Incorporating the Water Research Commission's SA Waterbulletin

THE WATER WHEEL

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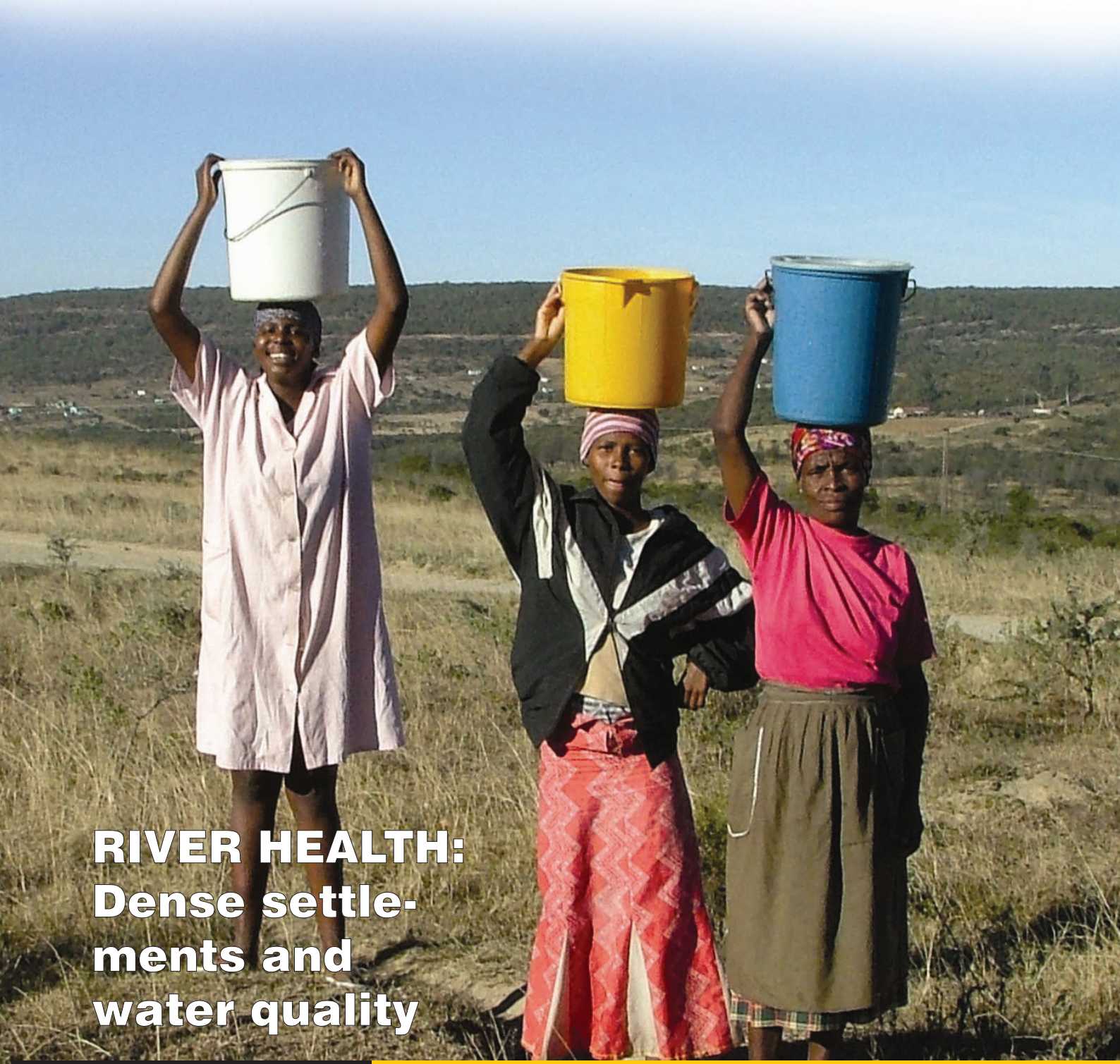
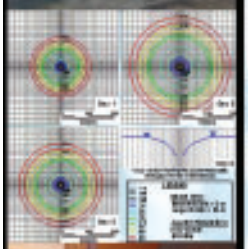


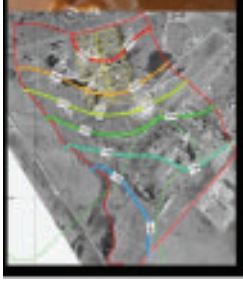
RIVER HEALTH: Dense settlements and water quality











JMA (Jasper Müller Associates) was founded on 1 October 1988, as a 1 man Professional Practice, specializing in environmental geohydrology. It has since grown into one of the biggest geohydrological specialist firms in South Africa, and currently employs 17 people, 9 of which are professionally qualified, and registered, earth and environmental scientists with SACNASP.

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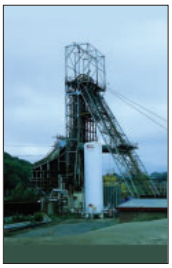
Communities rely on river water - p 7



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US and SA to Collaborate on Groundwater

United States ambassador to South Africa Dr Jendayi Frazer and Water Research Commission (WRC) chief executive officer Dr Rifka Kfir signing the Memorandum of Understanding between the United States Geological Survey and the WRC.

Groundwater research in South Africa received a boost in March when a Memorandum of Understanding (MoU) was signed between the Water Research Commission (WRC) and the United States Geological Survey (USGS).

The signing took place at the 2005 Biennial Groundwater Conference. The MoU aims to foster a suitable environment for the exchange of scientific and technical knowledge and the augmentation of scientific and technical capabilities of both organisations with respect to the earth sciences.

The USGS, which was established in 1879, is a government agency aimed at providing geologic, biologic, topographic and hydrologic information that contributes to the wise management of the United States' resources and promotes the health, safety and well-being of the public. South African counterpart the WRC aims to be the dynamic hub for water-centred knowledge, innovation and intellectual capital in the country. The organisation provides leadership for research and development through the support of knowledge creation, transfer and application. It also engages stakeholders in solving water-related problems.

"Groundwater cuts across all the key strategic areas of the WRC, from managing ecosystems to controlling pollution from industry and mining and basic water supply," commented WRC chief executive officer Dr Rifka Kfir. "For this reason, this MoU serves as a strategic step in the greater understanding and improved management of the country's underground water resources."

New Science Plan to Monitor Earth Intelligently

The CSIR Satellite Applications Centre (SAC) is working on a science plan for the development of an adaptable sensor network that can re-configure itself to answer user-defined queries about the state of the environment.

"A revolutionary new concept in earth observation will allow the animation and analysis of the behaviour of real world objects instead of just mapping their spatial distribution," explains Andrew Terhorst, Earth Observation manager at the CSIR. "This new breed of instrument, called a sensor web, will transform the way we explore, monitor and control the environment. It will have an impact on many areas, including disaster management, transportation planning, agriculture ecology, security and defence."

The sensor web is an observation system that provides a comprehensive, continuous monitoring presence of the earth, from which one can determine drivers of change. By combining information about large spatial areas, the sensor web gets an environmental awareness and can literally becoming a thinking presence within the environment.

A sensor web can be seen as one huge instrument whose surveying area can be expanded by using multiple sensors. Just as the connections between neurons in the brain give rise to intelligent behaviour, the sensor web measurements are shared, and interpreted, as they pass among its many pods.

A sensor web can, for example, be used to monitor the climate and concentrations of nutrients for agricultural purposes, to track flows of toxins in groundwater, to monitor traffic congestions or environmental conditions in an office building.

Water by Numbers

* **500 mm** – The average annual rainfall in South Africa.
* **860 mm** – The world average rainfall.
* **50 billion m³** – The average water that South African rivers receive a year.
* **34,2%** - The average level of the City of Cape Town's supply dams in February.
* **6 billion m³** – The water estimated to be available from South Africa's aquifers.
* **23** – The number of major dams (with a full supply capacity of over 2 000 million m^3) in South Africa.
* **13%** - The contribution of groundwater to bulk water supply in South Africa.
* **8** – The number of states sharing the Zambezi basin. They are Angola, Botswana, Namibia, Malawi, Zambia, Zimbabwe, Tanzania and Mozambique.
* **55%** - The percentage of Africa's population that has access to improved sanitation facilities.
* **16 000** – The number of people that die in South Africa every year from diarrhoeal diseases.
* **1/3** – The number of men and women in sub-Saharan Africa that are severely undernourished.
* **171 m** – The height of the Cahora Bassa Dam, on the Zambezi River, in Mozambique, the largest dam in Africa by height, according to the World Commission on Dams.
* **3,3 million ha** – The land under irrigation in Africa's most irrigated country, Egypt.
* **6 km** – The average distance that women in Africa and Asia walk to collect water.
* **10 ℓ** – The amount of water that the average person in the developing world uses a day.
* **10 million** – The number of viruses that one gram of faeces contains.
* **1,5 billion** – The average number of people in the world suffering from parasitic worm infections stemming from human excreta and solid waste in the environment.
* **95%** - The percentage of municipalities in South Africa applying the Free Basic Water policy, according to Department of Water Affairs & Forestry director-general Mike Muller.

More Groundwater Control Needed

Minister of Water Affairs & Forestry Buyelwa Sonjica at the 2005 Biennial Groundwater Conference.

Much work needs to be done to ensure the proper regulation, monitoring, and control of South Africa's groundwater resources.

So said Minister of Water Affairs & Forestry Buyelwa Sonjica. She was addressing delegates at the 2005 Biennial Groundwater Conference in Pretoria in March.

Until the promulgation of the National Water Act in 1998, groundwater was privately owned by the owners of the land under which the water was found. It is only after the new Act came into being that groundwater, as all water resources in South Africa, came to reside in the custody of the State.

Since then underground water resources have gained in significance, especially under government's basic water supply programmes. It is estimated that about two thirds of South Africa's rural population depends on groundwater for drinking purposes.

However, while groundwater resources have much potential they are delicate systems that are easily overexploited, noted Sonjica. She urged the industry to ensure that all research and development of the country's underground water resources should be undertaken with the sustainability of the resource in mind.

"In the immediate past we have not always been successful in overcoming our inertia to put a stop to inadvertent over pumping and stopping the deliberate over exploitation of underground water for personal gain," said Sonjica. "That is due to a complex legal problem, insufficient personnel, and a lack of will to protect our water resource,"

Sonjica pointed to the over pumping of fresh water from boreholes on Robben Island. This has resulted in the ingress of sea water into the aquifer, rending the water from the borehole unfit for use.

"One hopes that in the near future sufficient precipitation will recharge the aquifer forcing the sea water out again. In the meantime every drop of water is either delivered by tank ship from Cape Town or is supplied from an on-site desalination plant that is costly to run."

A similar incident occurred in the Northern Cape when electric pumps replaced diesel-powered pumps allowing the operators to 'switch on and forget' about the water supply.

DWAF's Groundwater Assessment Continues

The second phase of the Department of Water Affairs & Forestry's (DWAF's) Groundwater Resource Assessment programme is underway.

According to Dr Jan Girman of DWAF, the programme aims to deliver relevant information on groundwater resources in support of integrated water resource management. It comprises 11 projects, of which the first five have already started.

Phase II follows on Phase I which was completed in 2003. A national hydrogeological mapping programme, it culminated in the production of 21 map sheets of the Hydrogeological Map of South Africa.

"The project will take the national mapping programme to the next level, in other words, to quantify the groundwater resources," explains Dr Girman. Work is being carried out by a consortium comprising SRK Consulting, GEOSS, Water Systems Management and CSIR. The first five projects to be undertaken include determining the methodology for groundwater quantification; producing a groundwater planning potential map; calculating groundwater recharge and groundwater/surface water interaction; and the classification of aquifers and water use.

Water on the Web

http://igrac.nitg.tno.nl
The International Groundwater Resources Assessment Centre (IGRAC), an initiative of UNESCO and WMO, was launched in 1999. It is aimed at benefiting the entire international groundwater community with services on a free-of-charge basis. The centre is hosted at the Netherlands Institute of Applied Geoscience at Utrecht, in the Netherlands. One of the centre's main activities is the development of a global groundwater information system. The system is envisaged as an interactive and transparent portal for groundwater-related information and knowledge.

www.newscientist.com
This is the online version of the well read international *New Scientist* magazine. You have to be a subscriber to gain access to the online versions of the articles that appear in print. However, the magazine runs a free online news service featuring fascinating articles on science and technology issues. Themes are wonderfully varied, from the Mesopotamian marshlands of southern Iraq to the possibility of water on Mars.

www.scirus.com
Scirus is a science-specific search engine on the Internet. It searches more than 167 million science-specific Web pages. The website is great for use by scientists. As explained on the site: "we filter out non-scientific sites. So if you, for example, search for 'Dolly' the site will find the cloned sheep rather than Dolly Parton." A search for water + science + Africa brought back a staggering 2 386 results.

SA Welcomes Kyoto Protocol

South Africa has welcomed the coming into force of the Kyoto Protocol as government expressed growing concern about the effects of global climate change on the country.

It is reported that predictive modelling shows that over the next few decades, apart from moderate rises in global temperatures, there is likely to be a significant increase in the number of extreme weather events experienced by countries such as South Africa – including droughts, floods, increased incidents of malaria cases, and changes in rainfall patterns, resulting in reduced rainfall, especially in the western parts of the country. According to Minister of Environmental Affairs & Tourism Marthinus van Schalkwyk, these effects will impact negatively on South Africa's agricultural resources and biodiversity, especially in vulnerable regions such as the Cape Floral Kingdom, which is unique to the country.

According to data published by the World Meteorological Organisation in December last year, 2004 was the fourth-hottest year on record, surpassed only by 2002, 2003 and above all 1998. The year 2004 was reportedly 0,44°C hotter than the mean global temperature recorded between 1961 and 1980.

Government has expressed its concern over the potential effect of climate change on the country's biodiversity and agricultural resources

Water Also a Challenge for Developed World

While the world's eyes have been focused on developing countries and the challenges they face in increasing the percentage of the population with access to safe water and sanitation, the problems developed nations have to deal with have received less attention.

The developed world will have to spend millions to replace ageing infrastructure and keep up with tightening standards.

So said former Severn Trent Water director for asset management John Banyard. He was speaking in South Africa at the UK Institution of Civil Engineers' Fifth Brunel International Lecture.

Banyard pointed out that developed countries, such as the United Stated, the UK, and France, have their own challenges in terms of the United Nations Millennium Development Goals on water and sanitation. "Many of the developed nations are now struggling to balance the competing demands of sustainability with pleas from environmentalists for ever higher standards. At the same time, the infrastructure assets on which their societies depend are reaching the end of their useful lives."

The standard of treatment achieved in the developed world is extremely high, with requirements to meet demanding standards set by the European Union (EU) or the American Environmental Protection Agency. Additionally, current legislation such as the EU Water Framework Directive will ensure that enhanced standards continue to be provided over the next 15 years.

However, within developed countries the wishes of environmentalists to reverse centuries of environmental pollution are likely to carry a high price. To this has to be added the cost of simply maintaining the standard of infrastructure that society in the developed world enjoys today. Because all infrastructure has a finite life, it appears that over the next 20 to 50 years there will have to be a significant increase in spending on replacement of existing infrastructure compared to the level that is required today.

For example, a recent report by the Environmental Protection Agency in the USA put the price of renovating the country's water and wastewater infrastructure at US$1 trillion.

"It is interesting to speculate whether or not politicians or the public will accept this increased spend on water against the competing demands of transport, energy, education and the health service, or whether there will have to be a balance drawn between these demands and the aspirations for even higher environmental and medical standards. The one thing that is probably certain is that the public will not readily accept a reduction in the standard of water services that they currently receive, yet even this, without further environmental improvements, will probably cost more to deliver in the future than would be recovered by the charges levied today."

Developing countries will have to keep these challenges in mind as they work towards building up their water and sanitation infrastructure.

www.worldwater.org

The World's Water is a site dedicated to providing up-to-date water information, date and Web connections to organisations, institutions and individuals working on a range of global freshwater problems and solutions. There are four main sections: *Water Data* is devoted to tables, figures, and maps on the state of the world's water; *The Books* is about the *World's Water* series published by the Pacific Institute for Studies in Development, Environment, and Security of the US; *Water Links* provides links to other water websites; and *Water Conflict Chronology* track and categorises events related to water and conflict. The last link is an interesting one. Updated regularly it includes information on water conflicts from historic times till present under several categories. These include control of water resources where water supplies or access to water is at the root of tensions; where water is used as a military weapon; where water is used as a political tool; where water resources are the targets of terrorism; where water resources are military targets; and conflict related to development of water resources.

Africans to Look at Themselves to Develop

The Water Research Commission, in its capacity as a hub for water-centred knowledge, took part in the Knowledge Management Africa conference, held in Johannesburg in March.

The conference, which attracted about 500 delegates from all over the continent, was sponsored by the Development Bank of Southern Africa (DBSA). Themed "Knowledge to Address Africa's Development Challenges", the conference was aimed at providing a platform for knowledge dissemination and exchange among African stakeholders, including researchers, donors, academics, sector professionals, private sector and not-for-profit organisations.

Several focus areas were touched upon, including governance (accountability and public participation); service delivery (water and energy); knowledge systems (technology and indigenous knowledge systems); and agriculture (food security).

Perhaps the strongest message emanating from the conference was that Africa should stop looking at the First World for answers to its development challenges, but rather look towards its own expertise and indigenous knowledge to find solutions. The importance of good governance as the key to Africa's success was also pressed upon.

Delivery the keynote address South African deputy president Jacob Zuma said: "When Africa gained its independence from colonial powers after decades of struggle, the instruments of control by the colonising power had been entrenched. A particular culture of public service and governance, which did not put the interest of the indigenous people first, had taken root, which many countries still have to address today."

"The challenge now is how do we work together as all sectors to reverse the socio-economic challenges facing the continent, and to entrench a culture of democracy, good governance and peace," he continued. "It is the responsibility of every sector within the broader African society in the continent to work towards the regeneration of Africa and the reversal of stereotypes."

Dr Christopher Mlosy of the Manufacturing and Materials Technology Manufacturing Policy Unit of CSIR pointed out that the indigenous knowledge gathered over thousands of years by the people of Africa should not be underestimated. Not all indigenous knowledge needs to be replaced by modern science. Rather scientists needed to confirm indigenous knowledge and promote knowledge interaction.

According to Mlosy, Africa's biggest challenge is independence. "When we talk about development in Africa we always expect assistance from America and Europe. We should face the fact that these countries are not going to develop Africa. Rather we should look at coming up with solutions ourselves."

He said: "knowledge management must become a priority for governments in Africa and public policy should be geared towards encouraging knowledge production. At the same time, the utilisation of indigenous knowledge and systems in poverty alleviation and resource management in Africa is of practical importance."

The importance of sharing knowledge in the sustainable development and management of Africa's water resources was also reiterated at the conference. Despite its general abundance of water (Africa has about 5 400 billion m^3/y of water resources) the continent has the lowest water supply and sanitation coverage in the world. Very little of the continent's water resources are being exploited at present, only about 150 billion m^3/y of water is withdrawn for domestic, agricultural and industrial purposes at present.

Prof Ola Busari, water resource specialist at the DBSA.

Prof Ola Busari, water resource specialist at the DBSA, pointed out that national water resource management institutional frameworks in many African states remained weak, indicative of the poor and undemocratic governance that persisted in many of these countries.

Even more challenging was the fact that Africa had 60 international basins (basins shared between more than one country) making it difficult not to turn water into a political issue. "Negotiations around the sharing of water resources can take a long time, leading to delays in the development of these water resources," said Busari.

However, despite these challenges there have been positive movements towards improved water resources management, he noted. These included the establishment of the Water Task Force and the African Ministerial Initiative for Water, Sanitation and Hygiene under the African Ministerial Council on Water.

www.wrc.org.za

The official website of the Water Research Commission (WRC), this website is crammed with the latest news from the WRC, upcoming events (both locally and abroad), as well as a host of links to other interesting water websites. Clicking the *Publications* link allows the browser to sift through the latest reports and publications available from the organisation.

www.wsp.org

The Water and Sanitation Programme is an international partnership to help the poor gain sustained access to improved water supply and sanitation services. WSP receives support from public, private and non-governmental agencies in the water sector (15 are listed on the website, including the World Bank). The website includes information about the programme's projects in developing countries. It also features an interesting 'country at a glance' link, which information on the social and economic state of the country, structure of the economy and trade, among others.

Report Highlights Impacts on River Health

Urban development and dense human settlements are impacting, in some cases severely, on the main river system of the Eastern Cape. This is the main finding of the latest State-of-Rivers (SoR) report, which studied the Buffalo River.

The report is the latest published under the River Health Programme (RHP). Initiated by the Department of Water Affairs & Forestry (DWAF) in 1994, the programme has been designed to develop the capacity and information base to enable the country to report on the ecological state of its river systems in an objective and scientifically sound manner. At the same time, the RHP audits management strategies and actions related to water resources.

The SoR reporting format was developed as a collaborative venture between CSIR, DWAF, the Department of Environment Affairs & Tourism, and the Water Research Commission.

Littering in a high-density rural area north of Bhisho.

The Buffalo River System report is the first to be undertaken in the Eastern Cape. It highlights the significant impact that underdevelopment and human settlements can have on a river system.

THE SCORING SYSTEM

A number of indices or guides were used to calculate the ecological state of the river. This includes looking at the integrity of the habitat. This index looks at the impact of disturbances on habitats such as water abstraction, flow regulation, and river channel modification on the riparian zone and in-stream habitats.

Also used is the geomorphological index, which assesses river channel condition and channel stability. The channel condition is based on channel impacts evident in a river reach, for example, weirs, bridges or dams, and the type of channels, for example, bedrock or alluvial. The riparian vegetation index looks at the state of the plants growing near or on the banks of the rivers and streams.

Another index is the South African scoring system or SASS which is based on the presence of families of aquatic invertebrate fauna (for example, snails, crabs, worms, insect larvae, mussels and beetles) and their sensitivity to water changes. Their lifecycles are short, so changes in the composition and structure of aquatic invertebrate communities are often the first signs of change in overall river condition.

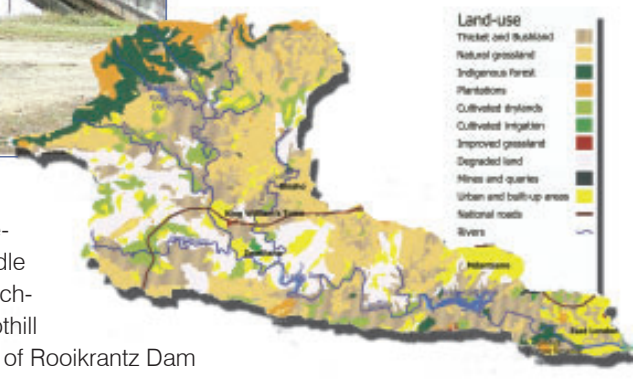
The last index used is the fish assemblage integrity index (FAII). It is reported that fish live longer and are more mobile, so they are good indicators of longer-term changes in a river reach.

THE BUFFALO RIVER CATCHMENT

Rising at an altitude of 1 200 m, the Buffalo River drains the forested Amatole Mountains of the Eastern Cape. It flows eastwards across the coastal plateau before entering the Indian Ocean at East London harbour. The river is 126 km long. The catchment supports about 570 000 people within its 1 287 km^2 area, so population pressure on surface water resources is very high. Less than 500 m^3 of water is available per person per annum, among the lowest in the country.

Left: The century-old Maden Dam is situated only 7 km from where the Buffalo River starts in the Amatole Mountains.

Bottom: The Buffalo River catchment.



The population density is the highest in the middle and lower reaches of the catchment (as much as 1 000 people per square kilometre). The largest towns are East London, Bhisho, King William's Town, Zwelitsha and Mdantsane.

Poor water quality poses a serious health risk for rural communities, since many households rely solely on untreated river water for domestic purposes.

A large proportion of the Buffalo catchment has been transformed from its natural condition. It is reported that almost 17% of the total catchment area is considered to be degraded thicket and grassland. Urban built-up and industrial areas cover almost 12% of the catchment. Along the Buffalo River, four dams supply the main areas of King William's Town, Zwelitsha, Mdantsane and East London. These are Maden Dam, Rooikrantz Dam, Laing Dam and Bridle Drift Dam. The latter is the largest impound on the river. The dam has a full supply volume of 101 million cubic metres.

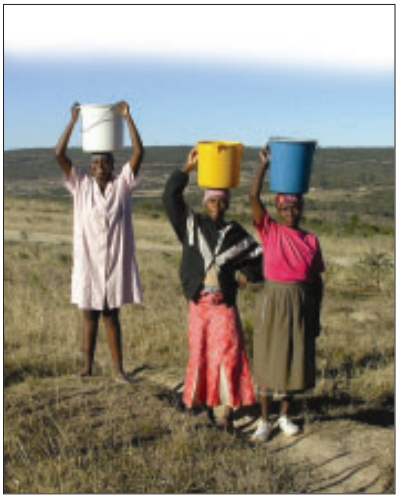
Agriculture is widespread in the middle reaches of the catchment, from the foothill zone downstream of Rooikrantz Dam to King William's Town and as far downstream as Bridle Drift Dam.

IMPACTS ON THE RIVER

The SoR found that while the Buffalo River is almost pristine at its source, urban developments and dense peri-urban and rural settlements impact the middle and lower reaches. At the headwater of the river alien plantations are reducing the runoff and thus the river flow.

The four dams on the river have no mechanisms for releasing water in a controlled pattern, for example, to stimulate natural river flows to maintain functioning aquatic ecosystems. In fact, overflow from the century-old Maden Dam and a trickle from a crack in the Rooikrantz Dam are the only water releases from these two upstream dams. Fortunately side streams augment the river flow.

The dams do offer some benefits, however. For example, Laing Dam, which supplies water to Zwelitsha, Bhisho, Berlin and parts of Mdantsane, acts as a silt trap and a sink for



Dense peri-urban and rural populations are impacting negatively on the quality of the Buffalo River

nutrients. It also dilutes saline effluent from upstream sources.

High population densities have several impacts on the river. These include cemeteries close to the rivers; excessive use of riparian trees for firewood; sand mining in the riverbeds; cattle crossings and

While many people in the Buffalo River catchment are served with at least basic water supply (a standpipe) there are still communities that rely on the river for their basic needs.

Invertebrate classification was one of the indices used to determine the quality of the Buffalo River system.

overgrazing; poor management practices associated with subsistence farming; and solid waste dumps or river banks.

INADEQUATE INFRASTRUCTURE

Expanding townships put pressure on water and waste systems, which cannot cope with the demand. Blockages in the sewerage systems, inadequate treatment capacity and poor management result in the discharge of partially treated and untreated sewage into the river and dams. For example, at Mdantsane the sewerage system was found to be too old and too small to cope with the large volume of sewage from this area. As a result, sewage flows via small tributaries into the Bridle Drift Dam. Moreover, pump failures at Potsdam wastewater treatment works result in raw sewage overflows, which enter the Bridle Drift Dam via Shangani Stream.

THE MINISTER OF WATER AFFAIRS ON THE BUFFALO RIVER REPORT

This report aims to raise awareness and understanding of the current state of one of our important rivers, the impacts on it and what actions we can take to improve it. Its goal is also to empower people at local level to take ownership of their rivers. This will assist the people of the Eastern Cape region to evaluate resource development issues with due consideration for the environment and conservation. Eastern Cape rivers have a rich potential and their sustainable development for food production, ecotourism, and commercial activities rely on them being kept healthy and protected.

The high nutrient loads cause eutrophication and result in potentially toxic algal blooms in the dam and excessive growth of water hyacinth. High faecal counts also threaten the health of the communities which still rely on the river for drinking water.

Industrial effluents were found to be either inadequately treated or not treated at all. Poor water quality poses a serious health risk for rural communities, since many households rely solely on untreated river water for domestic purposes.
The pollution of the Buffalo River basin also extends beyond the estuary, affecting marine and coastal water quality. According to the study the non-compliance with marine water quality standards will render coastal waters unfit for recreational and other beneficial users, including the non-attainment of blue flag beach status, which will in turn impact negatively on coastal tourism and related activities.

RECOMMENDATIONS

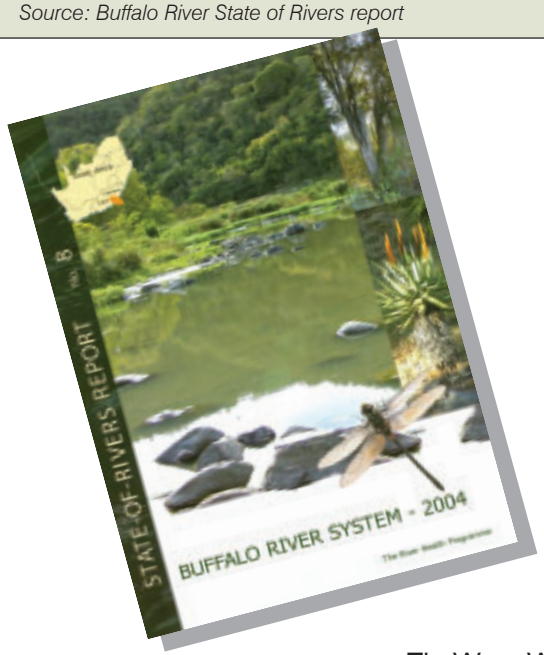
The report makes several recommendations to improve the state of the river. This includes establishing alien vegetation control programmes; restoring river banks that have collapsed or eroded; working with land care management programmes, the Working for Water programmes and others to educate the community; and monitoring agricultural practices and educating subsistence farmers about sustainable grazing practices. Improving the sewage treatment works and developing infrastructure to control water quality impacts, enlarging water and sewerage systems to cope with demand; as well as monitoring impacts and trends of nutrient levels; controlling river pollution; and improved management of dumping sites have also been suggested.

• *All photographs courtesy of Wilma Strydom.*

WATER SUPPLY AND SANITATION IN BUFFALO RIVER CATCHMENT

Type of water supply	Percentage of population
Clean piped water in the house	30%
Standpipe in the yard	30%
Standpipe within 200 m	18%
Standpipe further than 200 m	16%
Boreholes springs, rain tanks, dams, pools or rivers	6%
Type of sanitation	
Flush toilet	64%
Pit latrine (ventilated or unventilated)	25%
Bucket, chemical toilet and septic tank	3%
None	8%

Source: Buffalo River State of Rivers report



All information for this article was obtained from the State-of-Rivers Report: Buffalo River System. For more information, visit www.csir.co.za/RHP/ or contact Wilma Strydom at Tel: (012) 841-2284.

Projects Restoring Land and Water

With no vegetation to protect it soil is washed away and lands up in the canals and dams that make up the Tugela-Vaal water transfer scheme.

In a sleepy hollow in the foothills of the Drakensberg, in KwaZulu-Natal, local communities are not only learning to take care of their own land and water resources, but are also contributing to the protection of one of Gauteng's economic lifelines – the Tugela-Vaal water transfer scheme.

The communities of Mnweni and Okhombe form part of the Amangwane tribal authority in the northern Drakensberg area of KwaZulu-Natal. Situated between the formal conservation areas of Cathedral Peak and Royal Natal National Park the area is unique in that it is one of the few so-called 'high Berg' areas that are highly populated. Being part of the uThukela catchment it is also a crucial source of water to the country as a whole. One of the largest water transfer schemes in South Africa, the Tugela-Vaal, is situated here. This scheme provides valuable water to South Africa's economic hub, Gauteng, through a series of dams, canals and pipelines.

DEGRADED ENVIRONMENT

Scattered huts along the foothills of the majestic Drakensberg are home to several thousand people who make a living from raising livestock and subsistence farming, with little to no access to basic services. However, years of overgrazing and inappropriate land management practices have degraded parts of the landscape.

Dr Terry Everson of the University of Natal in Pietermaritzburg has been involved in land rehabilitation projects in Mnweni and Okhombe for the last ten years. Her programme, supported by institutions such as the Farmer Support Group, CSIR, Department of Agriculture and KZN Wildlife, also aims to build capacity within the local communities to manage their land and water resources better.

Dr Everson explains that when livestock such as cattle and goats are

The Okhombe community forms part of the Amangwane tribal authority in the northern Drakensberg area of KwaZulu-Natal.

allowed to eat too much of the vegetation in an area the water does not infiltrate properly into the ground when it rains. This leads to increased water runoff and soil erosion. Huge dongas have already formed in the area.

"The most challenging aspect of this project is changing people's mindsets."

The communities do not only lose land that could be used for food production. Huge loads of silt also lands up in the rivers of the catchment and get washed into the dams that make up the Tugela-Vaal water transfer scheme, such as Woodstock Dam and Sterkfontein Dam. This silt not only reduces the capacity of the storage reservoirs, but is expensive to remove.

REHABILITATING THE LAND

"To restore some of these degraded sites we have trained people from the community in the implementation of a number of different erosion control techniques," explains Dr Everson. This includes putting physical structures such as placing stone packs inside the dongas, stone lines, swales and cattle steps. Community members have also been assisted in planting vegetative structures such as vetiver grass planted on contour lines, trees planted in micro catchments and indigenous and exotic grasses planted on eroded slopes to improve water infiltration and reduce soil erosion.

Dr Everson's team are not the only ones looking to restore the area to its former beauty. Rand Water has been involved in Mnweni since 1996. "At one stage, prior to the establishment of the Lesotho Highlands Water Project, Gauteng, which is our main supply area, was drawing 10% of its total bulk water supply from the Tugela-Vaal scheme. In addition,

MORE ABOUT THE TUGELA-VAAL WATER TRANSFER SCHEME

In the early 1960s it was determined that the capacity of the Vaal Dam would not be sufficient to cater for the water needs of Gauteng. This resulted in the development of the Tugela-Vaal scheme, which was completed in 1974.

With the construction of the transfer scheme, a certain amount of water from the Tugela River, which starts at Mont Aux Sources, in the Drakensberg, is transferred via canals, pipelines and dams into the Vaal River system.

The Tugela River flows into the Woodstock Dam and then into the Driel Barrage further downstream. A certain amount of water is pumped from the Driel Barrage into canals which then flow via gravity into the Kilburn Dam. Water from the Kilburn Dam is then pumped underground, over the Drakensberg and into the Driekloof Dam.

This section of the scheme is used to generate electricity. Eskom built a hydroelectric power station in the Drakensberg mountain called the Drakensberg Pumped Storage Scheme. When electricity is needed water is dropped from the Driekloof Dam, through hydroelectric turbines, and into the Kilburn Dam. Then in quite periods the water is pumped back from the Kilburn Dam and into the Driekloof Dam.

When the Driekloof Dam is full water flows over a weir and into the Sterkfontein Dam where it is stored. Incidentally, when the Sterkfontein Dam was completed in 1986, it was the world's second-largest earth wall and the largest without a spillway. The dam has a surface area of 67 km^2, an average depth of 93 m and a total storage capacity of 2,62 billion cubic metres.

When water is needed in the Vaal River system, water is released from the Sterkfontein Dam and into the Nuwejaarspruit, which then flows into the Wilge River and then into the Vaal Dam.

Source: Rand Water

Overgrazing and inappropriate agricultural practices have led to increased runoff and loss of soil, resulting in huge dongas in some areas of the catchment.

The Tugela River.

many of the communities here were relocated when the dams for the transfer schemes were built. Thus we feel an obligation to assist the communities in this area to improve land management and contribute to poverty alleviation and economic development," says Rand Water project manager Arul Moodley.

The Rand Water Mnweni Trust was launched in 1999 as a joint effort between the water utility, the Wildlife and Environment Society of South Africa, Bergwatch and the communities of Amangwane. The trust was established with an initial capital investment of R2-million from Rand Water. Apart from initiating revegetation plans that focused on the planting of vetiver grass, the trust also developed the Mnweni Valley Cultural and Hiking Centre to promote ecotourism in the area.

Rand Water community relations manager Aubrey Nxumalo reports that training of community members in skills development workshops ranging from eco- and community-based tourism, conservation and visit management to mountain safety procedures, guide training and the use of maps and the global positioning system have been undertaken. The project aims to increase sustainable employment opportunities in Mnweni by 25% over the next five to ten years.

CASH BOOST

Another exciting development is that Rand Water launched a new project in the Mnweni area in April. Aimed specifically at addressing land rehabilitation and introducing improved land management techniques at a large scale, the project will be undertaken over the next two years with initial funding of R5,5-million. Importantly, the project will not only aim to rehabilitate degraded pieces of land, but also proactively eliminate degradation by introducing new farming techniques. Education and training will be the main components of the new project.

"The most challenging aspect of this project is changing people's mindsets," explains Nxumalo. "People have been farming in the same way for hundreds of years. In a sense they have to be 'retaught' in new ways that will not only safeguard their environment, but improve their income."

To replace lost indigenous vegetation it is envisaged that an indigenous nursery will be established boosting economic development in the area. Another initiative is to replace the traditional ox-drawn sledge, which causes a lot of environmental damage, with a friendlier horse-drawn solution.

MONITORING AND EVALUATION

Do these rehabilitation initiatives really work? To monitor and evaluate the work that has been done on Okhombe the Water Research Commission is sponsoring a community-participative project

under leadership of Dr Everson. "To assess which techniques have been successful in reducing runoff and soil erosion, it is necessary to monitor and evaluate the project activities," she explains. "This will enable the communities to make decisions on technologies that are sustainable."

One of the aims of the project is to implement participatory monitoring whereby the rural participants record and analyse differences and change. A total of 17 community members, who now form the Okhombe Monitoring Group (OMG), have been trained in assessing the rehabilitation techniques. Simple techniques are used to monitor soil erosion. Each technique is used on an eroded and rehabilitated site so that the two can be compared. For example, basal cover is determined using a square metre quadrant subdivided into 25 squares. A Morgan splash cup measures up- and down-slope erosion, while splash boards are used to measure the height of 'splash' when it rains.

Weirs are one of the monitoring techniques used by the Okhombe Monitoring Group.

In each sub-ward rainfall is measured with rain gauges. Donga profiles are measured to determine sediment deposited in the dongas. In addition, square metre run-off plots have been installed and water quality and quantity is measured from the runoff collected in two-litre bottles. All the monitoring sites have been fenced off to keep livestock out.

According to Dr Everson, the use of these techniques allows the communities themselves to determine the effectiveness of the different rehabilitation techniques on runoff and soil loss. "This provides an opportunity for learning where the people contribute to the monitoring process and are empowered to take subsequent decisions."

A member of the Okhombe Monitoring Group explains the monitoring techniques used to evaluate rehabilitation techniques to a group of visitors.

Grootvlei Mine is pumping 75 Mℓ/day of water to retain access to its underground workings.

Research Seeks Answers for Century-Old Problem

More than a decade of research by the Water Research Commission (WRC) and other agencies has gone into finding solutions to the potential pollution caused by potentially harmful water emanating from the gold mines on the Witwatersrand.

Mining has formed one of the pillars of the South African economy for more than a century. But the riches that have come from drilling thousands of meters under the earth come at a price. Mines can cause environmental devastation decades and even centuries after they close.

One of the most pressing effects of mining, especially in water-scarce South Africa, is the issue of contaminated water emanating from mine shafts and stopes into surface water resources.

ACID MINE DRAINAGE (AMD)

But where does this mine water come from?

The geological features that are mined contain varying proportions of metal sulphides, for example iron pyrite. As mining takes place these pyrites in the broken and crushed rock are exposed to water and oxygen causing it to oxidise. This generates sulphuric acid, resulting in AMD. The acidity generated by the sulphuric acid formation can mobilise and release heavy metals previously bound in the wastes, including arsenic, nickel, copper, zinc and aluminium, as well as solubilisation of

salts of sodium, chloride, potassium and fluoride. It is mainly these dissolved metals that give rise to the toxic nature of AMD.

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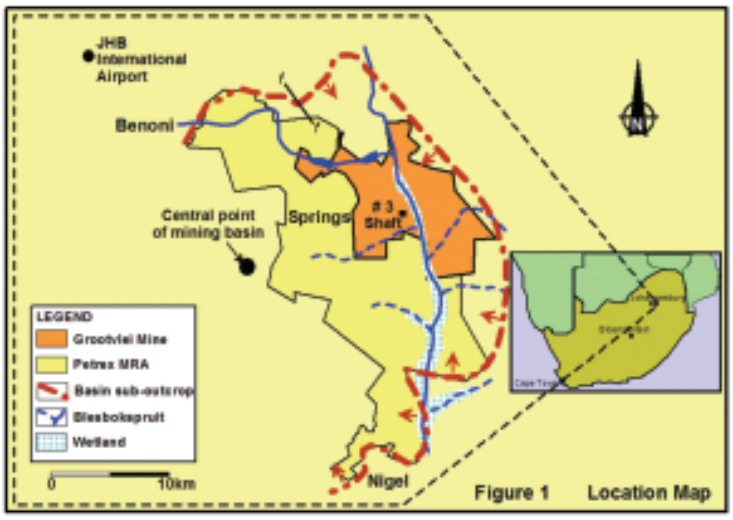
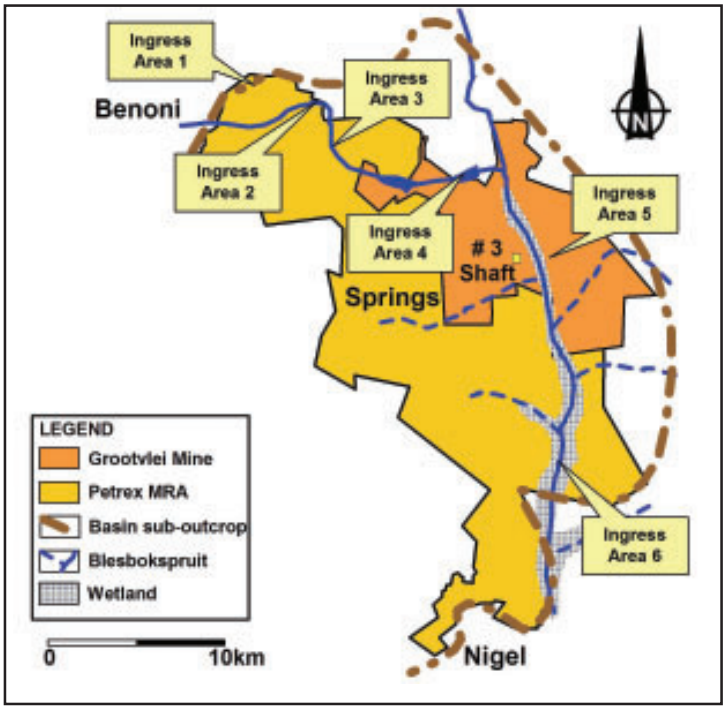
Meiring du Plessis, research manager responsible for most of the mining related research at the WRC, reports that AMD is not a new phenomenon and occurs all over the world where mining takes place and sometimes even without mining where ore bodies are naturally exposed. "The problem is that this acidic water does not remain inside the mines."

He explains that clean water from surface and underground infiltrates soil and enters the mine shafts and stopes and are then contaminated with the acid mine water. While a mine is operating this water is usually pumped out and treated to allow mining operations to continue unhindered. However, once mines close because of financial reasons or because the ore has run out, the water wells up in these old worked-out mine shafts.

When this contaminated water decants into streams and rivers above ground the acid attacks all available neutralising agents. As the pH rises the metals precipitate as hydroxides and oxides. It is the metals that remain in solution because of a lack of neutralisation or that are redissolved under changing environmental conditions, that is cause for concern and that pollute the surrounding environment. It is for this reason that DWAF insists on provision for the neutralisation of AMD wherever it enters the surface water environment even after mine closure.



Grootvlei location.



Map of Grootvlei indicating the six identified ingress areas.

Dr Steve Mitchell, director: water-linked ecosystems at the WRC points out that AMD and decanting mine water cannot be avoided. "The best we can do is to find out where this water will decant, what exactly the quality of that water will be, and how best to manage and treat the water in a sustainable and cost-effective manner so as to reduce the pollution of South Africa's limited water resources to an absolute minimum." As a result, the WRC has been funding research into this phenomenon for more than a decade. "We believe that through this research, the WRC has proactively been identifying problems and finding possible answers to questions that will arise in the future," says Du Plessis. "We can learn much from the way in which

Map of the Witwatersrand Basin.

the rest of the world are dealing with their AMD problems. However, they are primarily concerned with the acidity and metal content of AMD and therefore concentrate their efforts at its neutralisation. In view of our water shortages and the fact that we thus cannot rely on dilution to deal with the large quantities of salts that AMD is adding to water supplies, South Africa has to deal also with the salinity problems brought about by AMD."

WITWATERSRAND BASIN

One of the areas in South Africa where AMD and decanting mine water is becoming a real issue is the Witwatersrand Basin (Wits Basin). These goldfields, which stretch 350 km long and 200 km wide, have been mined to depths of about 3 500 m, and have yielded by far the most gold that has ever been mined in South Africa. But it has also left behind a myriad of shafts and stopes underground which has steadily filled up with water over the years.

The Wits Basin is subdivided into three main geological areas, namely the West Basin, the Central Basin and the Eastern Basin, which are all separated through geological features. It is believed that within these three basins, all the mines are interlinked through haulages, stopes, boreholes and worn-out plugs. Thus one mine will fill up with water, then the water will seep through to the next mine and so forth until it decants at the lowest point.

.... the gold mines in the basin were contributing as much as 35% of the salt load entering the Vaal Barrage by way of their point source discharges.

In 1955, on the Eastern Basin alone there were 24 operating mines and at least 90 shafts. Most of the mines have had to pump water from underground to either dewater areas where development was intended or to keep the existing workings from flooding.

As more and more mines closed through the years it was left to fewer mines to pump the water out. Pumping most of the water from the Eastern Basin is Grootvlei Mine, on the Central Basin ERPM and on the Western Basin Randfontein Estates.

Mining has been one of the pillars of the South African economy for more than a century, but not without cost. The effects on the environmental as a result of mining can be felt decades even centuries afterwards.

The Marievale Bird Sanctuary, which forms part of the RAMSAR wetland in the Blesbokspruit catchment is one of the areas threatened by acid mine drainage and decanting mine water.

The Institute for Groundwater Studies of the University of the Free State was one of the first institutions to undertake WRC funded research into AMD and decanting water on the Wits Basin. Published in 1995, the investigation focused on ways to control the inflow rate, water quality and the predicted impacts of flooded mines on the Central and East Rand Basins.

Among other things, the study found that there are four main sources of recharge into mines. These are direct recharge from rainfall events; seepage recharge; surface water losses from dams or streams; and recharge from groundwater (for example, on the East Rand most of the mining area is overlain by dolomites resulting in dolomitic groundwater contributing to the bulk of the inflow).

It was also one of the first reports to predict that, should Grootvlei Mine stop pumping water, the mine water would possibly decant at Nigel. Water ingress into mines is not new. Records of water ingress into these mines dates back to 1909 when Grootvlei abandoned the sinking of their No 1 shaft at 112 m due to an estimated 10 Mℓ/day ingress.

Another WRC report published in 2000 and undertaken by a research team from Stewart Scott, Pulles Howard & De Lange and Economic Project Evaluation, found that this mine water being pumped out on the Wits Basin had a definite effect on the area's water resources. In fact, the gold mines in the basin were contributing as much as 35% of the salt load entering the Vaal Barrage by way of their point source discharges. It was further estimated that this salt load was contained in only 6% of the flow.

However, as the authors point out: "It is important to realise that the effluents which are currently being pumped from underground mining operations to surface are largely derived from mining which has taken place over the last 100 years and are therefore not the sole responsibility of the pumping mines." An evaluation of the available treatment and preventative measures indicated that prevention of water ingress into mines (thereby reducing the volume of contaminated water that needs to be pumped and treated) would be the most cost effective of all the alternatives that were considered.

The Ancor sludge pump station. Sewage sludge is used to biologically treat the acidic water from Grootvlei Mine.

The BioSURE pilot plant at ERWAT's Ancor works. The plant is now being extended to treat 10 Mℓ/day of mine water from Grootvlei.

The Council for Geoscience is currently undertaking a project on behalf of the Department of Minerals & Energy to investigate the extent of the problem on the Witwatersrand. The main aim of the project is to investigate the ingress of water into these mined-out voids, where the water is entering, how quickly the mines are filling up, and where the water might possibly decant.

It is believed that up to 70% of the water to be found in the Wits mines are from groundwater sources. In addition, the project team has discovered about 460 openings, including shafts, stopes and sinkholes created by mining activities through the years, through which water might be entering the mined-out shafts (but it unlikely that all of these openings are leading to water ingress).

Moreover, chemical and isotope analysis on surface and underground water samples have shown that a significant percentage of water filling up the old mine shafts on the Wits Basin come directly from canals, rivers and dams.

THE CASE OF GROOTVLEI

To retain access to its gold reserves, Grootvlei pumps an average of 75 Mℓ of mine water a day. At present the water is treated at a high-density separation (HDS) plant to remove iron and condition pH levels before it is discharged into Blesbokspruit, reports environmental manager Irene Lea.

It is well known that a portion of this river downstream of the discharge point was declared an international RAMSAR wetland. However, while the HDS plant is effective in reducing iron concentrations in the mine water from more than 180 mg/ℓ to less than 1 mg/ℓ, the water discharged into the Blesbokspruit still contains high dissolved salt concentrations, specifically sulphate, calcium, magnesium, sodium and chloride, thus impacting on the downstream river water quality.

"As a result Grootvlei Mine is in the process of developing methods to reduce the impact of discharge on the river," says Lea. The mine's water management strategy is focused on two main objectives, firstly to reduce the volume of water pumped from underground and, secondly, to develop cost-effective, sustainable long-term treatment options.

REDUCING INGRESS

It is estimated that if surface water is effectively prevented from entering the underground basin, Grootvlei will have to pump only about 40 Mℓ/day of water in the long term.

The mine has identified six areas where surface infiltration can take place. Firstly, it has been found that about 2,5 Mℓ/day of water, mostly during the wet season, enters the mine through the shallow mining of the Main Reef outcrop in the north of the basin. Surface ponding also takes place over shallow mining in the north. Investigations have found that surface water influx to the mining basin via this area of ponding could

be as high as 40 Mℓ/day during the wet season and 7 Mℓ/day during the dry season.

The third area of possible water ingress is a fault that cuts across Cowles Dam. This fault was traced through the dolomitic aquifer into the underground workings. It is estimated that this fault could contribute up to 10 Mℓ/day of surface water to the underground workings. In addition, Ingress is taking place through Largo Colliery, a defunct coal mine that closed in 1953.

"The greatest challenge for the mine ..... is to find a sustainable treatment technology that will be able to improve the quality of the mine water and be operational even after the mine closes."

It is also estimated that up to 24 Mℓ/day of surface water could infiltrate along areas of shallow undermining in the southern part of the catchment, most notably in the wetlands associated with the Marievale Bird Sanctuary which forms part of the RAMSAR wetland in the Blesbokspruit. In this stretch of the river, inundation takes place over large stretches of the river due to insufficient drainage underneath roads and other infrastructure.

The last possible area where ingress probably takes place is through the shallow undermining of the Blesbokspruit in the northern part of the catchment. It is estimated that surface water inflow here could be as high as 24 Mℓ/day constantly during the wet and dry seasons. "Mine stopes only 7 m below the river have been found, and there is evidence of subsidence in the floodplain," notes Lea. "What makes matters worse is that significant ponding takes place in this area due to inundation of water against the R29 road."

The high-density separation plant thickeners at Grootvlei Mine.

Grootvlei Mine has budgeted R3 million to construct a canal across the area to reduce inflow into the mining basin. At the time of writing, the environmental impact assessment had already been completed, and the mine was awaiting final approval. "We hope to start the project as soon as possible," says Lea. "If we are successful, we could reduce ingress by 10 Mℓ/day."

IMPROVING WATER QUALITY

The second focus of Grootvlei Mine's water management strategy is finding cost-effective and sustainable ways to improve the quality of the water it discharges into the Blesbokspruit. The mine has selected a treatment technology, the so-called BioSURE process, to undertake partial desalination of 10 Mℓ/day of mine water by September.

The treatment technology was developed by Rhodes University's Environmental Biotechnology Group with support from WRC, East Rand Water Care Company (ERWAT) and BioPAD.

The process removes sulphate from the acid-rich mine water. Instead of expensive carbon and electron donor sources, primary sewage sludge, a byproduct from ERWAT, is being used. The process is reportedly cheaper than any other alternative that uses carbon or electron donor sources, reducing costs from around R5/kℓ to about R1/kℓ operational expenditure.

A pilot plant has successfully treated mine effluent from Grootvlei for the last few years. A modular treatment plant is now being built by ERWAT on behalf of Grootvlei at the wastewater treatment company's Ancor Works in Strubenvale. Existing infrastructure that is currently underutilised is being upgraded for the water treatment process. ERWAT will also operate the plant on behalf of the mine.

"The greatest challenge for the mine, for which we are actively searching for a solution, is to find a sustainable treatment technology that will be able to improve the quality of the mine water and be operational even after the mine closes," concludes Lea.

Photographs and graphics courtesy of ERWAT and Grootvlei Mine.

High-Tech Solution Helps Nut Farmers

The production of subtropical fruits and nuts, in this picture macadamia nuts, is to a large extent weather dependent.

If you are involved in "farm-truthing" and updating a computer routine intended to provide real-life practical but scientifically founded estimates of crop irrigation requirements and you receive an appreciative telephone call from a hard-bitten, well-informed agricultural consultant it means a great deal. Charles Crosby reports.

Agricultural consultants are playing an increasingly important role in agriculture in South Africa. They are generally part of the community they serve and consequently in close touch with the needs of their clients. Some are generalists and are particularly well informed about those little things that make such a difference in farming today. At the same time they have the background and ability to access specialist knowledge when this is required. Clients relatively inexperienced in the new technologies are best served by monthly visits during which comprehensive guidance can be provided. Well-established clients turn to the consultants for high-tech solutions when unexpected difficulties are encountered. The consultants are usually participants in the activities of grower associations and local study groups, and are in touch with the specialists in South Africa and overseas through personal contact and the Internet.

WHERE AND HOW DO CONSULTANTS LEARN THEIR TRADE?

While no two consultants will have followed the same path there does seem to be a degree of similarity. The career of Dries Alberts an agricultural consultant, based on Levubu, Limpopo Province, is a good example.

Alberts started at the Roodeplaat Horticultural Research Institute in 1966. During his ten-year stint here he made his first contact with macadamia nuts during this period. He was then transferred to be officer in charge of the Levubu experiment station of the Citrus and Subtropical Fruit Research Institute, Nelspruit, for a further ten-year stint. His next move was to Levubu cooperative as agricultural extension officer where he worked directly with the farmers.

This was about the time when private companies were formed to take over many of the production, input supply and marketing functions of the cooperatives, and Alberts moved across to a company as technical officer for a further four years. The farmers who had come to reply on him for information and advice pestered him to become a private agricultural consultant.

He enjoyed the challenge and down the years has extended his field of knowledge to cover all the facets of farming in the area, including the development of business plants, labour and legal aspects and the handling, packing and transport of products. He has taken the lead in developing integrated pest management (IPM) for SAMAC, the macadamia grower association, and this initiative has led to the establishment of a national forum.

SUBTROPICAL FRUIT AND NUT PRODUCTION AND THE FIVE-DAY WEATHER FORECAST

The production of subtropical fruits and nuts is to large extent weather dependent. These crops are produced under irrigation so that the atmospheric demand as well as the availability of rain and stored water is largely determined by weather. In addition atmospheric conditions can have a significant influence on the incidence of pests and disease. An additional complicating factor is that in the northern provinces we are dealing with a pattern of largely unpredictable summer rainfall and wide swings in the climatic factors that influence crop growth and this has a material influence on irrigation management.

To the uninitiated it is almost unbelievable that the farmers are not only informed on what day and at what time it will rain, but also how many millimetres can be expected.

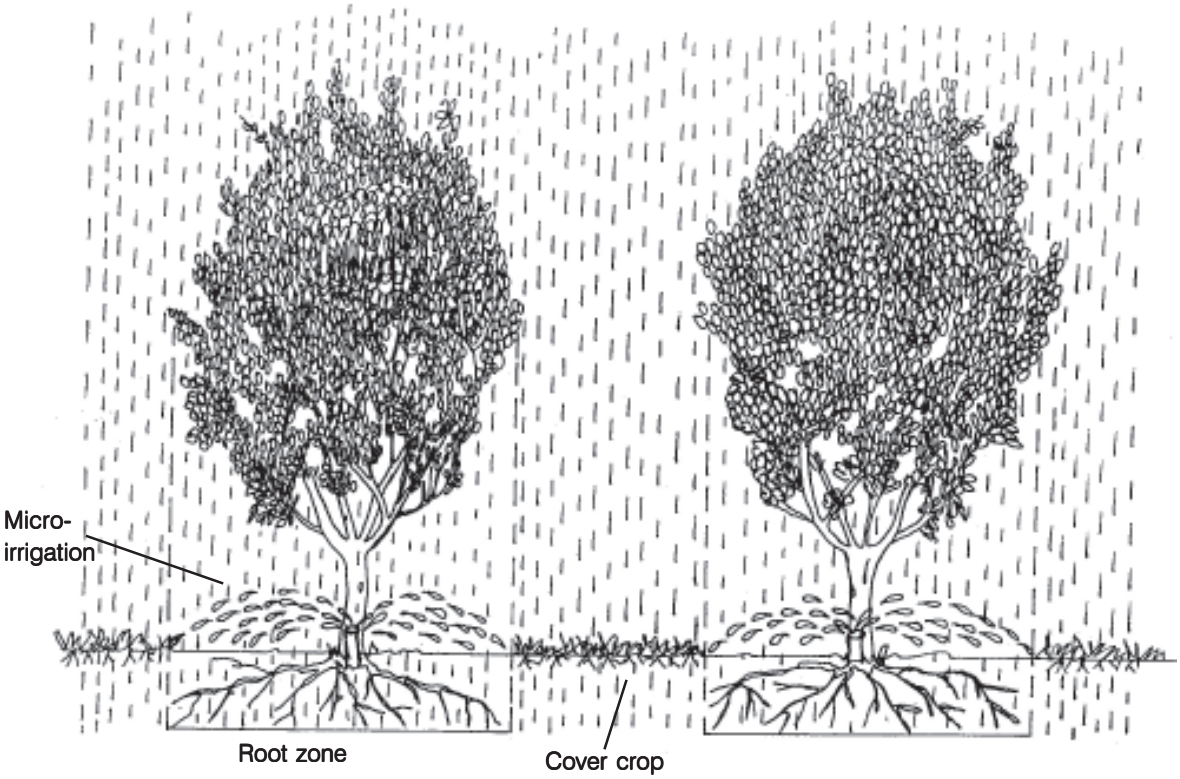
It is not surprising that one of the important services provided by Alberts to his clients is the five-day automatic weather station-based weather forecast managed by Dacorn, a Netherlands-based company represented in South Africa by CropSystems. A dedicated automatic weather station at Levubu, one of 800 weather stations worldwide in the Dacom network, measures temperature, relative humidity, and solar radiation and wind speed every 15 minutes and transmits the data to the Netherlands.

Agricultural consultant Dries Alberts. Agricultural consultants are playing an increasingly important role in agriculture in South Africa.

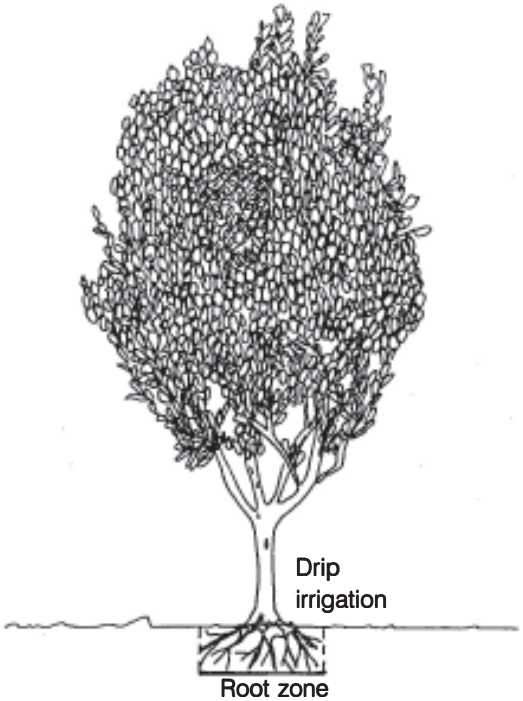
Dries Alberts advising a client.

This is an Internet connection via a conventional telephone line. The data is processed to develop a five-day weather forecast with an interval of four hours as well as an indication of likely disease and insect problems. Alberts consolidates this information and twice a week e-mails the forecasts, with recommendations, to his farmer clients.

To the uninitiated it is almost unbelievable that the farmers are not only



Conventional irrigation – canopy cover 70%, irrigated area and root zone 70%. Rain augments irrigation in summer.



Open hydroponics – canopy cover 70%, irrigated area only 10% – concentrated root zone. In spring no rain, only irrigation.

In summer, do the "outside" roots develop and contribute to the irrigation requirements of the tree?

THE IMPACT OF RAIN ON THE IRRIGATION REQUIREMENTS OF SUBTROPICAL FRUIT AND NUTS

Normal practice when estimating the crop irrigation requirements of subtropical fruits and nuts is to assume that the trees are mature and that the canopy drip line demarcates the area wetted during irrigation and the extent of the active root zone. When estimating crop irrigation requirements for design and planning purposes rain has a major impact during the summer months because rain falling on the canopy will find its way to the soil surface and augment irrigation. Indeed, in a high rainfall area such as Levubu, summer irrigation could be redundant in an exceptional year! This would, however, not be the case in September or October when the evaporative demand is high and the spring rains are still on their way, then the trees will be totally dependent on irrigation. Sapwat appears to be adequate for estimating both this peak system capacity, and the annual water requirement taking rain into account.

informed on what day and at what time it will rain, but also how many millimetres can be expected. They are given early warning notice as to what pest and disease problems are threatening, and when wind and humidity conditions will make spraying possible.

Alberts has gone even further and added plant stress and fire danger indices as well as irrigation advice.

IRRIGATION, THE SAPWAT MODEL AND THE "ANOMALIES"

Alberts finds the Water Research Commission initiated program SAPWAT useful when he visits with a client discussing irrigation and how it fits in with farm management and production. One of the reasons for this is that there is nothing vague about SAPWAT. Once the weather station, crop, irrigation method, and soils have been selected and a real-life crop production and irrigation strategy developed, the model should produce estimates of monthly and seasonal irrigation water requirements that are in line with what the client experiences in practice. If there are anomalies it should be possible to backtrack and check the appropriateness of inputs and make the necessary corrections. Of course the client's perceptions of irrigation water use are by no means above suspicion! Still it should be possible to reconcile and explain the differences.

Alberts first detected an anomaly when he compared SAPWAT output with the readings he was obtaining from a line of mature Macadamia trees where he was monitoring soil moisture content under the dripper line. His trees were not using nearly as much water as SAPWAT had prescribed. His set up approximates that of a drip irrigated orchard managed on the "open hydroponics" principle where the drip-irrigated area is only about 10% of the orchard area. The feeder roots are concentrated in this area and the plant nutrients are provided in accurately metered quantities through the irrigation water. Because the volume of the root system is limited it is also normally necessary to apply pulse irrigation to replenish the water content several times a day. The process is computer-controlled. In the spring when the trees are almost totally dependent on the irrigation water the system must be designed to cope with this peak demand. Consequently rain is left out of the calculation.

But can one afford to ignore rain in a high rainfall region? Fortunately, the method of managing the irrigation is self-compensating. When the water content of the profile under the dripper line reaches a predetermined level irrigation takes place and brings that water content back up to field capacity.

In the spring, assuming no rain, all the water required by the plant must be supplied through irrigation. In the summer months some of the water will be provided by rain and the demand on the irrigation system will automatically be less.

If, however, the wetted area is only 10% of the orchard area then it will only be 10% of the volume of water provided by the rain that will be utilised. That is assuming that it is only the active irrigated roots that will be tapping water. For all we appear to know, roots outside this active zone may be finding water for themselves in the rainy season.

In practice, at a management level, none of this is all that important in the irrigated area provided the irrigation system has adequate capacity and the water content of the soil is accurately measured and controlled. Where it is a factor is in developing figures for the total volume of water required for the season's irrigation. In an area with high rainfall such as Levubu this is probably not an important factor, but it would be in the Karroo. It would also be important when developing best management practices and arriving at realistic figures for crop irrigation requirements for catchment management and licensing purposes.

Groundwater Crucial to Rural Development

Groundwater, if developed and managed responsibly, has a crucial role to play in providing potable water to communities, reports Dr Kevin Pietersen, water resource management director of the Water Research Commission (WRC).

Speaking at the 2005 Biennial Groundwater Conference in Pretoria, he said that groundwater is an important drinking water supply source to many, especially rural, communities in South Africa. It is estimated that more than 400 communities in the country are dependable on groundwater for domestic purposes.

The main method of abstracting groundwater is by means of boreholes. Incidentally, a successful borehole in South Africa is defined as one with a yield of more than 0,1 ℓ/s.

GROUNDWATER IN SOUTH AFRICA

Groundwater currently contributes between 13% and 15% of the total water use in South Africa. It is estimated that the total groundwater use for the country is about 300 million cubic metres a year. The total harvest potential for the country is estimated at 19 000 million cubic metres a year.

According to Dr Peter Rosewarne of SRK, the main method of abstracting groundwater is by means of boreholes. In rural areas with extensive but generally low-yielding aquifers, such as the Karoo, the wind pump is a familiar sight. Less conspicuous are the higher yielding boreholes equipped with submersible or turbine pumps supplying irrigation, urban, mine and industrial requirements. In fact, it is estimated that there may be more than 1,1 million water yielding boreholes in the country.

The most favourable areas or aquifers regarding groundwater availability include the dolomites of the West and Far West Rand; Table Mountain Aquifers of the Western and Eastern Cape; and the coastal sand aquifers in the Western and Eastern Cape and northern KwaZulu-Natal. Other high-yielding aquifers include basement granites in the Polokwane-Dendron-Coetzerdam area, alluvial deposits along sections of large rivers such as the Limpopo and parts of the Karoo Sequence associated with dolorite dykes and ring structures.

In fact, reports Dr Rosewarne, potable groundwater is available over most of South Africa in sufficient quantities to supply small- to medium-scale domestic requirements, stock watering, and small-scale irrigation. The main area where availability is severely limited is the north-western parts of South Africa.

This is sufficient to supply a small rural community using a handpump.

According to Pietersen, groundwater has much potential in serving communities in areas where water infrastructure does not exist, and where water delivery is difficult due to arid conditions. In the Eastern Cape, for example, suitable high-yielding boreholes have been found associated with dolerite-ring and sill-complexes.

Traditionally, there has been a tendency to focus only on the short-term physical sustainability in providing basic water services to these communities. This includes the selection of a favourable site, the right type of pump and the type of well or borehole.

However, Dr Pietersen pointed out, this is not enough for the long term. For marginalised communities to improve their quality of life issues such as supplying enough water for productive use rather than just subsistence use should be considered. Communities should be involved and take ownership of their water resources. At the same time, the role of groundwater in maintaining the natural and economic resource base in the community; and the sensitivity of these systems to overexploitation should not be overlooked.

FIT FOR USE

Unfortunately, not all types of groundwater are fit for use. Diarrhoeal diseases can result from drinking borehole water that contains viruses, bacteria, protozoans and helminths.

MANAGING GROUNDWATER FOR TOMORROW

Dr Ricky Murray, hydrogeologist at Groundwater Africa recommends the following steps for establishing a groundwater management system:

- Obtain the support and buy in of the Water Services Authority (WSA), It is usually the local or district authority.
- Identify boreholes that are registered, and those that require registration.
- Identify priority monitoring sites from the WSA, catchment management agency, Department of Water Affairs & Forestry and other organisations.
- Prioritise monitoring sites from the above list.
- Define the monitoring objectives for each borehole.
- Identify and inform role players.
- Develop the project plan and budget.
- Define job descriptions.
- Secure funding.
- Implement the priority sites.
- Provide mentorship.
- Evaluate and make recommendations.

"In order for the water resources (the aquifers) to be managed in a sustainable and environmentally acceptable manner the following needs should be set up: water level, water quality and abstraction monitoring; data capture; data analysis; operational changes based on the data analysis; and reporting," notes Dr Murray.

Groundwater can play an increasingly important role in bringing basic water supply to far-flung communities.

In this regard a national microbial monitoring programme for groundwater is being implemented. The objectives are to measure, assess, and report on a regular basis the status and trends of the microbial water quality of South African groundwater resources.

Human health can also be affected by long-term exposure to either an excess or a deficiency of certain chemicals in groundwater. This includes iron, copper, zinc, cobalt, magnesium, chromium, and selenium.

These contaminants can be the result of industrial activities, for example, the unknown volume of hexavalent chromium (the cancer-causing chemical made famous by the movie *Erin Brokovich*) that was found in the groundwater outside the Bayer chemical factory in Durban.

Groundwater in South Africa often has high nitrate values, which can exceed 50 mg/ℓ (the maximum permissible level of nitrate in drinking water in South Africa is 20 mg/ℓ). This can cause a number of health concerns, including spontaneous abortion or still birth, gastric and other cancers, and hypertension. This nitrate either occurs naturally in the groundwater or it can be the cause of pollution, for example, effluent from industries.

Nitrate removal technologies have been developed and are in use in some parts of South Africa, for example in the northern parts of Limpopo, the Springbok Flats and the Namaqualand. However, it is reported that present denitrification technology is either user unfriendly, inefficient or expensive for developing nations. Efforts are underway at present to improve the situation.

COPING STRATEGIES

It is clear from these examples that while groundwater plays an essential part in the government's strategy to supply basic water services to all by 2008, innovative thinking will be required to develop groundwater resources and, at the same time, ensure responsible use and protection of human health, said Pietersen. This includes involving appropriate users in technology selection (especially women and children); facilitating democratic decision-making models; and developing groundwater management strategies. In addition, measures must be in place to protect the aquifer from threats. "We must also develop groundwater monitoring and protection systems that address not only environmental issues, but also health and service delivery considerations," noted Pietersen. "With implementation of these strategies groundwater can go a long way in providing water for basic human needs," he concluded.

WATER Kidz

Riding the Water Cycle

There is water all around us. In fact, between two thirds and three-quarters of the Earth is made of water. There is also water in the air, under the ground and in ice caps and glaciers in the very cold parts of our planet.

The Earth never gets new water, and water never disappears. This means the same water you brush your teeth with was used millions of years ago by a mother dinosaur to give her baby a bath. This is because water never stands still and is constantly recycled. We call this the water cycle.

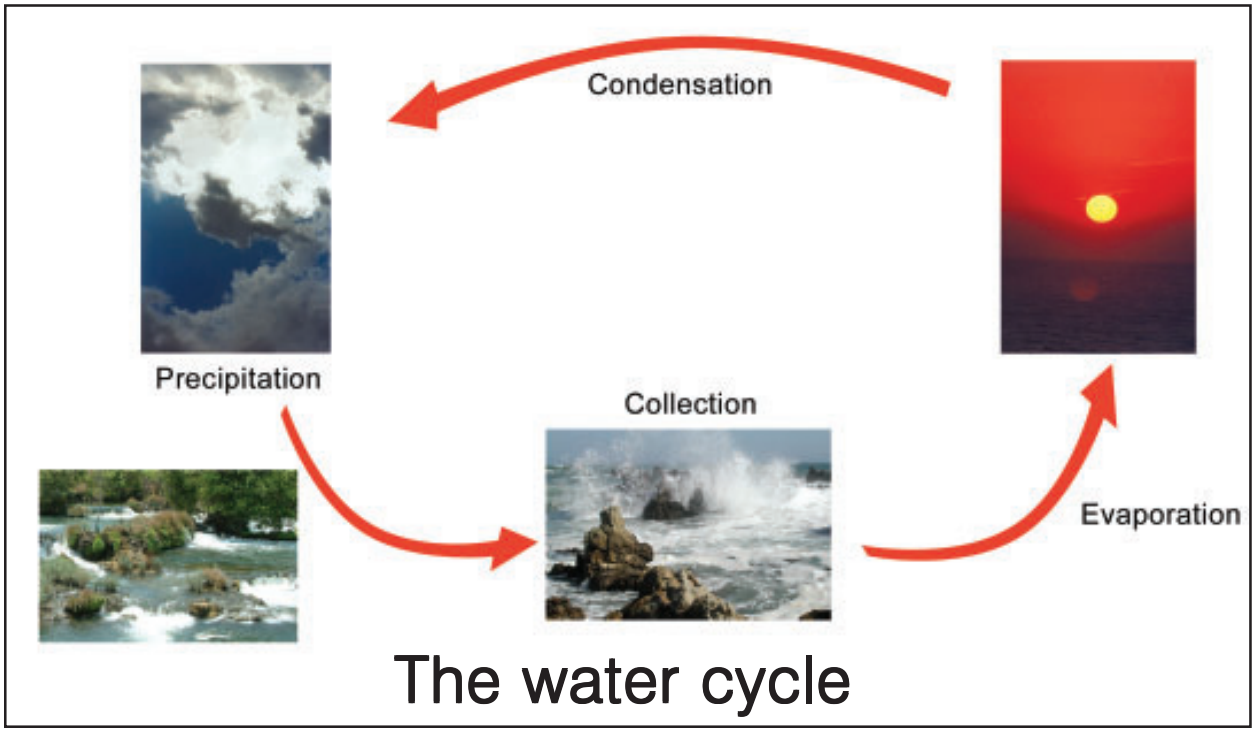
HOW DOES THE WATER CYCLE WORK?

The water cycle is made up of different parts. The water cycle starts with **evaporation**. That is when the sun heats up water in rivers or lakes or the ocean and turns it into vapour or steam. This vapour or steam then leaves the river or lake or the ocean and goes into the air. We also get **transpiration** which is when plants lose water out of their leaves.

When the water vapour or steam is up in the air it gets cold and changes back into liquid form. This forms clouds. This process is called **condensation**. Take a cold glass of water and hold it against the mouth of a boiling kettle. Do you see the water droplets forming on the outside of the glass? That is condensation.

The last step in the water cycle is **precipitation**. This is when water falls back to the earth (for example, when it rains, snows or hails). As more water fall to the ground we get **surface runoff** which is when some of the rain runs into streams and rivers and returns to the oceans.

Some of the water **infiltrates** the soil and is evaporated directly; some of it moves through the roots of plants and is transpired by the leaves. Other water **percolates** or seeps deeper into the ground into layers or rocks or soil underground that hold the water (these are called aquifers).



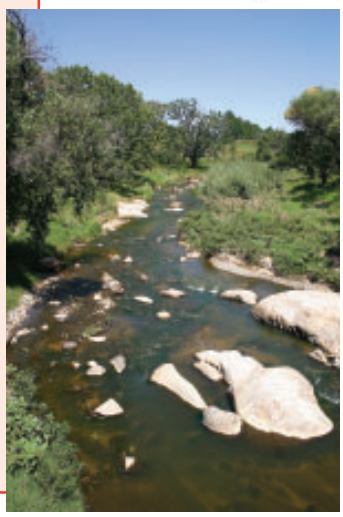
The water cycle

BUILD YOUR OWN WATER CYCLE

You will need:

1. A jar
2. Small plants
3. A bottle cap or a shell filled with water
4. Soil
5. Sand
6. Small stones

1. Fill the jar by first placing the small stones, then the sand, then the soil.
2. Then add the plants in the soil and add the bottle cap or shell of water in the jar.
3. Put the lid on the jar and place it in the sun.
4. Now watch how the water cycle works.



WATER WORDS

Condensation: The process of water vapour in the air turning into liquid water. Water drops on the outside of a cold glass of water are condensed water.

Evaporation: The opposite of condensation. It is the process of liquid water becoming vapour.

Freshwater: Water that contains less than 1 000 mg per litre of dissolved solids.

Glacier: Huge mass of ice, formed on land by the compaction and recrystallisation of snow.

Transpiration: The process by which water that is absorbed by plants, usually through the roots, is evaporated into the atmosphere from the plant surface, such as leaf pores.

Water cycle: The cyclic transfer of water vapour from the Earth's surface via evapotranspiration into the atmosphere, from the atmosphere via precipitation back to earth, and through runoff into streams, rivers and lakes, and ultimately into the oceans.

DID YOU KNOW?

- The Nile is the longest river in the world. Its main source is Lake Victoria, in east central Africa. From its farthest stream in Burundi, in eastern Africa, it extends 6 695 km in length.
- The Amazon in South America is the largest river in the world. This is because it flows through the Amazon rain forest – the largest and wettest rainforest on earth. In fact, the Amazon basin holds two-thirds of all the flowing water in the world. The river is fed by 1 000 tributary rivers, many of which are more than 1 600 km long.
- The largest freshwater flood in the world occurred 18 000 years ago in the Altay Mountains of Siberia, Russia. An ice-dam blocking a lake broke, allowing water to pour out. The lake was estimated to be 120 km long and 760 m deep.

Source: Guinness Book of Records

WATER WORD SCRAMBLE:

Put the letters in the right order:

All living things need _____ (**tawer**) to live.

When water evaporates it travels up in the air, gets cold and turns into liquid form to make _____ (**sdclou**).

When water freezes we call it _____ (**cei**).

Water falls back to earth as _____ (**nria**)

We _____ (**dkrni**) water in its liquid form.

About 97% of the earth's water is found in the _____ (**coena**)

Analysing Water Resources for Good of All

Brendan Hohls has been a principal aquatic scientist at the Department of Water Affairs & Forestry (DWAF) for four years. The Water Wheel asked him about his career in water.

Why did you choose to be in the water sector?
From a young age I had an interest in aquarium fish and fiddling around in the local streams looking at the aquatic life forms and plants growing around them. But I don't really feel that I directly chose to be in the water sector. Approaching the end of high school I started applying for bursaries and the possibility of getting a bursary to study hydrology was raised. I didn't really have an idea what hydrology was, but I did some reading and decided it had potential.

Where did you study?
I received all of my tertiary education at the University of Natal, in Pietermaritzburg. I did a B.Sc degree with majors in Hydrology and Botany. I then went on in the Hydrology field, completing an Honours degree.

What was your first job in the water sector?
In 1994 I started working for DWAF, based at what was then the Hydrological Research Institute at the Roodeplaat Dam. It is now called Resource Quality Services (RQS). I began working as an entry level hydrologist (not working in the field of hydrology, but rather various aspects of water quality).

What does your current job entail?
I work in the Resource Quality Monitoring subdirectorate of RQS. I am part of a team that is involved with the management and operation of the various national scale water quality monitoring programmes. I am responsible for the National (Inorganic) Chemical Monitoring Programme with the support and assistance of various experts in the field.

I am also involved in fish kill investigations for which RQS offers a support service to the DWAF regional offices. This takes various forms, including conducting the actual field investigations to providing logistic support and assisting in getting the appropriate samples to the correct laboratories to be analysed and then interpreting the water quality results to try and pinpoint the possible causes of a fish kill.

What is the most satisfying part of your job?
It is really a good feeling to be able to help people. My main contact with the public is when I am asked to help with the provision of water quality data for some or other interest or project. All historical water quality data as well as new data that results from the analysis of water samples conducted at the laboratories of RQS is housed on the water management system. The database is then accessed to download the data that the user is interested in. It is satisfying to be able to be of assistance to people in this way.

I have also been fortunate to represent the department at an international conference. It was very illuminating to be exposed to the research being conducted internationally, and to visit a foreign country at the same time.

The cherry on top though is when I am called upon to take photographs as part of my work. I am a completely obsessed amateur photographer and love the creative aspects that this involves while still needing to be technically proficient at the art and craft of photography.

WHAT IS AN AQUATIC SCIENTIST?

An aquatic scientist is someone who studies various aspects of inland and marine water environments, including physical (temperatures, water currents and water clarity); biological (plants, animals and microbes that live in water); chemical (organic and inorganic composition of water, water cleansing, water quality); and ecological (the ways in which organisms interact with their environments, how all these are affected by pollution, and their distribution patterns, conservation).

For more on this and other careers in water, see Water@Work available from the Water Research Commission.
To obtain a copy phone
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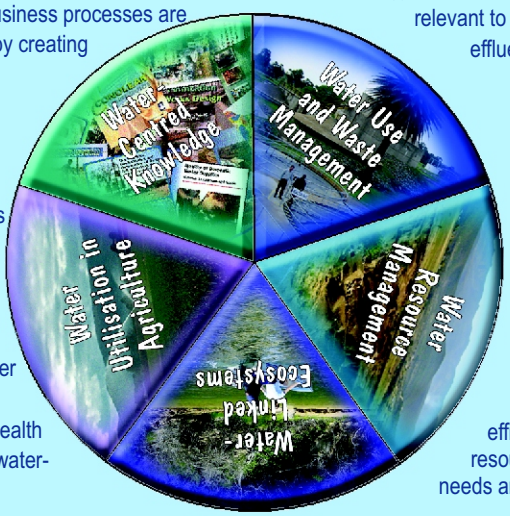
Water Research Commission

Invests in the creation, dissemination and application of knowledge through five Key Strategic Areas

The KSA focuses on knowledge management, including the development and protection of knowledge resources. The WRC functions as a knowledge organisation and hence its fundamental business processes are knowledge-based, thereby creating value for the WRC and Its stakeholders.

This KSA aims to proactively and effectively lead and support the advancement of technology, science, management and policies relevant to water supply, waste and effluent management, for the domestic, industrial and mining water sectors.



The strategic focus in this KSA is on increasing the efficient use of water for production of food, fibre, fuelwood and timber; ensuring sustainable water resource use; reducing poverty and increasing wealth of people dependent on water-based agriculture.

This KSA supports the implementation of the policy by developing tools and technologies for water resource assessment, guidelines and decision-support systems to support decision-makers in achieving equitable and efficient allocation of water resources among competing needs among competing needs.

Research undertaken within this KSA addresses the conservation of aquatic ecosystems in order to provide the knowledge for their sustainable functioning in terms of the national commitment to international conventions and the ongoing provision of goods and services which ecosystems deliver.

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