Watermark

The lasting impression of the Ecological Reserve

Water
Research Commission
TT 307/07

water affairs
& forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

My beloved is only water,
which is always flowing, and doesn't deceive,
which is always flowing, and doesn't change,
which is always flowing, and doesn't end.

Juan Ramón Jiménes (Author)

Will future generations
feel the same way?

Watermark: The lasting impression of the Ecological Reserve

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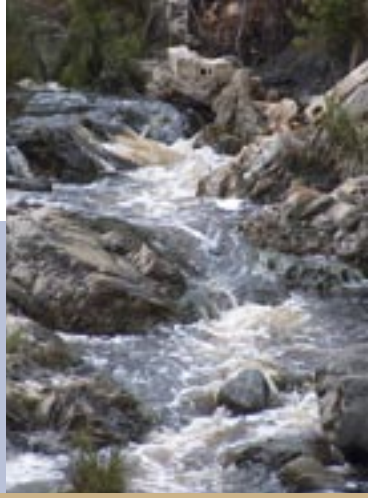

The Ecological Reserve is a concept that forms part of the strategy being developed by government to ensure that South Africa's water needs are catered for without depleting the resource for future generations.
This booklet explains what this Ecological Reserve is, where it fits into the National Water Act of 1998, and how it will help to ensure "some for all, forever".

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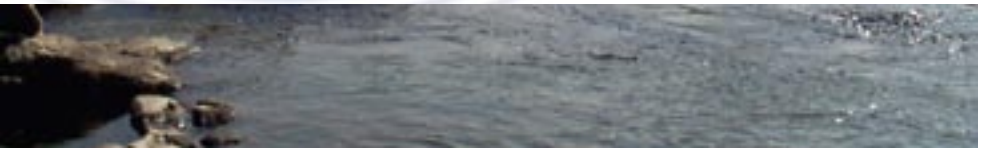

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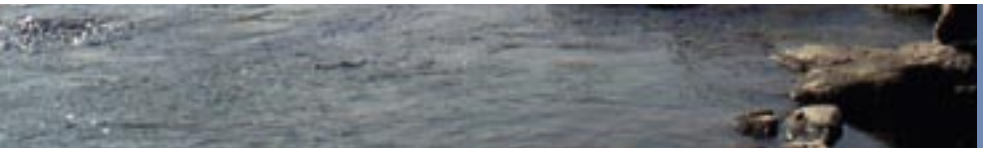


Introduction

In 2000 some 300 million people in sub-Saharan Africa had too little water to meet their basic survival needs – a figure expected to double by 2025. South Africa's Ecological Reserve is a formal set of guidelines that government has put in place to ensure South Africa is not part of this statistic.

This publication explores the rationale behind the Ecological Reserve and illustrates how it will help to ensure the adequate supply of water in the years to come.

The concept of the Reserve encapsulates a three-pronged sustainability approach: social, economic and environmental. Each of these three legs is taken into consideration when decisions are made regarding South Africa's water resources.

We cannot be separated from our natural environment. If the environment deteriorates, it has a direct impact on us and on our rights. The Department of Water Affairs and Forestry (DWAF), indeed government bodies the world over, have struggled to find a balance between serving the current needs of the people and protecting the water resource for future generations. The concepts of the Basic Human Needs Reserve and the Ecological Reserve are bold and effective steps in the right direction to achieving the required balance through legislation. First-world countries have used this very model in achieving their goals. However, South Africa is the first country to legislate this concept and provide this Reserve as right of law. Studies conducted and management strategies applied in the country further demonstrate the strides our country is taking ahead of many Western nations. The idea of the Reserve demonstrates that our government puts people first while at the same time considering future implications.

Water is crucial to environmental sustainability. It sustains the natural functioning of the ecosystem and ensures maintenance of the resource base from which goods and services are provided for society's use.

The principal reason for protecting this resource is to maintain the ecosystem integrity at a level that ensures continued delivery of the desired ecosystem goods and services, and which ultimately leads to human benefit socially, economically and environmentally.

Four myths about the Ecological Reserve

- The Ecological Reserve is water for *goggas* and fish.
- We can only use the water that is left over after we have allocated some for ecological purposes.
- More water for the Ecological Reserve means less water for the people.
- The Ecological Reserve is simply a way of giving consultants jobs.

The pages that follow demonstrate why the above beliefs are untrue. It is important to note that the Reserve's highest priority is basic human needs, and thereafter the requirements of the ecosystem, which benefits people further down the line.

The bigger picture

There is a misconception that the money being spent on defining and implementing the Ecological Reserve would be better spent on rural development. However, this doesn't take the bigger picture into account.

The Ecological Reserve is only part of South Africa's entire water resource, the rest being made up of the water that is set aside for basic human consumption, as well as that which is allocated to sectors such as industry and agriculture for equitable and efficient use.

Like the human body, South Africa's water resource needs to retain a certain amount of water for a sustained level of ecological function. Just as a human being would eventually dehydrate and die without this basic fluid, so would South Africa's water resource without an Ecological Reserve.

While the Ecological Reserve is not intended to protect the aquatic ecosystem at the expense of development, it does ensure that water resources are afforded a level of protection that will ensure sustainable development.

This chapter explains the role of the Ecological Reserve and identifies where it fits into South Africa's water policy.

"The provision of clean drinking water and adequate sanitation to all the people of South Africa remains one of the key challenges in the fight against poverty. There is a need to explore other means of using water efficiently, at the same time creating awareness of water conservation in communities."

Jabulani Sindane
Director-General: DWAF

Two parts of the Reserve

The Reserve consists of two parts – the Basic Human Needs Reserve and the Ecological Reserve.

- The Basic Human Needs Reserve is the water allocated for human consumption before any other water can be assigned. It provides for the essential needs of individuals and includes water for drinking, food preparation and personal hygiene. This Reserve ensures that people are never overlooked in favour of ecosystems or industrial use. Currently this amount is calculated as a minimum of 25 litres per person per day.
- The Ecological Reserve relates to the water required to protect and sustain the aquatic ecosystems in order to secure ecologically sustainable development and water use.

The what and why **of the Reserve**

The Ecological Reserve is the amount of water required by the natural system in order for ecosystems to recover and ultimately replenish themselves so that South Africans will not be short of good quality water in the future.

The Reserve contributes to the protection of water and therefore the sustainability of the resource. The Reserve is not a fenced off, protected area, but rather refers to the collective amount of water needed to sustain an area, based on scientific studies.

When investigating the reasons behind implementing a Reserve, it is vital to zoom out and examine the bigger picture. It is estimated that the world's population in urban areas alone will double in the next 50 years. Already, the number of people without safe drinking water is just short of a billion, and those without adequate sanitation services are close on double that figure. Water shortages do not only affect the water supply we drink. Without an adequate supply for agriculture, food shortages are not far off. The growing competition for water has also put so much stress on the aquatic and wetland systems that many of these important sources cannot function and be ecologically sustainable. International guidelines indicate that at least 30% of the average annual flow of a stream must remain in place in order for the stream and related ecosystems to maintain ecological health. Even today, water flow in a significant number of rivers is on or below this level. Only with fundamental changes in the way we manage water can we avoid a global crisis. We need a plan – and part of this is the Reserve.

The South African Bill of Rights states that everyone has the right to sufficient food and water and to an environment that is not harmful to their health or well-being. We all have an obligation to prevent pollution and ecological degradation. We need to promote conservation, and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. In this way, the Reserve is a response to South Africa's Bill of Rights.

As a nation we must use our natural resources in a manner that allows them to be sustained, and which supports development and growth. As significant contributors to the wealth of South Africa, naturally and financially, our natural resources must not be exploited to a point that is detrimental to future users. We never want to be in a situation where we have turned our farmlands into dustbowls or our rivers into sewage ditches.

Defining and quantifying the Reserve aids in water resource management. Its incorporation into our national water management policy serves both short- and long-term needs – a fine balancing act that has proven problematic in the past across the world. The Reserve serves to protect our water resources while addressing the current urgency for quality drinking water.

In the bigger picture, the Reserve forms part of a programme to classify the various water resources in South Africa. Known as the National Water Resource Classification System, this prescribes the Reserve and the availability of water, and therefore decisions on licences for agricultural and industrial water use will be based on this classification system. Many first-world countries use this classification approach, however, South Africa is the only country in which it is actually legislated.

The Ecological Reserve is being implemented by DWAF and determined using well-developed methodologies. It is set at a value so as to ensure that the natural ecology of each water body can be maintained or improved, but in a way that will have no or minimal impact on socio-economic factors.

1. Basic human needs. 2. Ecological needs. 3. Allocations for international obligations, inter-basin transfer and strategic needs for future use. 4. All other uses are authorised according to the criteria of equity, efficiency and sustainability.

Water allocation priorities of the National Water Act

The total ground and surface water is defined in terms of three basic use groups:

Name	Description
Basic human needs	The Basic Human Needs Reserve is the agreed amount of water guaranteed as a right for every South African citizen to suit basic human needs, such as cooking and cleaning.
Ecological needs	The Ecological Reserve is the agreed minimum amount of water required locally and/or downstream to maintain or improve local ecology.
Allocable water	This is the remaining quantity of water, once the total Reserve has been determined and subtracted from the quantified total amount of water that is economically available.

Placing present needs **in perspective**

The imbalances of the former regime have left many South African homes without basic necessities. Today, between 12 million and 14 million South Africans are without access to safe water and over 20 million are without adequate sanitation.

Apartheid policies left South Africa with a great disparity in both wealth and access to services and natural resources. A large proportion of the South African population is poor or vulnerable to poverty. The National Water Act (NWA) and, in part, the Reserve have been put in place to cater for these needs now and into the future. Under apartheid, the white minority had access to a high level of services such as water, sewerage, transport, electricity and housing, equal in most cases to the service levels of the developed world. Large sections of the black community, on the other hand, had little or no access to basic services.

LEGISLATION

1800-1920
South Africa experiences significant environmental pollution with the development of towns and industries.

Water management begins with the promulgation of the Public Health Act of the Union of South Africa in 1919.

1950s
South Africa moves from an agriculturally based economy to one in which industry and mining play a major role, causing concern over the maintenance of clean water.

The Department of Irrigation becomes the Department of Water Affairs.

1956
The Water Act is introduced, which aims to control industrial use of water and the treatment and disposal of effluents. Reconciliation of water supply with water demand becomes difficult – reuse of effluent plays a major role in the management of scarce water resources.

1983
Conservation of Agricultural Resources Act is promulgated, which provides for the conservation of natural agricultural resources by maintaining the production potential of land. Special focus is given to combating and preventing erosion and the weakening or destruction of water sources. Uniform effluent standards are established in 1984.

There was no real legislation governing access to water in South Africa, and access was generally linked to land ownership. The black population in South Africa therefore suffered a lack of water services, which was compounded by a lack of access to water for economic purposes, including irrigated agriculture.

DID YOU – KNOW? –

Only 44,7% of South African households have a tap inside their homes, 16,7% have a tap in the yard, 19,8% fetch water from a public tap, and over 14% access water from dams, rivers, boreholes, rainwater, water carriers or tankers.

The impressions left by the apartheid government are still experienced today. Within the poorest 53% of the population, a third live in shacks or traditional dwellings, about 70% have no access to piped water, and more than 80% have no access to modern sanitation.

Women and children are disproportionately affected by the lack of access to basic water services. Rural women in South Africa spend more than four hours a day collecting water and wood. Thousands of children worldwide die annually of avoidable diseases related to poor sanitation and the lack of clean water. (Information from www.wateryear2003.org.)

THE FUTURE OF FARMING

The NWA has given DWAF the tools to make water available to previously disadvantaged communities for economic activities such as irrigated agriculture.

Years of dispossession and alienation have robbed many of the descendants of black farmers of their skills, knowledge and understanding. In returning agricultural land to

TIMELINE

1989

The Environmental Conservation Act is promulgated, which ensures that the environmental effects of developments and activities are taken into account before decisions are made.

1997

The Water Services Act is promulgated, which gives legal force to the mandate of the Reconstruction and Development Programme (RDP). It is the governing legislation for water services and sanitation.

1998-1999

The NWA is promulgated. Chapter 3 of the NWA is enacted, which started the implementation of resource classification, the Ecological Reserve and Resource Quality Objectives (RQOs). These objectives guide the quality of all aspects of the water resource, which includes water quality, water quantity and the aquatic ecosystem quality. The RQOs embody an approach that strives towards a sustainable balance between protection, on the one hand, and water use and development on the other.

black communities, it is therefore necessary for the South African government to not only make water and access to capital available, but also to assist in restoring basic farming skills.

The Reserve allows government to rectify much of the ill effects caused by past inequities. The Reserve and other guidelines in the NWA work together, and only if the total resource is properly maintained through ecological sustainability can the basic human requirements be adequately met now and into the future.

DID YOU – KNOW? –

Until the beginning of October 1998, the Water Act 54 of 1956 was the legal and management framework for South Africa's water resources.

1994 – THE WAY FORWARD

The Reconstruction and Development Programme (RDP), a development manifesto of the African National Congress (ANC) government, recognised that a concrete programme of action was needed to address the imbalances of the past. With regards to water, the RDP stated that the fundamental principle of our water resources policy is the right to access clean water – "water security for all".

The NWA, following on from the RDP, has substantially altered the framework for access

Old vs. new legislation

The most significant difference between the new Water Act and the apartheid Water Act is that the latter was extremely dictatorial.

Water Act (1956)	National Water Act (1998)
Under the apartheid Act, the Minister decided who should get permits to receive water from State dams.	Today, the powers of the Minister vest mainly in policy matters.
Previously, a Minister could declare any area a State water control area and have direct control over such water.	The NWA stresses that the Water Affairs Director-General must devolve administrative powers down to local levels as far as possible.
A Minister in the former government could withdraw water permits issued to people without payment of a refund.	With the NWA, licences for the use of water must be subject to review because of population growth and the increase in water needs.
Under the old Act, the Minister appointed committees at his/her sole discretion to help with allocating water.	Under the NWA, interested parties have representation on catchment management agencies, which gives them a direct say in how water is controlled and distributed.
Groundwater was a private resource.	Groundwater is seen as part of the water cycle.
Water rights were linked to land ownership.	Equity is central to the Act: "Some for all, forever".

to untreated bulk water. In particular, the legislation has separated access to water from land ownership in rural areas, and has removed the previous expectation of permanent rights to water. Under the NWA all water will be allocated through time-limited licences. Since 1994 the government has brought water services to at least eight million people in both rural and urban areas. The Reserve is being put in place to help ensure that this is sustainable.

DID YOU – KNOW? –

Diarrhoeal disease remains the leading cause of infant and child morbidity and mortality in developing countries. In South Africa it is estimated that there are around 1,5 million cases of diarrhoea in children under five each year.

Sanitation studies

A recent study of diarrhoea in children in poor communities in South Africa revealed that there were higher levels of diarrhoea in situations where a communal tap was used rather than on-site taps. This seems to imply that on-site taps lower the risk of water-borne disease. Communal taps require water to be carried and stored, which appears to lead to higher contamination levels.

South Africa's **water policy**

The aim of the NWA is to manage water resources to achieve optimum short- and long-term social and economic benefits for all. This implies maintaining an optimum balance between protection of the environment and efficient use.

The NWA, which was passed in August 1998, is innovative in that it incorporates the concept of the Reserve, which now represents the only water right within South Africa.

In terms of this Act, the Ecological Reserve forms the basis from which South Africa's water resources and supply are protected, and is regarded as the basis from which all other water is maintained.

Equitable access to water services can be improved by changing the rules that govern access to water resources. Increased funds and better regulation can improve service provision.

GOVERNMENT OBLIGATIONS

Government strives to carry out its public trust obligations in a way that will:

- guarantee access to sufficient water for basic domestic needs;
- ensure that environmental requirements are met;

The National Water Act (1998)

The NWA is a people-centred act. It aims to achieve integrated water resource management to ensure equitable and sustainable use of, and access to, resources. It aims to ensure that the nation's water resources are properly protected, used, developed, conserved, managed and controlled.

The Water Services Act (1997)

The overall objective of the Act is to help municipalities to manage water service provision to ensure effective, efficient, affordable and equitable access to water services for all people. The Water Services Act provides a developmental regulatory framework for water services delivery by defining the roles and responsibilities of water services institutions. It allows for the setting of norms and standards for water services in the country. It also defines the regulatory and intervention functions of municipalities, the Minister of Water Affairs and Forestry, and Provinces.

DID YOU – KNOW? –

165 water service authorities currently provide 3,9 million poor households with free basic water.

- Department of Provincial and Local Government

- consider the interconnected nature of the water cycle – a process on which the sustainability and renewability of the resource depends;
- make provision for the transfer of water between catchments;
- respect South Africa's obligations to its neighbours; and
- fulfil its commitment as custodian of the nation's water.

OUR NATIONAL WATER POLICY

There are four key features mapped out in the NWA that outline government's approach to water protection and aid in the decision-making process:

1. The policy determines the level of protection required by classifying the resource according to a scale. This scale defines if the resource qualifies for Reserve status and what the quality level of the resource should be.
2. There are regulations in place to control actions that impact on South Africa's water resource, so that it is protected (e.g. waste standards and water use licensing).
3. The policy manages the demand for the resource so that utilisation remains within the limits required for protection.
4. The policy monitors the status of the country's water resources to ensure that the stated Resource Quality Objectives (RQOs) are being met.

Simply put, RQOs are numerical and narrative descriptions of the conditions that need to be met in order to properly manage the resource so that the Reserve can take effect.

Improvements

The NWA improves on the Act of 1956 in the following ways:

- meets increasing basic human needs of present and future generations;
- promotes equitable access to water;
- redresses the results of past racial discrimination;
- promotes efficient, sustainable and beneficial use of water in the public interest;
- facilitates social and economic development;
- protects aquatic and associated ecosystems and their biological diversity;
- reduces and prevents pollution and degradation of water resources; and
- manages floods and droughts more effectively.

Water **allocation**

The allocation of water and water services in the new policy seeks largely to address the inequities and shortcomings of the past. The NWA strives to achieve optimum use of the resource in a way that is environmentally sustainable, economically beneficial and which allows for equitable distribution.

The water allocation process, as defined by the NWA, aims to promote equity, address poverty, generate economic growth and create jobs. It also recognises that redressing the effects of previous discriminatory legislation provides social stability, which in turn promotes economic growth. Moreover, the water allocation process aims to allow for the sustainable use of water resources and will promote the efficient and non-wasteful use of water.

OPTIMUM RESOURCE USE AND PROTECTION

The Constitution places a duty on the national government, in cooperation with the other spheres of government, to make sure that our limited water resources are used to improve the quality of life of all South Africans. The NWA outlines how government should manage water so as to achieve optimum, long-term, environmentally sustainable social and economic benefits for society.

ADDRESSING CURRENT ISSUES

The water allocation process should support and facilitate broad-based Black Economic Empowerment by promoting larger scale productive commercial uses of water.

It could also play an important role in mitigating both the human suffering and the economic consequences of the HIV/Aids pandemic. This relates to its role in promoting and supporting subsistence and household food security initiatives.

THE RESERVE AND ALLOCATION

The Basic Human Needs Reserve and Ecological Reserve relate to the quality and quantity of water required to satisfy basic human needs and to ensure the ecologically sustainable development and use of

Impacts on water allocation

Considerations to be taken into account before any water is allocated for additional use:

- the needs of the Reserve in a particular area;
- relevant international obligations;
- the requirements of existing water use licences in the area; and
- the need to redress the impact of past racial and gender discrimination.

Equity

The principle of equity is central to the water law reform process, and special attention has been given to addressing the needs of those who were historically denied access to water or to the economic benefits of water.

Equity implies a concept of fairness that allows for different water management practices in response to different social, economic and environmental needs, and it is important to identify the policies, institutions and practices that will support this principle. This does not mean that the water allocation process will focus solely on issues of equity. It will also support water uses that generate employment and growth.

With equitable access comes a greater demand for water, as more people would have this resource provided as a right. The Reserve contributes to this allocation by ensuring a sustainable supply.

Equity in access to water services – The most important contribution to achieving equitable access to water services is the provision of funds and the regulation and direction of the institutions whose task it is to provide the services.

Equity in access to water resources – The previous water law linked access to water with ownership of land, which produced an uneven distribution of access to water. Well-watered land was most prized, causing even greater imbalances in access to water for agricultural use. Water for irrigated agriculture, which accounts for about 59% of all water use in South Africa, is not widely distributed. Less than half of the 60 000 commercial farmers in South Africa have irrigation as the major component of their business. It is not practical, nor possible, to divide up South Africa's water resources so that each person has access to the same amount of water.

the relevant water resource. In terms of the NWA, water must be assigned to meet these requirements before any other water can be allocated for any other use. First, however, the size of the Reserve must be determined.

THE BALANCING ACT

If reallocation of water is done too quickly, or haphazardly, the country may suffer economic or environmental damage as emerging users struggle to establish productive and beneficial uses of water. Conversely, if water reallocations take place too slowly, social and political pressures will force a quicker pace for water reform, which could destabilise the process.

Social and economic benefit

Water has to be allocated to a number of different and competing users who could all claim to be using the resource productively in some sense. The challenge is to set up a framework that ensures our water is used productively and optimally in the best interest of South African citizens.

The value of this idea is clearer when social and economic benefits are considered together. If two competing uses are judged on an economic basis, the more profitable use is selected. If judged on a social basis, the use that contributes more to a desired social need (such as a reduction in unemployment or better health) will be selected.

When social and economic values are combined, the problem becomes more difficult. The idea of optimum use weighs up different social, economic and environmental objectives.

Water and nature

South Africa faces specific challenges in proficiently using and protecting its water resource. The country has a dry climate as compared with the world average, and the physical challenges at ground level affect the water cycle as well as our economy. The implementation of the Ecological Reserve takes these conditions into account so that the management of the total resource can be adjusted to suit South African-specific conditions.

"As a world-class example of sustainability in action, the aim of the NWA is to balance the need for economic growth and development against the equally urgent need for water resource protection and conservation."

Barbara Schreiner, Deputy Director-General:
Policy and Regulation – DWAF

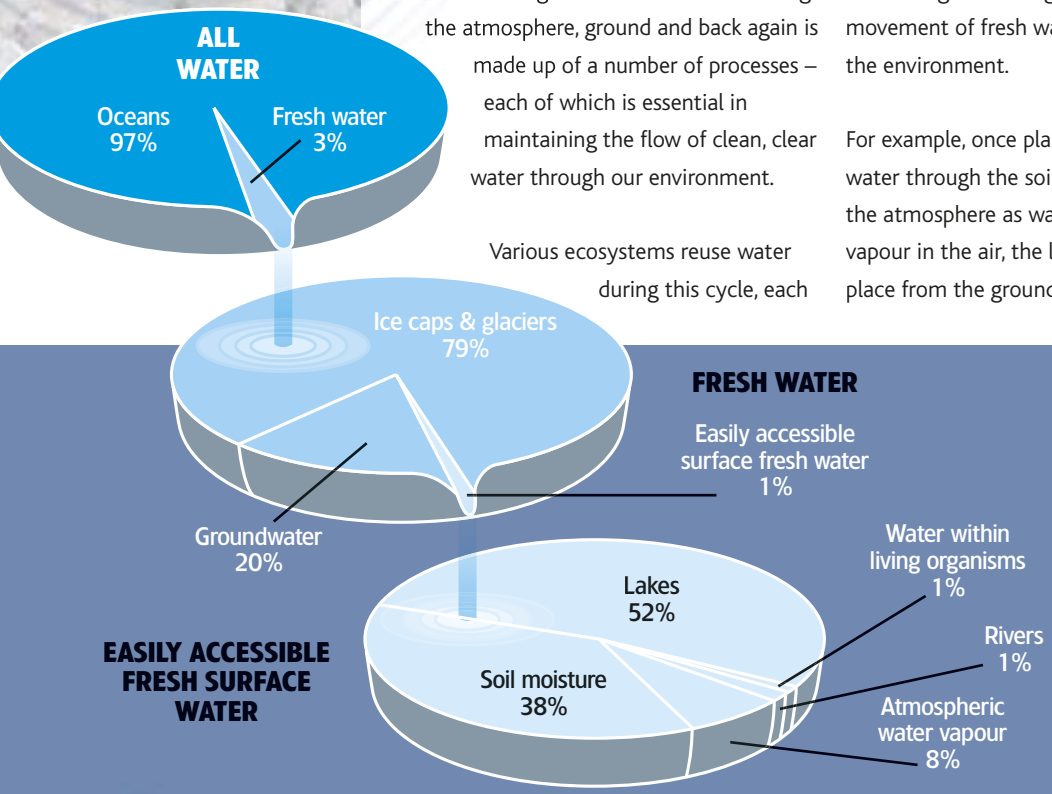
The **water cycle**

Every drop of water on the planet passes through the water cycle and is touched by various ecosystems along the way. The Ecological Reserve is pivotal in maintaining these ecosystems so that every South African can benefit down the line.

The never-ending movement of water through the atmosphere, ground and back again is made up of a number of processes – each of which is essential in maintaining the flow of clean, clear water through our environment.

Various ecosystems reuse water during this cycle, each time doing something that purifies or aids the movement of fresh water to another part of the environment.

For example, once plants have absorbed water through the soil, they release it into the atmosphere as water vapour. The more vapour in the air, the less evaporation takes place from the ground surrounding the plant.



Removing vegetation in a certain area leads to increased evaporation and greater erosion, ultimately reducing the amount of water that is available later on in the cycle.

DID YOU – KNOW? –

On a global average, most freshwater withdrawals are used for agriculture (69%), industry (23%) and municipal use (8%), i.e. household and domestic use.

from the system, but also by interfering with the natural ecosystems that keep this cycle in check. Clearing land for construction, for example, prevents water from seeping into the ground to be stored. The more water that remains on the surface, the greater the likelihood of flash floods, surface run-off and lower dry-season base flows.

The water cycle is crucial to life and for the ecological balance of our planet. However, excessive human consumption of fresh water for agricultural, industrial and personal use, along with the careless disposal of our waste water, is threatening the viability of the water cycle. This in turn adversely affects every living thing on the planet.

HUMAN IMPACT

We disturb the water cycle mainly by extracting huge amounts of fresh water

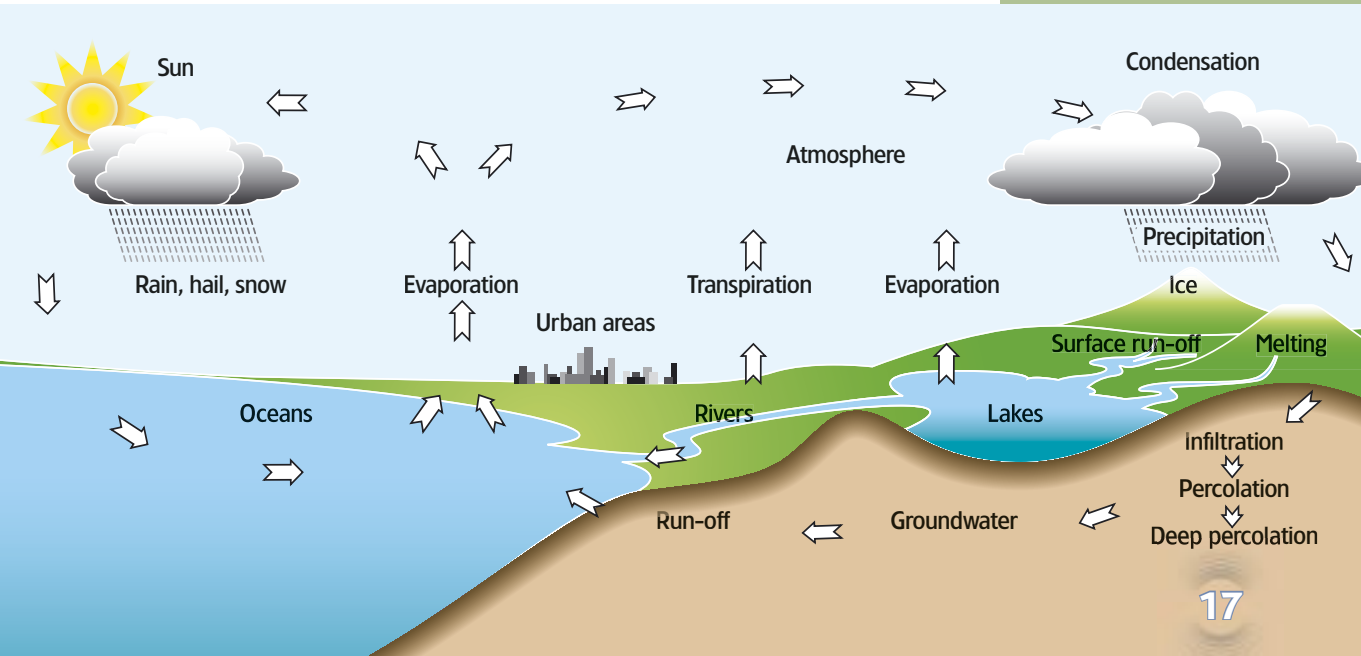
THE WATER CYCLE AND THE WATER ACT

All water in the water cycle, whether on land, underground or in surface channels, falling on, flowing through or infiltrating between such systems, is treated as part of the common water resource and therefore falls under the protection and management of the NWA.

The Earth's water

The Earth's total allotment of water has a volume of about 534 million cubic kilometres. Of this:

- 93% is sea water;
- 2,5% is contained in aquifers deep within the Earth;
- 2% is frozen in polar ice caps;
- 0,016% passes through the planet's lakes and streams;
- 0,0012% is atmospheric moisture;
- 0,0010% is locked within the bodies of living things; and
- 2,4818% – other.



Climatic **impact**

The South African climate oscillates between the extremes of drought and flood. The impact on the country's biodiversity, its water resources, the economy and the health of its people can be felt for years.

South Africa is famous for its sunshine, but challenged by its low rainfall. The annual average rainfall of less than 450mm – compared to a world average of about 860mm – leaves parts of our country quite literally high and dry. In the 1970s and 80s, South Africa suffered years of extreme drought. In the summer of 2000, however, we encountered the worst floods of the century. Both extremes adversely affect the water supply required to meet basic human needs as well as ensure ecological sustainability.

Low, irregular rainfall makes water storage and distribution essential. However, even this remains a challenge in South Africa. The country does not have many big rivers, the Orange River being the largest.

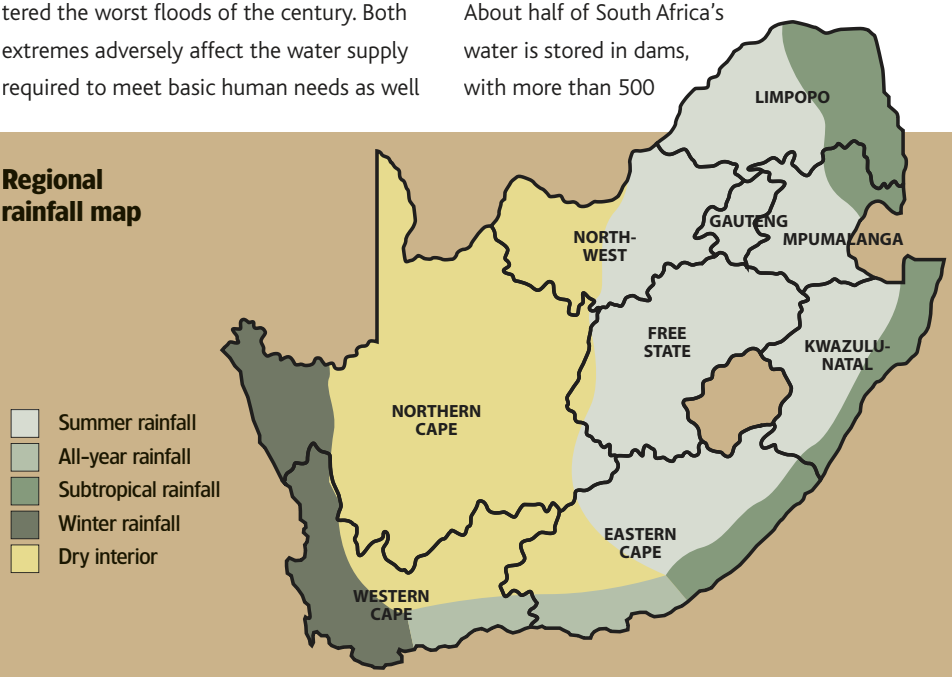
About half of South Africa's water is stored in dams, with more than 500

Managing climate change

While the climate itself cannot be controlled, the impacts of it can, and this is where the Ecological Reserve comes in.

- Integrated water resource management on a regional level helps to protect the resource, secures future food supply and avoids potential regional conflict.
- It provides food security by facilitating ongoing agricultural production.
- Managing use so that the water cycle is maintained helps to preserve natural resources and biodiversity.
- Proper water management helps to minimise the insect- and water-borne diseases that proliferate in drought and flood areas.
- It also helps to minimise the damage caused by flooding to infrastructure, homes and informal settlements.

Regional rainfall map



State-managed dams holding water for millions of people and their economic needs. Together with our river system and man-built canals, these dams are used to help move water from wetter to drier regions.

– FACT –

According to NASA, 2005 was the warmest year in over a century. The next-warmest year was 1998, followed by 2002, 2003 and 2004. Higher temperatures mean more evaporation, which increased roughly by 10% to 20%.

The country is linked by very few major water sources and this means that if one region is affected, there are bound to be consequences in the other regions through which the same system travels. Climatic anomalies, like El Niño in 1998, can exacerbate adverse effects on our river systems, negatively affecting various important economic regions in South Africa. The Ecological Reserve aims to enable the entire system to function in spite of rising temperatures and climatic anomalies. It is more than just a buffer that allows for the system to recover. Without the Ecological Reserve, central regions in South Africa will have no drinkable water – a trend that could spread quickly across the country.

CLIMATE CHANGE

Global climate change is a reality and a serious threat to sustainable development, especially in developing countries. It could undermine global poverty alleviation efforts and have severe implications for food supply, potable water, energy supply and environmental health.

The world is getting warmer, and both evaporation and precipitation are expected to increase in most areas of South Africa. Where evaporation increases more than precipitation, soil will become drier and river levels will drop. Lower river flows could reduce the amount of water available for agricultural, residential and industrial use.

Water quality also suffers. In areas where river flows decrease, pollution concentrations will rise because there will be less water to dilute the pollutants. Increased frequency of severe rainstorms could also increase the amount of chemicals that run off from industries, farms and streets into rivers.

EFFECTS OF CLIMATE CHANGE

It is estimated that agricultural production in sub-Saharan Africa could fall by up to a third in the next 50 to 60 years because of longer dry seasons and changes in rainfall patterns. Coastal fishery output, particularly in the west of the country, could drastically decrease due to warmer water currents.

Integrated water research management can allow for increased awareness and better facilities so that water-borne diseases decrease, while the agricultural industry, and therefore food supply for the future, is sustained.

It is estimated that agricultural production in sub-Saharan Africa could fall by up to a third in the next 50 to 60 years.

"Water is life, and in our country, where water is a scarce resource, we have the challenge of redressing past inequities in water allocation while simultaneously ensuring equity between generations."

Harrison Pienaar, Chief Director: Resource Directed Measures (RDM) – DWAF

Water, life and livelihood

Water shortages and deteriorated quality can have a knock-on effect throughout the economy, affecting far more than just our drinking supply. The aim of the Ecological Reserve is to ensure that this never happens.

The pages that follow examine and map out the everyday effects of how we use our country's water resource, what we need to do in order to protect it in terms of waste disposal and water treatment, and how innovative technologies can help us do it.

The studies and technologies mentioned here will help us classify the water resource, allowing for better management of the Ecological Reserve and South Africa's resource as a whole.

Water and **quality of life**

Although government has made progress in addressing backlogs in water services, the provision of water to meet basic human needs does not make allowance for water for income-generating activities. The Reserve attempts to balance these two needs.

Prioritising water allocations for emerging farmers and small grower forestry schemes, and revitalising defunct irrigation schemes has the potential to provide livelihoods for many people in rural areas. However, these do not address the needs of the large numbers of people who require water for small-scale activities. The quantities of water required are relatively small – research in small villages indicates that livelihoods can be significantly enhanced by the availability of 50 to 100 litres per household a day. If government is to cater for this, demands on our country's water supply will grow. The Reserve can help to ensure that supply is sustainable despite this increase in demand.

The demand for water does not necessarily need to be met via piped supplies or by using water abstracted from rivers. Rainwater harvesting from roofs or other hardened surfaces using tanks, small check dams or catchpits can supplement more conventional sources of supply. Groundwater is also useful in other ways. Soil moisture can be retained on cultivated land, and infiltration can be increased, by contouring or constructing other micro water-retaining structures, which have limited effects on water resources or downstream users.

WATER FOR FOOD SECURITY

Food security is often used as a motivation for the high priority given to water allocations for agriculture. One of the primary goals of the National Water Resource Strategy (NWRS) is to facilitate the most beneficial use 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 common understanding among interest groups of the concepts of food security and food self-sufficiency.

Food security refers to assuring sufficient food at all times, whilst food self-sufficiency refers

to the capability for own food production. Both principles can apply on an individual as well as 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 one's 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 determine the ability of a country to produce sufficient food to meet all its requirements. A strong, diversified and globally well-integrated economy with a high level of employment may better provide for national food security than the strife of self-sufficiency. Hong Kong and Singapore are successful examples of this.

HEALTH

Recent studies show that water-borne diseases are found to develop more readily in instances of reduced flow. When flow is changed and becomes too low for the region, river characteristics are altered to the point where water-borne diseases become a serious threat.

In developing countries, four-fifths of all illnesses are caused by water-borne diseases, diarrhoea being the leading cause of childhood death. Diarrhoea occurs worldwide and causes 4% of all deaths and 5% of health loss due to disability.

Malaria – which becomes more prevalent in low-flow areas – kills over a million people every year, a large percentage of which are in Africa, south of the Sahara. It is estimated that a person dies from malaria in Africa every 30 seconds.

Malaria is estimated to cost Africa more than R84 billion every year in lost Gross Domestic Product (GDP).

Malaria is estimated to cost Africa more than R84 billion every year in lost Gross Domestic Product (GDP). Economists believe that this disease alone sets potential growth back by up to 1,3% per year in some African countries.

Government takes these statistics very seriously and the Ecological Reserve is a key factor in dropping these terrifying numbers.

Without an Ecological Reserve to maintain river flow, South Africa will almost certainly see an increase in the instances of malaria and other life-threatening diseases, including bilharzia and cholera.

It is not just water-borne diseases that become problematic due to reduced flow. Toxicity of the resource can also create challenges. In the case of low flow, rivers carry sediment in the form of suspended load and bed load. In some cases the latter is charged with metals and other toxic materials. This sediment load is adjusted to the flow regime of the river over time, and changes to this regime accompanied by increases or decreases in the load can cause problems downstream.

AGRICULTURE

South Africa is currently self-sufficient with respect to most of its food requirements, thanks to rain-fed agriculture. While 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, 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. However, it 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. This takes 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 required for local production could be applied to other products that would create greater wealth and welfare.

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

DID YOU – KNOW? –

In 2005, water supply was provided to a further 1,51 million people, and sanitation to a further 1,3 million people.

South Africa, especially in rural areas, who do not have the financial means to purchase food and whose only solution to food security lies in achieving household food self-sufficiency. After meeting the requirements of the Reserve and honouring international agreements and obligations, the NWRS gives high priority to water for poverty eradication and related social needs in an attempt to develop the second economy. This may include water for own food production and the creation of microenterprises.

DID YOU – KNOW? –

About 25 000 litres of water is required to grow a day's food for a family of four.

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

The NWRS gives high priority to water for poverty eradication and related social needs in an attempt to develop the second economy.

The role of water **in the economy**

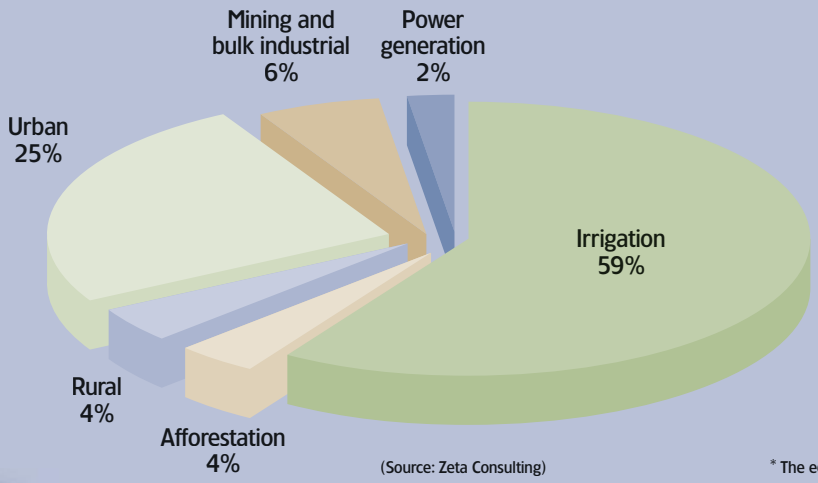
Water resources play a pivotal role in South Africa's economy, providing for all of its main industries, helping to produce many of the country's consumables and creating jobs.

The level of protection required by any body of water is determined through classification. Depending on the level of classification, decisions can be made regarding how that water is used and managed.

Water is critical to agriculture, forestry, industry, mining, power generation, bulk storage, recreation, and the provision of urban and rural water services. In agriculture, for instance, water is needed to produce food, fibre, fuel wood and timber. Such use can help

Where does our water go?

Total SA water yield: 13 trillion litres* per annum



(Source: Zeta Consulting)

DID YOU – KNOW? –

The agriculture, forestry and fishing industries increased their contribution to the total economic growth rate in South Africa by 5,4% in 2005.

- Statistics South Africa, 2005

* The equivalent of 5,2 million Olympic swimming pools

to reduce poverty and increase the earnings of people who depend on water-based agriculture, including subsistence, emerging and commercial farmers.

Around 59% of all available water in the country is used for irrigation agriculture. Domestic and urban use accounts for about 25% and mining and some large industries for about 6%. Commercial forestry plantations use about 4%.

Some economic sectors such as manufacturing and electricity generation use relatively small amounts of water to earn a large income for the country and its people, contributing significantly to South Africa's GDP. They also provide good employment. Other sectors, such as agriculture, use vast quantities of water while creating proportionately less income and employment.

The economic value of a water resource is traditionally assessed in terms of the amount of water that can be abstracted for off-stream use. Typical indicators include the number and value of jobs created by the use of the water, or the amount of revenue generated.

Water resources also provide other services that are often not included in economic valuation, in particular this applies to the services and benefits provided by aquatic ecosystems.

These can include:

- supply of good quality water;
- transport and/or purification of biodegradable wastes;
- recreation and aesthetic opportunities;
- food production;
- flood attenuation and regulation; and
- water-based transport.

While the development of tools for quantitative valuation of ecosystem services and benefits is still at an early stage, it is necessary that all the potential economic values of a water resource be identified when assessing its economic importance.

HOW WE VALUE WATER

Water is valued in qualitative terms (on a local, regional, national, seasonal and strategic basis) as well as quantitative (in Rands or product per litre, taking into account the goods and services offered by the resource).

This applies to both surface and groundwater resources.

THE ROLE OF GROUNDWATER IN THE ECONOMY

Groundwater is less affected by droughts, and the recharge cycle is on a much

DID YOU – KNOW? –

It takes about 22 litres of water to grow a single serving of lettuce – and almost 10 000 litres are required to produce a single serving of steak.

Economic overview of South Africa

South Africa is a middle-income, emerging market with an abundant supply of natural resources; well-developed financial, legal, communication, energy, and transport sectors; a stock exchange that ranks among the 10 largest in the world; and a modern infrastructure supporting an efficient distribution of goods to major urban centres throughout the region. However, growth has not been strong enough to lower South Africa's high unemployment rate. Daunting economic problems remain from the apartheid era – especially poverty and lack of economic empowerment among the disadvantaged groups. South African economic policy targets inflation and trade as means to increase job growth and household income.

longer timescale, with more protected storage than surface water. This makes it a strategically valuable resource, particularly during dry periods. The value of groundwater is also linked to dependency. A high dependency implies that there is no alternative resource. Moderate dependency means that alternative water sources are available, but at a cost. No dependency means that alternate sources of water can be used with no impact on the availability and cost of water supply services.

DID YOU – KNOW? –

Agriculture generates an estimated 5% of South Africa's GDP, and around 8% of its total exports. Manufacturing generates approximately 25% of our GDP, construction 4% and mining 7%.

THE ROLE OF ESTUARIES IN THE ECONOMY

Estuaries or river mouths (see explanation on page 36) are productive systems that provide a valuable supply of goods and services, ranging from recruitment to the marine fisheries to recreational opportunities. South Africa has roughly 255 functioning estuaries along its 3 100km coastline. These estuaries are affected by domestic and industrial usage (which influences the amount of water running into an estuary) as well as by the increasingly large numbers of people who reside in or visit coastal zones.

If estuaries and their catchments are to be managed in an optimal and sustainable way, it is necessary to understand the full economic value of the goods and services that they provide.

One of the most important values of estuarine systems is their contribution to recreational and subsistence fisheries. However, estuaries also act as nursery areas for numerous species of fish, and recreational and commercial harvesting impact heavily on the early stages of growth in fish species.

If the various economic sectors continue to feed on the resource without allowing the system to replenish itself, there will eventually be no more useful water, which will impact heavily on these sectors.

Fortunately, in recent years, the realisation of the value of estuaries has prompted better management of these areas in South Africa.

The implementation of the Ecological Reserve supports this in that it is mindful of the entire system, as well as future and current usage. Reserve determinations therefore take into account all social and economic impacts on an estuary before it is classified.

THE ROLE OF WETLANDS IN THE ECONOMY

Wetlands are increasingly recognised as areas of economic and ecological importance.

These areas are seasonally or permanently inundated or saturated with water, with the resulting plant and animal communities being adapted to these waterlogged conditions. Types of wetlands range from seeps and springs in mountain regions through to midlands marshes, swamp forests and finally river estuaries – all linked together by corridors of streambank wetlands.

Without sufficient protection of our water resources by wetlands, our already stressed agricultural regions will be characterised by water shortages, increased soil erosion, and ultimately the loss of agricultural potential.

Wetlands protect our water resources and are a vital component of river catchments, which, by virtue of their unparalleled value for flood control, water storage, stream-flow regulation, drought relief, soil erosion protection and wildlife protection, offer substantial benefits to people and their activities. *(Endangered Wildlife Trust)*

Different types of wetlands are estimated to have a value based on direct and indirect services. A rough estimate of the value of drained wetlands to agriculture is R725 per ha for grazing land and R1 500 per ha for cultivated land. *(XD B, Water and the economy, 2003)*

Payment for water services

Despite the successful implementation of the Ecological Reserve, the sustainable provision of water services depends on a better understanding of water user behaviour in relation to payment strategies.

To this end, the WRC has done studies among low-, mid- and high-income water users in the metropoles of Tshwane and Ethekwini and in the city of Cape Town. These studies have provided a better grasp of how changes in the price of water will change the quantity of water being used for different purposes. Payment strategies and tariff structures could therefore be refined as a means of encouraging better cost recovery for services.

Water quality **and environmental flow**

Drastic changes in the flow of South African rivers have a domino effect on the population and the ecosystem, from water quality, to wood supply, to livestock. It is therefore important to assess flow changes in order to manage our resources better.

Maintaining an Ecological Reserve of acceptable quantity and quality depends largely on sustaining the constant and acceptable flow of water, as established by researchers.

Water quality and quantity are closely linked in that any change in quantity will directly affect the quality of the resource. The determination and implementation of the Ecological Reserve rests on assessment studies done in the field, or on simulations and calculations done by new technology.

All aspects of the Reserve include both quantity and quality: there is little point in ensuring adequate flows in a river if the water is so polluted that it poisons everything, or in reducing river flow to the point where the concentration of certain chemical variables becomes critical.

Increasing water demands are degrading South Africa's aquatic ecosystems. Nowhere is this problem more apparent than in developing regions in semi-arid climates, where populations are reliant on very limited water resources. It is important that we assess changes in water systems as a result of our reliance on them, so that we may manage our aquatic resources in a more reliable manner.

Balancing the use of aquatic ecosystems for various human needs and the protection of these ecosystems so they continue to be used by present and future generations is one of the central challenges in water-resource management. Linked to this is the concept of environmental

– FACT –

1,2 billion people worldwide do not have access to clean water.

flow. Environmental flow is water maintained in a river, or released from a reservoir, to keep up water levels downstream. These flows are increasingly being recognised as a valuable tool in water-resource management, as they provide an indication of the volume and timing of the water required to maintain a river ecosystem.

ASSESSING FLOW

Downstream Response to Imposed Flow Transformations (DRIFT) is a new methodology administered via computer for assessing the environmental requirements for the maintenance of rivers that are subject to water developments. This methodology is used in the classification of a Reserve by DWAF. Previous assessment tools included Flow-Stressor-Response (FSR) and Building Block Methodology (BBM).

The output of DRIFT is a matrix of consequences and severity ratings that enable experts to predict and manage the impacts of changes in river flow.

DRIFT provides a holistic approach to environmental flow assessments, taking into consideration all parts of the intra-annual and inter-annual flow regime, and all living and non-living parts of the river ecosystem from source to sea. It is a scenario-based approach, combining data, experience from a multi-disciplinary team of specialist river scientists,

Different kinds of flow

Low flows: These are the daily flows that occur outside of high-flow peaks. They define the basic hydrological nature of the river: its dry and wet seasons, and degree of perenniality. The different magnitudes of low flow in the dry and wet seasons create different habitats and different hydraulic and water-quality conditions, which directly influence the ecosystem at any time of the year.

Small floods: Small floods are ecologically important. They stimulate spawning in fish, flush out poor-quality water, and mobilise and sort gravels and cobbles, thereby enhancing diversification of the riverbed and contributing to flow variability. They reset a wide spectrum of conditions in the river, triggering and synchronising activities as varied as upstream migrations of fish and the germination of seedlings on the river bank.

Large floods: Large floods trigger many of the same responses as small floods, but additionally provide scouring flows that influence the form of the channel. They mobilise coarse sediments, and deposit silt, nutrients, seeds on floodplains, and allow some species of fish access to breeding grounds. They inundate backwaters and secondary channels, and trigger bursts of growth in many species. They recharge soil moisture levels in the banks and scour estuaries, thereby maintaining links with the sea.

Flow variability: Discharges constantly change through each day and season, creating mosaics of areas that are covered and exposed for different lengths of time. The resulting physical diversity determines the local distribution of species: loss of flow variability means less physical diversity and therefore less biodiversity. This increases the chance of alien-invasive species in these areas.

The four modules of DRIFT

Biophysical – data on the river are gathered in order to predict how it would change in response to flow changes.

Subsistence – data on subsistence users of the river are gathered in order to predict how they would be affected if the river changed.

Scenario-building – scenarios are compiled, based on potential changes in river flow, to show how the river could change and what impacts this could have on subsistence users.

Socio-economic – this information helps to quantify the costs of these impacts.

and other local knowledge on the river of concern to predict how the river could change with flow manipulations.

Through custom-built programs, DRIFT predicts the social and economic impacts of these river changes on those who use the river for subsistence. The system is currently used by DWAF in its management of aquatic ecosystems. All data and knowledge that are collected are stored in a database so that they can be used again in the future to simulate any number of scenarios.

POPULATION AT RISK

A "population at risk" is the phrase used to identify people who live along the river and use its resources for subsistence. The first step in describing their links with the river is to delineate the width and length of the river corridor within which they live. This includes the distance people are prepared to walk to use the river, ease of access to the river bank and channel, and availability of alternate resources. The delineated corridor is further sectioned off and assessed according to the number of people and their use of water. The economic value of these resources can then be calculated.

Health professionals familiar with a particular area first identify all existing and potential health threats to the relevant population and their livestock. They then determine the occurrence of these threats by compiling health profiles of the people and livestock.

SEVERITY RATINGS

River scientists predict change in flow on a generic six-point scale, ranging from no change to critically severe change. Each point encompasses another range in itself, allowing experts to give a more specific severity rating for any one predicted change.

For financial calculations, the severity ratings are converted to percentages of resources lost or increased health risks.

Environmentally sustainable

Natural water systems can experience severe floods and droughts and yet recover and return to their original state. This bounce-back capacity (known as "resilience") allows the system to recover from human use as well. If water resources are overused – if too much water is taken out, too much pollution put in, or if too much structural change is made such as bulldozing of banks – they might not be able to recover. In this way the capacity to meet human demands can be reduced or even lost.

If the water resource is able to recover, that level of use can probably be sustained in the long term. It is not necessary for a water resource to be left untouched in order to remain functional. The intention of environmentally sustainable water use is to balance water use with the protection of the resource in such a way that the resources are not degraded beyond recovery.

This means that, even where the immediate demands for development are very high, society must find different development approaches that make sure that the use of water resources does not destroy their ability to recover.

Sociological effects of reduced flow on local rural communities

Reduction in flows
- facilitate animals crossing rivers to adjacent villages
  - more herdboys required to control cattle
    - fewer herdboys attending school.

Reduction in river flow
- reduction in fish
  - fishermen leave village in search of work
    - change in social structure of the village.

Reduction in lateral flooding
- reduction in wild vegetables growing alongside the river
  - fewer vegetables eaten by community
    - trace element deficiencies
      - increased incidence of disease and malnutrition.

The link between **flow and biodiversity**

The purpose of the Ecological Reserve is to maintain our water resource and the ecosystems that sustain it. It is therefore necessary to evaluate the effect that variables like pollution and reduced water flow have on both the environment and us.

THE EFFECTS OF FLOW CHANGES ON ECOSYSTEMS

Biophysical consequences of flow changes are usually built up in a sequence starting with the physical structure of the water bed, then water quality and thereafter vegetation, invertebrates, fish, birds and other wildlife. Sub-components are also considered – including physical features, chemical features, and communities or individual species. These are chosen based on their known susceptibility to flow changes, their role as key species or features, or their relevance to subsistence users.

FLOW IMPACTS

Fishing: Dams alter the natural pattern of ecosystem habitats and can prevent fish from accessing their breeding areas on the floodplain. Changes in water quality also affect fish numbers and diversity. This has a significant negative impact on their nutrition. Fishing is also central to the way of life in many areas and its loss can result in a depletion of community identity and traditions.

Vegetation: Most studies have shown that floods and flow reductions lead to a loss of wild vegetables and plants used by communities as a source of nutrition.

Wood fuel: There is a loss of wood fuel in mountainous areas where woody vegetation is restricted to the river margins. Changes in flooding regimes can affect the number of trees and shrubs, which impacts on the availability of wood used in cooking and heating.

Medicinal plants: Traditional healers rely heavily on wild plant resources growing alongside rivers. Some of these are found only in

the riparian zone, and changing flow negatively affects their availability.

– FACT –
One-fifth of the world's 10 000 species of freshwater fish are endangered, vulnerable or extinct.

Building materials: Many rural communities use natural resources such as wood, sand and mud as building materials for their homes. Loss of these resources from the riparian zone can be a consequence of flow changes.

Hunting: Subsistence hunting is a widespread and important source of food for rural communities. Some subsistence hunting is linked to flooding because animals are drawn to floodplains for water and grazing. Construction of dams can mean that floodplains are less boggy, which can allow access by vehicles and thus greater illegal hunting. Reduced flooding can affect the grass on the floodplain, which alters grazing patterns and reduces the number of animals in the area.

Water quality: Water downstream of dams is affected by chemical changes as a result of impoundment, or changes as a result of alterations in the natural flow regime of the river. Both of these impact on people using

Effects of polluted water

The effects of polluted water on human health, on the aquatic ecosystem and on various sectors of the economy, including agriculture, industry and recreation, can be disastrous. Deteriorating water quality leads to increased treatment costs of potable and industrial process water, and decreased agricultural yields due to increased salinity of irrigation water.

Not all health, productivity and ecological problems associated with deteriorating water quality are ascribed to human activity. Some water quality-related problems are inherent in the geological characteristics of the source area.

Numerous persistent and toxic metals and organic compounds such as pesticides are a cause for serious concern. Contamination of groundwater resources, or of sediments deposited in riverbeds, impoundments and estuaries by toxic and persistent compounds, can cause irreversible pollution, sometimes long after the original release to the environment has ceased.

What is an estuary?

An estuary is a wide tidal mouth of a river. In estuaries, the flow reverses due to the tidal currents. The depth depends primarily on the tides rather than the flow. An estuary has two sources of sediment: the river during floods and the ocean that supplies marine sediment through littoral drift (drift from along the shore).

This sedimentation creates several environmental and social problems. For example, sediment transport imbalances arise when changes occur in the river catchments, such as increased sediment yields and reduced flood force due to dam construction. Normally, floods flush estuaries to maintain the long-term sediment balance in the river estuary system, but with lower flood peaks sediment transport capacities at the estuaries are reduced and flushing efficiency decreases, resulting in marine dominance in many estuaries. In the long term, this may lead to the complete closure of some estuaries.

water downstream. The changes range from increased levels of pollutants to decreased concentrations of dissolved oxygen and greater salinisation, which affects the swimming patterns of freshwater fish.

Health: Skin and dietary problems can occur downstream as a result of reduced flow caused by dams. This can also cause certain algae to form, and attract more insects.

Safety: People often mistakenly believe that it is safe to inhabit floodplains once a dam is built and flow is reduced. However, no dam can control all floods that occur in a system. In fact, flood frequency and severity can increase once dams have been built in an area. When large floods do occur in dammed rivers, they

Human impact on estuaries

Leisure and industry – Estuaries are very attractive environments that many people view as an ideal place for leisure activities or as a place to develop industrial or port sites. Inevitably some developments occur that will affect the natural sediment dynamics of such estuaries.

Bridges – Many bridge spans are not wide enough to allow large floods to pass unhindered. The flow becomes concentrated, and the natural meandering tendency of the river channel becomes restricted, leading to scouring. The open areas have to be stabilised by vegetation.

Build-up of sediment – Flow can also be deflected due to sediment build-up, which can lead to sediment in the main channel. Dredging causes increased depth in the bed and results in a reduction in velocities, reducing the flushing ability of the estuary. Local sandbanks are shifted around the bedrock, which appears at uncharacteristically shallow depths as a result. Inlets have to be adjusted to prevent them from being silted up.

Dams – Water resource developments such as dams and abstraction works cause a reduction in stream flow. Dams reduce the natural variability inherent in the stream flow pattern of semi-arid countries such as South Africa. This leads to a reduced sediment transport capacity and reduced flushing efficiency, especially in river-dominated estuaries.

Both low flows and major floods are important for the normal functioning of an estuary. When the river flow is reduced, sediment tends to accumulate for a longer time and the volume might become too large to flush out during a single flood. It also starts to consolidate, which makes it much more difficult to erode.

Together with the reduced river flow, dams also tend to trap most of the sediment from the catchment. Sediment-free water has higher erosive capacity, but combined with the reduced stream flow the net effect is that less fluvial sediment tends to reach the estuary. Significant changes in land use, such as overgrazing and deforestation, could have the opposite effect in that total sediment yield from the catchment could increase with time, which could cause fluvial sedimentation in an estuary.

– FACT –
Freshwater animals are disappearing five times faster than land animals.

are potentially far more hazardous than in an "untamed" river. Effects of floods can also be exacerbated by dam releases, which are done to avoid overtopping.

Livestock: There is sometimes an increase in the number of livestock diseases when river flow is altered. There are also more nuisance insects such as black flies – blood-sucking pests of poultry and cattle. Severe attacks can lead to a loss in productivity, aborted foetuses and, in some cases, death. Flow changes can also lead to a reduction in grazing and browsing resources, and an increase in dangerous areas where cattle can sink in mud.

Erosion: Sediments settle in an impoundment when water flow slows. The water released through the dam wall thus carries an unnaturally low sediment load. The channel is eroded downstream, and sometimes at the coastline, to supplement the shortage. The sediment that would usually be carried in suspension is thus deposited in areas where this may not have occurred previously. This can lead to a reduction in channel depth and a corresponding increase in channel width, threatening riparian stability and farming activities.

Reduced sediment loads also affect deltas, which are formed at the mouths of rivers when sediments are deposited there faster than the ocean currents can erode them. Deltas are fertile agricultural regions and important breeding areas for fish. Reducing the downstream sediment load of a river results in less deposition at the mouth and therefore more erosion by the ocean. This can also lead to a straightening of the coastline and damage to harbours.

Environmental impact on estuaries

Not all sedimentation problems can be attributed to human impact. Storms and major floods also cause a shift in the natural balance. Temporary blocked mouths are a common feature in many South African estuaries and are remaining so for longer periods than in the past. This has seriously affected the ecological conditions in these estuaries, as the environmental flow requirements are not being met.

Environmental flood releases at medium and large dams and sediment flushing at small reservoirs are required to limit upstream and downstream impacts of dam and estuary morphology.

There is also a dire need for improved understanding of the hydrodynamics and sediment dynamics in estuaries. By understanding these processes and using predictive capabilities, ecologists could gain essential information on the physical behaviour of the system. This will also enable the effective implementation of new policies in estuaries, such as those related to the South African Water Act.

Freshwater flow to estuaries

The large variability of the South African climate leads to extremes in river flow. While storms can last for just minutes or several days, the hydrological critical low flows can last for years during droughts. This means that:

- The methodology used for the assessment of the Ecological Reserve in a particular area must allow for such variation.
- The proposed flow regimes must mimic natural or present-day flows from low to high.
- Models must incorporate the variability and non-stationary nature of sediment transport data.

Determining quality

In terms of the National Water Act, RQOs are used to define the level of protection that any particular water resource requires (see RQO definition on page 11). Resource quality is defined as:

- the quantity, pattern, timing, water level and assurance of in-stream flow;
- the water quality, including the physical, chemical and biological characteristics of the water;
- the characteristics and condition of the in-stream and riparian habitat; and
- the character, condition and distribution of living organisms in the region.

The present and historical condition of a water resource, its sensitivity, importance and potential for restoration are all factors that need to be taken into account when classifying a body of water.

Current and future availability **and quality of water**

The availability and quality of water today is a key factor in predicting South Africa's position in the future. This prediction helps to pinpoint what changes should be made in order to secure the long-term life of our water resource.

At the projected population growth and economic development rates, it is unlikely that the estimated demand on water resources will be sustainable. Water supply will become a major restriction to the future socio-economic development of the country, in terms of both the quantity and quality of water.

South Africa is an arid country with only 8,6% of the rainfall available as surface water. The scarcity of water is compounded by pollution of the surface and groundwater resources. Water quality describes the chemical, physical and biological characteristics of water, usually in respect to its suitability for an intended purpose (e.g. domestic, farming, mining or industrial) or its suitability to maintain a healthy ecosystem. These characteristics are controlled or influenced by substances that are either dissolved or suspended in water.

Water quality varies from place to place, depending on seasonal and climatic changes as well as the types of soils, rocks and surfaces through which the water moves. Human activities, such as farming, urban and industrial development, mining and recreation, can also significantly alter the quality of natural water.

WATER QUALITY PROBLEMS

Salinisation – Excess salt in water is a persistent quality problem, and is caused both naturally and by people. Natural causes are usually geological, while human causes are linked to point sources of pollution such as industry, urban and mine waste disposal.

Eutrophication – Eutrophication is the

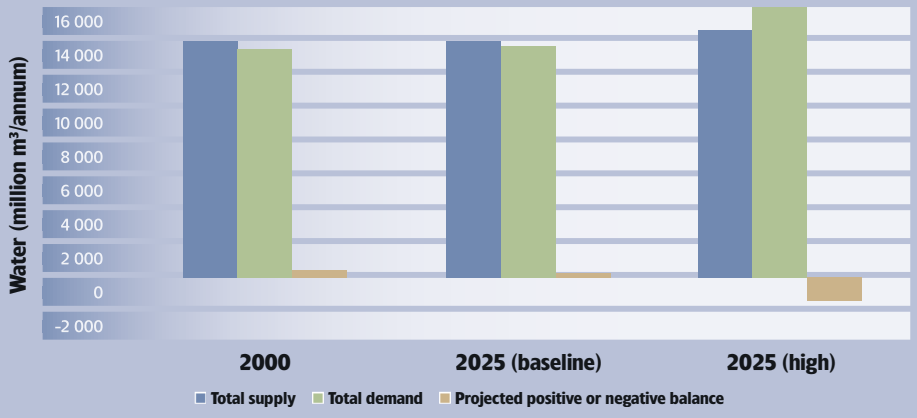
enrichment of water with the plant nutrients nitrate and phosphate, often as a result of sewage effluent. These nutrients encourage the growth of water weeds and algae, which cause problems in water purification, such as undesirable tastes and odours. They can also cause the production of potentially carcinogenic products, which means water has to be treated with chlorine and sometimes even with activated carbon before it is suitable to drink.

Micro-pollutants – Pollution by metals and man-made organic compounds, such as pesticides, poses serious health risks for people and animals. Pollution of this type tends to be highly localised and associated with specific industries or activities. Mining activities often expose pyrite rock formations to air and water, which produce acid rock drainage. DWAF has recently established a water pollution control works in the Brugspruit catchment in Mpumalanga, at huge cost, to treat acid rock drainage emanating from abandoned coal mines.

Microbiological pollutants – Water contamination by faecal matter is how diseases such as dysentery, cholera and typhoid are typically spread.

Erosion and sedimentation – Average sediment yields for South African catchments range from less than 10 to more than 1 000 tons/km^2 per annum. In some parts of the country, erosion has increased tenfold as a result of human impacts. This causes the loss of fertile agricultural soil, off-site damage like the loss of valuable reservoir storage, sediment damage during floods and increased water treatment costs, all of which cost the country in excess of R100 million each year.

SOUTH AFRICA'S SUPPLY AND DEMAND



(Source: Zeta Consulting)

Water quality and Reserve determinations

During the course of a Reserve determination, water quality is assessed in terms of:

- toxic substances (e.g. phenol);
- system variables (e.g. temperature); and
- nutrients (e.g. nitrates, phosphates).

Pollution and **waste disposal**

The South African economy is dependent on industry, mining and agriculture, which depend on water. This raises an important question: how is the waste produced by these sectors affecting our water resource?

Water pollution is defined as the introduction of chemical, physical or biological material that degrades the quality of fresh or ocean water, affecting the organisms living in it. This process ranges from the simple addition of dissolved or suspended solids to the discharge of the most insidious and persistent toxic pollutants such as pesticides, heavy metals and non-degradable, bio-accumulative chemical compounds.

Effective implementation of the Reserve depends on the controlling of water quality and therefore the release of these wastes into the water system.

The NWA includes standard tools that focus on controlling the use of water through mechanisms like licences for abstraction and waste disposal. It also includes quality guidelines for water that is returned to the river ecosystem, such as waste water from sewage treatment plants.

INDUSTRY AND MINING CONTROL

South Africa has a legacy of mining and industrial waste products that impact negatively on our water. In spite of efforts to the contrary, the quantity and range of waste products are expected to increase in the foreseeable future. Approaches such as pollution prevention, rehabilitation, waste beneficiation and water reuse are being investigated to assess their potential to reduce the negative impact of industrial and mining waste on water quality.

In order to prioritise those facets of industrial and mine-water management that need the most urgent attention, it is important to quantify the

– FACT –

Baseline studies have shown South Africa's total waste stream amounts to 539 million tons per annum, of which:

- **industrial and mining waste amounts to about 487 million tons per annum (90%); and**
- **non-hazardous waste amounts to approximately 52 million tons.**

water used and waste produced by different sectors. An investigation conducted by the WRC has established the benchmark for water use and waste produced by the major South African industries.

DID YOU – KNOW? –

Around 800 000 tons of liquid waste are disposed of each year as run-off into freshwater systems and the sea.

The international trend towards waste management is to minimise the production of waste by adopting cleaner production processes.

The environmental consequences of waste products are almost always long-term in nature, with impacts that may potentially last for hundreds of years. Waste producers are therefore expected to quantify the present and future environmental impact of their operations and to indicate how these will be remedied.

AGRICULTURE

In addition to existing laws governing pesticide use in the country, South Africa has recently adopted more laws to further protect the environment. However, these laws must be enforceable without placing undue costs on the manufacturer and the user.

An important aspect of this is groundwater. During a drought, groundwater is the only available resource and therefore minimum flow and acceptable quality need to be present. When found in soil or groundwater, persistent pesticides are difficult and expensive to remove. Therefore government and

Types of pollutants

Industrial effluents: Overtop that sometimes contains acids, alkalis, salts, poisons, oils and harmful bacteria is discharged after production processes.

Mining and agricultural wastes: Mines, especially gold and coal mines, are responsible for large quantities of acid water. Agricultural pesticides, fertilisers and herbicides sometimes wash into rivers and stagnant water bodies.

Sewage disposal and domestic wastes: Sewage as well as domestic and farm wastes often pollute rivers and dams.

Waste disposal alternatives

There is no completely safe way to dispose of toxic wastes. Some of the safer methods of dealing with toxic waste are:

Land disposal: Waste is buried in landfills and permanently sealed to contain the waste. Landfills may be lined with clay or plastic, or encapsulated in concrete.

Incineration: Low temperature (urban refuse) or high temperature incineration options are used. The latter is best for industrial wastes (tar, paint, pesticides, solvents) as it prevents the formation of chemical by-products. High-temperature incineration is not yet available in South Africa.

Chemical or biological treatment: Chemicals are added to waste to make it less toxic, or bacteria are added to help to degrade it, thereby reducing the amount of toxic residue.

industry need to make a concerted effort to prevent contamination by providing education programmes, training, regulation and monitoring and by using integrated pest management.

DID YOU – KNOW? –

Urban areas produce more than 15 million tons of solid waste a year, yet only a tenth of waste disposal sites are licensed.

SEWAGE AND SANITATION

Inadequate sewage disposal facilities combined with unhygienic practices impact on the population's health. These practices relate to:

- the lack of attention paid to infrastructure that needs ongoing maintenance and good operation;
- the lack of access to health and hygiene education;
- inadequate water supplies (quality and quantity);
- poor facilities for the safe disposal of water and other domestic waste; and
- inadequate toilet facilities.

The threat of pollution is heightened where there are no sanitation systems or where they do not function efficiently. This poses a risk to water supplies in rivers, dams and

Deaths from unsafe water, sanitation and hygiene

underground resources, and can cause serious health problems. The proper operation of sanitation systems is therefore an essential part of protecting the environment.

EFFECTS ON THE ECOSYSTEM

Some of the most common pollutants come from urban waste water, particularly from informal settlements that lack sewage and water purification facilities. This contributes to health problems like typhoid, cholera and gastroenteritis. Gastroenteritis is one of three main causes of death in South African children under the age of five. Between 1980 and 1987, almost a million South Africans contracted cholera.

Freshwater pollutants

Pollutants	Main source	Health and environmental effects
Sewage	Inadequate sanitation, poor operation and maintenance	Pathogens cause typhoid, cholera, gastroenteritis; eutrophication occurs, a process by which large additions of nutrients cause an overgrowth of algae and subsequent depletion of oxygen
Fertilisers	Agriculture	Eutrophication
Silt	Agriculture, construction, mining	Smothers aquatic organisms; affects light penetration
Pesticides	Agriculture and health services	Toxic; interfere with breeding of mammals and birds
Toxic metals	Industry	Health- and life-threatening
Salinisation	Industry, agriculture, landfill	Reduced crop yields; scale and corrosion in domestic and industrial water systems

Marine pollutants

Pollutants	Main source	Health and environmental effects
Sewage	Inadequate sanitation, poor operation and maintenance	Pathogens cause typhoid, cholera, gastroenteritis; nutrients cause eutrophication
Fertilisers	Agriculture	Eutrophication
Oil spills	Ships – leakage, cleaning of holds	Smother marine plants and animals
Plastics	Public	Death of marine animals
Pesticides	Agriculture and health services	Toxic; interfere with breeding of mammals and birds

Effects of pollution on rivers

1. Deoxygenation causes damage and death to fish.
2. Putrefaction of organic matter causes bad smells.
3. There is a growth of sewage fungus.
4. Suspended matter is deposited and accumulate on the river bed.
5. Poisonous substances are discharged into the river, killing fish and adversely affecting the health of people and livestock that drink from the river.
6. Discharge into river causes organisms to spread disease.
7. Excess sewage causes biological life to die, resulting in further contamination through decomposition.

All of the above are detrimental to human health and quality of life.

"Functional ecosystems provide the full suite of ecological services that we use, such as good-quality water and food, as well as those for cultural and recreational purposes. Failure to protect these ecosystems erodes their ability to meet our requirements."

Steve Mitchell,
Director: Water-linked Ecosystems, WRC

Current research, future management

The Water Research Commission funds various water quality research projects in support of the objectives set out by the National Water Act and administered by DWAF. These studies inform the careful planning and constant adjustment that are necessary to cater for changing conditions, and which also allows for the effective management of South Africa's water resource.

Human need is at the core of this classification system, in that no water may be allocated for additional usage until human and ecosystem needs have been catered for.

It is an approach that takes the current and future water state into account, ensuring that the most efficient policies and support systems are put in place to benefit all South Africans.

The following pages explain the link between the Reserve and resource management as well as the need for preliminary classification before water can be allocated.

Balancing use **with sustainability**

The key to sustainable water resource management is to allow it to be used and developed within certain limits. Effective management through Reserve determination is how this is achieved.

Reserve determination in a particular region must balance long-term protection requirements with economic and social demands, providing a way forward for protection and sustainability on the one hand, and development needs on the other. This determination takes into account the assessment by specialists who use Decision Support Systems (DSSs) to simulate the future circumstances of the resource. The views and advice of stakeholders are taken into account as well, but ultimately Reserve determination lies with the Minister of DWAF.

The DSSs generate ecological requirement scenarios, which allow for formal classification of the water resource. Ecological Reserve determination requires an understanding of the effects of changing water levels, flow rates and water quality on the ecological processes that govern the health of aquatic systems.

The main determinants of quantity and quality of a resource vary for different types of water, however, quality must be determined for all components (see table on left).

Once the quality of the various components is determined, RQOs can be set at any level, from no protection at all to maximum protection. The resource is then classified, and a Reserve determination can be made and duly implemented. It is equally important to monitor the implementation so that it is known whether Reserve requirements are being met.

Water quality management involves maintaining the suitability of water for specific purposes on a sustained basis by achieving a balance between socio-economic development and environmental protection. From a regulatory point of view, it involves the ongoing process of planning, developing, implementing

The main determinants of quantity and quality

Type of resource	Main determinants
Rivers	Flow
Lakes	Water level
Wetlands	Persistence of surface water and water level
Groundwater	Water level, outflow and rate of recharge
Estuaries	Flows for maintenance of salinity gradient, inflow requirements and mouth condition

How protection of the resource is enforced

Water quality management employs a combination of four environmental management instruments: regulatory, market-based, self-regulatory and civil management.

Regulatory – People are required to get a licence where the use of water potentially has an impact on water quality.

Market-based – In water quality management the pricing strategy, which includes a charge for waste disposal, makes provision for certain incentives that aim to:

- introduce new technologies or management practices;
- provide for the conservation and economically efficient allocation of scarce water resources; and
- remove elements of waste streams.

Self-regulatory – The ISO 14000 series of environmental standards provides a range of self-regulatory management instruments, which can be used by industry to improve their environmental performance. Before an organisation can obtain ISO 14001 certification, it must have complied with all legal requirements. In promoting ISO 14001 certification, DWAF will be able to extend its water quality management capacity.

Civil – The NWA requires the delegation of management functions to a regional or catchment level so as to enable everyone to participate. The importance of public participation is further emphasised by the National Environmental Management Act, which lays down the principle of transparent and participative management for cooperative environmental management. This entails establishing catchment-based institutions such as Water User Associations and Catchment Management Agencies to ensure public participation. Within water quality management, catchment forums have provided an ideal mechanism to facilitate the involvement of stakeholders in decisions affecting their water quality.

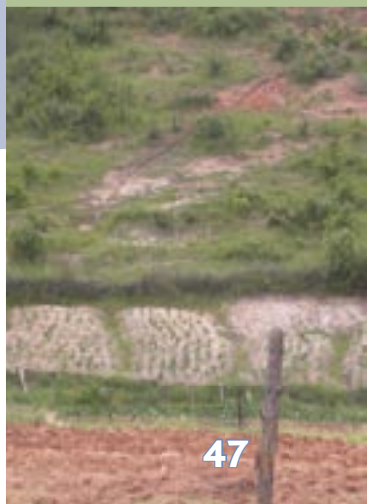
DWAF advocates participative management and allows other government departments and local interested and affected parties to be involved in decisions affecting the use, development and protection of water resources by means of forums and associations. This allows for the integration of socio-economic and environmental needs, which brings about sound and holistic decision-making.

and administrating the South African national water policy. This includes authorising any water usage that may impact on water quality and availability. Water quality management was previously based on pollution control, which concentrated primarily on source-directed management measures. The current approach consists of integrated source, remediation and resource-directed management, which recognises both the needs of the South African population and the aquatic ecosystem's water quality requirements.

The Water Act and resource management

The NWA caters for water management by:

- protecting water resources;
- establishing water management strategies and water management institutions;
- licensing water use, including discharges through coastal marine out-fall pipelines to the marine environment;
- implementing a National Pricing Strategy, including charging for waste disposal; and
- establishing a national monitoring system and a national information system.



The role of **the WRC**

WRC-funded research is of paramount importance in developing South Africa's water sector. Research and development initiatives support new and evolving legislation as well as water resource management and the sustainable provision of water and sanitation services.

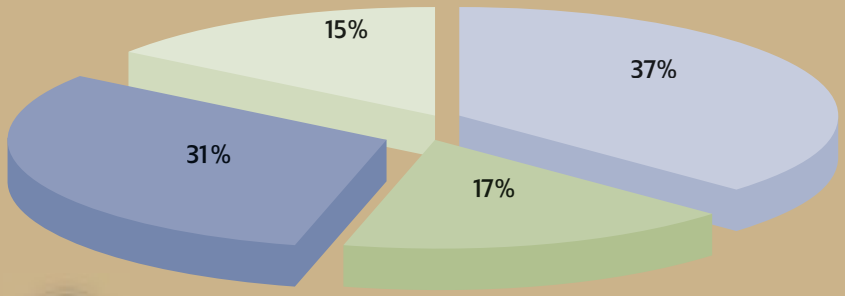
Investment initiatives into researching and protecting our aquatic ecosystems cater for greater water resource protection. WRC-funded research works towards improving Ecological Reserve determination methods and the implementation for social and economic development.

Approximately 80% of WRC funds are spent on research. The remaining portion is made up of allocations for consultancies, workshops and conferences, research sponsorships and mobility funding for capacity-building. The latter supports the mobility of researchers, with a view to building competence in historically disadvantaged research organisations and individuals.

COMPUTER-BASED DECISION SUPPORT

Ecological Reserve determination is a complex process that requires consistency and ease of management that takes into account the current landscape of the water sector. The WRC has implemented a computer-based

Utilisation of research project funds



The WRC uses its research project funds for the following activities:

- Water resource management
- Water-linked ecosystems
- Water use and waste management
- Water utilisation in agriculture

DSS that uses current knowledge to quantify the components of the Reserve.

To adequately assess licence applications, it is necessary to evaluate the existing water use as well as future requirements and their impact on the natural flow regime. These impacts can then be compared with the requirements of the Reserve.

Two important tools for assessing in-stream flow requirements of rivers, which have significantly refined the ability to determine and implement the Reserve, are DRIFT (see page 31) and SPATSIM (Spatial and Time Series Information Modelling) – both of which were developed by the WRC.

DRIFT enables predictions of the biophysical state of the resource. Flow is manipulated using computer software to predict the effects on the river and the goods and services it delivers, which allows for an informed decision-making process.

SPATSIM takes into account the location of rivers, basin boundaries, and so forth, and integrates this information into a national database for knowledge exchange. Part of the objective is to design and programme a software package that accommodates all the steps and procedures required to quantify the Reserve. The emphasis of SPATSIM is on the quantity component of rivers and the technical integration of water quality data,

The five focus areas of the WRC

The WRC has five strategic areas relating to water-centred knowledge. Each provides an integrated framework for investment in addressing a portfolio of key issues. These strategic areas focus on solving problems related to national needs, and support society and the water sector across the spectrum of water-related topics.

Water resource management – This focuses on generating the knowledge, tools and skills to ensure that South Africa's water resources are protected, used, developed, conserved and managed to achieve environmental, social and economic sustainability.

Water-linked ecosystems – This focuses on providing knowledge to ensure the sustained functioning of aquatic ecosystems and the ongoing provision of ecosystem goods and services.

Water use and waste management – This deals with researching effective and efficient water service provision to, and use of water in, the domestic, industrial and mining sectors. It includes the prevention of pollution and the development of technologies for treatment of water and waste water.

Water utilisation in agriculture – This deals with meeting the needs of present and future generations of subsistence and commercial farmers by researching the qualitative and quantitative role water plays in agriculture and forestry. The WRC supports the development of water-efficient production technologies, decision-support models and information systems.

Water-centred knowledge – This focuses on providing internal, knowledge-based support for the WRC, the water sector and society through IT services, knowledge sharing, scientific communication and the furthering of public understanding of science.

tools, techniques and methodologies within the Ecological Reserve DSS. The follow-on from this is the development of hydrological procedures and tools to support the implementation of the water quantity component of the Ecological Reserve for rivers.

RIVER SALINITY

Research conducted by the WRC in 2005 confirmed that agricultural land use impacts on river salinity, particularly in areas where irrigation is intensive and the geology of the area is naturally saline. Greater insight into this process of salinisation enhances our capacity to manage the salt loads in affected rivers, helping to ensure that water remains fit for use by consumers.

WATER AND SOCIETY

Knowledge concerning the role of water in societal development and how people perceive it is crucial. It can lead to equitable access to water and acceptable provision of water services. Effective use of water can alleviate poverty, achieve sustainable livelihoods and promote quality of life.

INTERNATIONAL FOCUS

The WRC has strengthened its African and global positioning of South African water research, contributing to many Africa-based research initiatives. This has enhanced the country's position internationally and benefited the local water sector. The WRC has expanded its role as an active member of the Global Water Research Coalition (GWRC), and South African research has also been showcased by WRC staff members through participation in many global events and several contributions to global training courses.

Glossary **of terms**

Aquifer: A layer of soil or rock able to hold or transmit water.

Catchment: The area from which rainfall flows into a river.

DRIFT: Downstream Response to Imposed Flow Transformations – a new methodology for assessing the flow requirements for the maintenance of rivers.

DSSs: Decision Support Systems – a paradigm to support decision-making. DSSs generate ecological requirement scenarios, which allow for formal classification of the water resource.

Estuary: A partially or fully enclosed body of water, which is open to the sea permanently or periodically, and within which the sea water can be diluted to an extent that is measurable, with fresh water drained from land.

GWRC: The Global Water Research Coalition is a non-profit organisation. It is an international water research alliance of 12 world-leading research organisations.

Hydraulic: Use of liquid for mechanical tasks, including erosion, etc.

Hydrodynamics: The science of forces acting on, or exerted by, fluids.

NWA: The National Water Act controls pollution of water sources, regulates water use, water use charges, the protection of water resources and the granting of licences to use water.

NWRS: The National Water Resource Strategy provides information about ways in which water resources will be managed, including the institutions to be established.

RDP: The Reconstruction and Development Programme is an integrated, coherent socio-economic policy framework. It seeks to mobilise all our people and our country's resources toward the final eradication of apartheid and the building of a democratic, non-racial and non-sexist future.

Riparian: Situated or taking place along a river. Somebody who owns land along a river.

RQOs: Resource Quality Objectives guide the quality of all aspects of the water resource, which includes water quality, water quantity and the aquatic ecosystem quality.

Sediments: Minerals or organic matter deposited by water, air or ice. The matter that settles to the bottom of a liquid.

SPATSIM: An integrated hydrology and water resource information management and modelling system. It provides access to different types of hydrological and water resource information.

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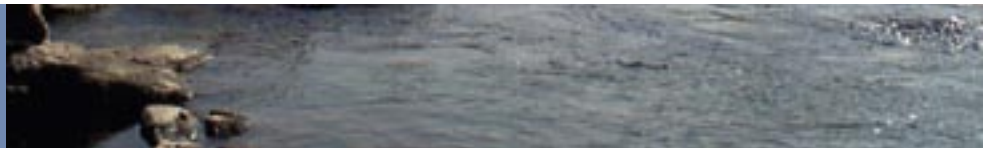

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