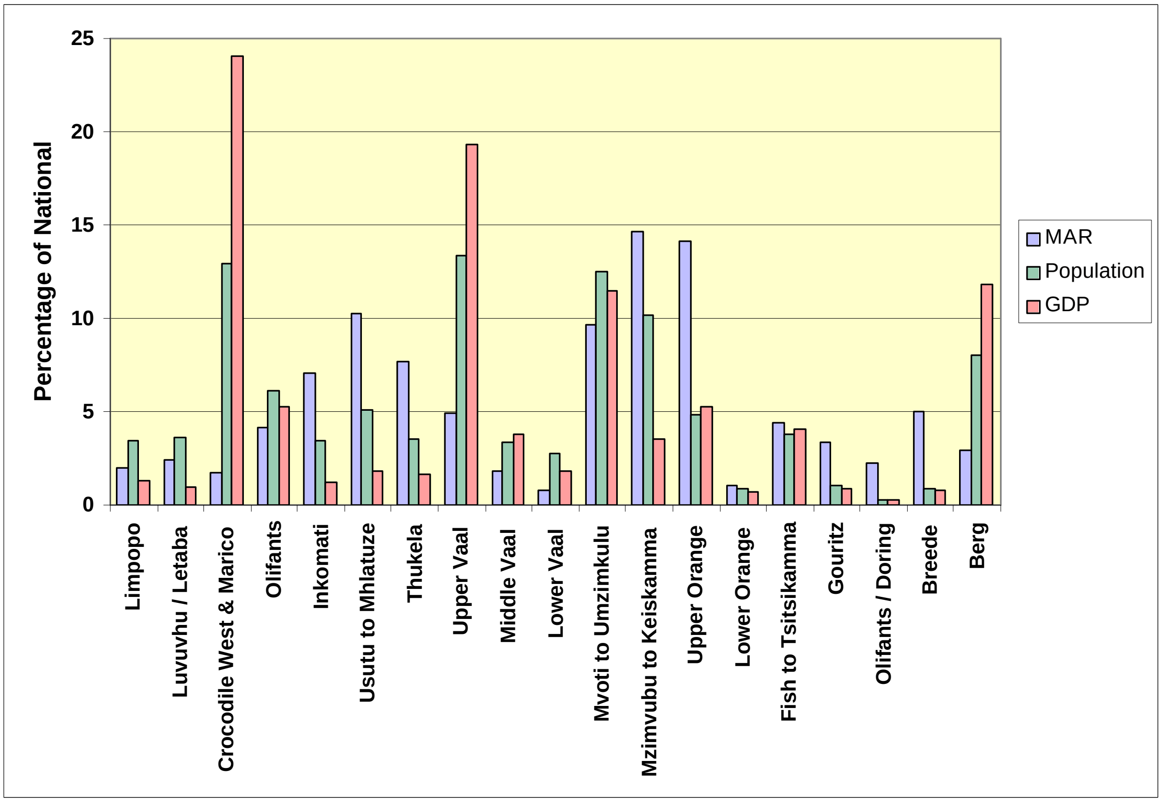
between the National Water Resource Strategy (NWRS) and catchment management strategies is also described.

Every care had been taken to compile and present the best available data and statistics on the availability of and requirements for water in each water management area, to disaggregate the data to subdivisions of each area, and to provide estimates of the water requirements of user sectors[1]. It is however important to note that the information given in the NWRS is intended to identify areas where there are imbalances in availability and requirements, and to serve as background for the formulation of more detailed, nationally-consistent strategies to reconcile the two in each water management area. The data is not sufficiently accurate to consider the water balance in smaller geographic areas, nor to address the water requirements of individual user sectors in these areas. Work at a substantially greater level of detail, to be carried out by or on behalf of the catchment management agencies, will be required as the basis for the formulation of strategies for each water management area, and to facilitate the actual allocation of resources among users and user sectors. Similarly, it should be noted that the strategic perspectives given in this chapter are of a broad national nature, whilst those in Appendix D relate to the requirements of the 19 water management areas, as well as providing an indication of the requirements of adjacent or linked catchments. The information given in Appendix D serves as a basis for further, more detailed work during the development of the catchment management strategies.

In particular, the water management area availability data does not represent the quantities of water that may be allocated by the catchment management agencies, referred to in section 23 of the Act[2]. These determinations are necessary before general, compulsory licensing of water use can be undertaken (see Part 2 of Chapter 3). They require, among other things, the Reserve to be determined for all significant water resources in the water management area, and they will form part of the development of the catchment management strategies.

A graphical comparison of the natural occurrence of water, the population and the economic activity per water management area is given in Fig. 2.3, which clearly demonstrates the exceedingly varied conditions among the water management areas. The Crocodile West and Marico water management area for example, where the largest proportional contribution to GDP is produced, is one of the management areas with the smallest mean annual runoff. In contrast, economic activity in the Mzimvubu to Keiskamma water management area is relatively low, despite it being the water management area with the highest mean annual runoff in the country.

Fig. 2.3: Comparison of the mean annual runoff (MAR), population and economic activity (GDP) per water management area



2.2 A BROAD PERSPECTIVE ON THE WATER SITUATION

Water resource development and management in South Africa have continuously evolved over the years to meet the needs of a growing population and a vibrant economy. Considering the constraints imposed by nature these developments have largely been made possible by recognising water as a national asset, which permits its transfer from where it is available to where the greatest overall benefits for the nation can be achieved. South Africa is today recognised internationally for its progressive water legislation and its sophistication in water resources management.

Sufficient water resources have been developed to ensure that all current requirements for water can reasonably be met without impairing the socio-economic development of the country. Specific cases where problems may be experienced are covered in the remainder of this chapter and in Appendix D.

An inheritance from the previous water act, which in many instances linked access to water resources to land ownership, is the current inequity in water use among the country's population groups. Situations also occur where people do not have access to a reliable source of potable water. This is largely due to a lack of infrastructure and funding for its provision and operation, since sufficient water resources are normally available, especially groundwater resources in rural areas. Putting both of these situations right is of exceptional priority for the Department of Water Affairs and Forestry (the Department), and they are being addressed by the Department in close co-operation with other relevant government departments and institutions (see Chapter 5).

To meet the country's growing water requirements, water resources are highly developed and utilised in large parts of the country. As a result of the many control structures (dams and weirs), the abstraction of water and return flows to rivers, as well as the impacts of land use, the flow regime in many rivers has been significantly altered. In some instances this has resulted in a severe degradation of the quality of water and the integrity of aquatic life in rivers. The anticipated further industrialisation of the economy and urbanisation of the population will result in further deterioration of the country's rivers unless appropriate and timely corrective measures are taken. There are indications that, during the last three decades, the use of groundwater for intensive irrigation schemes has substantially increased in some areas (see Note 3 to Table 2.2 below). This, and to a lesser extent dewatering of mines, has lead to localised depletion of groundwater resources and in some cases deterioration of water quality. Much of the focus of the National Water Resource Strategy (NWRS) is therefore on the sustainable use of the country's water resources. A principal objective of the NWRS is to ensure an adequate supply of water to underpin the prosperity of the country and the wellbeing of its population. This has to be achieved within a framework that protects the water resources, as described in Part 1 of Chapter 3.

Water of naturally poor quality, which limits its utilisation, also occurs in some areas. This applies to both surface and groundwater. Where feasible, special management techniques may be applied to improve water quality to appropriate standards for particular uses.

Because attention in the past was mainly focused on the development of new resources as demand increased, partly since large unused potential was still available, efficiency in water use has not developed to the same level of sophistication as resource management. With the present high level of water resource utilisation in the country, water use efficiency must be substantially improved. The Department is developing an extensive programme for water conservation and water demand management, which forms an important element of the NWRS. In addition, measures are to be introduced to ensure the most beneficial utilisation of water in the country, both from a social and an economic perspective. These measures will include the re-allocation of some water from low benefit uses to higher benefit uses over time.

Provided that the water resources of South Africa are judiciously managed and wisely allocated and utilised, sufficient water of appropriate quality will be available to sustain a strong economy, high social standards and healthy aquatic ecosystems for many generations. The aim of the NWRS is to encourage and promote actions that ensure the long term sustainable and beneficial utilisation of the country's water resources.

2.3 WATER RESOURCES

South Africa depends mainly on surface water resources for most of its urban, industrial and irrigation requirements. In general, surface water resources are highly developed over most of the country. About 320 major dams, each with a full supply capacity exceeding I million cubic metres, have a total capacity of more than 32 400 million cubic metres (see Table 2.1), equivalent to 66 per cent of the total mean annual runoff. Groundwater, while also extensively utilised, particularly in the rural and more arid areas, is limited due to the geology of the country, much of which is hard rock. Large porous aquifers occur only in a few areas.

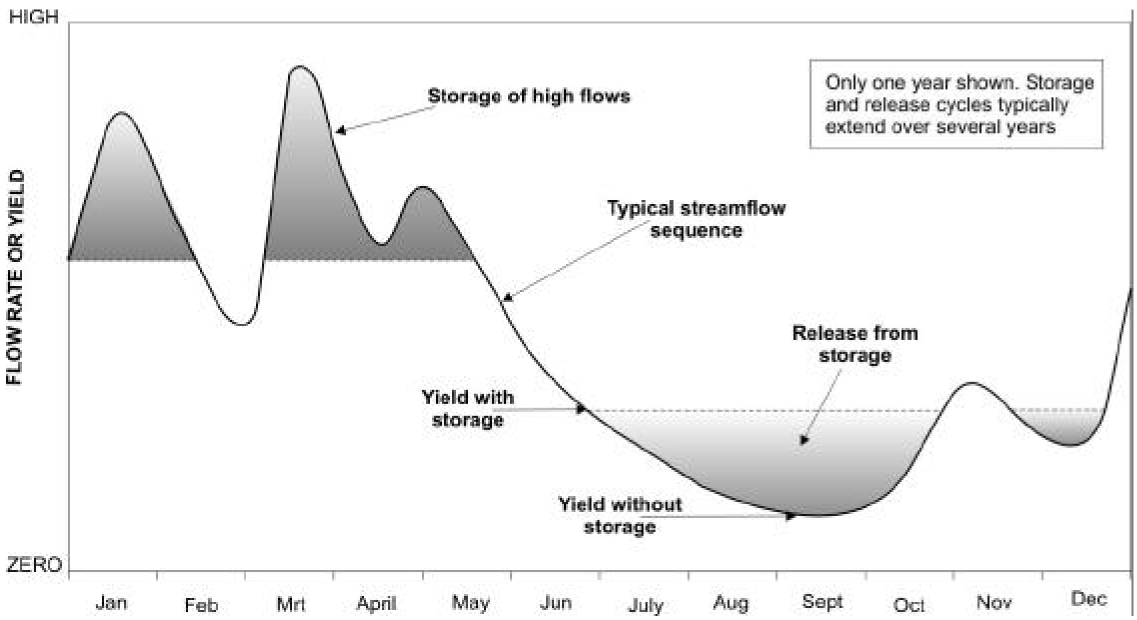
In the northern parts of the country (water management areas 1 to 5 and 8 to 10) both the surface and groundwater resources are nearly fully developed and utilised. Over-exploitation occurs in some localised areas. The reverse applies to the well-watered south-eastern region of the country (water management areas 11, 12 and 13) where there are still significant undeveloped and little-used resources.

The total mean annual runoff of South Africa under natural (undeveloped) conditions is estimated at a little over 49 000 million m^3/a, which includes about 4 800 million m^3/a and 700 million m^3/a of water originating from Lesotho and Swaziland respectively, which naturally drains into South Africa. The flows from neighbouring countries into rivers bordering on South Africa have been excluded, and the mean annual runoff thus represents the long-term average total renewable fresh water resources occurring in the country. A portion of this runoff needs to remain in the rivers to satisfy the requirements for the ecological component of the Reserve[3] (see Part 1 of Chapter 3), while only part of the remainder can practically and economically be harnessed as usable yield (see Box 2.1 for an explanation of "yield").

Box 2.1: Yield, reliability, available water and assurance of supply

The yield from a water resource system is the volume of water that can be abstracted at a certain rate over a specified period of time (expressed in million m^3/a for the purposes of the NWRS). For domestic, industrial and mining use water is required at a relatively constant rate throughout the year, whereas strong seasonality of use occurs with respect to irrigation. Because of the typically large fluctuations in stream flow in South Africa, as illustrated over a 12-month period in the diagram below, the highest yield that can be abstracted at a constant rate from an unregulated river is equal to the lowest flow in the river. By regulating stream flow by means of dams, water can be stored during periods of high flow for release during periods of low flow, as shown by the dotted lines on the diagram. This increases the rate at which water can be abstracted on a constant basis and, consequently, the yield. The greater the storage, the greater the yield that can be abstracted, within certain limits.

Diagrammatic presentation of stream flow and storage



Because rainfall, runoff and thus stream flow vary from year to year, low flows (and floods) are not always of the same duration and severity. The amount of water that can be abstracted without failure (the yield) therefore also varies from year to year. The amount of water that can be abstracted for 98 out of 100 years on average is referred to as *the yield at a 98 per cent assurance of supply*. Implicit in this is the acceptance that some degree of failure with respect to supplying the full yield will, on average, occur two years out of every 100 years. For a specific river and water resource infrastructure, the higher the assurance of supply required (or the smaller the risk of failure that can be tolerated), the smaller the yield that can be abstracted, and vice versa. For the purposes of the NWRS all quantities have been adjusted to a 98 per cent assurance, where applicable, to facilitate comparison and processing. This is necessary because yields or water requirements are not directly comparable when at different assurances of supply, but first need to be normalised to a common standard.

Available water refers to all water that could be available for practical application to desired uses. The total yield locally available includes the yield from both local surface water and groundwater resources, as well as contributions to the yield by usable return flows from the non-consumptive component of upstream water use in the area under consideration. Total water available includes the total local yield plus water transferred from elsewhere.

Also refer to the Introduction to Appendix D

A summary of the mean annual runoff and the estimated average annual requirements for the ecological component of the Reserve per water management area is given in Table 2.1, together with an estimate of the total storage capacity in large dams - full supply capacity exceeding 1 million cubic metres - in each area. In estimating the water available for abstraction it was assumed that maintaining the ecological flow requirements in drought conditions would be approximately equivalent to the impact of the ecological component of the Reserve on the yield [4]. All quantities relate to a particular water management area only, that is, quantities reflect water that originates in that particular area. Where more than one water management area is located along the same river, such as along the Vaal and Orange Rivers, the quantities from upstream water management areas have to be added to those of the water management area under consideration to reflect the actual, cumulative situation for the management area under consideration.

Great efforts have been made since the 1920s to assess the potential of the country's water resources. Various techniques were applied and different sources of information were used, the results of which are documented in a wide range of departmental reports. The numerical data given with respect to yield and available water can therefore be accepted as being of relatively high reliability. However, the figures are subject to review in future as some of the influencing factors change and as new extreme climatic events are observed over time. There is also evidence that the underlying patterns of the water cycle may be changing as a result of climate change, which may cause additional variation. In this manner, the database gradually expands to provide a more reliable assessment of resources. It is for this reason that the statistics on mean annual runoff given in Table 2.1 are slightly at variance with information published previously (also refer to section 2.4.1 below).

Quantification of the water requirements for the ecological component of the Reserve, while also soundly founded, is based on the currently still incomplete understanding of the functioning of ecosystems and their habitat requirements. These figures are therefore subject to improvement as better insights are gained through monitoring, studies and improved assessment methodologies. As reflected in Table 2.1, current provisional assessments indicate that, as a national average, about 20 per cent of the total river flow is required as ecological Reserve, which needs to remain in the rivers to maintain a healthy biophysical environment. This proportion, however, varies greatly across the country, from about 12 per cent in the drier parts to around 30 per cent in the wetter areas. Owing to a lack of better factual data it has provisionally been assumed that provision of the ecological water requirements in the lowest reach of a river will be sufficient to meet estuarine freshwater requirements as well.

The component of the Reserve required for basic human needs has to be abstracted from the water resource, and is therefore catered for under water requirements in Section 2.4.

In addition to appropriate quantities of water being made available for use, it is also essential for water to be of a suitable quality for a particular use, either for human and economic purposes or for the maintenance of ecosystems. Pollution of surface water occurs when too much of an undesirable or harmful substance is discharged into a resource, so that the natural assimilative capacity of the resource is exceeded and the water is rendered unfit for subsequent uses. The deterioration of the quality of surface water resources is one of the major threats to South Africa's capability to provide sufficient water of appropriate quality to meet its needs and to ensure environmental sustainability. Pollution of groundwater occurs where harmful substances, in excess of the natural assimilative capacity of the soils overlying the aquifer system, infiltrate into the ground and come into direct contact with underground water. Such pollution is of particular concern because it is difficult, costly and time consuming to rehabilitate (also refer to Box 2.2 on Water Quality). Water quality management therefore forms an integral part of the strategy for water resource management, as discussed in more detail in Part 2 of Chapter 3.

Table 2.1: Natural mean annual runoff and the ecological Reserve (million m³/a) and storage in major dams (million m³)

	Water Management Area	Natural Mean Annual Runoff (1)	Ecological Reserve (1, 2)	Storage in major dams (3)
1	Limpopo	986	156	319
2	Luvuvhu/Letaba	1 185	224	531
3	Crocodile West and Marico	855	164	854
4	Olifants	2 040	460	1 078
5	Inkomati (4)	3 539	1 008	768
6	Usutu to Mhlatuze (5)	4 780	1 192	3 692
7	Thukela	3 799	859	1 125
8	Upper Vaal	2 423	299	5 725
9	Middle Vaal	888	109	467
10	Lower Vaal	181	49	1 375
11	Mvoti to Umzimkulu	4 798	1 160	827
12	Mzimvubu to Keiskamma	7 241	1 122	1 115
13	Upper Orange (6)	6 981	1 349	11 711
14	Lower Orange (7)	502	69	298
15	Fish to Tsitsikamma	2 154	243	739
16	Gouritz	1 679	325	301
17	Olifants/Doring	1 108	156	132
18	Breede	2 472	384	1 060
19	Berg	1 429	217	295
	Total for South Africa	**49 040**	**9 545**	**32 412**

1) Quantities refer to the water management area under consideration only, thus water originating in that water management area.
2) Total volume, based on preliminary estimates. The impact on yield will be smaller than this number.
3) Includes dams constructed to end-2003 with capacity exceeding 1 million cubic metres, but excludes dams constructed solely for flood control (Qedusizi in WMA 7 and Beervlei in WMA 15). Accounts for accumulated sediment according to most recent surveys and includes dead storage
4) Includes the Komati catchment in Swaziland (mean annual runoff = 517 million m³/a).
5) Includes the Pongola catchment in Swaziland (mean annual runoff = 213 million m³/a).
6) Storage includes Katse and Mohale dams in Lesotho.
7) Includes contributions from the Senqu and Caledon Rivers in Lesotho (mean annual runoff = 4 765 million m³/a).

Major sources of pollution of surface waters are agricultural drainage and wash-off (irrigation return flows, fertilisers, pesticides and runoff from feedlots), urban wash-off and effluent return flows (bacteriological contamination, salts and nutrients), industries (chemical substances), mining (acids and salts) and areas with insufficient sanitation services (microbial contamination). Pollution of groundwater results from mining activities, leachate from landfills, human settlements and intrusion of sea water.

The relevant contributions of different components (surface water, groundwater and return flows) to the available yield in each of the water management areas are indicated in Table 2.2. It should be noted that substantial volumes of water are returned to streams after use, and are then available for re-use, provided that the quality of the return flows satisfy the relevant user requirements. In fact, the total usable return flows are close to double the current yield from groundwater. The negative yields from surface water in the Middle Vaal, Lower Vaal and Lower Orange water management areas reflect the fact that river losses due to evaporation and seepage are greater than the additional yield contributed by local runoff in these areas.

According to estimates of undeveloped resource potential, the yield from surface water can be increased by about 5 400 million m^3/a by further resource development. This estimate excludes possible developments which are unlikely to be economically viable or of otherwise doubtful feasibility. In addition, substantial quantities of water could become available by increasing the re-use of return flows. There is specific potential for this at some coastal cities, where wastewater is at present discharged to the sea. The potential also exists for further groundwater development, although generally on a smaller scale than the other options. In many instances groundwater exploitation could also have an impact on surface water availability. More detailed information on the groundwater situation in South Africa, as well of groundwater/surface water interdependencies, is given Box 2.3.

Desalination of seawater offers particular opportunities for coastal users. Although generally still more expensive than developing (and transferring) surface resources, the technology is tending to become more competitive as a result of advances in the field, particularly through the introduction of more cost-efficient membrane technologies. Desalination is practised on a large scale in many Middle Eastern countries and specific local situations exist in South Africa where small-scale desalination has proved to be more cost-effective than transporting fresh water over long distances.

Consideration has in the past been given to other options and less-conventional sources to augment water supplies in South Africa. These include the importation of water from, for example, the Zambezi River, rainfall augmentation by cloud seeding, the shipping of fresh water from the mouths of large rivers and towing icebergs to South Africa. Although most of these ideas are technically feasible, there are various degrees of environmental, political and legal considerations attached to each one. Based on current scientific understanding and cost structures, it is not anticipated that any of these options will be competitive at a significant scale compared to the options discussed under section 2.5, particularly within the time frame of the first edition of the NWRS.

Table 2.2: Available yield in year 2000 (million m³/a) (1)

Water management area	Natural Resource		Usable return flow			Total local yield
	Surface water (2)	Ground water (3)	Irrigation	Urban	Mining and bulk industrial	
1 Limpopo	160	98	8	15	0	281
2 Luvuvhu/Letaba	244	43	19	4	0	310
3 Crocodile West and Marico	203	146	44	282	41	716
4 Olifants	410	99	44	42	14	609
5 Inkomati	816	9	53	8	11	897
6 Usutu to Mhlatuze	1 019	39	42	9	1	1 110
7 Thukela	666	15	23	24	9	737
8 Upper Vaal	598	32	11	343	146	1 130
9 Middle Vaal	(67)	54	16	29	18	50
10 Lower Vaal (3)	(54)	126	52	0	2	126
11 Mvoti to Umzimkulu	433	6	21	57	6	523
12 Mzimvubu to Keiskamma	777	21	17	39	0	854
13 Upper Orange	4 311	65	34	37	0	4 447
14 Lower Orange (4)	(1 083)	24	96	1	0	(962)
15 Fish to Tsitsikamma	260	36	103	19	0	418
16 Gouritz	191	64	8	6	6	275
17 Olifants/Doring	266	45	22	2	0	335
18 Breede	687	109	54	16	0	866
19 Berg	403	57	11	37	0	505
Total for country	**10 240**	**1 088**	**675**	**970**	**254**	**13 227**

1) Transfers into and out of water management areas are not included above, but are covered in Table 2.4
2) Yield from run-of-river and existing storage, after allowance for the impacts on yield of the ecological component of the Reserve, river losses, alien vegetation, rain-fed sugar cane and urban runoff.
3) Estimated use from existing boreholes ad springs. As a result of development of groundwater for irrigation since the compilation of the database for the NWRS, total groundwater use may exceed this estimate. The increase is mainly due to growth in irrigation water requirements, and therefore does not significantly impact on the overall water balances given in the NWRS.
4) Negative figures under surface water caused by river losses being larger than the incremental runoff from within the water management area.

Box 2.2: Water quality

Water quality refers to the physical, chemical and biological characteristics of water. It describes how suitable the water is for its intended purpose in nature or for use by different water users. Different ecosystems and different user groups can have widely variable water quality requirements. The quality of water to maintain trout streams is not the same as that needed for irrigation, which is also not the same as that needed for drinking water or other purposes.

The factors influencing water quality can either be natural or result from human activity. The main natural factor that influences the quality of water is the geology of the formations over which water flows or through which it percolates, which gives rise to sediment load and mineralisation of the water. Vegetation, the slope of the land and flow rate may also influence water quality. The impacts of human activity on water quality are more varied and complex. Diffuse pollution results from various land use activities; most significantly agricultural practices and human settlements as well as the precipitation of pollutants from the air. Point sources of pollution typically are where urban, industrial and mining effluent is discharged to streams other and receiving waters. Water resource management interventions such as diversion, storage and inter-catchment transfer of water also impact on water quality.

Physical characteristics (mainly temperature, sediment load and turbidity) impact on aquatic life, recreational uses and the treatment of water for other uses. The main impacts of chemicals in the water relate to salinisation (dissolved salts) which may render water unfit or very costly to treat for application to many uses such as irrigation and household use. Eutrophication, which is the enrichment of water with plant nutrients, gives rise to excessive growth of macrophytes and microscopic plants such as algae and cyanobacteria in rivers and reservoirs. Cyanobacteria (often referred to as blue-green algae) is toxic, and may cause the water to be unfit for recreational, irrigation and domestic use.

Pollution by metals and manufactured organic components such as herbicides and pesticides is also becoming an increasing problem in South Africa due to industrialisation, and can have serious impacts on human and animal health. Microbial contamination, arising mainly from untreated sewage entering water resources due to poorly maintained or a lack of sanitation services, poses a widespread problem in South Africa, carrying pathogens that may cause water borne diseases such as diarrhoea and cholera.

The main activities that can contribute to the determination of water quality are mining (acidity and increased metals content); urban development (salinity, nutrients, microbiological); industries (chemicals, toxins), and agriculture (sediment, nutrients, agro-chemicals, salinity through irrigation return flows). The pollution of surface waters is generally more common and noticeable than with regard to groundwater. In contrast pollution of groundwater is often not readily detectable and may be very difficult, costly and time-consuming to remedy. More detail on water quality management is given in section 3.2.4.

A general perspective on the water management areas in which physico-chemical water quality characteristics may be outside the ideal ranges is given in the table below.

	Water management area	Domestic use								Irrigation use				Recreational Use
		F	TDS	Ca	Mg	SO_4	Cl	Na	K	SAR	EC	pH	Cl	
1	Limpopo													
2	Luvuvhu / Letaba											(+)		
3	Crocodile West & Marico											(+)		X
4	Olifants	X									L	(+)		X
5	Inkomati													
6	Usutu to Mhlatuze						X				L	(+)	L	
7	Thukela													X
8	Upper Vaal					X								X
9	Middle Vaal													X
10	Lower Vaal													X
11	Mvoti to Umzimkulu													X
12	Mzimvubu to Keiskamma											(+)		X
13	Upper Orange		X					X				(+)		
14	Lower Orange		X					X		L	M	(+)	M	X
15	Fish to Tsitsikamma		X	X		X	X	X		L	LMH	(-) (+)	LMH	X
16	Gouritz		X	X	X	X	X	X	X	LM	H	(-)	H	
17	Olifants / Doring													
18	Breede						X				L		L	X
19	Berg													

Key

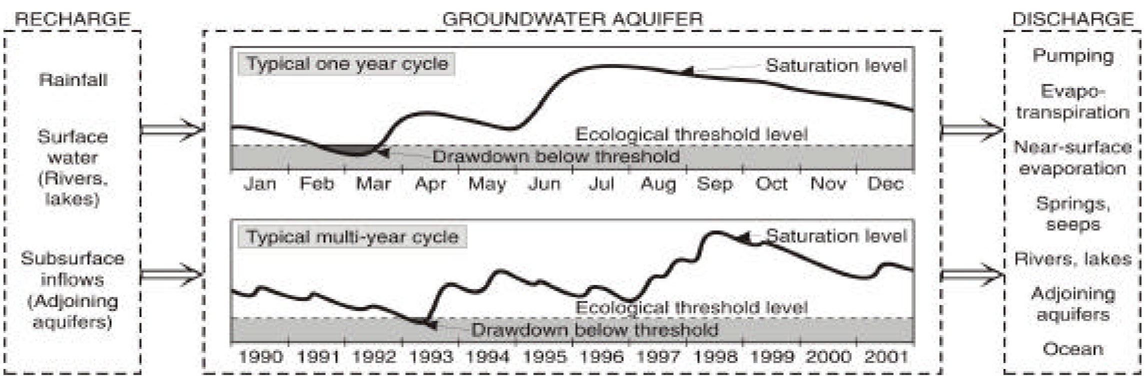
Domestic use: X indicates that the water quality indicator is outside the ideal range for domestic use at some locations in the water management area.
F = Fluoride; TDS = Total dissolved salts; Ca = Calcium; Mg = Magnesium; SO_4 - Sulphate; Cl = Chloride; Na = Sodium; K = Potassium.
Irrigation use: A symbol indicates that the water quality indicator is outside the target water quality range for irrigation use at some locations in the water management area, where L, M and H means Low, Medium or High risk, (+) = alkaline and (-) = acidic.
SAR = Sodium Adsorption Ratio; EC = Electrical Conductivity; pH = a measure of acidity/alkalinity; Cl = Chloride; b = Boron.
Recreational Use: X indicates that the water quality indicator is occasionally outside the acceptable levels for recreational use at some locations because toxic cyanobacteria have been found.

Box 2.3: Groundwater

Groundwater and surface water are different occurrences of the same resource. The interactions between the two, the effects on one of using the other, and the role of groundwater in supporting ecosystem functioning are imperfectly understood. However, some general information on the nature and role of groundwater should help to clarify this situation.

Excluding water locked in the polar ice caps, groundwater constitutes about 97% of all fresh water on Earth. The remainder occurs in lakes, rivers and swamps. Although groundwater is not abundant in South Africa because of the predominantly hard rock geology, it is relatively easily accessible throughout the country and is a vital source of supply to many users. Groundwater is extensively used for rural domestic purposes, stock watering, water supply to villages and smaller towns as well as irrigation in localised areas. In general it can be found within reasonable distance from where it is required throughout most of South Africa, and therefore constitutes a primary source of water over much of the country.

Groundwater replenishment - recharge - is primarily from rainfall, but also occurs through seepage from other water bodies. Depending on the magnitude of the recharge event, groundwater levels respond in a typical rising trend followed by a steady, long-term decline as a result of discharge from the system (see diagram below).



Diagrammatic representation of aquifer saturation level (water table) response to recharge and discharge

Natural discharge in the form of river baseflow, seepage and evapo-transpiration from plants could be linked to groundwater's ecological support. The balancing role of regional groundwater storage is of great importance for both natural and managed water resource systems, whilst there also is a growing recognition of the ecological importance of groundwater, particularly where it links to groundwater-dependent ecosystems. Additional lowering of the groundwater table by means of abstraction (through pumping) beyond its ecological threshold level will impact on the ecological services of the system, which includes estuaries, wetlands and springs.

The Annual Harvest Potential, derived from an evaluation of the mean annual recharge of groundwater (adjusted for drought period rainfall), gives an indication of the maximum volume of groundwater that may be abstracted without depleting the aquifers, although some natural discharge functions may be impacted. The Harvest Potential for the whole of South Africa was estimated at 19 000 million cubic metres per year (Mm^3/a). Of this, approximately 6 000 Mm^3/a, stored as general recharge, could be abstracted without impacting on surface water resources. Although a substantial quantity of groundwater therefore appears to be available for use it occurs mainly as a diffuse source in many separate aquifers. Only that part which occurs in suitable quantities at locations where demands exist, and where its use will be economically feasible or socially justifiable will eventually be abstracted.

Estimates of present groundwater use in each water management area are given in Table 2.2. No separate allowance was made in Tables 2.5 and 2.6 for the potential future development of groundwater. Instead, the potential given for development is a conservative estimate of the combined potential for both surface and groundwater, primarily based on the more readily quantifiable surface resource potential.

Consideration also needs to be given to the quality of groundwater and to what extent it conforms to user requirements. Groundwater may be too mineralised for direct use without treatment, particularly in the drier parts of the country. However, the use of groundwater conjunctively with surface waters also offers significant potential benefits as it facilitates the optimal blending of the most wanted characteristics from both components.

Optimal management and utilisation of groundwater resources will require improved capacity to assess groundwater potential and monitor trends, and a better understanding of aquifer functioning, the interactions between surface and groundwater and the impacts of groundwater use on ecological functioning. Proposals to expand and refine the groundwater monitoring and assessment system are outlined in Part 6 of Chapter 3.

2.4 WATER REQUIREMENTS

For the judicious management of water resources an appropriate knowledge and understanding of the requirements for water is as essential as knowledge of the resource itself. A factor that compounds the already complex water resource situation in South Africa is the large variation in water requirements across the country, which is similar to the variation that exists with regard to the availability of water resources. In addition to differences in the requirements of the various water use sectors relating to quantity, quality, temporal distribution and assurance of supply, divergent social and economic values associated with water and abilities to pay have to be taken into account. In addition, a variety of external factors can impact on growth rates. Importantly, certain priorities with regard to the provision of water also need to be recognised, relating to the primary roles of water in sustaining life, and in supporting social and economic development.

For the purposes of the NWRS information and statistics are provided here with respect to the main user sectors. The ecological component of the Reserve is not included as a use since it is allowed for as a part of the resource that may not be abstracted (refer to section 2.3). Water to meet international obligations is covered in section 2.7.2. It is not included as a user sector as it does not constitute an internal use of water in South Africa, but is accounted for in the reconciliation tables (Tables 2.4, 2.5 and 2.6). The water use sectors that are covered are the following -

- Rural requirements, which mainly represent domestic use and stock watering requirements in rural areas.
- Urban requirements, which include all water used in urban areas for domestic, industrial, commercial, parks and other communal purposes.
- Mining and bulk users, representing large mining and industrial users abstracting directly from the resource or bulk supply systems, not from municipal systems.
- Power generation (also refer to water use of strategic importance under section 2.7.3).
- Irrigation for agricultural production.
- Afforestation, as a formally declared stream flow reduction activity (see Part 2 of Chapter 3).
- Transfers of water out of a particular area, which constitutes a requirement for water from that area. (These are not shown as a requirement in Table 2.3, but are included in the reconciliation tables).

The provision of water for basic human needs (the human component of the Reserve) is included under rural and urban requirements and is taken as the first 25 litres/person/day of these requirements.

2.4.1 Current water requirements

The base data on water requirements was obtained through a series of country-wide situation assessments. Data was obtained from a wide range of sources, and various methods were use for its verification and enhancement.

Estimated water requirements for the year 2000 for the different water use sectors, standardised to the equivalent quantities at a 98 per cent assurance of supply for the purposes of direct comparison, are given in Table 2.3 (refer to Box 2.1 for an explanation of assurance of supply). In many cases, such as for certain irrigation practices, considerably more water than indicated in the table is abstracted when it is available, but on the understanding by the user that there is a high risk of inadequate water being available in some years. Although the statistics are acceptable for the purposes of the NWRS, their accuracy varies significantly among user sectors as well as geographically. Uncertainties exist in particular with regard to the quantities of water abstracted for irrigation and, as this sector represents more than half of the country's total water use, it will be receiving particular attention in the relevant programmes of the Department.

Table 2.3: Water requirements for the year 2000 (million m³/a)

	Water management area	Irrigation	Urban (1)	Rural (1)	Mining and bulk industrial (2)	Power generation (3)	Afforesta-tion (4)	Total local require-ments
1	Limpopo	238	34	28	14	7	1	322
2	Luvuvhu/Letaba	248	10	31	1	0	43	333
3	Crocodile West and Marico	445	547	37	127	28	0	1 184
4	Olifants	557	88	44	94	181	3	967
5	Inkomati	593	63	26	24	0	138	844
6	Usutu to Mhlathuze	432	50	40	91	0	104	717
7	Thukela	204	52	31	46	1	0	334
8	Upper Vaal	114	635	43	173	80	0	1 045
9	Middle Vaal	159	93	32	85	0	0	369
10	Lower Vaal	525	68	44	6	0	0	643
11	Mvoti to Umzimkulu	207	408	44	74	0	65	798
12	Mzimvubu to Keiskamma	190	99	39	0	0	46	374
13	Upper Orange	780	126	60	2	0	0	968
14	Lower Orange	977	25	17	9	0	0	1 028
15	Fish to Tsitsikamma	763	112	16	0	0	7	898
16	Gouritz	254	52	11	6	0	14	337
17	Olifants/Doring	356	7	6	3	0	1	373
18	Breede	577	39	11	0	0	6	633
19	Berg	301	389	14	0	0	0	704
	Total for country	**7 920 62%**	**2 897 23%**	**574 4%**	**755 6%**	**297 2%**	**428 3%**	**12 871**

1) Includes the component of the Reserve for basic human needs at 25 litres/person/day.
2) Mining and bulk industrial that are not part of urban systems.
3) Includes water for thermal power generation only, since water for hydropower, which represents a small portion of power generation in South Africa, is generally also available for other uses. (For ease of direct comparison with Eskom these numbers have not been adjusted for assurance of supply; the quantitative impact of which is not large).
4) Quantities given refer to impact on yield only. The incremental water use in excess of that of natural vegetation is estimated at 1 460 million m³/a.

Comparison of the statistics contained in this document with information published by the Department previously will reveal what appear to be significant discrepancies in both the available yield and in water requirements. These can be attributed to differences in some primary assumptions, revised definitions, the standardisation of yield and requirements to a common assurance of supply, and new sources of data becoming available. A reconciliation of information contained in the NWRS with that published in the *Overview of Water Resources Availability and Utilisation in South Africa* (1997) is given in Box 2.4.

Comparison of the requirements in Table 2.3 with the corresponding return flows in Table 2.2 provides an indication of the extent to which water use is consumptive. On average, usable return flows from the rural, irrigation, urban and mining/bulk sectors are estimated at 0, 9, 33 and 34 per cent respectively. Only a portion of the water used non-consumptively becomes available for re-use, with large quantities of effluent return flows, particularly from urban and bulk industrial users in coastal areas, being discharged to the ocean. Water use in the rural areas, as well as for irrigation and thermal power generation, is predominantly consumptive.

Agricultural irrigation represents more than 60 per cent of the total water requirements in the country, urban requirements constitute about 23 per cent and the remaining 15 per cent is shared by the other four sectors (all standardised to 98 per cent assurance of supply).

Fig. 2.4 gives the relative contribution of different economic sectors to the national economy. Although the economic sectors do not correspond directly to water use sectors, valuable insights can nevertheless be gained from this comparison. Particularly noteworthy from a water resources perspective is the fact that the direct contribution of the agricultural sector to the gross domestic product (GDP) is only about 4.5 per cent. Of this percentage only an estimated 25 to 30 per cent is from irrigated agriculture. Therefore, even though irrigation represents about 60 per cent of the total water use, its contribution to the gross domestic product is less than 1.5%. The remaining percentage comprises rain fed cultivation and livestock farming, and afforestation.

It is important though, that the sectoral contributions to the GDP are not viewed as an absolute indicator because of the strong linkages and inter-dependencies that exist among economic sectors. The agricultural sector in particular has strong forward linkages by supplying raw materials as inputs to other primary and secondary sectors. In 1985 approximately 58% of the total value of agricultural production was delivered as raw materials to processing plants, which contributed about 8,5% to the total value of industrial production. Agriculture also creates a strong demand for goods and services, such as fertiliser, machinery and financial services through its backward linkages. In total, agriculture was estimated to support approximately 25% of the manufacturing sector's contribution to the GDP. In some areas as much as half of some key multipliers from the agricultural sector have effects in areas remote from the primary agricultural activities. Similar considerations also apply to other primary sectors such as mining, and to a greater or lesser extent to all components of the economy.

The general indications, however, are that the economic impact per unit of water used in at least some parts of irrigated agriculture is substantially less than in other sectors. It will be necessary to obtain additional reliable information in this regard, and take it into account in the formulation of catchment management strategies, where the target should be to strive for the overall most beneficial use of water.

Additional perspective is gained when comparing the proportionate employment per economic sector, as shown in Fig. 2.5 with respect to those formally employed in 1994. Employment by the agricultural sector (irrigation and rain fed farming combined) accounted for about 11 per cent of total national employment, which is significantly higher than the proportionate economic production of this sector, reflecting the relative labour intensiveness of agriculture. The same applies to the construction, government and community sectors. In contrast, the manufacturing,

Box 2.4: Reconciliation of information given in the NWRS with information published previously

Significant differences appear to exist when direct comparisons are made between information given in the NWRS and that published in 1997 in the *Overview of Water Resources Availability and Utilisation in South Africa*. A summary of the main differences and the reasons for them follows.

Reference date

The *Overview* report used 1996 data as a reference base and also gave a high water use scenario for the year 2030. In the NWRS the year 2000 is used as reference date, with a base as well as a high projection of water requirements for the year 2025.

Mean annual runoff

Based on the availability of longer records and improved assessments of stream flow, a slight adjustment to the mean annual runoff has been made, from 50 150 million m^3/a in the *Overview* report to 49 040 million m^3/a in the NWRS. (If only water that originates in South African territory is considered, the mean annual runoff is estimated to be 43 500 million m^3/a).

Water requirements

The total water requirements for South Africa are stated as being 20 045 million m^3/a in the *Overview* (at 1996 development levels), compared to 12 871 million m^3/a in the NWRS (at year 2000 reference date). These figures are not directly comparable, however, because of different approaches and definitions. In the *Overview* report environmental water requirements were included with the other water use sectors. In the NWRS it is argued that water for environmental purposes should remain in the rivers where it is actually needed. The NWRS therefore accounts for environmental requirements as a reduction in the yield of a water resource rather than as the abstractable or out-of-river requirements of other water use sectors. Furthermore, the water requirements given in the *Overview* report represent the combination of estimated actual requirements by different user groups (by sector and geographic area) without any adjustments having been made with respect to the assurance of supply (also refer to Box 2.1), whereas all the requirements in the NWRS have been standardised to a 98 per cent assurance of supply. It is typical, for example, for large quantities of water to be used for irrigation when it is available, even though it is accepted that it is at a low assurance of supply. In some parts of the country larger areas are also planted when water is available, whilst some of that land may lie fallow for several years during dry periods. In the calculations for the NWRS irrigation water requirements were based on the areas that would generally be under irrigation and are given at the standard 98 per cent assurance of supply.

After making adjustments according to the above to prove a direct comparison, and allowing for growth in demand between 1996 and 2000, the water requirements in the *Overview* report would amount to 13 700 million m^3/a .

Although this figure is quite similar to the 12 871 million m^3/a of the NWRS, differences still occur with respect to specific sectors and geographic areas. These are attributable to continuous improvements being made to the databases.

Yield potential

In the *Overview* report, a maximum yield potential of 33 000 million m^3/a is given, compared to about 20 000 million m^3/a in the NWRS. Similar to the situation with water requirements, adjustments need to be made to environmental requirements and assurance of supply, which reduce the estimate in the *Overview* report to about 26 000 million m^3/a.

The still lower estimate of yield potential in the NWRS is attributable to the fact that the purpose of the estimate in the *Overview* report was to give a theoretical ceiling value. The NWRS, in contrast, reflects the current greater sensitivity to environmental sustainability and also excludes developments of doubtful economic viability.

Figure 2.4: Sectoral contributions to the GDP (1997)

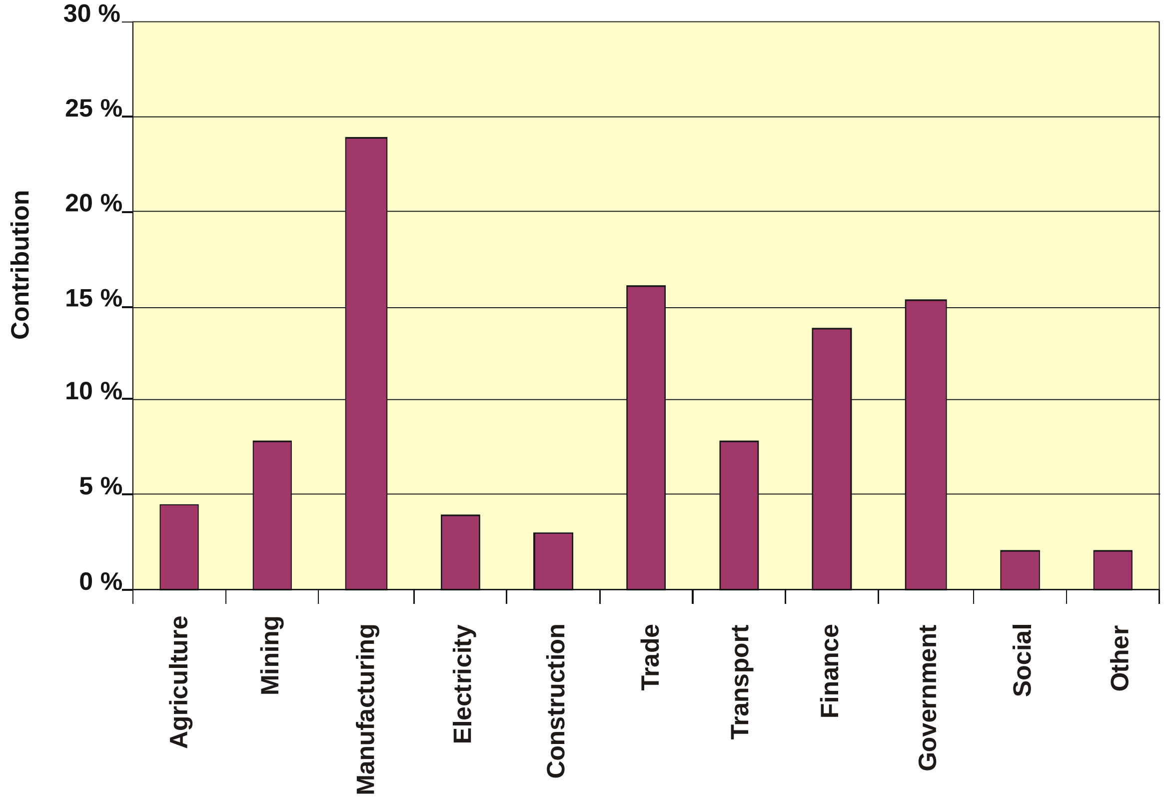
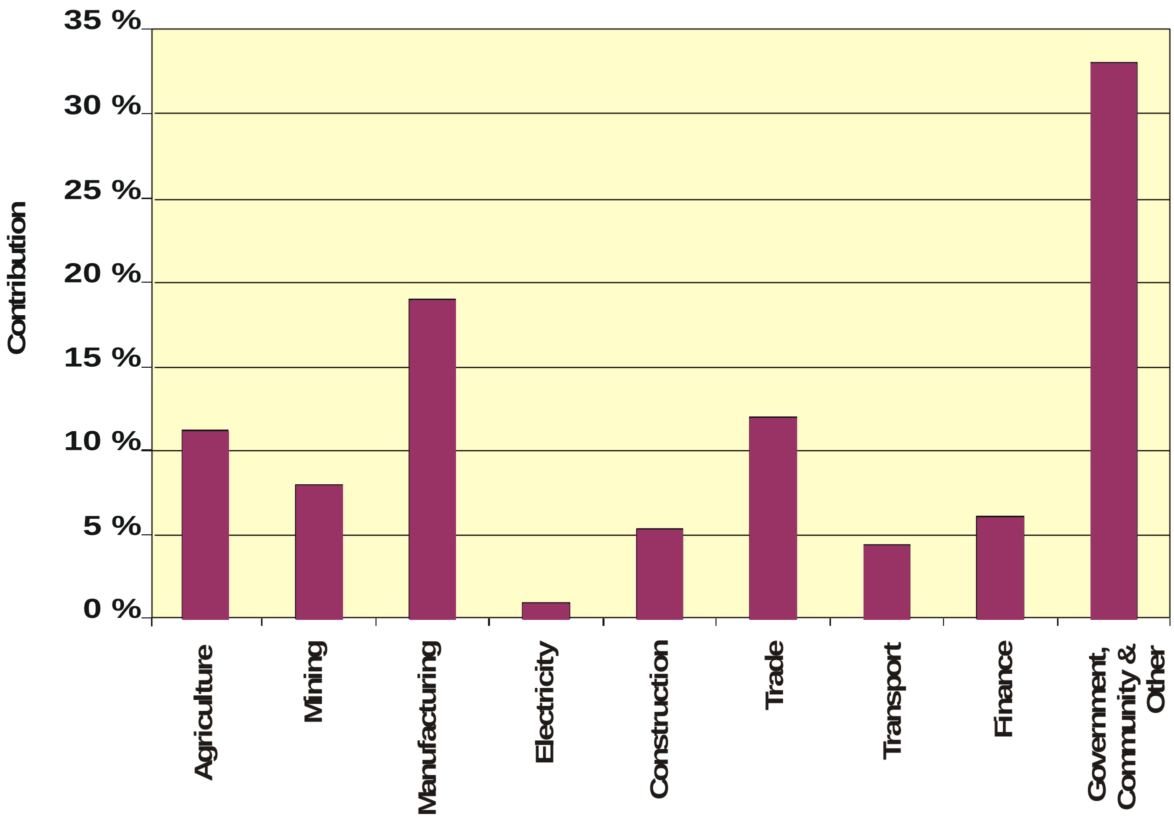


Figure 2.5: Formal employment per sector (1994)



electricity, trade, transport and finance sectors offer less employment per unit of economic production than the national average, with mining being neutral.

For irrigated agriculture only, employment is just over 1.5 per cent of the national total (10 to 15 per cent of the total agriculture sector), which is similar to its contribution to GDP. Employment per unit of economic production with respect to irrigation farming is thus close to the national average for all sectors of the economy and is substantially less than for agriculture as a whole. The same applies to employment opportunities per unit of capital invested. Whereas the employment/capital ratio is comparatively high for the total agricultural sector, irrigated agriculture does not hold above average employment creation advantages. This reflects the capital intensive nature of modern irrigation farming.

2.4.2 Future water requirements

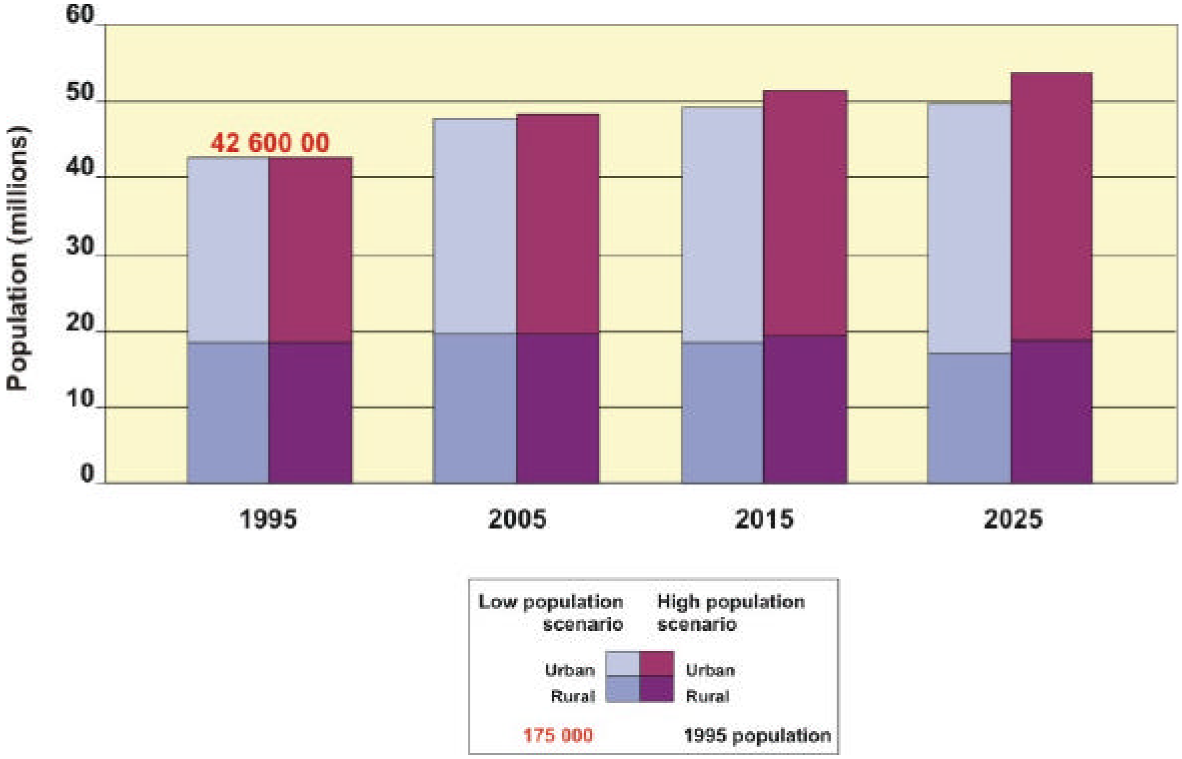
There are many factors that influence the requirements for water in South Africa. These include climate, the nature of the economy (i.e. irrigated agriculture, industrialisation) and standards of living. Of these, climate has in the past been a relatively stable factor (but see Box 2.10 for a discussion of the possible implications of global climate change), while in most cases control can be exercised over the growth in demand for irrigation water. However, population, standards of living and economic activity have their own inherent growth rates and each is dependent on a wide spectrum of external influences. Population and economic growth relate to socio-economic standards, and are therefore regarded as the primary determinants with respect to future water requirements.

Projections of population growth and the future distribution of people between urban and rural areas and different regions is not a simple matter. Changes in national policies since 1994 in combination with the influence of global economic trends on South Africa have stimulated migration to certain areas and population declines in others. Specifically evident are the strong urbanisation trend and the negative impact of HIV/AIDS. Recognising that the future will not be a simple extension of the past, a detailed study of the expected demographic and socio-economic changes in the country, and the associated impacts on water requirements, was conducted to serve as background to the NWRS. The main outcome was the expectation of lower population growth rates than previously, mainly due to the impact of HIV/AIDS, as well as reduced reproduction rates linked to urbanisation and economic growth. The high and low population scenarios that were developed are shown diagrammatically in Fig. 2.6. Evident from the diagram is a slowing in the population growth rate in later years and small to negative growth in the rural population.

Estimates of the future population[5] were initially made for the country as a whole, and then subdivided into smaller geographic units to facilitate the estimation of future water requirements on a regional basis. Because of the trend towards urbanisation and the expected stronger economic growth in the major urban and industrial centres, the greatest long-term uncertainty about future water requirements exists in these user sectors. Greater attention was therefore given to the main urban centres in the subdivision of population, with less substantiation of the population projections for smaller centres and some rural areas. The population projections for the latter areas will need to be examined in more detail during the development of catchment management strategies.

Scenarios were also developed for economic growth, and for the influence of economic growth on future water requirements, in an attempt to narrow the uncertainties which the future holds. Multi-variate analyses were performed in order to develop scenarios of possible low and high economic growth for different geographic regions in the country. Gross Geographic Product (GGP) was considered the most relevant economic indicator for the purposes of the NWRS because of relationships that can be established to water usage. The outcome was an upper scenario of average real growth in GDP of over 4 per cent per year for the period up to 2025, and a less favourable low growth scenario of roughly 1.5 per cent per year. In general, economic growth is expected to be substantially higher in the larger urban and industrialised areas and those which are favourably located with respect to resources and transportation routes than in the rural areas. Consideration was given to the trend towards growth in service and manufacturing industries, and the expected impact of changing trade patterns on manufacturing, transport infrastructure and export facilities.

Figure 2.6: Diagrammatic presentation of anticipated population growth (RSA total)



Based on these scenarios, initial estimates of possible future water requirements were made until the year 2025. Eskom's projections of future water requirements for power generation were added. Provision was also made for known and probable future developments in irrigation, mining and bulk use, as described under the respective water management areas in Appendix D. (Specific quantities, rather than general annual growth rates, were allowed for in these sectors.)

Apart from the requirements for water in the established user sectors, which can be calculated with relative ease, the quantities of water required for redressing inequities and poverty eradication will depend strongly on the specific requirements of local and regional development strategies. Such water requirements are difficult to project, and quantitative allowances were made only where sufficient information was available. However, through appropriate application of the reconciliation strategies given in the NWRS (refer to Part 2.5, Chapter 3 and Appendix D), sufficient resources could be made available to meet all priority requirements for water.

Given the general trends in the country towards urbanisation and continued economic growth, future growth in water requirements is expected to occur in the economically more favourably located urban areas. (Caution should, however, be exercised not to misinterpret temporary migration from rural areas to towns as a long term sustainable growth of population in these areas, as this may be an interim step towards migration to the larger cities). Relatively strong growth is also foreseen in the mining sector, with water demand for mineral exploitation anticipated principally in the northern regions of the country.

Within the spectrum of population and economic growth scenarios, a base scenario was selected for estimating the most likely future water requirements. This comprises the high scenario of population growth together with higher average levels of urban domestic water requirements[6] resulting from a more equitable distribution of wealth. The ratio of domestic to commercial, communal and industrial water use for urban centres in the year 2000 is maintained. A possible upper limit scenario is also proposed. This scenario is based on the same assumption of high population growth and a high standard of service provision flowing from rapid socio-economic development, with the distinction that these are combined with strong economic growth in which commercial, communal and industrial water use increases in direct proportion to growth in GDP. The upper scenario is intended to serve as a conservative indicator to prevent the occurrence of possible unexpected water shortages. Figures for both scenarios are presented in section 2.5. No adjustments have been made to reflect the impact increased water use efficiency would have.

2.5 STRATEGIES TO BALANCE SUPPLY AND DEMAND (RECONCILIATION)

2.5.1 Current situation

A reconciliation of the available water and total requirements for the year 2000, including transfers between water management areas and to neighbouring countries, is given in Table 2.4. The transfer of water from the Upper Orange River to the Upper Vaal water management area via the Lesotho Highlands Water Project (LHWP) is reflected as being from the Upper Orange water management area. Consequently the table does not explicitly reflect the fact that water is being imported into South Africa from another country. The transfer of 170 million m^3/a out of South Africa relates to water being delivered from the Crocodile West and Marico water management area to Gaborone in Botswana (7 million m^3/a), the minimum flow released from the Inkomati water management area to Mozambique (109 million m^3/a), and abstractions from the Orange River Project by Namibia (54 million m^3/a). The bulk of the transfers is between water management areas, either by aqueducts or in the form of yield released along rivers. (Refer to Box 2.5 for an explanation of quantities relevant to the inter-catchment transfer of water).

Deficits exist in more than half of the water management areas, whilst a surplus still exists for the country as a whole. This demonstrates the regional differences in the country, and highlights the potential risks of generalisation. Similarly, a surplus or a deficit shown in a particular water management area is unlikely to be representative of the area as a whole, and anomalies are most likely to occur in some catchments or smaller areas within the water management area. Furthermore, the water availability and water balance figures are relevant to current water use patterns and the existing geographic occurrence of resources, abstractions and return flows. Often it is not practical or economically viable for water to be transferred from areas of surplus to areas of deficit (as demonstrated in Appendix D 2.3 with respect to the Crocodile West and Marico water management area). Imbalances within water management areas will be handled according to the catchment management strategies to be developed by catchment management agencies.

In addition, it should be noted that in many cases the deficits shown do not imply that present actual use exceeds the amount of water reckoned to be available, but that the allowances made for the implementation of the ecological component of the Reserve cannot be met fully at present levels of use. Whilst the requirements for the Reserve are only indicative at present and have not yet been implemented, it is prudent that all known and estimated requirements are included in the NWRS. This will help to ensure proper implementation management when the Reserve is formally brought into effect in catchments across the country. It is intended to follow a phased approach for the implementation of the Reserve, in order to minimise possible negative impacts on existing users.

Table 2.4: Reconciliation of the requirements for and availability of water for year 2000 (million m³/a)

Water management area		Reliable local yield	Transfers in (3)	Local requirements	Transfers out (3)	Balance (1, 2)
1	Limpopo	281	18	322	0	(23)
2	Luvuvhu/Letaba	310	0	333	13	(36)
3	Crocodile West and Marico	716	519	1 184	10	41
4	Olifants	609	172	967	8	(194)
5	Inkomati	897	0	844	311	(258)
6	Usutu to Mhlatuze	1 110	40	717	114	319
7	Thukela	737	0	334	506	(103)
8	Upper Vaal	1 130	1 311	1 045	1 379	17
9	Middle Vaal	50	829	369	502	8
10	Lower Vaal	126	548	643	0	31
11	Mvoti to Umzimkulu	523	34	798	0	(241)
12	Mzimvubu to Keiskamma	854	0	374	0	480
13	Upper Orange	4 447	2	968	3 149	332
14	Lower Orange	(962)	2 035	1 028	54	(9)
15	Fish to Tsitsikamma	418	575	898	0	95
16	Gouritz	275	0	337	1	(63)
17	Olifants/Doring	335	3	373	0	(35)
18	Breede	866	1	633	196	38
19	Berg	505	194	704	0	(5)
	Total for country	**13 227**	**0**	**12 871**	**170**	**186**

1) Brackets around numbers indicate a negative balance.
2) Surpluses in the Vaal and Orange water management areas are shown in the most upstream water management area where they become available (that is, the Upper Vaal and Upper Orange water management areas.)
3) Transfers into and out of water management areas may include transfers between water management areas as well as to or from neighbouring countries. Yields transferred from one water management area to another may also not be numerically the same in the source and recipient water management area (refer Box 2.5). For this reason, the addition of transfers into and out of water management areas does not necessarily correspond to the country total. The same applies to Tables 2.5 and 2.6. The transfer of water from Lesotho to South Africa is reflected in the tables as being from the Upper Orange water management area (see also Appendix D 13.)

Nevertheless, in many areas current levels of use take no account of the need to sustain the ecological functioning of the resource, and substantial changes will have to be made when the Reserve is implemented. This situation is addressed in more detail for each water management area in Appendix D.

Existing surpluses will generally be taken up in the foreseeable future by growth in the domestic, urban, industrial and mining requirements for water. In a few instances – see Appendix D – existing surpluses may be applied beneficially to irrigation or afforestation.

Although not explicitly quantified, water quality must also be considered in the reconciliation under discussion here. For example, the surplus shown for the Fish to Tsitsikamma water management area in Table 2.4 is attributable to poor quality return flows from irrigation. This is volumetrically in excess of requirements at the estuary, but not of appropriate quality for most upstream uses without blending or treatment.

Box 2.5: Volumetric considerations in transferring water between catchments

Inter-catchment transfer schemes convey specific quantities of water that are physically measurable. The impact on the yields in both the source and the receiving catchments as a result of the water transferred is however dependent on complex inter-relationships and can differ substantially from the quantity of water transferred.

The yield of a water resource system (see Box 2.1) is determined by parameters such as stream flow characteristics, climate, the size and configuration of the water resource infrastructure, water use characteristics and land use, which are all unique to that specific water resource system. Transferring water from one catchment to another will change the flow characteristics in both catchments. The extent to which these characteristics will be affected will, amongst others, depend on the quantity transferred relative to the natural or prevailing flow in the respective water courses, the points of abstraction and discharge, variations in the rate of transfer and the assurance at which water is transferred.

Flow characteristics, however, constitute only one of the parameters determining the yield, and this, in turn, is subject to the interplay with all other influencing parameters that occur in different quanta and combinations in the source and recipient catchments. A prime example of how the above factors can contribute to cause impacts on yield that are different to the quantity transferred is offered by the Thukela-Vaal Transfer Scheme. In this case an average volume of 530 million m^3/a is transferred from the Thukela River Basin (Thukela water management area) to the Vaal River Basin (Upper Vaal water management area) at a transfer rate that may vary from zero to the maximum capacity of 630 million m^3/a . As a result of the transfer the residual yield from the Thukela System is reduced by 377 million m^3/a . However, the impact on the Vaal River System is an increase in yield of 736 million m^3/a. A change in any of the other parameters, such as the construction of a new dam, will likely affect the yields.

This example clearly demonstrates one of the advantages of transferring water and operating water resources in a systems context, namely that leverage can be applied to achieve a greater overall yield and utility from water resources.

The figures for yield given in Tables 2.4, 2.5 and 2.6, and in the corresponding series of tables in Appendix D, represent the impact on yield of relevant transfers. Because the impact of transfers on yield may be different in source and recipient catchments, addition of the figures for transfers in and out will not necessarily result in a total that balances. The quantities reserved for transfer as stipulated in Appendix D refer to the physical quantity of water that may be transferred (unless otherwise specified), and may differ from the impacts of the transfer.

Of the total requirements for water of 12 871 million m^3/a approximately 9 500 million m^3/a is abstracted from surface water resources. The remainder is supplied from groundwater, the re-use of return flows, and the interception of water by afforestation. Total requirements therefore represent approximately 20 per cent of the total mean annual runoff of 49 040 million m^3/a . A further 8 per cent is estimated to be lost through evaporation from storage and conveyance along rivers, and 6 per cent through land use activities. For the country as a whole, approximately 66 per cent of the natural river flow (mean annual runoff) therefore still remains in the rivers. Typically, the temporal flow distribution of this remaining water has been significantly altered as a result of upstream regulation and use, and no longer reflects the natural stream flow characteristics. However, it substantially serves to meet the requirements of the Reserve and to honour downstream international commitments. Potential also exists for a portion of the remaining water to be abstracted for allocation to users, provided that sufficient infrastructure exists or can be developed. Should the surface resources be developed to the full potential regarded as feasible, more than 50% of the mean annual runoff will still remain in the rivers.

2.5.2 Future perspective

Tables 2.5 and 2.6 give a perspective on the possible future requirements for water, as well as the water that will potentially be available under the base and high scenarios respectively. This data serves as additional background to the development of national strategies and also provides strategic perspectives for the respective water management areas. The base scenario, which is regarded as the more probable, does not show pronounced deviation from the year 2000 situation. However, for both the base and high scenarios deficits are generally projected to increase and surpluses to diminish. (The growth in surplus for the Crocodile West and Marico water management area is the result of growing waste water return flows in the area - see also discussion below). Many problems of a more localised nature are masked by generalisation and will only be able to be identified through scrutiny of the more detailed information for individual water management areas and the catchments within them.

Dramatic growth in the main urban areas is projected under the high growth scenario, which is regarded as an upper extreme for testing the resilience of proposed strategic action plans. Of note is the growth in local yield with respect to the year 2025 scenarios, as compared to local yield in year 2000. This is as a result of projected increases in return flows from urban/industrial areas. Of specific importance is the substantial potential for resource development, principally through the construction of new storage dams, which exceeds the overall shortfall in the country, although the available water is often not in the desired locations. Potential also exists for further development of groundwater resources. In general though, the practically exploitable quantities are substantially smaller than for surface water. Furthermore, close interdependencies exist between surface and groundwater and development of the latter may impact on surface water availability (refer to Box 2.3 and the Introduction of Appendix D). The potential for resource development as given in Tables 2.5 and 2.6 should therefore be regarded as being representative of the total undeveloped resource potential for both surface and groundwater. In specific cases, where larger potential for groundwater development may exist, these are described under the relevant water management areas in Appendix D.

From the demographic projections, which also reflect the economic driving forces in the country, it is expected that future growth in water requirements will largely be in the main metropolitan centres. Apart from catchments already under stress, particular attention will therefore have to be given to ensuring adequate future water supplies to these areas, as well as ensuring equitable access to existing supplies.

Table 2.5: Reconciliation of requirements for and availability of water for the year 2025 base scenario (million m³/a)

	Water management area	Reliable local yield (1)	Transfers in	Local requirements (2)	Transfers out	Balance (3)	Potential for development (4)
1	Limpopo	281	18	347	0	(48)	8
2	Luvuvhu/Letaba	404	0	349	13	42	102
3	Crocodile West and Marico	846	727	1 438	10	125	0
4	Olifants	630	210	1 075	7	(242)	239
5	Inkomati	1 028	0	914	311	(197)	104
6	Usutu to Mhlathuze	1 113	40	728	114	311	110
7	Thukela	742	0	347	506	(111)	598
8	Upper Vaal	1 229	1 630	1 269	1 632	(42)	50
9	Middle Vaal	55	838	381	503	9	0
10	Lower Vaal	127	571	641	0	57	0
11	Mvoti to Umzimkulu	555	34	1 012	0	(423)	1 018
12	Mzimvubu to Keiskamma	872	0	413	0	459	1 500
13	Upper Orange	4 734	2	1 059	3 589	88	900
14	Lower Orange	(956)	2 082	1 079	54	(7)	150
15	Fish to Tsitsikamma	456	603	988	0	71	85
16	Gouritz	278	0	353	1	(76)	110
17	Olifants/Doring	335	3	370	0	(32)	185
18	Breede	869	1	638	196	36	124
19	Berg	568	194	829	0	(67)	127
	Total for country	**14 166**	**0**	**14 230**	**170**	**(234)**	**5 410**

1) Based on infrastructure in existence and under construction in the year 2000. Also includes return flows resulting from a growth in requirements.
2) Based on the assumptions given in paragraph 2.4.2. The assumed growth in urban and rural water requirements results from the anticipated high population growth and current ratios of domestic to public and business water use. Allowance has been made for known developments in urban, industrial and mining sectors only, with no general increase in irrigation.
3) Brackets around numbers indicate a negative balance.
4) More detail for each water management area is given in the corresponding tables in Appendix D.

Table 2.6: Reconciliation of requirements for and availability of water for the year 2025 high scenario (million m³/a)

	Component/Water management area	Reliable local yield (1)	Transfers in	Local requirements (2)	Transfers out	Balance (3)	Potential for development (4)
1	Limpopo	295	23	379	0	(61)	8
2	Luvuvhu/ Letaba	405	0	351	13	41	102
3	Crocodile West and Marico	1 084	1 159	1 898	10	335	0
4	Olifants	665	210	1 143	13	(281)	239
5	Inkomati	1 036	0	957	311	(232)	104
6	Usutu to Mhlathuze	1 124	40	812	114	238	110
7	Thukela	776	0	420	506	(150)	598
8	Upper Vaal	1 486	1 630	1 742	2 138	(764)	50
9	Middle Vaal	67	911	415	557	6	0
10	Lower Vaal	127	646	703	0	70	0
11	Mvoti to Umzimkulu	614	34	1 436	0	(788)	1 018
12	Mzimvubu to Keiskamma	886	0	449	0	437	1 500
13	Upper Orange	4 755	2	1 122	3 678	(43)	900
14	Lower Orange	(956)	2 100	1 102	54	(12)	150
15	Fish to Tsitsikamma	452	653	1 053	0	52	85
16	Gouritz	288	0	444	1	(157)	110
17	Olifants/Doring	337	3	380	0	(40)	185
18	Breede	897	1	704	196	(2)	124
19	Berg	602	194	1 304	0	(508)	127
	Total for country	**14 940**	**0**	**16 814**	**170**	**(2 044)**	**5 410**

1) Based on infrastructure in existence and under construction in the year 2000. Also includes return flows resulting from a growth in requirements.
2) Urban and rural requirements based on high growth in water requirements as a result of population growth and the high impact of economic development. Allowance has been made for known developments in urban, industrial and mining sectors only, with no general increase in irrigation.
3) Brackets around numbers indicate a negative balance.
4) More detail for each water management area is given in the corresponding tables in Appendix D.

While issues of importance have been identified with respect to each of the water management areas, the following areas are of specific note from a national perspective (refer to Appendix D for a more detailed discussion of all the water management areas).

- **Crocodile West and Marico water management area:** Large additional transfers of water to the Pretoria-Johannesburg area in the upper reaches of the Crocodile catchment will be required in future from the Upper Vaal WMA. This will result in growing quantities of return flows becoming available downstream of these centres, and specific attention will need to be given to the optimal balance between the transfer of water and re-use of return flows.
- **Olifants water management area:** Deficits that will result from implementation of the Reserve and the provision of water supplies for future power generation and mining in the Olifants area, and also to support mining in the Limpopo water management area, will have to be addressed. Possible impacts on Mozambique will have to be considered.
- **Inkomati water management area:** Current deficits and impacts associated with implementation of the Reserve will need to be addressed. Joint management with Swaziland of the Komati River will be particularly important, while the impact on Mozambique will also have to be considered.
- **Upper Vaal water management area:** This water management area, which serves as the main source of water for the Gauteng region, should be adequately supplied until close to 2025, given the projections in the base scenario. Future transfers into the area may be required towards the end of the period to provide for growth in the Johannesburg area and neighbouring water management areas. The existing surplus transfer capacity is to be reserved for urban, industrial and mining developments, and not for irrigation.

  Despite indications that the Upper Vaal water management area will be adequately supplied with water until about 2025, there is always the possibility that additional water may be required earlier should growth be higher than projected in the base scenario. Because of the impact on the national economy and the long implementation periods associated with large water transfer schemes it is prudent to proceed with the planning process in this regard. The Treaty on the Lesotho Highlands Water Project (LHWP), signed in 1986, provides for further phases to be constructed after Phase 1. However, the present needs for augmentation of the Vaal River System are fundamentally different from those contained in the Treaty, and current projections of future water requirements are dramatically lower than those of the 1980s. Whilst development of Phase 2 (Mashai Dam) of the LHWP remains a possibility, options such as the Thukela Water Project and the transfer of water from the Upper Orange water management area to the Upper Vaal area are also under consideration. A final decision will only be taken after further investigation and due consultation with the co-basin countries.
- **Mvoti to Umzimkulu water management area:** Adequate future water supplies must be ensured for the important Durban-Pietermaritzburg metropolitan area.
- **Berg water management area:** Provision must be made for the future water requirements of the greater Cape Town area. Particular stress may be experienced in this water management area should the high-growth scenario be realised, or should the impact of climate change start to manifest itself in this part of the country, as some scenarios suggest (see section 2.6.2 and Box 2.10).

In general, sufficient water can be made available at all significant urban and industrial growth points in the country for water not to be a limiting factor to economic development. However, given the long lead times for developing new supply schemes, co-operative planning will be required between water users and water management institutions to ensure that water can be made available when it is needed.

2.5.3 Development opportunities

Opportunities for increased water use other than those that arise from urban, industrial and mining growth are also addressed as part of the analysis of the respective water management areas in Appendix D. Opportunities include the following -

- The possible expansion of irrigation in the Upper and Lower Orange and Fish to Tsitsikamma water management areas, utilising water from the Upper Orange water management area.
- The utilisation of surplus water available from the Pongolapoort Dam in the Usutu to Mhlathuze water management area.
- The refurbishment of currently under-productive irrigation schemes and the potential for additional development in the Mzimvubu to Keiskamma water management area.
- Possible forestry development in some catchments in the Usutu to Mhlathuze, Thukela, Mvoti to Umzimkulu and Mzimvubu to Keiskamma water management areas.
- Expansion of irrigation in the north-eastern part of Limpopo Province from the Nandoni Dam in the Luvhuvhu River.

2.5.4 Reconciliation interventions

It is important that the strategies adopted are stable over time and can endure even if circumstances change. The strategies and interventions should be able to deal with existing and short term imbalances while conforming to the broad goals of the NWRS, which include the achievement of equity, long-term stability of supply and optimality in the management of water resources. Strategies should also be flexible but stable within the envelope of the high and low scenarios of future water requirements. Adjustments to deal with changed circumstances should mainly be with respect to the timing and sequencing of the different elements of the strategy. The NWRS therefore allows for changes in emphasis and the revision of action plans as growth and developments occur and improved insights are gained. In this way the continued relevance of the Strategy will be assured.

The main interventions by which a balance between the availability of and requirements for water may be achieved are addressed below. The principal considerations in planning reconciliation interventions are briefly described in Box 2.6 and further details of the interventions are given in Chapter 3 under Strategies for Water Resource Management.

- **Demand management**

  For many years the tendency has been to resort to constructing additional infrastructure where the demand for water has exceeded the supply. As water use approaches its full potential however, the cost of resource development increases and the environmental impacts become more pronounced. Management of the demand for water is an obvious option for reconciling imbalances between requirements and availability, and has been applied with great success by some users. For example, as is evident from Table 2.4, of the 10 water management areas currently in deficit, 4 would change to a surplus situation if a 10 per cent saving in user requirements could be achieved. Additional perspective with respect to the individual water management areas can be found in Appendix D.

  Compared with supply-side management, the management of demand in South Africa is relatively under-developed, although there are world-class examples of water use efficiency in some areas of industry and agriculture that will help to set benchmarks. Some quantitative data is available on water savings resulting from demand management programmes, notably in some of the metropolitan areas and the larger municipalities, but in general insufficient information exists to make reliable estimates of the potential savings in each water management area.

  More information will become available as the effects of the Department's water demand management programme become evident (see Part 3 of Chapter 3), and these will be accounted for in the water availability and requirements data in future editions of the NWRS.

In the meantime continuous improvement of and investment in enabling mechanisms, relevant technology and supporting infrastructure for water demand management are priorities in the NWRS.

Box 2.6: Planning interventions to balance supply and demand

In line with the objectives of equitable and sustainable social and economic development, government has progressively adopted a more comprehensive and holistic approach to the planning of interventions to resolve problems of inadequate water availability. This approach accords with the requirements of national policies and legislation relating to the environment, and is informed by internationally accepted best practice.

Whenever there is a water shortage, a range of possible solutions will be investigated, taking account of the availability of surface and groundwater and the interactions between them, and the integration of water quality and water quantity issues. Options will include the following -

- Demand-side measures to increase water availability and improve the efficiency of water use, considered from the start of the planning process in parallel with other solutions (see Part 3 of Chapter 3).
- Re-allocation of water, including the possibility of moving water from lower to higher benefit uses by trading water use authorisations (see Part 2 of Chapter 3).
- The construction of new dams and related infrastructure, including inter-catchment transfers. Where infrastructure construction is indicated as an optimal solution, a range of alternative developments, including the implications of no development, will be presented.

The significant impacts of all development options and other interventions will be assessed and social and environmental considerations will be accorded the same attention as those of a technical, financial and economic nature. The social, environmental and economic impacts of all development options will be evaluated to ensure that the benefits arising from such actions will exceed the costs, that the benefits and costs will be distributed equitably, and that the gender dimensions of the benefits and costs are taken into account. Particular attention will be paid to improving the quality of life of the poor, and ensuring that that any negative impacts are minimised or mitigated so that affected communities are not worse off than they were before.

In terms of the Act comprehensive impact assessments may be required to determine the effect of proposed water uses on the water resource, and will be mandatory before a major government water work is constructed. Impact assessments will be undertaken in accordance with the regulations to the Environment Conservation Act, 1989, which are still in force under the National Environmental Management Act, 1998, until replaced by new regulations.

Government recognises the importance of gaining public input to the review of options for managing water resources including infrastructure development and water users, stakeholders and the public will be involved at all key stages of a development project or a scheme. The Department's commitment and general approach to public consultation is discussed in Chapter 4, which also describes the Act’s specific requirements for consultation.

Note: The November 2000 World Commission on Dams Report - *Dams and Development: A New Framework for Decision-Making* - is the most recent and most comprehensive approach to decision-making for the development of dams. The Department is currently working with the South African Multi-Stakeholder Initiative on the World Commission on Dams on a systematic review of the Commission's recommendations in the South Africa context. The aim is to build national consensus on the many issues surrounding large water resource developments, and to guide policy and practice. Among other matters the question of ensuring that communities that were negatively impacted by dams in the past have access to the same benefits that arise from new developments is under consideration.

- **Water resource management**

  In its widest sense, water resource management would include all the reconciliation interventions described briefly here and in more detail in Chapter 3. In the context of this discussion, however, it refers to the regulation of stream flow through storage and the control of abstractions and releases for the purpose of providing appropriate quantities of water at specific times and locations, and of such quality and reliability to meet user requirements. It also includes the conservation of resources through the minimisation of evaporation and effective release management.

Water resources over much of South Africa have been linked through inter-catchment transfers of water and are managed as large integrated systems. In this way water can be transferred from catchments where it is plentiful to where most needed, thereby reducing the potential risks of failure through the combined utilisation of resources over large geographic areas. A high level of sophistication has been reached in this regard, and greater utility is thus obtained from South Africa's water resources than the sum of the component parts. There is nonetheless scope for improving the management of many of the smaller or localised water resource projects, while regular revision of the operating strategies for large water resource systems is required to account for growth and other relevant changes.

- **Managing groundwater resources**

  A systematic approach to groundwater was neglected in the past as a result of its "private water" status under the previous legislation, and relatively little was invested in comprehensive resource assessment. Through research and development investment in the past five to ten years it has become clear that groundwater in utilisable, if limited, quantities can be found virtually everywhere, even in the aquifer systems that are classified as "poor". Deep drilling has shown potential for large scale development of groundwater in some areas such as those underlain by the Table Mountain Group geological formations in the south-western Cape. With a focus on the development of local resources groundwater's role in reconciling future demand and supply could rise significantly, and meeting relatively small water requirements from groundwater would be especially attractive.

- **Re-use of water**

  In the interior of the country most of the water used in a non-consumptive manner is directly recycled for re-use, or is returned to the rivers after treatment, thereby becoming available for re-use. In urban and industrial areas such as Pretoria and Johannesburg approximately 50 per cent of the total water requirements becomes available as return flow and is re-used. Similar return flows are available in coastal cities such as Cape Town, and the Durban/Pietermaritzburg area, but only about 5 and 15 per cent respectively is re-used in these cities. Should it compare favourably with other options, greater re-use could therefore be a substantial source of water, especially for coastal cities.

  Return flows normally have a significant impact on the quality of the receiving waters and this aspect needs to be specially managed. Where return flows are re-used directly, sophisticated treatment processes and proper management may be required, depending on the quality of the return flow and its intended applications.

- **Control of invasive alien vegetation**

  Provisional estimates show that annually about 1 400 million m^3 of surface runoff, or close to 3 per cent of the national mean annual runoff, is intercepted by invading alien vegetation. If the spread of such vegetation is not controlled, the impact is likely to increase

  Through government's inter-departmental Working for Water Programme (see Part 3 of Chapter 3), large areas are being cleared of alien vegetation. The removal and containment of such vegetation should, where applicable, form part of catchment management strategies.

- **Re-allocation of water**

  Differential benefits are derived from water use by different user sectors and by users in different parts of the country. Water should ideally be applied to best advantage to achieve the greatest overall benefit for the country from a social, economic and environmental perspective. The re-allocation of water between user sectors is an obvious and powerful option for realising this goal. (Refer also to Box 2.7 on priorities for the allocation of water and Box 2.8 with respect to food security).

To avoid unnecessary disruption, the NWA provides for the gradual re-allocation of water as the need arises in different parts of the country. The main enabling mechanisms are compulsory licensing, supported by water demand management and the trading of water use authorisations (see Parts 2, 3 and 4 of Chapter 3).

Trading in and re-allocation of water can, of course, only be implemented where an adequate water resource and the required infrastructure is available, and provided the impact of water trading is acceptable. It may not be physically possible to trade water use allocations between certain locations. Furthermore, trading between different sectors of water users may impact on the quantity and quality of return flow, and may also result in the water being required at a different assurance of supply, all of which need to be properly accounted for.

- **Development of surface water resources**

From Tables 2.5 and 2.6 it is evident that substantial potential for further development of surface water resources still exists in some parts of the country. Possible resource developments are listed in Tables 3.8.2 and 3.8.3 in Part 8 of Chapter 3.

A factor that reduces the feasibility of new capital-intensive water resource infrastructure developments is the current projection of smaller growth rates than previously used in water requirements in many parts of the country. This would result in longer pay-back periods for the redemption of capital and lead to a reduction in the economic viability of investments. It may reduce the options for new resource development in favour of inducing changes in water use patterns and re-allocation among users.

- **Inter-catchment transfers**

Due to the spatial imbalances in the availability of and requirements for water in the country, as demonstrated by the preceding information and statistics, inter-catchment transfer of water is a necessary reality in South Africa.

From Table 2.4 it can be determined that the transfer of yield between water management areas amounts to over 6 000 million m^3/a. Some of these transfers are from upper to lower water management areas through releases along rivers, as in the Vaal and Orange Rivers, while others are effected through inter-catchment water transfers. The quantity of water physically transferred from one catchment to another amounted to about 3 000 million m^3/a in year 2000 and it is evident that more water will have to be transferred in future. In comparison, the total surface water yield in the year 2000 amounted to about 11 000 million m^3.

Refer to Box 2.5 for an explanation of the difference between the physical transfer of water and transfer of yield. Refer also to Box 2.9 for a summary of the Inter-catchment Transfer Policy, and to Part 4 of Chapter 3 for water use charges relating to transferred water.

Box 2.7: Priorities for allocating water

Water is one of the most fundamental natural resources and it is one of the primary principles of the National Water Act that the nation's water resources are managed in such a manner that their use will achieve optimum long-term social and economic benefits for all people. Water is also a finite resource, and it is recognised that water allocations may have to change over time to meet this objective on an ongoing basis.

The NWA gives highest priority to water for the Reserve, which includes water for basic human needs and for the natural environment. Thereafter international obligations as agreed with neighbouring countries must be respected and honoured.

Beyond this, water should be allocated to ensure that the greatest overall social and economic benefits are achieved. But consideration must not only be given to this primary aim, but also to potential disbenefits to society where water is made available to competing optional uses. This applies both to long-term allocations for water use as well as to short-term curtailments in supply during periods of drought and temporary shortage. Where surplus or unused water exists, prioritisation need not apply, provided that the water is not used wastefully.

To facilitate the most beneficial utilisation of water, a general guide on priorities for water use is given below. The priorities are listed in descending order of importance, although the order may vary under particular circumstances.

- Provision for the Reserve.
- International agreements and obligations.
- Water for social needs, such as poverty eradication, primary domestic needs and uses that will contribute to maintaining social stability and achieving greater racial and gender equity.
- Water for uses that are strategically important to the national economy.
- Water for general economic use, which includes commercial irrigation and forestry. In this category, allocation is best dictated by the economic efficiency of use. With the introduction of water trading, demand will automatically adjust over time to reflect the value of water in particular uses.
- Uses of water not measurable in economic terms. This may include convenience uses and some private water uses for recreational purposes, which are likely to be of low priority.

Additional factors to be considered in assessing priorities for the allocation of water are the level of assurance of supply required, the extent to which to use is consumptive and the quality of return flows.

It is important to realise that all water use by a particular sector or user is unlikely to be of the same priority. Water to maintain primary production functions, for example, would be of higher value and priority than the additional water required for other uses in the same enterprise. This also relates to the efficiency of water use, with greater efficiency leading to a higher value of water. The same principle applies to a greater or lesser extent to all uses of water.

Box 2.8: Water for food security

Food security is often given as a motivation for according high priority to water allocations to irrigated agriculture. One of the primary goals of the NWRS is to facilitate the most beneficial utilisation of South Africa's water resources by all user sectors. However, since irrigated agriculture is by far the largest user sector in the country, it is appropriate to retain a proper perspective on the matter so that there is a common understanding among interest groups of the concepts of food security and food self-sufficiency.

Food security refers to the assurance of having sufficient food available at all times, whilst **food self-sufficiency** refers to the capability for own food production. Both principles can apply to individuals as well as on a national level. The national situation is addressed first.

Although food self-sufficiency can make a major contribution to food security, the ability to produce own food depends on many external factors other than soil, water and climate. In a modern economy, elements such as the availability of machinery and sufficient liquid fuels, and access to technology, finance and management skills may also be prominent in determining the ability of a country to produce sufficient food to meet all its requirements, thereby achieving food security through self-sufficiency. A strong, diversified and globally well-integrated economy with a high level of employment may better provide for national food security than to strive for self-sufficiency. Hong Kong and Singapore are successful examples in this respect.

South Africa is currently self-sufficient with respect to most of its food requirements, the bulk of which is produced by rain-fed agriculture. Whilst irrigated agriculture also makes a major contribution to the national food basket, particularly vegetable production, a large proportion of commercial production under irrigation is for export (such as sugar, citrus, deciduous fruits and table grapes), and of non-food products (such as wine and tobacco). In this respect, commercial irrigation contributes to food security through trade links, foreign earnings and employment creation, similar to many other sectors of the economy, but does not directly provide for food self-sufficiency.

Since most crops grown under commercial irrigation represent economic use of water, such irrigation should be subject to the same allocation criteria as other economic uses, taking all forward and backward linkages into consideration, where preference is to be given to uses that achieve the greatest overall benefits for the nation. In certain cases it may be to South Africa's advantage to import more food or other products if the water and other resources consumed for the its production in South Africa could be applied to other products that would create greater wealth and welfare and where the balance of impacts would be favourable.

Different considerations apply to irrigation for meeting the basic needs of people, such as subsistence irrigation and small scale irrigation for communal gardens. There are many unemployed and impoverished people in South Africa, especially in the rural areas, who do not have the financial means to purchase food and whose only solution to food security is through achieving household food self-sufficiency. After meeting the requirements of the Reserve and honouring international agreements and obligations, the NWRS therefore affords high priority to water for poverty eradication and related social needs. This may include water for own food production and the creation of micro-enterprises. Relatively small volumes of water can, if managed optimally, support the production of sufficient food to meaningfully improve the livelihood of people living in extreme poverty.

The Department is also aware of the importance of maintaining a vibrant and sustainable rural economy, and of maintaining a proper balance from a national socio-economic perspective between the rural and urban economies and populations. It is not the role of the Department to engineer this however, but rather to work together in consultation with other departments to support the achievement of government's policy objectives.

Box 2.9: Inter-catchment transfer of water

The National Water Act recognises both the relative scarcity of water in South Africa and the uneven and often unfavourable distribution of water resources in both space and time. The national government is therefore entrusted with the responsibility to effect the equitable allocation of water for beneficial use and to ensure that sufficient water is available to support the continued growth and wellbeing of the country. This includes the preparation of guidelines for the spatial redistribution of water as well as the actual implementation of inter-catchment transfer projects, where applicable.

An inherent benefit of linking the country's water resources over a large geographic area is that it can, in certain circumstances, help to manage the consequences of climatic variability through the transfer of water supplies to areas that may be suffering from severe drought conditions, from areas where the prevailing conditions are less critical. This not only helps to prevent disasters, but also provides the opportunity of operating the available resources in a systems context, thereby achieving an overall yield that is greater than the sum of the component parts.

The same technical, environmental, social and economic considerations as are applicable to any water resource development and use of water are applicable to inter-catchment transfers of water. Key considerations and items of specific relevance to inter-catchment transfers can be summarised as follows -

- Priorities for water use are stipulated in the NWA and are also contained in the NWRS. The highest priority in a catchment is to be afforded to the provision of water for the Reserve and to honoring international rights and obligations. Thereafter, consideration is to be given to the most beneficial use of water (actual and potential), both within the source and the (potential) recipient basins.
- The allocation of water away from a catchment can only be justified if it results in an overall benefit from a national perspective. Any negative impacts, or the loss of opportunity as a result of the transfer, must be outweighed by the advantages that are created. Full consideration must be given to any possible negative impacts in the source basin and all reasonable measures must be taken to mitigate such impacts in the interest of those affected.
- The maintenance of environmental integrity is of particular importance in all water resource developments. The inter-catchment transfer of water may have unique impacts on natural ecosystems that extend beyond those associated with in-catchment developments, and these need to be considered and provided for. In addition to comprehensive environmental impact assessments being undertaken in both the source and receiving areas, specific consideration must be given to the possible transfer of organisms and changes in habitat conditions.
- Interbasin transfers will only be permitted subject to water conservation and demand management by the relevant authorities and user organisations in the receiving region conforming to the applicable criteria in this regard. Similarly, inefficient or non-beneficial use of water in a source basin cannot serve as reason for not transferring water.
- The transfer of water for the express purpose of meeting the requirements of the ecological component of the Reserve in the receiving catchment will not be considered.
- Water should not be reserved over unduly long periods of time for possible future use within or outside a catchment, in this way foregoing opportunities for the interim beneficial use of such water. Where appropriate, water use licences of short duration may be issued.
- In determining the volumes of water to be transferred from one catchment to another, water that is not already gainfully utilised and water resource potential still to be developed will be considered first. The re-allocation and inter-sectoral redistribution of water from existing to more beneficial uses should only be effected where merit can be clearly demonstrated on an economic and social basis.
- Conforming to the principle in the NWA that water is a national resource that belongs to all people, no payment is to be made to a source catchment for the actual water transferred. A portion of the water resource management charge raised in the recipient catchment will, however, revert to the source catchment and opportunities will be sought to mitigate any negative impact that may result.
- All costs associated with the transfer of water will be borne by the users of the transferred water. These include normal water use charges in terms of the prevailing pricing policy together with project and operational costs, as well as the cost of possible mitigation measures.
- The national government will normally initiate, plan and authorise inter-water management area transfers.

- **Water quality considerations**

  Although not a reconciliation intervention in itself, water quality is a fundamental element of water resource management and is a primary consideration in all the options for the reconciliation of water requirements and availability. In addition to making sufficient quantities of water available for use at specific locations and times as required, it is essential that water also be of appropriate quality for the intended use, whether it be for abstraction or for the purposes of the ecological Reserve. All the intervention options will impact on water quality in some way. These impacts may manifest themselves in the quality of water delivered to the user, the treatment or blending requirements to render the water fit for the purpose intended, the quality of return flows, and the assimilative capacity of and resultant water quality in streams and other water bodies from which water is abstracted or into which it is discharged. The regulation of water resources by dams may also assist in managing water quality as a result of the mixing and balancing effects of storage, as well as impacting on it by, for instance, increasing salinity levels due to evaporation from the water surface of reservoirs. Where problems are encountered as a result of excessively high salinity levels the blending of waters of different quality, as well as desalination, may have to be resorted to.

  It is necessary for the chemical, biological and physical characteristics of water to be addressed when the water resource management options and other interventions are considered. Also refer to Protection of Water Resources in Part 1 of Chapter 3.

- **Environmental considerations**

  Similar to water quality, environmental considerations are also integral to all reconciliation interventions. The impacts on both the social and natural environment need to be taken into account, and assessed together with the technical, economic and other factors.

  Social impacts broadly refer to how people's lives and livelihoods may be affected, and relate to social networks and ways of life, economic activities, and gender, cultural and religious issues. Developments that may be to the benefit of some people could however have negative impacts on others. Inundation of land by storage reservoirs for example, may impact on access routes, fragment and separate communities, necessitate the relocation of people, render former productive land inaccessible, cause inundation of historical and archaeological sites; whilst the positive impacts of the new storage are likely to result from the additional water that can be made available to users, less frequent curtailments in supply, and the creation of recreation opportunities.

  All water resource developments also impact on the functioning of aquatic ecosystems, typically by changing habitat conditions as a result of changed flow and water quality regimes.

  All interventions to reconcile the requirements for and availability of water are thus likely to have some impacts, which need to be identified and evaluated together with other relevant factors to enable an informed decision to be reached.

Varying combinations of the above intervention options will be employed depending on their suitability in each water management area or sub-area. Interventions may also be guided by considerations related to the quality of water.

It is essential that the growth in water requirements together with the main factors influencing water requirements and availability be monitored and regularly be re-assessed, and that appropriate adjustments to management strategies be made. A minimum requirement in this respect is the five-yearly review of the NWRS as specified in the National Water Act.

2.6 OTHER FACTORS INFLUENCING WATER AVAILABILITY AND WATER REQUIREMENTS

Both the availability of water and the requirements for water are subject to complex interrelationships and external influences, which are beyond the scope of the NWRS to address in detail. Population is generally accepted as one of the main drivers of water demand, as discussed in Section 2.4.2. However, water requirements for basic human needs are relatively small, representing less than 5 per cent of the current national requirements for water, or about 1 per cent of the mean annual runoff. The main stimulants for increased water demand are economic activity and standard of living, the latter in itself being closely related to economic activity. Recognition of this relationship provides a useful guide for the management of water.

Two key influencing factors with respect to resource availability not specifically addressed previously - land use and climate change - are described below.

2.6.1 Land use

The Act recognises the potential influence of land use practices on the proportion of rainfall that reaches streams or penetrates to groundwater. Currently, afforestation is the only stream flow reduction activity that is subject to authorisation as a water use, although other land-based activities are being investigated. Other factors that may influence water availability and that were accounted for in the NWRS database are invasive alien vegetation, some rain-fed cultivation of crops and impervious surfaces in urban areas. It is important that consideration be given in relevant catchment management strategies to the protection of mountain catchment areas from which large quantities of runoff originate.

In some parts of the country, overgrazing and denudation has significantly increased the quantities of sediment that reach the rivers, leading to a loss of reservoir storage and significant changes in the morphology of some rivers. It has been estimated that the costs associated with the combined downstream losses from sediment are an order of magnitude greater than the national investment in soil conservation. The management of land must therefore become a focus for co-operation among the government departments responsible for administering land use.

2.6.2 Climate Change

Climate change has the potential to impact very significantly on both the availability of and requirements for water in South Africa.

There is evidence that global temperatures are rising. Some climate models suggest that this could increase the variability of climate and decrease rainfall in South Africa. According to these models stream flow could decrease, possibly by as much as 10 per cent by 2015 in the most affected parts of the Western Cape. The models suggest that the reduction in runoff will progress from the west to the east coast by about 2060. The effect on groundwater recharge is less predictable, but could even be greater. An increase in the variability of stream flow would mean that, even if the average rainfall were to remain the same, natural yields and reliability would be reduced and the unit cost of water from dams would increase. The water requirements of plants, and therefore irrigation requirements, would also increase should warmer climatic conditions manifest themselves. A decrease in water availability will also impact on water quality, thereby further limiting the extent to which water may be used and developed. (See Box 2.10 for more detail.)

Whilst phenomena have been observed internationally that point to the likelihood of changing climatic patterns, there is as yet little conclusive evidence of any accelerated large scale and persistent long-term climatic shifts in South Africa. It is prudent, however, to anticipate the possibility of climate change and to take this into consideration in the development of catchment management strategies. A balance will have to be sought between preparedness and overreaction, to prevent valuable resources being wasted. The situation is therefore being monitored, with special attention given to monitoring selected, relatively unimpacted benchmark catchments; and needs to be formally re-assessed with each five-yearly review of the National Water Resource Strategy over the long term (also refer to Part 6 of Chapter 3). The implications of climate change are addressed in more detail in the water management area reports, particularly for those geographic areas that are could experience the greatest impact.

Box 2.10: Climate change

Scientific observations have shown that the average air temperature of the earth has increased by between 0.3ºC and 0.6ºC during the past 100 years. About two-thirds of this increase has occurred over the past 40 years and there is strong evidence that much of the warming can be attributed to human activities[1].

Although climate change is expected to affect many sectors of the natural and built environments, water is considered to be the most critical. South Africa, because of its general aridity and high variability of rainfall in space and time, is especially vulnerable to changes in water availability, with its implications for social and economic development.

A study[2] has recently been carried out to assess the potential effects of global climate change in South Africa, Lesotho and Swaziland, and to identify the sectors and areas of high vulnerability to climate change and propose adaptation measures to offset adverse consequences. In the study, four global circulation models (GCMs) were used to estimate possible changes in temperature and precipitation. This was followed by application of a suitably modified Agricultural Catchments Research Unit (ACRU) model to estimate the potential impacts on hydrological response in terms of stream flow and recharge into the unsaturated soil above the groundwater table (the vadose zone).

There was general agreement among the GCMs with regard to climate projections. In all cases an extension of summer season characteristics was indicated, with continental warming of between 1ºC and 3ºC, the maximum focusing on arid regions and the minimum occurring along coastal regions. There was less agreement with regard to precipitation, but in general terms reductions of the order of 5 to 10 per cent of current rainfall were suggested. Estimates made using the GCMs to generate local-scale climate data indicated the likelihood of an increase in the duration of the dry-spell in the interior and north-eastern areas of the country, followed by more intense convective rainfall events and the possibility of more frequent and severe flood events. The probable net effect would be greater evapo-transpiration and more stress on arid and marginal zones.

Hydrological responses were assessed using one of the hotter, drier GCM scenarios. Runoff was found to be highly sensitive to changes in precipitation, since a relatively small fraction of rainfall is converted to runoff. Groundwater recharge was found to be even more sensitive. The conclusion from the study was that, under the hot and dry scenario, South Africa could realistically expect to experience a decrease in runoff of up to 10 per cent in some areas. A related "threshold" study indicated that a runoff reduction of this magnitude could manifest in the western parts of the country by 2015. The decrease in runoff would move progressively from west to east and could be expected to reach the east coast by 2060. Recharge into groundwater displayed a more patchy and less systematic pattern.

It must be emphasised that these conclusions are not predictions or forecasts. They are at best projections of how the global climate system may possibly evolve in the future, and how such changes may affect climate on a local scale. Water resources planners will use the projections to create scenarios of future water availability, but there must be interaction between all water-dependent sectors to ensure that all available measures are considered to adapt to changing circumstances and reduce vulnerability. Nevertheless, it is important that no development or investment decisions are made that neglect to take into account the actual or potential affects of climate change on water resources.

1. Global warming is widely attributed to the release into the atmosphere of greenhouse gases, which are defined by the Kyoto Protocol as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_20), hydroflourocarbons (HFCs), perflourocarbons (PFCs) and sulphur hexaflouride (SF_6).
2 South African Country Study on Climate Change: Vulnerability and Adaptation Assessment Study, 2000 (in press).

2.7 WATER RESOURCES UNDER THE DIRECT CONTROL OF THE MINISTER

A proportion of the available water, in respect of both quantity and quality, in each water management area is under the direct control of the Minister in terms of his or her national responsibilities. This includes the Reserve, water to meet international obligations, a possible provision to meet realistic future requirements, transfers between water management areas and water uses of strategic importance. The water that is to be reserved for specific purposes in each of the water management areas is discussed in Appendix D.

2.7.1 The Reserve

The highest priority is afforded to provision of water for the purposes of the Reserve. The first objective is to ensure that sufficient quantities of water of appropriate quality are reliably available to provide for basic human needs. In terms of current policy, a quantity of 25 litres per person per day has been incorporated for this purpose under the urban and rural requirements in Table 2.3. Should this quantity be increased in future, the Reserve will be re-determined.

The second priority is the provision of water for safeguarding and sustaining healthy ecosystems, including fauna and flora. Owing to the complex interdependence amongst species in nature, and our extremely limited knowledge of the wide spectrum of habitat and water requirements, only provisional estimates of the ecological water requirements are presented in this edition of the NWRS. Although based on a countrywide assessment of the conservation status of rivers and estuaries, and the scientific estimation of water requirements, much further work is still required. A programme for the improved determination of the Reserve has therefore been initiated and refinements to the Reserve will continue to be made in future editions of the NWRS.

2.7.2 Water required for international rights and obligations

South Africa is committed to the joint management and equitable utilisation of the international waters that it shares with neighbouring countries, as negotiated from time to time through relevant bi-national and multi-lateral forums. South Africa will not implement water resource developments that may have negative impacts on a co-basin country or countries without prior consultation with those countries. This is described in the Revised Protocol on Shared Watercourses in the Southern African Development Community, discussed in Chapter 5.

Where agreements exist on specific quantities of water to be available to a particular country, these are addressed under the respective water management areas in Appendix D. It is anticipated that agreements will also be reached in respect of water quality issues in rivers flowing from one country into another.

2.7.3 Water use of strategic importance

Analogous to the importance of water as a primary life-sustaining resource, electricity is fundamental to the functioning of modern society. It is also a high-value economic use of water. Much of the country's economic activity, as well as its social stability, depend on a sufficient and reliable supply of electrical power. The abstraction and storing of water for use at power station operated by Eskom, as the organisation entrusted with generating the bulk of the country's electricity, is therefore regarded as being water use of strategic importance. All water that is taken from a water resource or stored for whatever purpose at Eskom power generation facilities will therefore be authorised by the Minister (see Part 3 of Chapter 3). Water use designated as being of strategic importance will, however, be subject to the same efficiency criteria and water demand management requirements as is applied to other uses. Dry-cooling of power stations should be applied where feasible when new generating capacity is built.

2.7.4 Contingency to meet projected future growth

Projections of the future requirements for water are given in Tables 2.5 and 2.6 for each of the water management areas, together with an indication of the resource potential that could still be developed. The best strategies for the future reconciliation of requirements and availability will be combinations of various possible interventions as referred to in Section 2.5.4. Only under certain conditions will further resource developments and transfers of water prove to be desirable.

It is therefore not generally practical for reservations to be made of specific quantities of water to allow for future growth. However, there are certain instances where the limited resources still available must be reserved. In this respect, clear statements are made in Appendix D with regard to each of the water management areas where –

- known quantities of water need to be reserved for specific uses or transfer;
- general reservations that are not quantifiable at present need to be made for future priority uses; and
- dam sites need to be reserved for specific purposes.

This will ensure that optimal development choices are not forgone and developments are not allowed in one area that will unwittingly prejudice another. These reservations will be reviewed as part of the formal process of revision of the NWRS.

2.7.5 Reservations for transfer between water management areas.

Allocations reserved for transfer between water management areas are also regarded as water use of strategic importance, and are established by the Minister in the NWRS. The relevant quantities are given in the respective water management area reports in Appendix D.

Notes to Chapter 2

[1] Since the information on water availability and water requirements presented in the tables in this Chapter and in Appendix D appendix was derived small changes have been made the boundaries of the some of the water management areas - see Part 5 of Chapter 5 and Appendix E. These changes have insignificant impact on the statistics presented, and any discrepancies will be corrected at the first revision of the NWRS.

[2] Section 23 - Determination of quantity of water which may be allocated by responsible authorities (see Part 5 of Chapter 3 for a definition of a responsible authority):- (1) Subject to the national water resource strategy the Minister may determine the quantity of water in respect of which a responsible authority may issue a general authorisation and a licence from water resources in its water management area. (2) Until a national water resource strategy has been established, the Minister may make a preliminary determination of the quantity of water in respect of which a responsible authority may issue a general authorisation and licence. (3) A preliminary determination must be replaced by a determination under subsection (1) once the national water resource strategy has been established. (4) A responsible authority must comply with any determination made under subsection (1) or (2). (5) In making a determination under subsections (1) and (2) the Minister must take account of the water available in the resource.

[3] Section 1(1)(xviii) of the NWA defines the Reserve as follows: 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 No. 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. The Reserve is therefore one of the important links between the National Water Act and the Water Services Act.

[4] The ecological component of the Reserve is determined for "average" hydrological conditions and also for drought conditions.

[5] The demographic database was compiled prior to the results of the 1996 National Census being available. The database was subsequently adapted to reconcile it with the National Census results by making changes in areas where the census appeared to provide superior information. The 2001 National Census results were not presented in terms of urban and rural populations, but gave a total population of 44.82 million. Projections made by Statistics SA from the 2001 National Census (a total population mid-year 2003 of 46.43 million) and by the Department from the 1996 National Census (a total population in

April 2005 of 48.43 million - urban 26 million, rural 22.43 million) indicate that the projections from the demographic database are realistic for the first ten year period.

[6] Government is committed to eliminating the backlog on basic water services and to progressively improving levels of service over time - see references to the Water Ladder in the Strategic Framework for Water Services, discussed in Note 6 to Chapter 1.